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Analysis of the Effect of Price Liberalization Policy on Production of the Main Crops Grown in New Halfa Agricultural Corporation

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Abstract: The study was conducted to measure the extent of instability and analysis of sources of changes in mean production of the main crops grown in New Halfa Agricultural Corporation before and after the adoption of liberalization policy. The study used time series data covering the period before the adoption of liberalization policy (1970/71 to 1991/92) and the period after the adoption of liberalization policy (1992/93 to 2007/08). The main crops included in the study were sorghum, cotton, wheat 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 of crops. The findings of the study showed that sorghum and wheat witnessed a continuous increase in instability during the two periods. The instability in groundnuts was high during the pre-liberalization policy and less during post-liberalization policy. The instability in cotton decreased during post-liberalization policy. The decomposition analysis of sources of change in mean production indicated that the main contribution of change in mean production was change in mean area in wheat, cotton, groundnuts and in sorghum was due to change in mean yield. The change in the variance of yield accounted for large shares of the changes in the variance of production of cotton. The changes in the variance of area accounted for large shares for wheat and sorghum. The change in the area and residual term were important in explaining the changes in the variance of production of groundnuts. Programs and policies such as rehabilitation of irrigation system, adoption of improved technologies, strengthening of agricultural research and extension can play a vital role in achieving stability in agricultural production in New Halfa Agricultural Corporation.

Key words:

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[12].

The total arable land in Sudan is estimated at 84 million hectare, and only about 7.14 million hectare are utilized in agricultural production[11]. 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 and 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 veges. 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[12].

New Halfa Agricultural Production Corporation is located at the west of the River Atbra between latitudes 15^0 – 17^0 N, in arid climatic zone, characterized by annual rainfall 250 – 500 mm. The agricultural area in the scheme is estimated at 144900 hectare. The main crops cultivated in the scheme are cotton, groundnuts, sorghum and wheat. The main objectives of New Halfa Agricultural Corporation were resettlement of people affected by the construction of High Dam, increase export earnings, self satisfaction of sorghum and wheat and utilize the country's share of Nile water[1].

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[9]. The spatial variations have been an important dimension of the spectacular growth

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of agriculture in Sudan caused by differences in agro-climatic situations, levels of infrastructural facilities and inherent socio-economic characteristics of different regions of the country[10]. The instability of economic phenomena is generally understood as the departure from what may be considered to be a s passage through time[4]. 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[4].

The objectives of this paper were to measure the extent of instability in the production and analysis of the contribution of different components to changes in mean production of the main crops grown in New Halfa Agricultural Corporation 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 used secondary data covering the period from 1970 to 2008. The sources of the data were the Ministry of Agriculture and Forestry, Department of Statistics in New Halfa scheme.

The standard deviation and coefficient of variation were used by many economists for estimating the instability in agricultural production. Hazell[8] estimated the instability in Indian food production using the coefficient of variation, Farih[5] adopted the standard deviation and coefficient of variation for studying the instability in agricultural production in Sudan. Singh (1989), Gangwar[6] 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[7], and Bohrnstedt and Goldbreger[3],the variance of agricultural production V(P), can be expressed as

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

where $\bar{A}$ $\bar{Y}$ and 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:

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

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 equation (2), average production in the first period is

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

and in the second period is

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

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,

$$\bar{A}_2 = \bar{A}_1 + \Delta \bar{A}$$

$$\bar{Y}_2 = \bar{Y}_1 + \Delta \bar{Y}$$

$$\text{Cov } (A_2,Y_2) = \text{Cov } (A_1,Y_1) + \Delta \text{ Cov } (A,Y)$$

Equation (4) can, therefore be written as

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

The change in average production, Δ E(P) is then obtained by substracting equation (3) from equation (5). Thus,

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

which can be arranged as in (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,

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

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

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

Which can be expressed as

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

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

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

which can be arranged as in (2).

RESULTS AND DISCUSSION

Measurement of instability in area and yield 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 be declined. The standard deviations (SD) of area and productivity of principal crops were computed and is presented in (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 sorghum, cotton and groundnuts in New Halfa declined continuously during period II (post-Prices Liberalization Policy). Wheat in New Halfa was the only crop which observed an increasing trend in area in the second period while its productivity instability decreased 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: (4) indicates that the standard deviation (SD) of sorghum production was (67.09%) in period I and became (88.37%) in period II. Wheat production fluctuation was (43.41%) and (61.44%) during the first and the second period, respectively. Cotton production recorded the lowest fluctuation in period II (27.62). Fluctuations of groundnuts production declined in period II to (39.30).

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

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 (1).The magnitude of change in mean production and the relative contribution of different sources to change in mean production are presented in (5). The increase of production was observed in sorghum and groundnuts, wheat and cotton registered a decrease in production. Increase in the mean yield and mean area accounted for large shares of the increase in mean production for sorghum and groundnuts. Increase in the mean yield accounted for 62.65 percent in sorghum and 35.27 percent in groundnuts whereas the increases in the mean area accounted for 27.17 percent in sorghum and 54.07 percent in groundnuts. The increase in production of sorghum was mainly attributed to increase in mean yield whereas the increase in production of groundnuts was mainly attributed to increase in mean area. The decrease in production of cotton and wheat was mainly attributed to decrease in area. Changes in covariances between areas and yield were not important in accounting for increases in mean production except for groundnuts and sorghum. Interaction effect between changes in mean yield and mean area was small and not significant.

Source of Change in Variance of Production: (6) shows the components of change in variance of production of individual crops, which have been obtained by using the equations in (2). Changes in the variance of areas accounted for large shares of the changes in the variance of production for sorghum, groundnuts and wheat. They accounted for 146.15, 57.88 and 51.52 percent of increase in the variance of production of sorghum, groundnuts and wheat, respectively. These large shares of the change in the variance of production were not consistent with the negative change in the standard deviation of areas as depicted in (6). Change in mean yield accounted for small shares of the changes in the variance of production for cotton. It accounted for 6.01 percent of the increase in variance of cotton but they acted to reduce the variability in case of wheat, groundnuts and sorghum. Changes in mean area accounted for 31.04 percent in case of wheat and 55.80 percent in case of cotton and it was negative in case of groundnuts and sorghum, it accounted for -70.48 percent and -8.22 percent, respectively, so it acted to reduce the variability. Changes in variance of yield accounted for about 83.88 percent in case of cotton and in case of wheat, groundnuts, and sorghum accounted for (22.56%), (28.49%) and (-86.14%), respectively. Changes in the covariance between area and yield accounted for small share in the variance of production in case of most crops. They accounted for 5.25 percent in case of wheat, 31.60 percent in case of cotton and 30.80 percent in case of groundnuts, it accounted for -7.88 percent in case of sorghum so the change in covariance acted to reduce the variability in case of sorghum. Interaction between changes in mean yield and mean area had stabilizing effects in most crops. They accounted about 0.56 percent, -0.70 percent, -2.47 percent and -0.07 percent of the change in the variance of wheat, cotton, groundnuts and sorghum, respectively.

Interaction between changes in mean area and mean yield covariance had de-stabilizing effects on groundnuts (27.60%) and stabilizing effects on wheat, cotton and sorghum which shares accounted for -11.01 percent, -39.95 percent and -27.13 percent, respectively. Interaction term between changes in mean yield and mean area covariance had de-stability effects on wheat, groundnuts and sorghum, which shares accounted for (11.60%), (34.47%) and 12.06 percent, respectively but they acted to reduce the variability in case of cotton (-2.54%). Interaction between changes in mean area and yield and change in area-yield covariance had stabilizing effects in case of wheat, cotton and sorghum and de-stabilizing effect in case of groundnuts. Changes in the residual term acted to reduce the variability in case of cotton (-43.34%) and they acted to increase the variability in case of wheat (6.18%), groundnuts (19.33%) and sorghum which share was higher (89.01%).

Table 1: Components of change in average production

Sources of change	Symbol	Components of change
Change in mean yield	$\Delta\bar{Y}$	$\bar{A}_1 \Delta \bar{Y}$
Change in mean area	$\Delta\bar{A}$	$\bar{Y}_1 \Delta\bar{A}$
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)

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

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

Table 3: Instability in area and productivity of principal crops in New Halfa Agricultural Corporation (in percent)

Crop		Period I	Period II
Sorghum	A	77.20	61.69
	Y	23.29	19.03
Wheat	A	34.73	36.58
	Y	33.83	32.35
Cotton	A	23.37	15.44
	Y	52.56	22.57
Groundnuts	A	48.07	21.05
	Y	54.62	27.19

*A=area
**Y=yield

Table 4: Instability in crop production in New Halfa Agricultural Corporation (Percent)

Crop	Period I	Period II
Sorghum	67.09	88.37
Wheat	43.41	61.44
Cotton	63.91	27.62
Groundnuts	90.42	39.30

Table 5: Contribution of different sources to change in mean production in New Halfa Agricultural Corporation during the study period (percent)

Source if change	Sorghum	Wheat	Cotton	Groundnuts
Change in mean yield	62.65	-50.53	18.88	35.27
Change in mean area	27.17	133.98	78.35	54.07
Change in area-yield covariance	9.19	14.28	-5.24	14.20
Interaction between changes in mean yield and mean area	0.95	2.39	7.49	-3.49

Table 6: Components of change in the variance of production of crops in New Halfa Agricultural Corporation during the period(percent)

Source of change	Wheat	Cotton	Groundnuts	Sorghum
Change in mean yield	-16.53	6.01	-49.55	-16.23
Change in mean area	31.04	55.80	-70.48	-8.22
Change in yield variance	22.56	83.88	28.49	-86.14
Change in area variance	51.52	19.70	57.88	146.15
Interaction between changes in mean yield and mean area	0.56	-0.70	-2.47	-0.07
Change in area, yield covariance	5.25	31.60	30.80	-7.88
Interaction between change in mean area and yield covariance	-11.01	-39.95	27.60	-27.13
Interaction between change in mean yield and area covariance	11.60	-2.54	34.47	12.06
Interaction between change in mean area and yield and change in area yield covariance	-1.10	-10.44	23.94	-1.54
Change in residual	6.18	-43.34	19.33	89.01

Conclusion: The study of instability indicated that the principal crops, sorghum and wheat witnessed a continuous increase in instability over the two sub-periods under study. The instability in groundnut production witnessed a decrease during post liberalization period and had the highest instability during pre-liberalization period. Cotton witnessed sharp decrease in instability from pre-liberalization period to post-liberalization period. The instability in area and yield 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 productivity would help declining production instability.

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

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

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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