The supply response of rainfed agricultural crops to price changes in South Darfur State, Sudan

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ABSTRACT

The objective of this study is to examine the supply response of rainfed agricultural crops to price changes in South Darfur State. The study was based on data collected for the period 1987- 2004. The data included area, production, rainfall, and relative prices. The analysis of data was based on the Nerlovian partial adjustment model. The results revealed that the supply response of individual crops was positive but generally low in the short-run and fairly high in the long-run. These results could be a useful tool for policies intended to enhance the production efficiency of rainfed agriculture in the State. The study also demonstrated the importance of having adequate and timely adoption of agricultural technology to promote the low response of individual crops and to maintain a sustainable food security for the State.

INTRODUCTION

Agriculture is the backbone of Sudan economy. The agricultural sector is the main source of food whether directly through domestic food production or indirectly through the provision of foreign exchange for the importation of inputs used in domestic production of food. The importance of the agricultural sector in the national economy may also be seen from its contribution to the gross domestic product (GDP). Moreover, it is the main source of livelihood in the economy.

With regard to the type of technology adopted, the agricultural sector in the Sudan is divided into three sub-sectors, modern irrigated, mechanized rainfed and traditional rainfed sub-sectors.The traditional rainfed sector occupies an area of 18 million feddans, it covers 40% of the total cultivated land and contributes about 25% of the agricultural production, thereby, providing subsistence for more than 70% of the rural population.The sector produces millet, sorghum, sesame, groundnut and gum Arabic; all of which are considered to be both cash and subsistence crops (Federal Ministry of Agriculture, 2004).

Southern Darfur State (SDS) is situated in the south west of Savannah belt bordering Central Africa, Chad and Western Darfur State to the west and Northern Darfur State to the north. The State depends on traditional rainfed sub sector through shifting cultivation for providing cash crops and food grains that are characterized by low productivity and limited resou-rcees. The State is also characterized by chronic mass poverty and low standard of living caused by low productivity, low rate of saving and capital formation, the existence of underemployment and disguised une-mployment and the poor level of technology has also been observed. From the cultural and political sides, the high rate of illiteracy and the emphasis on traditional values are also characteristic features.

The population of SDS has grown from 1.2 million in 1983 to 2.1 million in 1993 with an annual growth rate of 5.03%. According to the estimates of the central bureau of statistics, the population of SDS increased to 3,334,463 persons in 2004 with an annual growth rate of 4.1%. This significant proportion of the increase in population was the result of immigration from Northern Darfur State due to deteriorating environmenttal conditions, civil war and tribal conflicts in addition to immigration from neighboring countries. It has been realized that the rural sector accounts for 80% of the total population followed by 15% for the urban sector and 5% for the nomadic sector.

The State is composed of different types of soils varying from goz in the north to light and heavy clay in the south. The choice of the selected crops is based on their adaptability to the soil and their importance as major food and cash crops in the State.

Food grains are important food items in SDS and the majority of the population depends largely on it. Millet represents the main stable food and occupies 51% of the total area cultivated in the State and represents 75% of the total area cultivated for millet in the country (Table 1).

Table 1. Area (feddan = 0.42 ha) and productivity (kg/feddan) of major crops in SDS.

Season	Millet		Sorghum		Groundnut	
	Area	Productivity	Area	Productivity	Area	Productivity
1991	1334	265	573	340	590	426
1992	1227	310	222	316	519	364
1993	2274	63	1041	70	1129	203
1994	2083	119	739	236	1140	200
1995	1590	115	381	202	729	146
1996	1623	111	595	141	1099	246
1997	2930	71	753	135	1686	194
1998	2033	177	597	235	1184	288
1999	2048	102	643	108	1644	267
2000	2848	103	957	139	2204	228
2001	2765	115	911	162	2346	277
2002	2661	1103	1412	124	1156	179
Average	2166	138	744	186	1320	251

Source: South Darfur Ministry of Agriculture – Nyala, 2004

Supply response in developing countries means the variation of agricultural output and acreage mainly due to variation in general prices. Because much of the agricultural price policy is made on a commodity by commodity basis, the supply response literature has concentrated on the short and long-run supply response of individual crops to changes in (relative) output and input prices (Binswanger, 1989). Most of the studies done on the supply response in the peasant agriculture in developing countries were related to how producers respond to changes in the relative prices of different agricultural commodities. The effect of changes in relative prices on acreage have been studied by Nerlove (1958) and Krishna (1963).

For an accurate assessment of elasticities, Nerlove (1958) drew attention to the importance of specifying prices elasticities carefully and introduced partial adjustment of a dynamic framework known as the Nerlovian model.

Beynon (1989) and Binswanger (1989) found that individual crops respond strongly to price changes. Reviews by Askari and Cumming (1976) showed that one year elasticity for individual crops could be high and that might vary depending on the charactaristics of the crops or regions. But the response of individual crops to price change differs fundamentally from the response of all agriculture. Their analysis of supply responses concentrated on the response of individual crops to price changes. Theoretically, there are three possible responses of supply responses to price changes (positive , zero and negative).

A normal supply responses means that the higher (lower) the price level, the greater (smaller) will be the level of output offered for sale. Krishna (1963) reached the result that farmers would retain more and hence market less, out of a given food grain production if the market price of food is lowered. He concluded that traditional farmers respond positively to variations in food prices.

With reference to Sudan, a study by Medani (1975) for different cash and subsistence crops including millet, sorghum and groundnuts covering the period from 1951 to 1965 suggested that there was a relatively high price elasticity of sorghum supply estimated at about 0.3 and 0.59 for the short and long-run, respectively. Another study by the same author for the same crops in traditional farming gave rather lower elasticities than those previously obtained from the pervious study. The elasticities were 0.10 and 0.23 for the short and long run, respectively, indicating that output of sorghum responded poorly to price changes.

In the case of groundnuts and millet, using time- series data for the period 1951 to 1965 he found the short and long – run elasticities were in the range of 0.72 to 1.62 and 0.09 to 0.36 for groundnuts and millet, respectively. However, empirical estimates of agricultural supply respo-nses in Sudan have shown mixed results. There were differences in terms of magnitude of responses to prices, but the individual crops respond positively to price change (Medani, 1970; Ali, 1978; Kabalo, 1984).

The general objective of this study was to investigate the supply response of rainfed crops to price changes in South Darfur State. However, the specific objectives are as follows:

i-To measure the magnitude of supply response to price changes.

ii-To examine the response of individual crops in short and long run periods.

MATERIALS AND METHODS

i- Source of data

The data was collected from the Ministry of Agriculture and Natural Resources in Southern Darfur State, which estimated yield and acreage for different crops by crop cutting surveys. The rainfall data was obtained from the meteorological station in the State (Nyala). The relative prices of crops used in the study are the wholesale market prices as farm gate prices are not available. The study used secondary data collected for the period 1987-2004, as the model of supply response analysis is based on time series data. The data includes area, production, rainfall and relative prices.

ii- Method of analysis

The analysis of the supply response of this study was based on the Nerlovian partial adjustment model. Nerlove (1958) hypothesized that farmers decision to grow crops is based on price expectations. He postul-ated that each expectation depended upon the prices realized (received) in the past.

Nerlove derived expressions of expectations by assuming that an expected price exists for the producer and denoted as P^e_t . The expected price is explained as the sum of past expected prices (P^e_{t-1}) and a proport-ion (γ) of the difference between actual past price (P_{t-1}) and the past expected price. Where γ is the coefficient of price expectation.

$P^e_t = P^e_{t-1} + \gamma(P_{t-1} - P^e_{t-1})$ __________ (1)

where

P^e_t : the expected real price

P_{t-1} : the actual price in the last period.

γ : coefficient of price expectation

P^e_{t-1} : the expected real price in the last period

Then the reaction, over time to changes in price expectations, expressed in forms of output (Q) as follow:

$Q_t = Q_{t-1} + \beta(Q^e_t - Q_{t-1})$ _________________ (2)

Where

Q^e_t = The expected supply in time (t)

Q_t : the actual supply

β : the coefficient of expectation

An observable variable is added to the equation in order to distinguish the expectation and adjustment coefficient for the shift variable (Zt) which is important in determining the acreage or yield of a particular crop e.g rainfall, fertilizer.

$Q^e_t = \acute{\alpha}_o + \acute{\alpha}_1 P^e_t + \acute{\alpha}_2 Z_t$ _______________________ (3)

Where Z_t shift variable e.g. rainfall, yield, conflict etc…

Combining equation (1), (2) and (3) to eliminate non-observable variables and imposing a restriction that $\gamma = 1$, yield the following reduced form:

$Q_t = b_o + b_1 P_{t-1} + b_2 Q_{t-1} + b_3 Z_t + V_t$ ___________(4)

Where:

$b_o = \beta\, \acute{\alpha}_o$

$b_1 = \beta\, \acute{\alpha}_1$

$b_2 = 1 - \beta$

$b_3 = \beta\, \acute{\alpha}_2$

V_t = error term

$b_1$and $b_1/1-b_2$ are short and long run price elasticities.

The estimated values of $\acute{\alpha}_o$ and $\acute{\alpha}_1$ for different values of β can be estimated by least squares techniques. Two types of functions were estimate-ed:

1- The acreage response function (cropped area is used as depended vari-able for rainfed crops).

$A_t = f(P_{t-1}, A_{t-1}, T, RF_t, D_i)$ ________________(5)

The equation in the form of log is:

$Log A_t = bo + b_1 \log P_{t-1} + b_2 \log A_{t-1} + b_3 \log RF_t + b4 T + D_i + v_t$ ___(6)

Where:

A_t : cropped area

P_{t-1} : lagged real price

T :   time variable

RF_t : rainfall index

D_i : dummy variable (to indicate periods of conflicts in Darfur, it is specified as1 for the years 1987, 1988, 2002, 2003, 2004 and zero for all other years).

v_t: error term

The yield response function**:** Yield is used as a dependent variable for the crops as follows:

$Y_t = f (P_{t-1}, T, Y_{t-1}, RF_t, D_i)$ ________________ (7)

The equation in the form of log is

$Y_t = c_o+c_1\log P_{t-1} + c_2 \log Y_{t-1} + C_3T+C_4RF_t + D_i + V_t$ _____________ (8)

Y_t: Yield

P_{t-1}: lagged real price

Y_{t-1}:lagged yield

RF_t: rainfall variable

D_i : dummy variable (to indicate periods of conflict in Darfur, it is specified as1 for the years 1987, 1988, 2002, 2003, 2004 and zero for all other years).

T: time variable

V_t: error term

RESULTS AND DISCUSSION

Results of acreage function

The acreage model function was applied here as described in the methodology. The results of the acreage model for the analysis of rainfed crops response to price changes was shown in Tables 2 and 3 for the different selected crops.

Sorghum

Sorghum acreage function in Table 2 shows positive response where price coefficient is significant at 5% level. The short-run price and long-run price elasticities in Table 3 were found to be 0.21 and 0.31, respectively. R^2 which implies the coefficient of multiple determination shows that included explanatory variables explain about 74% of the variation in the independent variable (acreage). F-statistic shows that the models is statistically significant at 1% level.

Millet

The estimated price coefficient is significant at 1% level. The short and long-run price elasticties were found to be 0.91 and 1.12, respectively. F- statistic shows that the model is statistically significant at 1% level and R^2 is reasonably high (80%).

Sesame

The price coefficient of sesame is statistically insignificant. The estimated short-run price elasticity of sesame is 0.44 and the estimated long-run price elasticity was found to be 0.31. R^2 is found to be very weak and amounted to 22%, the F-statistic shows that the model is statitically significant at 5% level of significance.

Karkadae

The estimated price coefficient is statistically significant at 10% level of significance. The estimated short –run price elasticity was found to be 1.14 and the calculated long-run price elasticity was found to be 4.07. R^2 is 70%. F statistic indicated that the model is statistically significant at 1% level of significance.

Results of yield function

The results of yield function were presented in Tables 4 and 5.

Sorghum

The estimated price cofficients of sorghum yield function shows that it is statistically siginificant at 5% level of significance. The short price elasticity is found to be 0.49. The long price elasticity is 0.5. R^2 is found to be 0.75. F statistic indicates that the model is statistically significant at 5% level of significance.

Millet

The estimated short-run price coefficient is 1.09 and statistically significant at 1% level of signifiance, the derived long-run price elasticity is 1.18. R^2 is found to be relatively low which is 0.58. F – statistic indicated that the model is statistically significant at 1% level of signif-icance.

Groundnut

The price coeffiient of groundnut is statistically signficant at 5% level of significane and recorded short-run price elasticity of 2.01and long-run price elsticity of 2.07. R^2 was found to be 60% and F-statistic shows that the model is statistically significant at 1% level of significance.

Table 2. Acreage regression coefficients for the rainfed crops in South Darfur State.

Crop	Constant	P_{t-1}	A_{t-1}	RF_t	D	T	R^2	DW	F- value
Sorghum	4.42*** (3.22)	0.21** (1.98)	0.33 (0.21)	0.91*** (3.11)	-0.09*** (9.11)	0.23* (1.96)	0.74	1.22	16.1
Millet	11.4*** (7.8)	0.91*** (4.21)	0.19 (1.19)	0.04 (0.59)	-0.89*** (4.01)	1.23** (2.35)	0.80	0.91	8.5
Groundnut	0.98** (2.01)	0.86*** (5.40)	0.73** (2.75)	-0.74** (2.31)	-0.94*** (3.55)	25** (2.11)	0.69	0.21	12.4
Sesame	5.66*** (3.22)	-0.09 (0.01)	0.96 (1.04)	0.51 (0.43)	-0.13*** (9.11)	0.99** (2.00)	0.62	0.11	2.4
Karkadae	0.45 (0.91)	1.14* (1.94)	0.72** (2.61)	0.03 (0.44)	-0.01 (1.04)	3.02** (2.01)	0.70	0.40	7.04

Figures in parenthesis indicate t- value.
DW is Durbin-Waston statistic.
*, **, *** Significant at 10%, 5% and 1% level of probability, respectively.

Sesame

The price coefficient of sesame is statistically insignificant. The estimated short-run price elasticity of sesame is 0.44 and the estimated long-run price elasticity was found to be 0.31. R^2 is found to be very weak and amounted to 22%, the F-statistic shows that the model is statitically significant at 5% level of significance.

Karkadae

The estimated price coefficient of Karkadae yield function shows that it is statistically significant at 5%. The short –run price elasticity is found to be 0.41 and the estimated long-run price elasticity is 0.36. R2 is found to be very weak and amounted to 14%. F – statistic indicated that the model is fit at 1% level of significance.

Table 3. Acreage, short –run and long-run price elasticities and adjustment coefficient for selected crops.

Crop	Partial adjustment coefficients	Elasticities	
		SR*	LR*
Sorghum	0.67	0.21	0.31
Millet	0.81	0.91	1.12
Groundnut	0.27	0.86	3.18
Seasame	0.04	-0.09	-2.25
Karkadae	0.28	1.14	4.07

Source: obtained from Table 2.
***** SR = short –run, LR = long-run.

Table 4. Yield regression coefficients for the rainfed crops in South Darfur State.

Crop	Constant	P_{t-1}	Y_{t-1}	RF_t	T	D	R^2	DW	F- value
Sorghum	0.11	0.49**	0.02	0.66**	2.33*	0.25	0.75	0.50	3.14
	(0.04)	(2.22)	(0.11)	(2.29)	(1.89)	(0.28)			
Millet	0.19	1.09***	0.08	1.04***	1.75**	-0.08*	0.58	0.21	19.21
	(0.14)	(3.24)	(1.01)	(3.24)	(2.03)	(1.89)			
Groundnut	1.01	2.01**	0.03	0.94***	1.09**	-1.59***	0.60	0.40	22.04
	(0.92)	(1.98)	(0.01)	(3.44)	(1.99)	(3.01)			
Sesame	0.94	0.44	-0.40**	-1.11**	0.58**	0.04	0.22	0.11	3.80
	(0.81)	(1.44)	(1.98)	(2.02)	(2.14)	(1.05)			
Karkadae	0.04	0.41**	-0.11	-3.22***	1.09*	-2.01**	0.14	0.21	11.21
	(0.12)	(1.99)	(1.33)	(4.04)	(1.87)	(2.08)			

Figures in parenthesis indicate t- value.
DW is Durbin-Waston statistic.
*, **, *** Significant at 10%, 5% and 1% level of probability, respectively.

Table 5. Yield, short –run and long-run price elasticities and adjustment coefficient for selected crops.

Crop	Partial Adjustment coefficients	Elasticities	
		SR*	LR*
Sorghum	0.98	0.49	0.50
Millet	0.92	1.09	1.18
Groundnut	0.97	2.01	2.07
Seasame	1.40	0.44	0.31
Karkadae	1.11	0.41	0.36

Source: obtained from table 4.
*****SR = short –run, LR = long-run

CONCLUSION

The supply response of agricultural crops to the price changes, had attracted considerable attension amongst agricultural economists and policy makers. Thus, if the response of farmers is high, then the elimination of the price distortion, trade restrictions and high taxes, will enhance production and increase exportable surpluses.The ultimate impact of these would be the overall growth of the agricultural sector.This study measures the rainfed agriculture supply response in South Darfur State. In order to examine supply response of rainfed crops to price changes, the study uses the Nerlove model (1958). The study is based mainly on secondary data. Two separate estimates functions were estimated for the rainfed crops in the State. The findings tend to confirm the predominant view that prices have a positive impact on agricultural production. The positive signs of the price coefficients indicate that the rainfed farmers respond to price changes, but the response of these crops is low, also the results showed that the rainfed crops recorded low elasticities in the short – run and moderatly high elasticity in the long-run. This may be due to the absence of new technolog-ies, drought periods and to the recent conflict in Darfur. The Government may use results from supply response analysis as a guide to improve the response of individual crops that have low or negative response to price changes. The results indicated that sesame has negative response.

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إستجابة الزراعة المطرية للتغير فى الأسعار بولاية جنوب دارفور

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الخلاصة

هدفت هذه الدراسة إلى فحص استجابة الزراعة المطرية إلى التغير في الأسعار في ولاية جنوب درا فور. اعتمدت الدراسة علي المعلومات التي جمعت للفترة 1987الي 2004م وشملت المعلومات المساحة، الإنتاج ، منسوب الأمطار والأسعار . أظهر نموذج نيرلوف بصورة عامة أن استجابة المحاصيل الفردية موجبة ولكنها ضعيفة في المدى القصير والي حد ما عالية فى المدي البعيد .خلصت الدراسة الي أهمية توفير التقانة الحديثة وتطبيقها في الوقت المناسب من أجل تحسين استجابة المحاصيل المطرية واستدامة الأمن الغذائي في الولاية.