# Testing for Decreasing Risk Aversion in Traditional Farming: The Case of Sudan

by

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# Testing for Decreasing Risk Aversion in Traditional Farming: The Case of Sudan

Risk aversion is considered an important barrier to technological change and growth in developing agriculture. Adoption rates and the distributive effects of modern technology is largely influenced by the risk behavior of agricultural producers. A risk programming model is used to measure the degree of risk aversion for various income groups and test the hypothesis of decreasing risk aversion in the traditional farming sector of the Sudan. The behavioral assumption of DARA is supported. The study, however, did not provide enough evidence to support the hypothesis that household subsistence requirements directly influence production decisions and dictate the optimal cropping mix in traditional farming.

Differential rates of adoption of the green revolution technologies have been observed in developing countries. The causes and implications of this pattern of agricultural development have been extensively investigated. Differences in adoption are mainly attributed, among other factors, to variations in the size and risk preferences of farm firms [Schluter, 1971; Bhaduri, 1973: 120-137; Heibert, 1974: 764-768; Newbery, 1975: 130-148; O'Mara 1980]. Theoretical models have been developed to provide analytical explanations for the differential responses of agricultural producers to technological change. Results obtained under different behavioral specifications show that farmers attitudes towards risk influence adoption rates and determine the distribution of gains from the new technology

(Feder, 1980: 263-82; Just, Zilberman and Rausser, 1980: 40-56]. Modern technologies have favourable distributional effects under increasing relative risk aversion (IRRA) when small farmers use larger shares of their lands in the more rumunerative, though riskier alternatives than large size farms. While this is not the common empirical finding there have been a few supporting cases [Mutiah, 1971: 62-78; Schluter, 1971; Sharma, 1972: 52-74]. On the other hand there is substantial empirical evidence to support the hypothesis of decreasing risk aversion where larger firms adopt technology faster and receive more benefits [Shetty, 1971: 146-153; Rochin, 1972: Rao, 1975]. This indicates the importance of studying the risk behavior of agricultural producers and the associated implications on agricultural development.

Diversification indexes were employed by Aziz and D'Silva [1984] to examine the allocative behavior of farmers in the traditional rain-fed sector of the Sudan. Their indices were derived directly from actual areas planted to different crops by various groups of farmers. Poor farmers were found to have smaller diversification indices than middle and large farmers. This result, contrary to the common theoretical belief and previous empirical findings, suggest increasing rather than decreasing risk aversion. One problem with their method is that it does not take into account the riskiness of the alternative crop enterprises. The present study examines those results by using a risk programming approach to model the choice problem of this same group of farmers when outcomes are random. Wealthy farmers were found to cultivate larger areas and realize higher yields than other social groups due to their ability to hire more labor. Accordingly, farmers were classified by farm size into 3 income groups. The coefficient of absolute risk aversion (ARA) for each group is estimated and compared to test for decreasing ARA in traditional farming.

The study also examines the hypothesis that in such traditional settings household subsistence requirements influence farmers production strategies and dictate the pattern of cropping mix. Part one reviews alternative methods of measuring risk preferences and defines the approach employed by the present paper. The farming system in the study area is described in part two. Part three develops the empirical model. The procedures of the analysis and results are discussed in part four. Part five concludes the study.

Alternative approaches to measuring risk attitudes

The most basic approach to measuring risk attitudes is experimental. In this method the reactions of individuals involved in true gambles are observed [Luce and Suppes, 1965: 20-40]. Simulated rather than actual gambling situations are also used to elicit risk attitudes of agricultural producers [Officer and Halter, 1968; O'Mara, 1971: 257-77; Dillon and Scandizzo, 1978: 425-35; Kennedy, 1978: 106-120; Binswanger, 1980: 395-407].

Antle [1987] suggests an econometric procedure for eliciting the parameters of the utility function of agricultural producers. His flexible moment-based (FMB) method is based on observations of farmers actual production decisions and hence more relevant to producers behavior and policy analysis than the non-econometric approach. The FMB approach focuses on the characteristics of the population rather than the individual members. Antle's method also allows for formal testing of hypotheses about risk behavior using production survey data and saves on the costs of conducting expensive experiments. Experimental methods, however, do not need the statistical assumptions required to identify and estimate the structural parameters of the econometric model.

A rather simple procedure is employed by this study to estimate an average coefficient of ARA. The procedure compares the observed average farm choices to simulated optimal solutions for various levels of ARA. The level that generates solutions consistent with the actual choices of farmers is considered a consistent estimate of the average coefficient of risk aversion [Hazell, 1971: 53-63; Brink and McCarl, 1978: 259-263]. Farmers are classified into income groups and a coefficient of ARA is estimated for each group. The estimated coefficients are compared to examine the structure of the underlying utility function and investigate the validity of the behavioral assumption of decreasing absolute risk aversion (DARA). The mean-variance (E-V) model is used to simulate the behavior of agricultural producers under uncertainty.

## The Farming System

The study is conducted in the traditional rain-fed sector of the Sudan. The traditional sector is the largest in Sudan occupying more than 10 million acres of arable land and hosts most of the animal wealth of the country. The sector contributed about 50% of Sudan's foreign exchange earnings in 1982/83 [Ministry of Finance, 1984]. The sector is also the major food supplier for the country.

Traditional farming methods and primitive hand tools are utilized for cultivation. The lack of external credit and extension institutions has limited farmers access to modern inputs. Technology is labor intensive and no chemical inputs used. Shifting cultivation (fallowing) is the only soil enriching practice. Local money lenders provide the only source of credit in a non-competitive, unorganized capital market. Seeds are acquired from previous harvest or local merchants. A communal tenure system prevails where land is relatively abundant.

A typical village (Kazgil) was selected in Western Sudan, south of El-Obeid City. A sample of 18 farmers were surveyed during the 1983-84 season. Four major crops are grown, two food crops (millet and sorghum) and two cash crops (sesame and groundnuts). The crop production cycle adopted by farmers show four peak periods of agricultural activities. Namely the second half of June, second half of July, August and October. Crops compete during these periods for labor. Labor hiring is a major activity practiced by farmers, particularly the wealthy ones.

Due to their ability to hire more labor, wealthy farmers are able to cultivate larger areas and realize higher yields than other social groups. Accordingly farm size measured by land area is used to classify farmers into three income groups. Farmers cultivating less than 8 makhmas[1] are classified poor whereas, those planting more than 15 makhmas are considered wealthy. Each group was found to employ a different technology (Table 1).

The Empirical Model

The two-moment (E-V) model of uncertain decisions is employed to characterize the decision problem of the farm firm. Constant ARA and normality of returns are maintained by the model's structure [Markowitz, 1959; Freund, 1956: 253-63]. Producers buy and sell in competitive factor and product markets. Faced with random returns, farmers are assumed to choose the portfolio of crop enterprises that will maximize their expected utility of returns U(R) given their resource constraints. The (E-V) method postulates a quadratic utility function to be maximized subject to the technological, institutional and physical constraints of the system. The decision problem of the farm firm is therefore represented with the following model:

(1) $\text{Max}_X \; U(R) = R'X - \frac{1}{2} \lambda \; X'V(R)X$

subject to:

(2) $AX \leq B$

where:

a. X is a (4x1) vector of areas under the four production activities X = (M D S G)' where (M) is millet, (D) is sorghum, (S) is sesame and (G) is groundnuts.

b. R is a (4x1) vector of expected net returns per makhmas for the 4 enterprises.

c. $V_R$ is the (4x4) positive definite variance-covariance matrix of expected returns.

d. $\lambda$ is the Arrow-Pratt measure of ARA.

e. A is a (6x4) matrix of the production technology and subsistence requirements coefficients (4 labor, a land and a consumption constraint).

f. B is a (6x1) vector of resource availability and minimum consumption constraints.

Average farm models are constructed for the 3 income groups. The models' data is given in Table (1). Linear production technologies are measured. The survey data plus a secondary time series on crop yields are separately used to estimate V(R). While the covariance matrix coefficients estimated from both data sets are slightly different in magnitudes they had the same signs. All farmers are assumed to face the same spread (covariance) of returns -- V(R) given in Table (2). This is equivalent to assuming that production technology (levels and combination of factor inputs) do not influence risk (yield variability), and hence V(R) does not vary across farm types. The fact that all farmers employ labor intensive technology and primitive farming methods, and use no protective factors such as chemical inputs and improved cultural practices, led to the assumption of independence between V(R) and factor inputs. Consequently, optimal portfolio selection is the only instrument of risk management left to the risk averse farmer, in absence of risk reducing inputs such as fertilizer, pesticides, regular irrigation and the like. And hence, the decision problem of the agricultural producer is to choose the optimal mix of the risky alternative enterprises. Groundnuts (G) is the riskiest and most profitable crop whereas sorghum (D) has the lowest risk and expected returns.

An upper limit on labor availability for the four labor periods is derived using the effective household size and an estimate of hired labor supply. The highest observed participation of hired hands is considered the maximum amount of external labor available for each group of farmers. Minimum household subsistence requirements from staple grains are estimated from household consumption budgets. Farmers in the study area are found to have stronger tastes for millet (M) over sorghum (D). Lack of data precluded the estimation of the substitution elasticity between the two commodities. A fixed coefficient alternative is used to reflect consumers preference. The linear specification assumes that millet contributes 1.3 times as much utility as sorghum to people's utility function. The average farm size is used as the upper limit on acreage for each group.

Procedures and Results of the Analysis

Optimal solutions of the model are obtained under alternative behavioral and institutional assumptions. The model specification that offers the best approximation to the actual choices of farmers is used to estimate the coefficient of ARA. Estimates of the measure of ARA for the 3 income groups are utilized to investigate the validity of DARA in traditional farming. Farmers' behavior is simulated under the following scenarios:

A) The Market Scenario

Full integration in the market economy is assumed. In this specification production decisions are responsive to market forces and independent of subsistence needs, e.g. no consumption constraint.

B) The Subsistence Scenario

This specification assumes that household subsistence needs directly influence production decisions (a different objective criterion) and dictate cropping patterns. A minimum consumption constraint is imposed.

Solutions were obtained for various levels of ARA e.g. varying ($\lambda$) in both scenarios. Tables 3 and 4 summarize the results of the model simulations described above. Optimal solutions obtained under risk neutrality ($\lambda$=0) are inconsistent with the observed farm plans under both scenarios for all groups of farmers. The most plausible plans were obtained at 0.006, .002, and .0008 levels of ARA ($\lambda$) for the poor, middle and rich groups respectively under the market scenario. The results support the hypothesis of DARA. Rich farmers are observed to allocate larger plots to the risky alternatives (the cash crops G and S). Sorghum is grown only by the poor whereas millet is produced on all farms.

The results did not provide evidence that subsistence requirements dictate the optimal cropping mix. Similar solutions are obtained under both scenarios for the poor. The subsistence scenario on the other hand, failed to generate plausible solutions for the middle and rich groups at all levels of $\lambda$. This indicates that while the poor are closer to subsistence farming, other groups show greater participation in the market economy. This result implies different effects of market stimuli on different social groups.

Conclusion

Risk aversion is considered an important barrier to technological change and agricultural growth in developing countries. The risk behavior of agricultural producers influence adoption rates and the distributional impact of agricultural innovations. A risk programming model was used to measure the degree of risk aversion and test the hypothesis of DARA in the traditional farming sector of the Sudan. As technology is labor intensive and land is relatively abundant in this sector, the scale of the operation reflects the social status and financial capacity of the farmer to hire more labor and cultivate larger land areas. Accordingly, the farming population was classified by farm size into 3 income groups. The coefficient of ARA for each group was estimated and compared to examine the utility structure. Results supported the validity of the behavioral assumption of DARA. They also suggest that pure diversification indexes such as those used by Aziz and D'Silva [1984] are misleading when riskiness of the alternative production opportunities is not taken into consideration.

A minimum consumption constraint was included to investigate the effects of household subsistence needs on farmers' production plans. The hypothesis that subsistence needs directly influence production decisions and dictate the optimal farm plans in traditional farming was not supported. Greater participation in the market economy was observed among higher income groups.

Table (1): Model Coefficients for the 3 farm types[1]

| | Poor | | | | | Middle | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | D | S | G | RHS[a] | M | S | G | RHS[a] | M | S | G | RHS[a] |
| Labor 1[b] | 9.5 | 7.5 | 7.2 | 6.5 | 62 | 9.6 | 7.7 | 15.3 | 126 | 5.8 | 8.5 | 24 | 260 |
| Labor II | 9.8 | 12 | 21 | 14.5 | 110 | 17.6 | 11.4 | 24 | 220 | 10.2 | 18 | 23 | 400 |
| Labor III | 10.5 | 11.5 | 9 | 6.5 | 110 | 12.7 | 15.5 | 13 | 298 | 11.2 | 19.4 | 21.6 | 420 |
| Labor IV | 7.9 | 6 | 5.3 | 4.8 | 50 | 7.3 | 3.4 | 11.5 | 80 | 4.5 | 6 | 11.2 | 260 |
| Land | 1 | 1 | 1 | 1 | 8 | 1 | 1 | 1 | 15 | 1 | 1 | | 12 |
| Consump. Constraint[c] | 1.14 | .76 | | | 6 | .96 | | | 9 | 1.04 | | | 12 |
| expected net returns[d] | 26 | 17 | 24 | 21 | | 24 | 32 | 40 | | 32 | 39 | 50 | |

(1) A sample of 18 farms were surveyed, 6 farms from each group (type).
(a) Right hand side contains the elements of the B vector in the model.
(b) Labor coefficients in man hours/makhmas.
(c) Consumption constraint coefficients in sacks.
(d) In Sudanese pounds per makhmas.

Table (2): Covariance of expected returns matrix

| | M | D | S | G |
|---|---|---|---|---|
| M | 527 | 83 | - 51 | -585 |
| D | | 100 | -111 | -207 |
| S | | | 617 | 427 |
| G | | | | 4111 |

Table 3: Model Solutions: The Market Scenario (A)
(crop shares in makhmas)

| | Enterprise | λ Actual | 0.00 | .0001 | .0008 | .001 | .002 | .006 |
|---|---|---|---|---|---|---|---|---|
| 1. Poor | M | 3.35 | 7.5 | 7.5 | | 5.3 | 4.9 | 3.47 |
| | D | 1.33 | 0.0 | 0.0 | | 0.0 | 0.0 | 1.34 |
| | S | 1.75 | 0.0 | 0.0 | | 1.96 | 2.24 | 2.22 |
| | G | .85 | 0.0 | 0.0 | | .30 | .35 | .47 |
| 2. Middle | M | 4.31 | 0.0 | 0.0 | | 1.75 | 4.78 | 6.7 |
| | S | 7.56 | 5.06 | 5.06 | | 9.37 | 7.14 | 5.1 |
| | G | 1.33 | 8.94 | 8.94 | | 2.88 | 2.08 | 1.2 |
| 3. Rich | M | 8.12 | | 3.32 | 7.6 | 8.89 | 11.4 | 13.1 |
| | S | 12.25 | | 11.59 | 12.02 | 11.37 | 10.1 | 9.2 |
| | G | 5.00 | | 10.1 | 5.35 | 4.74 | 3.5 | 2.7 |

Table 4: Model Solutions: The Subsistence Scenario (A)
(crop shares in makhmas)

| | | Enter- prise | λ Actual | 0.00 | .0001 | .0008 | .001 | .002 | .006 |
|---|---|---|---|---|---|---|---|---|---|
| 1. | Poor | M | 3.35 | 7.5 | 7.5 | | 5.63 | 5.26 | 4.47 |
| | | D | 1.33 | 0.0 | 0.0 | | 0.0 | 0.0 | 1.20 |
| | | S | 1.75 | 0.0 | 0.0 | | 1.85 | 1.9 | 1.30 |
| | | G | .85 | 0.0 | 0.0 | | .02 | .38 | .55 |
| 2. | Middle | M | 4.31 | 7.9 | 7.9 | | 7.9 | 7.9 | 9.12 |
| | | S | 7.56 | .97 | .97 | | 2.8 | 3.8 | 3.4 |
| | | G | 1.33 | 5.14 | 5.14 | | 3.4 | 2.3 | 1.32 |
| 3. | Rich | M | 8.12 | | 10.53 | 10.53 | | 11.41 | 13.1 |
| | | S | 12.25 | | 3.12 | 8.9 | | 10.1 | 9.2 |
| | | G | 5.00 | | 11.35 | 5.57 | | 3.5 | 2.7 |

## Footnotes

[1]One makhmas is approximately 1.6 acres.

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