Risk and Resource Analysis of Rainfed Tanks in South India

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Abstract

The objectives of this paper are to quantify a measure of risk behaviour of tankfed farmers using the safety-first principle, to study the effects of socio-economic variables on risk aversion and to analyse the influence of risk aversion on input use decisions. There has been a skewed distribution of coefficients towards more risk aversion. Among the socio-economic determinants, size of the family, capital available for agriculture, and ownership status of tanks had a significant influence on risk aversion. The larger the family size, the higher was the risk aversion. Capital available for agriculture negatively influenced risk aversion. The ownership of tanks had a positive influence on risk aversion. The results showed that risk played a significant role in the use of labour and fertilizer inputs. Credit had significantly influenced the use of these resources as well.

Introduction

The advent of the Green Revolution and subsequent developments in agriculture have shown the impact of modern technologies, reflected in the present level of foodgrain production (201 million tonnes in 1998–99). However, it is felt that development has been skewed in favour of well-endowed (irrigated) areas, with no comparable productivity gains in risk-prone low-rainfall areas. It is further confounded by the prediction that 246 million tonnes of foodgrains would be needed in the year 2010 to satisfy the burgeoning population (Kumar 1998). On the one hand, demand for foodgrains has been rising, while on the other hand supply prospects are not very encouraging as there is hardly any scope for augmenting production through area expansion. However, there is scope for enhancing productivity through proper rainfed technology and management. Despite their greater significance, rainfed lands are inherently characterized by high climatic risk arising from the stochastic nature of rainfall.

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The problem of productivity variation (risk) among farms is more pronounced in areas with uncertain water supply (Abel 1975). The presence of risk in agriculture has long been viewed as having a significant influence on farmers' production decisions (Bond and Wonder 1980). While there can be no question that risk is an obvious characteristic of the agricultural decision environment, very little is known about the attitudes of farmers towards risk. Keeping in view the pivotal role of risk in an uncertain water supply regime and inadequate empirical studies on risk behaviour in India, the present study was conducted in select rainfed tank-irrigated regions in South India. The specific objectives were as follows: (i) to quantify a measure of risk behaviour of tankfed farmers; (ii) to study the effects of socio-economic factors on risk aversion; and (iii) to analyse the influence of risk aversion on input use decisions. The following hypotheses were tested in this study:

(a) Risk aversion is the most prevalent attitude among rainfed tank farmers.

(b) There is a possible influence of socio-economic characteristics on the risk behaviour of farmers ; and

(c) There exists an influence of risk on resource use decisions.

Methodology

Sampling

Chengalpattu and Sivagangai districts in Tamil Nadu were purposively selected. Both the districts are considered to be tank-intensive districts. There are 583 tanks in Chengalpattu and 1,180 tanks in Sivagangai, inclusive of both Public Works Department (PWD) and Panchayat Union (PU) tanks (Palanisami 1997). From the list of modernised rainfed tanks, one tank from each of the selected districts was randomly chosen. They are Somangalam, in Chengalpattu, and Kilavanur, in Sivagangai district. In the next stage of sampling, 50 farmers were randomly selected from each tank command . Thus, a total of 100 farmers constituted the sample size for the study. The study was conducted during 1998–99, which was a normal year.

The registered command area of Somangalam (PWD[1]) and Kilavanur (ex-zamin[2]) tanks are 116.39 and 34.36 hectares respectively. Both were modernised recently by Public Works Department (PWD), Tamil Nadu, with the assistance of European Economic Community (EEC). The components of the modernisation programme were improvement of weak bunds, correction of leakage of sluices and weirs and lining of distributary channels. The cropping pattern in these tankfed areas included predominantly paddy (over 96 per cent) and to a very limited extent pulses and vegetables. The average rainfall in Somangalam and Kilavanur regions is 1,459 mm and 663 mm respectively, the maximum being from the Northeast monsoon in both the tanks.

Analytical Framework

Safety First principle is one of the best approaches to the measurement of risk. The principle was elegantly applied by Roy (1952), Shahabuddin, *et al*. (1986) and Parikh and Bernard (1988).

Safety First Principle. The principle assumes that the individual's objective is to minimise the probability of experiencing a shortfall in income below a certain initial level. Two measures were formulated on the basis of this principle. The first was by Roy (1952) and later by Moscardi and de Janvry (1977). Roy's approach was applied by Shahabuddin, *et al.* (1986) and Parikh and Bernard (1988). Here the principle is to minimise the probability of a fall (π) below specified levels of disaster (E*) so that

$$\text{Min } P(\pi < E^*)$$
$$\text{or Min } F(E^*),$$

where P refers to probability, and F is the cumulative distribution function. For empirical simplicity, it can be written as

$$\text{Min } \frac{E^* - E}{\sigma}$$

where E is the expected income, E* is the disaster level of income, and σ is the standard deviation of income.

1. Quantification of Measure of Risk:

This is an application of the model used by Parikh and Bernard (1988) and Timothy (1991).

(i) *Disaster level of income* (E*)

$$E^* = C_{min} + COT – LAS – NAI,$$

where C_{min} = minimum consumption needs

$$= 2212\left[\text{FAM} - \frac{\text{CHILR}}{2}\right];$$

with 2212 being the minimum number of calories per person in rupees (obtained from the Eighth Plan Document at 1992–93 prices). 'FAM' is the family size, including children, and 'CHILR' represents the number of children.

COT = credit outstanding, which includes both institutional and non-institutional credit;

LAS = liquid assets, which include business and livestock assets

NAI = non-agricultural income of trade and industry.

(ii) *Expected income (E)*

E= VO (1+ DMG)–Sc–Ic–Fc–BLc–Pc–Lc

where VO is the value of output on the farm, which includes outputs from both owned and leased-in land. DMG is the weighted crop damage variable. This was obtained by enquiring how much they perceived to have lost due to the adversity by giving prices of the crops as weightages (K_i). Hence,

$$\mathrm{DMG} = \frac{\sum \mathrm{K}_i \mathrm{DMG}_i}{\sum \mathrm{K}_i}$$

From the obtained expected value of output was deducted the cost of seed material (Sc), cost of irrigation (Ic), cost of fertilizers and manures (Fc), cost of bullock labour (BLc), cost of plant protection chemicals (Pc) and cost of labour (Lc).

(iii) Standard deviation (σ)

The standard deviation of household income was derived from the approximate income calculated from aggregation of all sources of income during the past three years. This was confined to three years to avoid memory bias.

These three variables were used in obtaining the risk-aversion variable.

$$R_{\mathrm{i}} = \frac{E_i^* - E_i}{\sigma_i}$$

where i=1 to n, and n = number of farms.

2. Determinants of Risk Aversion:

To test the second hypothesis, we identified four socio-economic variables for which data were available,viz., family size, farm size, amount of capital available for agriculture, and the ownership status of the tank. Using regression analysis, the possible influence of these socioeconomic characteristics on the farmers' risk behaviour was assessed. The following risk behavioural model has been examined empirically in a sampling context in our study.

RAC= f(FAM, ARM, CAP, DUM)

where RAC = risk-aversion coefficient,
FAM = family size,
ARM = area of the farm in hectares,
CAP = capital[3] available for agriculture in rupees, and
DUM = 1 for PWD tank, and zero otherwise.

Based on scatter analysis and past studies, the above model was estimated in linear form by using the Ordinary Least Squares (OLS) method.

3. Resource Use Models:

It is hypothesised that farmers' risk aversion attitude presumably affects decisions regarding resource use in crop production. To test the hypothesis, the following two models were framed by integrating risk aversion with choices of labour and fertilizer usage. The influence of risk aversion on input use was studied by fitting linear regression models and was estimated using the Ordinary Least Squares (OLS) method.

VARIABLES	MODEL I (Labour use)	MODEL II (Fertilizer use)
Dependent (Y)	LAB	FERT
Explanatory (X_i)	RISK, HYVA, CREDIT, FERTM, ACROP, DUM	RISK, WATER, FLAB, CREDIT, HYVA, DUM

where,

LAB = labour used per hectare in man days,
RISK = risk-aversion coefficient,
HYVA = percentage of area under high-yielding varieties,
CREDIT = crop loan received,
FERTM = value of fertilizers and manures,
ACROP = cropped area in hectares,
WATER[4] = quantity of water used per hectare,
FLAB = family labour in man days per hectare, and
DUM = 1 for PWD tank, and zero otherwise.

Results and Discussion

Risk behaviour was quantified in rainfed tank-irrigated regions in South India using the 'safety first' criterion. The distribution of the risk-aversion coefficient is presented in Table 1. It was found that 93 per cent of the farmers were risk averters, the degree ranging from moderate to strong (<10). There existed a higher proportion of strong risk averters in Tank II (ex-zamin), which lies in the low-rainfall region. The distribution of R_i values was skewed towards more aversion.

The results of the linear regression model to study the influence of socio-economic variables on risk behaviour are presented in Table 2. The R^2 of the model was 0.56, indicating that 56 per cent of the variation in the risk coefficient is explained by the variables included in the model. The family size had a one per cent significant influence with a coefficient of -1.79, indicating that an increase in family size by one unit reduced the risk preference, or, in other words, increased risk aversion.

Table 1: Pattern of Risk Behaviour

(in no)

Risk Behaviour	Tank I (PWD)	Tank II (ex-zamin)	Total
< - 10	19 (38)	24 (48)	43 (43)
-10 to 0	16 (32)	21 (42)	37 (37)
0.01 to +10	9 (18)	4 (08)	13 (13)
> +10	6 (12)	1 (02)	7 (07)
	50 (100)	50 (100)	100 (100)

(Figures in parentheses indicate percentage of total)

The policy implications include educating the farmers on smaller family size and risk aversion. The dummy variable has greatly influenced the risk-aversion coefficient at the 1 per cent level. The positive influence implies that PWD-owned tankfeds have greater risk preference. The estimate suggests that capital available for agriculture negatively influences risk aversion. Another variable (area of the farm) has insignificant influence on risk behaviour.

Table 2: Results of Risk Behavioural Model

Variables	Symbol	Coefficient
Constant	C	4.42^{*} (2.62)
Family size	FAM	-1.79^{*} (0.27)
Area of farm in hectares	ARM	-0.15 (0.15)
Capital for agriculture (in Rs.)	CAP	-0.0014^{*} (0.0003)
Dummy for ownership of tanks	DUM	3.86^{*} (1.43)

$R^2 = 0.56$; $\bar{R}^2 = 0.54$; N = 100

(Figures in parentheses are standard errors)
** Significant at 1 per cent level*

Table 3 shows the results of the Labour and Fertilizer Use Models. The R^2 of the labour use model was 0.74 with a high level of significance. The use of labour was influenced considerably by the RISK variable at the 5 per cent level with a coefficient of 1.31. This means that a one unit increase in risk preference has increased the labour use by 1.31 units. HYV area, value of fertilizer and manures and cropped area had no influence on labour use. Borrowed crop loan had significantly influenced the labour use at the 1 per cent level with a coefficient of 0.04. Tank ownership had a considerable influence on labour use at the 10 per cent level of significance.

The fertilizer use model had a significant R^2 of 0.82. The RISK variable influenced fertilizer use significantly at the 1 per cent level. Credit had an influence at the 10 per cent level of significance with a coefficient of 0.06. The rest of the variables were found to be insignificant on fertilizer use.

Table 3: Results of Labour and Fertilizer Use Models

Variable	Labour Use Model			Fertiliser Use Model		
	Coefficient	t-value	Significance	Coefficient	t-value	Significance
Constant	36.41	1.05	*	700.01	6.27	***
Risk	1.31	1.69	**	11.97	5.40	***
HYVA	0.08	0.39	NS	0.22	0.42	NS
Credit	0.04	3.69	***	0.06	1.59	*
FERTM	0.01	0.74	NS	–	–	–
ACROP	2.87	0.58	NS	–	–	–
WATER	N.A.	–	–	–0.59	–0.92	NS
FLAB	N.A.	–	–	0.46	0.69	NS
DUM	8.13	1.44	*	2.98	0.18	NS

$R^2 = 0.74$; $\bar{R}^2 = 0.68$; $F = 11.21^{***}$ $R^2 = 0.82$; $\bar{R}^2 = 0.77$; $F = 17.69^{***}$

Significance: *** – 1 per cent level; ** – 5 per cent level; * – 10 per cent level

NS – Non-Significant

Summary and Conclusions

The basic thrust of this paper was to obtain an estimate of the risk aversion variable using the safety-first principle. The distribution of coefficients was skewed towards risk aversion, indicating that a large number of farmers were more risk averse. Secondly, the role of socio-economic variables in determining the farmer's level of risk aversion was examined. Among the socio- economic determinants, the influence of family size, capital available for agriculture, and ownership status of tanks were found significant. The larger the family size, the higher was the risk aversion. Capital available for agriculture negatively influenced risk aversion. Tank ownership had a positive influence on risk aversion. The policy implications include educating the farmers on smaller family size and risk aversion through community organisers, creating more non-farm opportunities and suggesting standardisation of rain-fed tanks. Finally, the integration of risk aversion with choices of labour and fertilizer inputs and estimation showed that risk played a significant role in the use of labour and fertilizer inputs. Credit had significantly influenced resource usage. The policy option would be to disburse more credit to improve resource use so as to enable farmers to realise higher productivity.

Notes

1. PWD tanks are standardised tanks with a command area of more than 40 ha.
2. Ex -Zamin tanks are non-standardised, irrespective of their command area.
3. Capital utilised in agriculture for inputs was used here as a proxy for liquid cash available at the farm level.
4. This was analysed on the basis of the depth and frequency of irrigation on the farm.

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