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Decision-Making in Risk-ridden Tankfed Farms in Tamil Nadu – An Application of Advanced Breakeven Analysis

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INTRODUCTION

Farming is fraught with risk and uncertainty conditions. There is an increased risk and uncertainties in the agricultural production environment with reference to rainfall, yields and prices. In the light of a fluctuating economic environment, rational decisions are made possible through an application of advanced breakeven techniques (Dillon, 1993). In our study, the tankfed zone was selected due to the increased risks and uncertainties faced by these areas in terms of productivity. The productivity variation (risk) in terms of farm income is evident in tankfed farms (Randhir, 1991). In Tamil Nadu there are more than 39,000 tanks in the state, with varying sizes and types. Sengupta (1993) reported that tank irrigation is an attractive proposition to the farmers because it is estimated that the average net returns from tank irrigated hectarage in terms of foodgrains is about three times higher than those from the unirrigated hectarage. The potential for future expansion in irrigation in Tamil Nadu is dependent much on the tanks. This is because, the tanks have wider geographical distribution and hence any investments done to improve/restore the tanks would reach the vast majority of the people. Keeping in view the importance of tank irrigation and its risk-riddeness, this study was undertaken in a tankfed environment in Tamil Nadu.

In farm situations, decision-making is not only confined to a single enterprise but also spanned across enterprises. Enterprise budgeting enables to conduct breakeven analysis. Breakeven analysis for agricultural decision-making has been proposed and discussed (Barnard and Nix, 1979). Some of the advantages of breakeven analysis are (i) Maximum potential yield losses due to detrimental weather can be investigated with potential yield analysis. (ii) Breakeven output price can be used as a simple risk management tool to evaluate the impact of marketing decisions under price variability. (iii) Breakeven analysis is also useful from the input side. For instance, for input requirements breakeven analysis can be used to study the economic impacts of the need for additional irrigation during an unseasonable drought to avoid yield loss. The utilisation of breakeven input (diesel) price analysis can be employed in the

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light of growing concerns regarding diesel/petroleum prices. (iv) While certain input prices may rise, input substitution can alleviate rising costs of production to some degree embodied in breakeven total cost analysis. The usefulness of breakeven concepts in agriculture could be epitomised on two accounts: (i) to determine maximum input usage and minimum yield level and (ii) to arrive at a minimum price level of output in fluctuating economic situations. The risk can be assessed by setting out a breakeven analysis (Sturrock, 1967). Advanced breakeven estimates were developed by Dillon, 1993. In the light of an intricate decision-making environment filled with interactions and complexities, the need for developing advanced breakeven techniques is evidenced by a request for such research (Kay, 1986). In this paper, we focused our attention of empirical application of the advanced breakeven analytical procedures on three major crops: paddy, ground-nut and green gram within and between crop enterprises.

METHODOLOGY

The study was conducted on three major crops in Chengalpattu district of Tamil Nadu State during 1999-2000. Madurantakam tank was purposively selected based on inter-farm variations in productivity. The tank has five sluices and six surplus weirs. The registered command area of this tank is 1,141.02 hectares and is maintained by the Public Works Department. The average rainfall was 1,086.92 mm, the highest being in the northeast monsoon season. The command area received supplemental irrigation with open wells and bore wells. The cropping pattern in the command area showed that 62.05 per cent of the area was under paddy, followed by groundnut (18.08 per cent) and greengram (9.02 per cent). The other crops included vegetables, sugarcane and ragi grown to a limited extent. A sample of 120 farms from the tank ayacut was randomly selected based on probability distribution of area under each sluice. Crop enterprise budget estimates were derived for the sample. These enterprise budgets permit to compute breakeven points, which have an appeal as a farm management planning device particularly in risky situations. Breakeven analysis was employed in three areas: breakeven points for a single enterprise, and breakeven points between enterprises, and the elasticity of breakeven points between enterprises.

(i) *Breakeven Points for a Single Enterprise*

Breakeven equations are given in Table 1 for all conceivable budget components: product price, product yield, input requirements, variable cost, fixed cost and total cost. For each constituent of profit of an enterprise, breakeven estimates are compared with budget estimates to work out allowable deviations to retain net return non-negative. For example, minimum levels of product price or yield as well as maximum levels of input utilisation, variable cost, fixed cost or total cost are assessed by performing sensitivity analysis of profits for a single agricultural enterprise.

TABLE 1. BREAKEVEN POINTS FOR A SINGLE ENTERPRISE

Single enterprise breakeven point for[1] (1)	Equation (2)
Product price	$P_{ei} = \frac{VC_{ei} + FC_{ei} + \pi_{ei}}{Y_{ei}}$
Yield	$Y_{ei} = \frac{VC_{ei} + FC_{ei} + \pi_{ei}}{P_{ei}}$
Variable cost	$VC_{ei} = P_{ei}Y_{ei} - FC_{ei} - \pi_{ei}$
Fixed cost	$FC_{ei} = P_{ei}Y_{ei} - VC_{ei} - \pi_{ei}$
Total cost	$TC_{ei} = P_{ei}Y_{ei} - \pi_{ei}$
Input requirement	$I_{ei} = \frac{P_{ei}Y_{ei} - VC_{ei}' - FC_{ei} - \pi_{ei}}{r_{ei}}$

where e_i , e_j are enterprises,

P_{ei} = Product price of enterprise i,

Y_{ei} = Yield of product i,

r_{ei} = Input price for input x required for the enterprise i,

I_{ei} = The level of input x required for the enterprise i,

Vc_{ei} = Variable cost for enterprise i,

Fc_{ei} = Fixed cost for enterprise i,

Vc_{ei}' = Variable cost for enterprise i exclusive of costs for input x,

π_{ei} = Profit of enterprise i, and

TC_{ei} = $VC_{ei} + FC_{ei}$.

(ii) *Breakeven Points between Enterprises*

In farm situations, decision-making needs span across enterprises. The study of interactive effects of changes on relative profitability between production alternatives is possible with breakeven analysis between agricultural enterprises. Between enterprises breakeven analysis involves equating the profit functions of two alternative production enterprises 'i' and 'j' and solving for each constituent of profit. The derivations are presented in Table 2.

TABLE 2. BREAKEVEN POINT ANALYSIS ACROSS ENTERPRISES

Cross-enterprise breakeven point for[2] (1)	Equation (2)
Product price	$P_{ei} = \frac{VC_{ei} + FC_{ei} + \pi_{ej}}{Y_{ei}}$
Yield	$Y_{ei} = \frac{VC_{ei} + FC_{ei} + \pi_{ej}}{P_{ei}}$
Variable cost	$VC_{ei} = P_{ei}Y_{ei} - FC_{ei} - \pi_{ej}$
Fixed cost	$FC_{ei} = P_{ei}Y_{ei} - VC_{ei} - \pi_{ej}$
Total cost	$TC_{ei} = P_{ei}Y_{ei} - \pi_{ej}$
Input requirement	$I_{ei} = \frac{P_{ei}Y_{ei} - VC_{ei}' - FC_{ei} - \pi_{ej}}{r_{ei}}$

where $\pi_{ej} = P_{ej}Y_{ej} - VC_{ej} - FC_{ej}$,
See footnote to Table 1.

(iii) Elasticity of Breakeven Points among Enterprises

Each of the breakeven elasticity concepts can be interpreted as the percentage change in the first component for enterprise 'i' that must accompany a 1 per cent change in the second component given for enterprise 'j' to maintain equivalent net returns between the two production alternatives. For instance, the breakeven elasticity of paddy price to greengram price is the percentage change in the paddy price that must accompany a 1 per cent change in greengram price to retain relative profitability. Empirically, breakeven elasticity of price 'i' to price 'j' is:

$$\frac{\partial(P_{ei})}{\partial(P_{ej})} \cdot \frac{P_{ej}}{P_{ei}}$$

where $P_{ei} = \dfrac{VC_{ei} + FC_{ei} + \pi_{ej}}{Y_{ei}}$

$$P_{ei} = \frac{VC_{ei} + FC_{ei} + P_{ej}Y_{ej} - VC_{ej} - FC_{ej}}{Y_{ei}}$$

$$P_{ei} = (VC_{ei} + FC_{ei} + P_{ej}\,Y_{ej} - VC_{ej} - FC_{ej})\;Y_{ei}^{-1}$$

$$\frac{\partial(VC_{ei} + FC_{ei} + P_{ej}Y_{ej} - VC_{ej} - F_{ej})Y_{ei}^{-1}}{\partial P_{ej}} \cdot \frac{P_{ej}}{P_{ei}} = \frac{Y_{ej}}{Y_{ei}} \cdot \frac{P_{ej}}{P_{ei}}$$

In similar fashion, elasticities for all breakeven points between enterprises are derived and are presented in Table 3.

TABLE 3. BREAKEVEN ELASTICITY ANALYSIS AMONG ENTERPRISES

Between enterprises breakeven analysis for [3] (1)	Equation (2)
Product price$_{ei}$ to Product price$_{ej}$	$\epsilon P_{ei} P_{ej} = \frac{\partial P_{ei}}{\partial P_{ej}} \cdot \frac{P_{ej}}{P_{ei}} = \frac{Y_{ej}}{Y_{ei}} \cdot \frac{P_{ej}}{P_{ei}}$
Yield$_{ei}$ to Yield$_{ej}$	$\epsilon Y_{ei} Y_{ej} = \frac{\partial Y_{ei}}{\partial Y_{ej}} \cdot \frac{Y_{ej}}{Y_{ei}} = \frac{Y_{ej}}{Y_{ei}} \cdot \frac{P_{ej}}{P_{ei}}$
Product price$_{ei}$ to Cost$_{ej}$	$\epsilon P_{ei} C_{ej} = \frac{\partial P_{ei}}{\partial P_{ej}} \cdot \frac{C_{ej}}{P_{ei}} = \frac{-1}{Y_{ei}} \cdot \frac{C_{ej}}{P_{ei}}$
Yield$_{ei}$ to Cost$_{ej}$	$\epsilon Y_{ei} C_{ej} = \frac{\partial Y_{ei}}{\partial C_{ej}} \cdot \frac{C_{ej}}{Y_{ei}} = \frac{-1}{Y_{ei}} \cdot \frac{C_{ej}}{P_{ei}}$
Product price$_{ei}$ to Input requirement$_{ej}$	$\epsilon P_{ei} I_{ej} = \frac{\partial P_{ei}}{\partial I_{ej}} \cdot \frac{I_{ej}}{P_{ei}} = \frac{-r_{ej}}{Y_{ei}} \cdot \frac{I_{ej}}{P_{ei}}$

(Contd.)

TABLE 3 *(Concld.)*

Between enterprises breakeven analysis for [3] (1)	Equation (2)
$Yield_{ci}$ to Input $requirement_{cj}$	$\epsilon Y_{ci} I_{cj} = \frac{\partial Yei}{\partial Iej} \cdot \frac{Iej}{Yei} = \frac{-rej}{Yei} \cdot \frac{Iej}{Pei}$
Human labour $requirement_{ci}$ to Product $price_{cj}$	$\epsilon H_{ci} P_{cj} = \frac{\partial Hei}{\partial Pej} \cdot \frac{Pej}{Hei} = \frac{-Yej}{Wei} \cdot \frac{Pej}{Hei}$
Human labour $requirement_{ci}$ to $Yield_{cj}$	$\epsilon H_{ci} Y_{cj} = \frac{\partial Hei}{\partial Yej} \cdot \frac{Yej}{Hei} = \frac{-Yej}{Wei} \cdot \frac{Pej}{Hei}$
Human labour $requirement_{ci}$ to $Cost_{cj}$	$\epsilon H_{ci} C_{cj} = \frac{\partial Hei}{\partial Cej} \cdot \frac{Cej}{Hei} = \frac{-1}{Wei} \cdot \frac{Cej}{Hei}$
Human labour $requirement_{ci}$ to Human labour $requirement_{cj}$	$\epsilon H_{ci} H_{cj} = \frac{\partial Hei}{\partial Hej} \cdot \frac{Hej}{Hei} = \frac{Wej}{Wei} \cdot \frac{Hej}{Hei}$

where ϵ is the breakeven elasticity of component i to component j,
P_{ei} = Product price of commodity i,
Y_{ei} = Yield of product i,
I_{ei} = Input x required for the production of commodity i,
r_{ei} = Input price for input x for the production of commodity i,
C_{ei} = Cost for production of commodity i,
P_{ej} = Product price of commodity j,
Y_{ej} = Yield of product j,
I_{ej} = Input x required for the production of commodity j,
r_{ej} = Input price for input x for the commodity j,
C_{ej} = Cost for production of commodity j,
H_{ei} = Human labour requirement for commodity i,
W_{ei} = Wage for labour for the production of commodity i,
H_{ej} = Human labour requirement for commodity j,
W_{ej} = Wage for labour for the production of commodity j.

RESULTS AND DISCUSSION

Net returns of each crop enterprise given in Table 4 have shown positive value. Advanced breakeven equations are applied empirically on data of enterprise budget estimates of three major crops, viz., paddy, groundnut and greengram. Breakeven estimates for single enterprise analysis are presented in Table 5. Breakeven points comprise yield, product price, variable cost, fixed cost and input requirements for net returns above total cost. Yield and product price of an individual enterprise can move to a lower level and still allow for a non-negative net returns above total cost. Breakeven estimates of variable cost, fixed cost, total cost and input requirements for each enterprise can move up to a higher level and still remain at positive net returns.

TABLE 4. ESTIMATED BUDGET COMPONENTS FOR PADDY, GROUNDNUT AND GREENGRAM

Components (1)	Paddy (2)	Groundnut (3)	Greengram (4)
Yield (kgha^{-1})	4,700	1,526	498
Product price (Rs. kg^{-1})	4.29	9.92	12.6
Variable cost (Rs. ha^{-1})	13,516	11,205	3,435
Fixed cost (Rs. ha^{-1})	3,861	2,516	1,478
Total cost (Rs. ha^{-1})	17,377	13,721	4,913
Net returns above variable cost (Rs. ha^{-1})	6,647	3,933	2,840
Net returns above total cost (Rs. ha^{-1})	2,786	1,417	1,362
Seed requirement (kgha^{-1})	77	105	16
Fertiliser requirement (kgha^{-1})	185	69	3
Human labour requirement (man-hours ha^{-1})	1,124	872	354
Animal labour requirement (pair hour ha^{-1})	67	67	34

The percentage allowable deviations in the budgeted items are also given in Table 5. It is obvious that product price of paddy can drop by about 13 per cent from the budgeted estimate of Rs. 4.29 to the level of Rs. 3.69 and still retain non-negative net returns above total cost. When crops encounter adverse factors, yield would decline. Under such situations, yield of greengram can diminish by about 21.7 per cent from the budgeted estimate of 498 to the level of 390 and still have positive net returns

TABLE 5. RESULTS OF SINGLE ENTERPRISE BREAKEVEN ANALYSIS

Breakeven points for (1)	Paddy (2)	Groundnut (3)	Greengram (4)
Yield (kgha^{-1})	4,050.58 (-13.82)	1,383.16 (-9.36)	389.92 (-21.70)
Product price (Rs. kg^{-1})	3.69 (-13.82)	8.99 (-9.36)	9.86 (-21.70)
Variable cost (Rs. ha^{-1})	16,302.00 (20.61)	12,621.92 (12.65)	4,796.80 (39.64)
Fixed cost (Rs. ha^{-1})	6,647.00 (72.15)	3,932.92 (56.32)	2,839.80 (92.14)
Total cost (Rs. ha^{-1})	20,163.00 (16.03)	15,137.92 (10.32)	6,274.80 (27.72)
Input requirements			
Fertiliser requirement (kgha^{-1})	433.97 (134.58)	182.99 (292.28)	N.A.
Human labour requirement (man-hrha^{-1})	1,563.43 (39.09)	1,112.56 (27.58)	632.07 (75.72)
Animal labour requirement (pair-hrha^{-1})	335.92 (401.37)	178.04 (165.73)	91.16 (168.11)

Figures in parentheses indicate the percentage change from the level budgeted for the factor above it.
N.A. = Not available.

above total cost. Although enterprise budget estimates indicate that positive net returns prevail in all enterprises, greengram performs relatively more favourable in a risky, highly variable environment. While net return analysis demonstrate that greengram is a less profitable crop than paddy, it displays a greater ability to withstand relative fluctuations in yield, price, variable costs and fixed costs. It is evident from Table 5 that allowable deviations of green gram crop to retain non-negative net returns is higher than for paddy for all breakeven points such as product price (21.7 per cent), variable cost (39.64 per cent) and fixed cost (92.14 per cent). On the contrary, groundnut is less profitable and less favourable under risky situations than paddy crop. While comparing the performance of groundnut with that of greengram, groundnut reaps more net return than that of greengram. But greengram performs more favourably under risky environments than groundnut.

Paddy production can absorb greater absolute input requirements before suffering a negative net return above total cost than groundnut production. Greengram as a nitrogen-fixing crop does not require nitrogenous fertiliser and other fertilisers are also not applied largely. Therefore, calculation of breakeven estimates for fertiliser requirements for greengram production is not applicable. Though these results are indicative of profitability and riskiness for decision-making, other criteria like crop rotation, government policy restrictions, etc., also need to be considered.

The results of cross enterprise breakeven analysis (Table 6) for paddy to other crops indicates its relative economic desirability more so to greengram than groundnut. In all cases, product price and yield could decrease from the current budgeted levels or cost could increase to a considerable level in absolute terms; still these deviations could be sustained by paddy and maintain an equivalent net returns above total costs. In addition, all three input requirements can increase quite significantly in relation to the other crops and still allow paddy production to be performed profitably. Between breakeven estimates analysis for groundnut to other crops displays its relative economic desirability more so to greengram than paddy.

TABLE 6. RESULTS OF CROSS-ENTERPRISE BREAKEVEN ANALYSIS

Cross break-even point for	Yield (kgha^{-1})	Product price (Rs.ha^{-1})	Variable costs (Rs.ha^{-1})	Fixed costs (Rs.ha^{-1})	Total costs (Rs.ha^{-1})	Input requirement		
						Fertiliser (kgha^{-1})	Human labour (man-hrsha^{-1})	Animal labour (pair-hrsha^{-1})
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Paddy to:								
Groundnut	4,380.87	3.99	14,885.08	5,230.08	18,746.08	307.35	1,339.94	199.15
Greengram	4,368.02	3.98	14,940.20	5,285.20	18,801.20	312.27	1,348.64	334.12
Groundnut to:								
Paddy	1,664.01	10.82	9,835.92	1,146.92	12,351.92	-179.14	639.56	-40.29
Greengram	1,520.46	9.88	11,259.92	2,570.92	13,775.92	73.42	881.32	71.30
Greengram to:								
Paddy	611.03	15.46	2,010.80	53.80	3,488.80	N.A.	73.65	-96.90
Groundnut	502.38	12.71	3,379.80	1,422.80	4,857.80	N.A.	343.13	28.93

N.A. = Not available.

Relative comparisons between enterprises imply that greengram does possess some more degree of allowable alterations in various budget components than paddy crop does. Breakeven analysis for greengram indicates more flexibility to groundnut than to paddy production.

Breakeven elasticity analysis focused on two alternative enterprises, viz., paddy and greengram because of favourable performance of both enterprises. To maintain brevity of presentation, breakeven elasticities are computed for cross effects of three factors: product price, total cost and human labour requirement. The results of breakeven elasticity analysis are presented in Table 7. Product price elasticity of an enterprise to product price of an alternative enterprise showed the desirability of the production of paddy under an increasing price market. All product price comparisons for paddy are inelastic implied that as prices for other commodities increase by 1 per cent, the price of paddy can increase by less than 1 per cent in order to maintain relative profitability. Paddy performs better than greengram with regard to fluctuation in not only product price but also total cost.

TABLE 7. RESULTS OF CROSS-BREAKEVEN ELASTICITIES OF ENTERPRISES

Breakeven elasticity for factor i to factor j	Paddy		Greengram	
	Greengram	Groundnut	Paddy	Groundnut
(1)	(2)	(3)	(4)	(5)
Output price to:				
Output price	0.3112	0.7508	3.2133	2.4125
Total cost	-0.2436	-0.6805	-2.7693	-2.1866
Human labour requirement	-0.0891	-0.2547	-1.1356	-0.8185
Human labour requirement to:				
Output price	-0.8805	-2.1242	-11.2121	-8.4178
Total cost	0.6894	1.9254	9.6629	7.6298
Human labour requirement	0.2523	0.7207	3.9626	2.8560

CONCLUSION

Empirical application of advanced breakeven analysis on all three crops, viz., paddy, groundnut and greengram showed an ability to withstand some degree of fluctuation while maintaining non-negative returns above total costs. Nevertheless, paddy and greengram production are especially desirable in terms of overall profitability in the light of a fluctuating environment. In tankfed situation, paddy is able to withstand a significant fall in product yield and price and rise in costs and input requirements. Paddy is more profitable and more adjustable to risk than groundnut under varying environment. Breakeven elasticity analysis also implies that paddy cultivation is more favourable under increasing price market and soaring cost situations. However other factors such as crop rotation, soil fertility and government policy restrictions, etc., need to be considered while making production decisions.

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NOTES

1. Breakeven equations are calculated by arithmetic manipulation of the profit equation and solving for the individual contituent by setting profit (π) to zero.

2. Breakeven equation between enterprises are derived by equating the profit functions of two separate agricultural enterprises 'i' and 'j'; solving for each constituent.

3. Breakeven elasticities are computed by applying the elasticity formula to the appropriate breakeven equation across enterprises.

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