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Efficiency of small-scale farmers in Ethiopia: a case study in the Baso and Warana sub-district

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ABSTRACT

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The objective of this study is to explore the possibilities of improving production and income on small farms through better allocation of resources. It pertains to the area that represents the low potential cereal crops zone (LPCZ) of Ethiopian highlands in the Shoa region. The basic primary data were drawn from 50 randomly selected farms in the area, and secondary data were obtained from ILCA. LP and MOTAD are used as analytical tools. The results of the study indicates a substantial potential for increasing net farm cash incomes by efficient allocation of available resources under current level of technology.

The study further revealed that small-scale farmers in the study area operate at a relatively higher risk under the existing situation than would be the case under an-optimal situation. Thus, small-scale farmers should allocate resources optimally not only to increase cash income but also to reduce risk.

INTRODUCTION

Agriculture contributes 50% to Ethiopia's GDP and 90% to the value of her exports (NRDC/CPSC, 1983; MSFD, 1984). The problems of small-

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scale farmers have received much attention in a policy context in Ethiopia for two main reasons. Firstly, they contribute about 90% of the total agricultural production and 84% of the marketed surplus. This implies that a substantial increase in their productivity would affect national income significantly. Second, the small-scale farmers form the majority of the rural poor, so an increase in their productivity means an increase in the level of social welfare and a limit on the number of those requiring direct welfare assistance.

Prior to 1975, agrarian economy in Ethiopia was feudal and the land tenure system was insecure. The overall effect of all this was a stagnant agriculture. The land tenure problem has now been removed through the socialist land reform that took place in 1975. Yet, agriculture remains stagnant (MOA, 1985; FAO, 1982). It is, therefore, important, to examine why agriculture is still stagnant when the supposed problem of tenure insecurity has been solved through major land reforms and other obstacles that inhibit rural productivity are removed. The answer to this question is well documented in the study made by Belete (1989). According to Belete, the major factors contributing to stagnant agriculture in Ethiopia are: (1) inefficient utilisation and organisation of land, (2) persistency of subsistence production, (3) lack of improved technology for small-scale peasant production, (4) shortage of work oxen for cultivation,' and (5) lack of production incentives. Additionally, environmental constraints such as soil loss due to deforestation and consequent erosion, population pressure on highland agriculture and peasant distabilisation due to man-made and natural disasters have inhibited the development of agriculture in Ethiopia.

The factors mentioned above might have aggravated the economic risks that already prevailed in the country, and this in turn might have led small-scale farmers to become inefficient in their resource allocation.

This paper investigates the efficiency of small-scale farmers in the Baso and Warana Woreda of Shoa region by developing risk models for crop–livestock farming under different existing animal cultivation practices so as to identify the most crucial constraints the farmers presently face. This study area represents the low-potential cereal crops zone (LPCZ) of Ethiopian highlands in the Shoa region. The following discussion will first deal with methodology. Then, design of the study and the empirical results are discussed. Finally, in the last section, summary and policy implications are drawn.

METHODOLOGY

The static linear programming (LP) model is perhaps the most widely used technique to examine efficiency. Many studies in Africa (e.g. Clayton, 1961; Ogunfowora, 1970; Heyer, 1971; Shapiro, 1973; Abalu, 1975; Farington, 1979; Crawford, 1982) have successfully used the technique to solve a variety of farm management problems. The theory and application of LP in relation to agriculture are well documented in Heady and Candler (1958) Agrawal and Heady (1972), Beneke and Winterboar (1973) and Hazell and Norton (1986).

However, given that the risk attached to outcome of farm income affects farmer's decision making, it is necessary to incorporate risk into the analytical framework. This consideration suggests that both LP and risk programming models must be used. In this study, we employ the Minimization of Total Absolute Deviation (MOTAD) programming model (Hazell, 1971) to analyse the farmer's short-run behaviour under risk. The theory and application of MOTAD in relation to agriculture are well documented in Anderson, Dillon and Hardaker (1977) and Hazell and Norton (1986). For both the LP and MOTAD models, a dual objective of household consumption insurance and cash income maximization is used.

The LP model is specified as:

Maximize $Z = CX$

subject to

$$AX < B$$
$$X > 0$$

where A is the $m \times n$ matrix of input–output coefficients, C is an $n \times 1$ vector of prices or other weights of the objective function, B an $m \times 1$ vector of resource supply or other constraints; X an $n \times 1$ vector of activities, and Z the objective function of the household farm expressed in cash income.

The mathematical formulation of MOTAD can be written as:

$$\text{Minimize } A = 1/s \sum_{h=1}^{s} |(g_{hi} - C_i)X_i|$$

subject to

$$\sum_{i=1}^{n} a_{ji}x_j < bi \qquad (j = 1, 2, 3, \ldots, m)$$

$$\sum_{i=1}^{n} f_i X_i < \lambda \qquad (\lambda = 0 \text{ to unbounded})$$

$$X_i > 0 \qquad (i = 1, 2, 3, \ldots, n)$$

where A is the mean absolute deviation of cash income over the S observations, g_{hi} the observed cash income of activity i in observation h, C_i

sample mean cash income of activity i, X_i the level of activity i, $a_{ji}x_j$ the specified coefficient for the jth constraint corresponding to the ith activity, b_j the specified jth constraint's level, λ the mean net cash income which is parameterized from the maximum attainable level down to zero, and f_i represents the expected gross returns.

In the empirical analysis, four animal cultivation practices are considered. These are:

(1) the traditional system where farmers own a pair of oxen for cultivation;
(2) the traditional system where farmers own one ox and acquire a second through rental arrangement;
(3) the traditional system where farmers own one ox and acquire a second through exchange arrangement; and
(4) the traditional system where farmers own no ox but hire a pair of oxen for cultivation.

DESIGN OF THE STUDY

The Baso and Warana sub-districts are in the LPCZ of the highland areas of Ethiopia. Primary data were collected from 50 randomly selected farms belonging to five (5) peasant associations during the 1985/86 agricultural year. The average crop land area, based on the 50 farms is 2.9 ha and the coefficient of variation for this average crop land is 0.19. This average crop land was used to develop the LP models for the first two animal cultivation practices. However, farmers who practice the third and fourth animal cultivation practices are found to cultivate 22% and 38% less than the land cultivated by farmers owning two oxen. The LP models for the third and fourth animal cultivation practices were, therefore, developed on the basis of 2.3 and 1.8 ha of crop land, respectively. Time-series data on yields, post-harvest prices, costs and area for different food and non-food crops for seven years (1978–1984) were obtained from the International Livestock Centre for Africa (ILCA). To remove inflationary trend from the gross margin series, nominal gross returns were converted to real values with 1978 Birr [1] as a base, using the implicit price deflator GDP.

EMPIRICAL RESULTS

Tables 1 through 4 present the existing and normative plans for the four traditional animal cultivation practices considered. Normative plans I to XIII in Table 1, I to VII in Tables 2 and 3, and I to V in Table 4 are all

[1] Birr 2.07 = US$1.

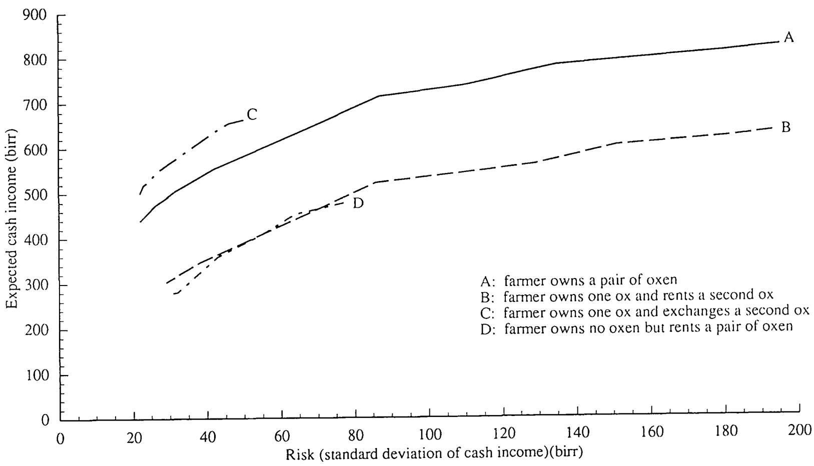

Fig. 1. Risk-expected income efficiency frontiers for the four traditional fraction techniques in Baso and Warana Woreda.

based on minimizing mean absolute deviations subject to expected net cash income levels obtained by parameterizing the value of the objective function from its LP model that disregards risk. Figure 1 shows the MOTAD efficiency frontiers of the discerned income risk tradeoffs for the different traditional cultivation practices.

The gap between the actual and the optimal plans (the profit maximizing LP solutions) is considerable for each of the practices. The results indicate that the cash income for the optimal plan that disregards risk show 57% higher than the cash income for the existing plan under the agricultural practice where farmers own a pair of oxen for traction (Table 1). The cash income increase for the other agricultural practices is as follows: 58% and 47% for farmers who own one ox and acquire a second through traditional rental arrangement (Table 2) and exchange arrangement (Table 3), respectively, and 59% for those farmers who own no ox but depend on seasonal renting of a pair of oxen (Table 4). The results, therefore, suggest that a reallocation of the existing resources in an optimal way under the indigenous technology would increase the productivity on small-scale farms.

Further, the results indicate that some of the risk-efficient plans are superior to the existing plans in the sense that they have higher returns and lower risk. Farmers who own a pair of oxen for traction, for instance, operate at a higher risk (coefficient of variation of 33.5%) compared to the profit-maximizing plan that disregards risk (coefficient of variations of 24%). Thus farmers can reduce risk and still obtain higher returns by adopting the profit-maximizing plans that disregards risk. Nevertheless, if farmers wish to avert risk, they may adopt a plan that has less variability in

TABLE 1

Existing and optimal risk-efficient plans derived via MOTAD for the situation where farmers own a pair of oxen for cultivation in Baso and Worana Wored [a]

Item	Existing plan	Normative plans at change of basis													
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV [b]
Crop land (ha)	2.9	1.76	1.88	1.96	2.02	2.10	2.38	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Cash income [c] (Birr)	522	439	455	473	489	502	554	614	713	736	739	781	810	813	822
Standard deviation (Birr)	173	22	24	26	29	31	42	59	87	109	111	135	180	183	195
Coefficient of variation (%)	33.20	5.01	5.27	5.50	5.93	6.17	7.58	9.61	12.20	14.81	15.02	17.30	22.22	22.50	23.72
Long-rain crops (ha)															
barley	1.15	0.54	0.68	0.74	0.76	0.81	0.92	0.92	0.92	0.92	0.91	0.49	0.55	0.53	0.44
wheat	0.30	0.24	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.41	0.43	0.64	0.98	1.01	1.10
oats	0.08	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.51	0.27	0.27	0.47	0.07	0.06	0.06
horsebeans	0.35	0.29	0.33	0.36	0.38	0.39	0.45	0.45	0.67	0.67	0.67	0.67	0.67	0.67	0.67
fields peas	0.27	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
lentils	0.14	–	–	–	–	–	–	–	–	–	–	–	–	–	–
linseed	0.11	–	–	–	–	0.05	0.15	0.67	–	–	–	–	–	–	–
Short-rain crops (ha)															
barley	0.50	0.40	0.24	0.19	0.16	0.12	–	–	–	–	0.02	0.45	0.39	–	–
lentils	–	0.10	0.26	0.31	0.34	0.38	0.50	0.50	0.50	0.50	0.48	0.05	0.11	0.10	–
Cows + followers (numbers)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ewes + followers (numbers)	10	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Human labour (man days)	214	151	161	166	171	176	195	211	229	235	235	226	238	238	235
Ox labour (ox-pair days)	43	43	47	49	50	52	59	66	69	72	72	65	72	72	71

[a] Family food consumption requirements were specifically considered as constraining factors on the farm output mix; thus, each of the normative plans is derived with barley production forced in at 0.94 ha, wheat at 0.17 ha, oats at 0.06 ha, horsebeans at 0.29 ha and field peas at 0.13 ha.

[b] Corresponds to the profit maximising LP solution without consideration of risk.

[c] The cash income does not include value of production for home consumption.

TABLE 2

Existing and optimal risk-efficient plans derived via MOTAD for the situation where farmer's own one ox and acquire a second through traditional rental arrangements (minda) in Baso and Worana Woreda [a]

Item	Existing plan	Normative plans at change of basis							
		I	II	III	IV	V	VI	VII	VIII [b]
Crop land (ha)	2.9	2.1	2.2	2.9	2.9	2.9	2.9	2.9	2.9
Cash income [c] (Birr)	400	303	346	424	523	562	603	621	632
Standard deviation (Birr)	173	29	38	59	86	129	151	180	193
Coefficient of variation (%)	43.3	9.6	11.0	13.9	16.4	23.0	25.0	29.0	30.6
Long-rain crops (ha)									
barley	1.15	0.80	0.92	0.92	0.92	0.92	0.51	0.55	0.44
wheat	0.30	0.17	0.17	0.17	0.17	0.57	0.78	0.99	1.10
oats	0.08	0.06	0.06	0.06	0.51	0.11	0.31	0.07	0.06
horsebeans	0.35	0.39	0.45	0.45	0.67	0.67	0.67	0.67	0.67
field peas	0.27	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
lentils	0.14	–	–	–	–	–	–	–	–
linseed	0.11	–	–	0.67	–	–	–	–	–
Short-rain crops (ha)									
barley	0.50	0.13	–	–	–	–	0.42	0.39	0.49
lentils		0.37	0.50	0.50	0.50	0.50	0.08	0.11	0.01
Cows + followers (numbers)	1	1	1	1	1	1	1	1	1
Ewes + followers (numbers)	10	4	4	4	4	4	4	4	4
Human labour (man days)	214	173	190	210	229	241	230	238	235
Ox labour (ox-pair days)	43	51	57	56	59	74	67	72	71

[a] To fulfil the family food consumption requirements, each of the normative plans is derived with barley production forced in at 0.94 ha, wheat at 0.17 ha, oats at 0.06 ha, horsebeans at 0.29 ha and field peas at 0.13 ha.

[b] Corresponds to the profit maximising LP solution without consideration of risk.

[c] The cash income does not include value of production for home consumption.

returns to fixed farm resources, and the alternative choices corresponding to different degrees of risk are presented in Tables 1 through 4.

The results further indicate that farmers who depend on seasonal renting of a pair of oxen are deficit producers. In other words, they must enter the market to purchase part of their subsistence food requirements. Those farmers who own one ox have managed to produce enough to fulfil

TABLE 3

Existing and optimal risk-efficient plans derived via MOTAD for the situation where farmer's own one ox and acquire a second through traditional exchange arrangements (mekenajo) in Baso and Worana Woreda [a]

Item	Existing plan	Normative plans at change of basis							
		I	II	III	IV	V	VI	VII	VIII [b]
Crop land (ha)	2.3	2.07	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Cash income [c] (Birr)	450	500	518	524	550	646	650	654	662
Standard deviation (Birr)	64	22	23	24	27	44	45	46	50
Coefficient of variation (%)	14.2	4.4	4.4	4.6	4.9	6.8	6.9	7.0	7.6
Long-rain crops (ha):									
barley	1.07	0.71	0.95	0.99	0.99	0.87	0.84	0.81	0.71
wheat	0.21	0.33	0.25	0.21	0.21	0.33	0.36	0.39	0.49
horsebeans	0.36	0.36	0.36	0.37	0.44	0.44	0.44	0.44	0.44
field peas	0.16	0.16	0.24	0.16	0.16	0.16	0.16	0.16	0.16
Short-rain crop (ha):									
barley	0.46	0.45	0.20	0.17	0.17	0.29	0.32	0.35	0.46
oats	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
lentils		0.01	0.26	0.29	0.29	0.17	0.14	0.11	–
Cows + followers (numbers)	1	1	1	1	1	1	1	1	1
Ewes + followers (numbers)	10	4	4	4	4	5	11	11	11
Human labour (man days)	179	166	185	186	188	194	193	192	192
Ox labour (ox-pair days)	36	51	57	58	59	57	57	56	56

[a] To fulfil the family food consumption requirements, each of the normative plans is derived with barley production forced in at 1.15 ha, wheat at 0.21 ha, oats at 0.04 ha, horsebeans at 0.36 ha and field peas at 0.15 ha.
[b] Corresponds to the profit maximising LP solution without consideration of risk.
[c] The cash income does not include value of production for home consumption.

their subsistence food requirements. This tends to suggest that availability of draught power for cultivation is a limiting factor in this study area.

SUMMARY AND POLICY IMPLICATIONS

This study has indicated the existence of considerable economic inefficiencies in the Baso and Warana areas of Shoa region. To this, however, a caveat must be entered. It may be that our representative farm models are

TABLE 4

Existing and optimal risk-efficient plan derived via MOTAD for the situation where farmer's own no ox but depend on Seasonal renting of a pair of oxen in Baso and Worana Woreda [a]

Item	Existing plan	Normative plans at change of basis					
		I	II	III	IV	V	VI [b]
Crop land (ha)	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Cash income [c] (Birr)	300	276	280	359	409	454	477
Standard deviation (Birr)	72	29	32	43	55	64	77
Coefficient of variation (%)	24.0	10.5	11.4	12.0	13.5	14.0	16.4
Long-rain crops (ha)							
barley	0.45	0.40	0.40	0.36	0.31	0.27	0.61
wheat	0.56	0.47	0.47	0.51	0.56	0.60	0.26
horsebeans		0.43	0.43	0.43	0.43	0.43	0.43
fields peas	0.29	–	–	–	–	–	–
Short-rain crop (ha)							
barley	0.50	0.45	0.45	0.45	0.45	0.45	0.45
oats		0.05	0.05	0.05	0.05	0.05	0.05
Cow + followers (numbers)	1	1	1	1	1	1	1
Ewes + followers (numbers)	10	6	7	11	15	18	18
Human labour (man days)	132	139	135	142	147	151	153
Grain purchase in kg (barley/horsebeans/ fieldpeas)	–	296/10/ 80	325/10 80	346/10/ 80	378/10/ 80	400/10/ 80	210/10 80

[a] The amount of land required to fulfil the family food consumption requirement, is 2.36 ha of which barley requires 1.41 ha, wheat at 0.26 ha, oats at 0.05 ha, horsebeans 0.45 ha and field peas at 0.19 ha. Note that the representative farm has to purchase barley, horsebeans and field peas since it can not fulfil the requirement from own production.

[b] Corresponds to the profit maximising LP solution without consideration of risk.

[c] The cash income does not include value of production for home consumption.

not adequately representative or that the typical farmer in the study area does not follow behaviorial assumption of our model, i.e. does not secure subsistence needs and then maximize net cash income. Nevertheless, if the model is adequate, the economic inefficiency of the small-scale farmers in the study area would seem to raise a question concerning agricultural policies, lack of incentives to producers and harsh weather conditions that prevail in Ethiopia. The results indicate that high degree of risk is associated with the existing farm plans for all the synthetic agricultural practices in the study area. The profit-maximizing normative plans which disregard risk are slightly less risky than the existing plans, but are still more risky compared to the risk-efficient plans. This means that sets of alternative plans along with the associated risk involved must be derived as has been done in this study. The farmer can then choose a particular plan based on his personal attitude to risk.

The results have important implications for two policies currently being debated. Firstly, the results indicate that there is some scope to improve the efficiency of small-scale farmers through the reallocation of the existing resources in an optimal manner. Policy makers should therefore focus attention on the correction of some of the key variables, such as imperfect market structures, that tend to inhibit optimal resource-allocation and other socio-economic institutional constraints, such as land tenure and labour hiring, that may prevent small-scale farms from attaining the appropriate combination of inputs. In short, small-scale farmers must be provided with the right mix of incentives.

Second, major agricultural operations, such as land preparation and sowing, are vital for production of annual crops. Efficiency of these operations depends mostly on availability of draught power (work oxen) for cultivation. Thus, in the short run, to overcome shortage of draught power, a credit scheme should be developed by which draught oxen would, be made available for farmers on medium-term loans. It is self-justified that credit scheme should in the first instance be targeted towards those farmers without oxen, so that they can own at least one ox. In the long run, the search for improved animal traction techniques (e.g. single-ox plough) must continue.

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