FARM SIZE AND ECONOMIC EFFICIENCY IN SUGAR CANE PRODUCTION IN KWAZULU-NATAL

BY

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I hereby certify that, unless specifically indicated to the contrary in the text, this dissertation is the result of my own original work.

Swaibu Mbowa

ABSTRACT

There is a dilemma in South African agriculture in the choice of an agrarian system that will achieve the dual goals of growth and equity. Uncertainty prevails about the viability of very small farms, and how the country's extremely limited and fragile agricultural resources can be utilized in an efficient and productive manner. In this study efficiencies in resource utilization on small and large sugar cane farms are examined, and information is provided on the implications that might hold for the reallocation of resources between farm size groups in pursuit of land redistribution. In any industry where there are specialized resources to specific firms like labour and management, it is difficult to define an efficient farm size because returns to these specialised productive factors will differ, as such influencing costs per unit, resource valuation and eventually the size of operation. In this situation there will tend to be an optimum distribution of firm size rather than optimum size of a firm. This renders any study of optimum size rather dispensable. However, in South Africa where government is encouraging small farm development, the question of efficiency and equity becomes relevant and it is not possible to simply abstract from this issue.

The study is based on data collected from a sample of 160 small and large sugar cane units in the North Coast region of the KwaZulu-Natal sugar cane belt during March/April 1995. The sample was stratified to maximize the variation of the farm size variable in order to study the effect of this variable on efficiency. The study shows that small farms as compared to large farms; are deficient in human resource capital, less competitive in the credit market, incur high input costs relative to farm income, have less incentive to acquire more farming knowledge, and of less capacity to adopt better farming methods. A linear discriminant model shows that human capital capacities of farm operators, information, farm size, and wealth are important determinants of the likelihood of adoption of appropriate and improved farm practices on sugar cane farms. Major implications are that: adequate information through training on better farming methods will improve the managerial capabilities of farmers, and sugar cane farmers with different resource endowments should be targeted distinctively in the provision of extension support services.

Economies of size, whereby large farms reduce their costs by spreading fixed machinery, labour and management costs, information, and transaction costs in the credit market over more output are evident in the data. Results indicate that farms producing less than 500 tons of cane (operating approximately less than 10 hectares under sugar cane) exhibit substantial economies of size. Such economies tend to decline with size of enterprise, and farms with output of about 2500 tons (50 hectares of land under sugar cane) appear to have near constant returns to scale. This implies that small farms producing less than 500 tons (ten ha of sugar cane) require significantly more resources to produce a rand's worth of output than larger farms. The major policy implications are that, if commercial farms are subdivided in the land resettlement programme, significant efficiency loss may occur if the resettled farms produce less than 500 tons. Little efficiency loss is expected if resettled farms produce more than 2500 tons (50 hectares). Finally, empirical evidence using a tobit (econometric) model suggests significant linkages between scale efficiency and farmers' education, managerial adeptness, training, age, and size of farm holdings. This implies that efficiency of very small scale sugar cane farms (producing less than 500 tons) can be enhanced by land consolidation, farm operators' education, training and extension services for expansion and propagation of modern techniques of cane production.

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INTRODUCTION

With government policies focusing on issues of equity and efficiency, the relationship between farm size and farm efficiency is of interest to South African (SA) agricultural policy makers (Van Zyl, 1994). Land reform has been accorded high priority by the national government and is expected to alter the distribution of farm sizes appreciably over a short period of time (Department of Land Affairs, 1996: 4). In KwaZulu-Natal, as a vehicle to uplift the living standards of people in rural areas, the South African Cane Growers' Association (SACGA) is directing resources to develop small sugar cane growers (Chadwick and Sokhela, 1992). This is compatible with recent policy shifts in South African agriculture where policy makers and the World Bank believe small farmers can and should play a key role in developing rural areas in SA (World Bank, 1994: 33).

In discussing small farm development strategies it is important to understand factors that could impede the attainment of policy objectives. This may relate to the nature of technology involved in production of specific crop commodities, proprietorship and managerial proficiency of individual farm operators. In the SA sugar industry, productivity differences are evident between small and large sugar cane farms. The industry's average yield on small farms is 40 tons per hectare, compared to 55 tons per hectare on large scale farms (SACGA, 1994). This is an indicator of a possible efficiency loss to the industry if emphasis is placed on small farm operations, although some argue that efficiency of large scale farms results from policies which favour large farms over small-scale family type farms (Van Zyl, 1994; Binswanger, 1994).

In this study some information is provided on the trade-off between equity and efficiency if large sugar cane farms are subdivided into smaller units under the land redistribution programme. The critical question discussed is the viability of very small farms, and what might be the effects on economic efficiency on the sugar industry if farm size-structure were to change. Reasons for focusing on sugar cane farming include; the long history of small farms operating alongside large-scale farms, and the importance of the crop in the agricultural economy of KwaZulu-Natal, where it accounts for about 41% of gross value of agricultural products in the province (Erskine, 1982).

The main purpose of the study is to examine how efficiency of resource use on sugar cane farms varies with the size of a farm business and what implications variations in performance might hold for the reallocation of resources between size-groups in pursuit of land redistribution. A profile on characteristics of small and large sugar cane farms, and factors that influence the adoption of recommended farm practices on sugar cane farms are investigated. Adoption of agronomic practices specific to sugar cane farming, are used to measure farmer managerial adeptness. Identifying factors that influence adoption of appropriate cultural practices by sugar cane farmers may also help to explain productivity differences between the two farm groups, given that the potential for increasing farm output through appropriate farming practices, indirectly relates to farmers' managerial qualities (Kalirajan and Shand, 1988).

Farms studied are individually (privately) owned, and varied from one to six hundred hectares. Small farms are defined as 20 hectares and below under sugar cane according to the South African Cane Growers' Association (SACGA). The sample was stratified into small and large scale farms to obtain a significant difference between farm sizes.

Chapter 1 outlines the production structure and economic importance of the sugar industry in the agricultural economy of KwaZulu-Natal. Chapter 2 deals with theoretical considerations in analysing economies of size. Theory in production economics states that management, like a machine, is an indivisible and lumpy input. Economies of size may arise from lumpiness of labour and management inputs. The quality of management affects returns to size and may also provide increasing returns to size (Groenewald, 1991). The adoption and use of any technology involves fixed transaction and information costs (Lyne, 1996). Information costs are fixed and therefore introduce size economies (Huffman, 1974; Welch, 1978: 259). On large farms, these costs can be spread over large volumes of output (Lyne, 1996). The influence of human resource capital on farm performance through the adoption of better farming methods is studied. Chapter 3 provides the research methodology adopted in the study. The conceptual frame work in the modelling of farm size efficiency is outlined in this chapter. The non-parametric (DEA) approach of frontier estimation used in the study is explained.

Chapter 4 outlines data sources and methods employed in data collection. Characteristics of small and the large sugar cane farms studied are presented in this chapter. Empirical analysis and results of the study are presented in chapter 5. Conclusions and policy implications are presented in Chapter 6, while Chapter 7 contains the summary.

CHAPTER 1

STRUCTURE AND ECONOMIC IMPORTANCE OF SA SUGAR INDUSTRY

1.1 Sugar cane production in KwaZulu-Natal

The South African sugar industry consists of 45270 cane farmers of whom 43510 (96%) are small-scale producing approximately 9.7 percent of the industry's total production[1] (SACGA, 1994). The sugar cane sector has demonstrated the capacity to absorb a substantial amount of the labour force. The low technical and management requirements for growing sugar cane, implies that the crop could play a leading economic role in the rural peasant areas of KwaZulu-Natal (FAF, 1992). The economic importance of sugar production in KwaZulu-Natal is illustrated with an estimated R 2336 million having been generated in the 1992/93 season (SASA, 1993). This has far reaching economic implications for a province with approximately 25% of the country's population, but supported by only 15% of the country's GNP (Development Bank of South Africa, 1994: 18).

1.2 Production structure of the sugar industry

Sugar cane production in KwaZulu-Natal has the potential to bring about positive growth impacts on rural poor in the region. Growth at a sectoral level is considered inclusive of the rural poor when small scale units participate directly in the production of export crops and

[1] Total production in the entire industry is estimated to be about 15 million tons of sugar cane (Directorate Agricultural Statistics, 1996).

enjoy higher incomes generated from these activities (Carter *et al.*, 1993). Carter *et al.*, (1993) contends that the employment generated by an agricultural system largely depends on the size distribution of farms participating in the production of the crop.

The dilemma however, in the sugar cane sector in particular, and SA agriculture in general emanates from: (a) the skewed distribution of present land ownership, for example, in the sugar industry, about 96% of cane growers are small-scale "Black" producers, but approximately 78% of total area under sugar cane is occupied by large-scale "White" *quota* growers (Figure 1.1, Figure 1.2 and Table 1.1); (b) the political dilemma to diffuse pressure on the demand for land as a limited resource; (c) the uncertainty that remains about the viability of farms of various sizes. This has brought challenges to agricultural policy makers in SA in the choice of an agrarian structure to achieve the dual goals of growth and equity in the country's agricultural sector in general.

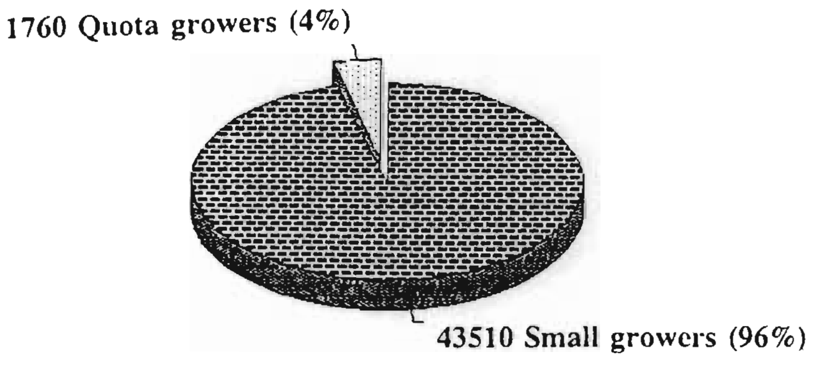

Figure 1.1 Number of small & large (quota) growers in the SA sugar industry (1992/93) season
Source: SACGA (1994).

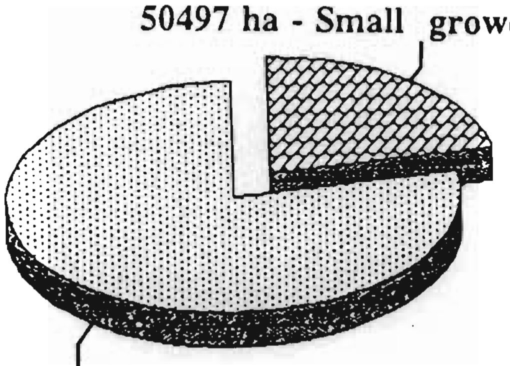

Figure 1.2 Land resource distribution in the SA sugar cane industry (1992/93) season
Source: SACGA (1994).

Table 1.1 Land distribution and number of small and large (quota) growers in the SA sugar industry, 1992/1993 season.

REGION[2]	SMALL GROWERS			LARGE (QUOTA) GROWERS		
	Number	Total (Ha)	Area (Ha)	Number	Total (Ha)	Area (Ha)
N. Irrigated	228	1559	6.8	339	29336	87
North Coast	12094	15504	1.3	443	22338	50
Zululand	21559	24804	1.2	387	57937	150
Midlands	4958	3331	0.7	334	39362	118
South Coast	4671	5299	1.1	257	34337	134
TOTAL	43510	50497	-	1760	183310	-

Source: South African Cane Growers Association (SACGA), 1994.

[2]According to the SACGA the sugar industry is subdivided into five major regions, that is: (1) North irrigated region; (2) Zululand; (3) North Coast; (4) Midlands; and (5) South Coast region (details of this subdivision of the sugar industry are given in chapter 4).

1.3 The sugar cane sector in view of policy changes

Production of both cane and sugar in South Africa is controlled in terms of the Sugar Act of 1978 and the Sugar Industry Agreement of 1979 (Wilkinson, 1981: 21). Specific interests of cane growers in relation to price and costs of production are addressed by the SACGA (South African Sugar Association SASA, 1982/83: 119). The sugar industry for many years was highly regulated. The control of sugar cane production was effected by a quota system and control of registered quota land[3]. A grower therefore was obliged to supply cane to a mill from his registered quota land controlled by the Central Board (Wilkinson 1981 :22). The quota in effect was also a contract between a grower and miller (Ortmann, 1985b: 49). A grower therefore was obliged to supply a certain mill and transfer of a quota from one mill to another could only be effected with permission of mills concerned. The quota system acted as a barrier for entry into the industry, therefore sugar cane production was kept at less than the industry's full potential level.

The SA sugar industry is at present undergoing major policy changes (SASA, 1994). The policy changes include: (1) the removal of all quota restrictions on the production of sugar cane with effect from 1998; (2) freedom of entry into the industry by prospective new growers; (3) the termination of the requirement to register quota land; (4) the authorisation of greater freedom for growers and millers to regulate their own affairs without the constraints of regulatory structures in order to improve efficiencies; (5) the need to provide free access to the sugar industry; and (6) introducing changes to ensure equity in the sharing

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[3]Basic quotas were established on the mean of grower's best two consecutive yields on registered land (referred to as *farm mean peaks*)

of proceeds between growers and millers (SASA, 1994). Relaxing entry conditions to the industry is expected to increase cane production, particularly from small cane growers.

1.4 Productivity indicators in SA sugar industry

Sugar cane yields in the SA sugar industry since mid 1960 have been highly erratic following fluctuations in the industry's rainfall (Figure 1.3). The four year drought conditions from 1990 to 1994 significantly affected the overall industry's average yield, with 1993/94 most affected[4]. There are signs of recovery from the drought period, nevertheless average yield in the entire industry remains below previously attainable levels (Table 1.2 and Figure 1.3). Compared to other major cane producing countries in the world (Brazil, India and Cuba), before the drought period, cane yields in SA remained relatively high (Figure 1.4 and Table 1.3). Yield figures presented in Figure 1.3 are based on tons of cane per hectare under sugar cane. In Figure 1.4 yield is computed in terms of tons of cane per hectare harvested based on data available from the Food and Agricultural Organization of the United Nations (FAO) 1970-94 statistics.

[4]The most affected regions in the industry were South Coast, Midlands South, and some parts along of the coastal strip of the North Coast region, Pongola - North irrigated region, and Eastern Transvaal (SA Sugar Journal 1993/94).

Table 1.2 Sugar cane production, area planted, yield and total rainfall in the South African sugar industry, 1963/64 - 1995/96 crop seasons.

Season	Production ('000 Mt)	Area ('000 ha)	Yield (Mt/ha)	Rainfall (mm)
1963/64	9939	250	40	973
1964/65	10661	291	37	1039
1965/66	8406	327	26	737
1966/67	14103	339	42	995
1967/68	16913	337	50	982
1968/69	13720	331	41	764
1969/70	14788	330	45	1011
1970/71	12144	330	37	784
1971/72	16751	319	53	1238
1972/73	16805	316	53	1117
1973/74	16454	323	48	797
1974/75	16895	338	50	1133
1975/76	16814	341	49	895
1976/77	19221	342	56	1453
1977/78	19009	357	53	1106
1978/79	18932	362	52	1037
1979/80	18412	378	49	880
1980/81	14062	384	37	676
1981/82	19532	393	50	1007
1982/83	19339	406	48	933
1983/84	13423	412	33	606
1984/85	22356	407	55	1415
1985/86	18803	411	46	1035
1986/87	18252	401	46	966
1987/88	21021	388	54	1004
1988/89	19811	380	52	1802
1989/90	18581	375	50	1020
1990/91	18026	373	48	1122
1991/92	20015	379	53	1048
1992/93	12955	386	34	657
1993/94	11244	384	29	596
1994/95	15683	394	40	855
1995/96	16671	404	41	906

Source: Directorate Agricultural Statistics (1996), & Meteorology Dept. SA Sugar Experiment Station.

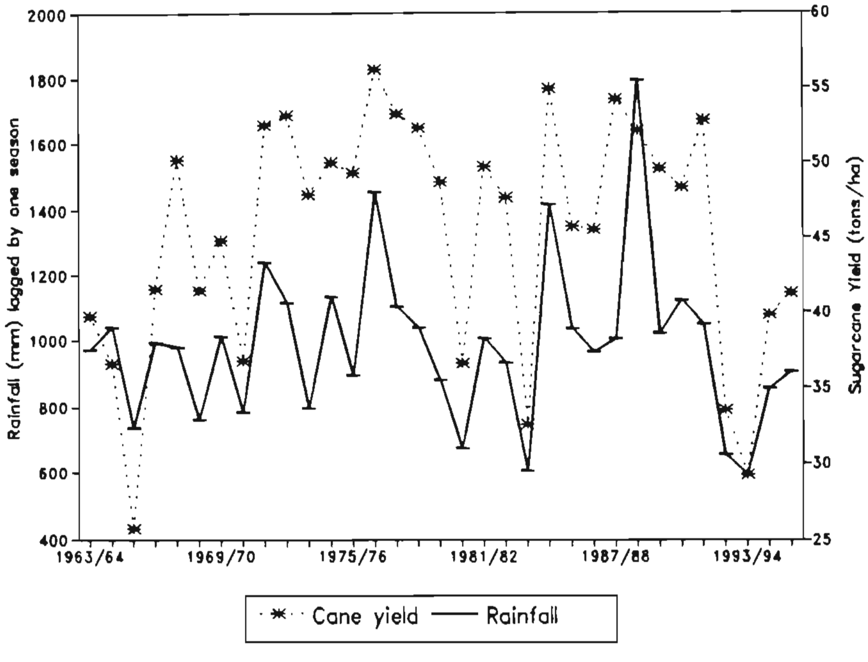

Figure 1.3 Sugar cane yield & rainfall in the SA sugar industry
Source: Directorate Agricultural Statistics (1996) & SA Sugar Experiment Station.

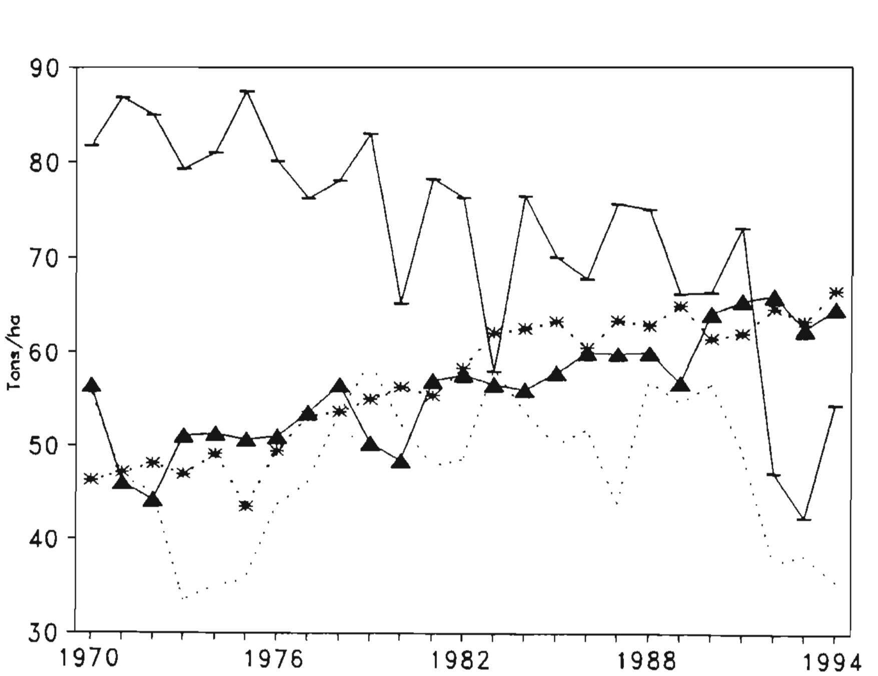

Figure 1.4 Sugar cane yield trends in SA & major world producers
Source: FAO Year-book, 1970-1994 series.

Table 1.3 Production ('000 mt), area harvested ('000 ha), yield (tons/ha) of SA and major world sugar cane producing countries (1970-94).

	SOUTH AFRICA			CUBA			BRAZIL			INDIA		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
1970/71	186	15196	82	1455	80981	56	1725	79753	46	2393	135024	56
1971/72	193	16751	87	1160	54000	47	1692	79595	47	2749	126368	46
1972/73	193	16400	85	1000	45000	45	1750	84000	48	2615	115378	44
1973/74	195	15454	79	1500	50068	33	1959	91877	46	2452	124867	50
1974/75	205	16599	81	1600	56000	35	1967	96412	49	2752	140805	51
1975/76	206	18000	87	1500	53500	36	2069	89935	43	2771	140196	51
1976/77	240	19221	80	1236	53900	44	2095	103282	49	2762	140604	51
1977/78	250	19009	76	1240	57000	46	2267	120171	53	2866	153007	53
1978/79	250	19500	78	1246	66400	53	2413	129223	54	3220	181628	56
1979/80	222	18412	83	1313	77311	59	2542	139337	55	3119	156450	50
1980/81	215	14014	65	1300	68000	52	2642	148436	56	2666	128800	48
1981/82	250	19532	78	1400	67000	48	2817	155571	55	2648	150522	57
1982/83	260	19800	76	1550	75000	49	2886	168037	58	3192	183647	58
1983/84	232	13423	58	1200	69700	58	3485	216534	62	3358	189506	56
1984/85	246	18755	76	1400	75000	54	3862	241518	63	3167	177020	56
1985/86	269	18803	70	1348	67400	50	3912	247199	63	2953	170319	58
1986/87	270	18287	68	1326	68500	51	3946	238493	60	2849	170648	60
1987/88	265	20000	75	1500	65600	43	4323	273855	63	3055	182480	60
1988/89	265	19864	75	1297	73700	57	4117	258449	63	3287	196723	60
1989/90	280	18500	66	1350	73500	54	4053	262792	65	3500	198000	57
1990/91	272	18026	66	1350	76230	56	4269	262674	62	3438	220000	64
1991/92	275	20078	73	1435	71000	49	4210	260888	62	3686	241046	65
1992/93	275	12955	47	1550	58000	37	4203	271475	65	3786	249256	67
1993/94	266	11244	42	1150	44000	38	3863	244304	63	3650	227850	62
1994/95	289	15676	54	1100	39000	35	4213	279768	66	3578	231000	65
1995/96	-	-	-	-	-	-	-	-	-	-	-	-

Source: Food & Agricultural Organization of the United Nations (FAO) yearbook, 1970-1994 series.

1.5 Sugar production and export

Since 1970 average sugar production in the SA sugar industry has been approximately two million metric tons per annum of which about 40% is exported (Table 1.4). Consumption of sugar in the domestic market, has been relatively stable with gradual increases over the last 20 years (Figure 1.5).

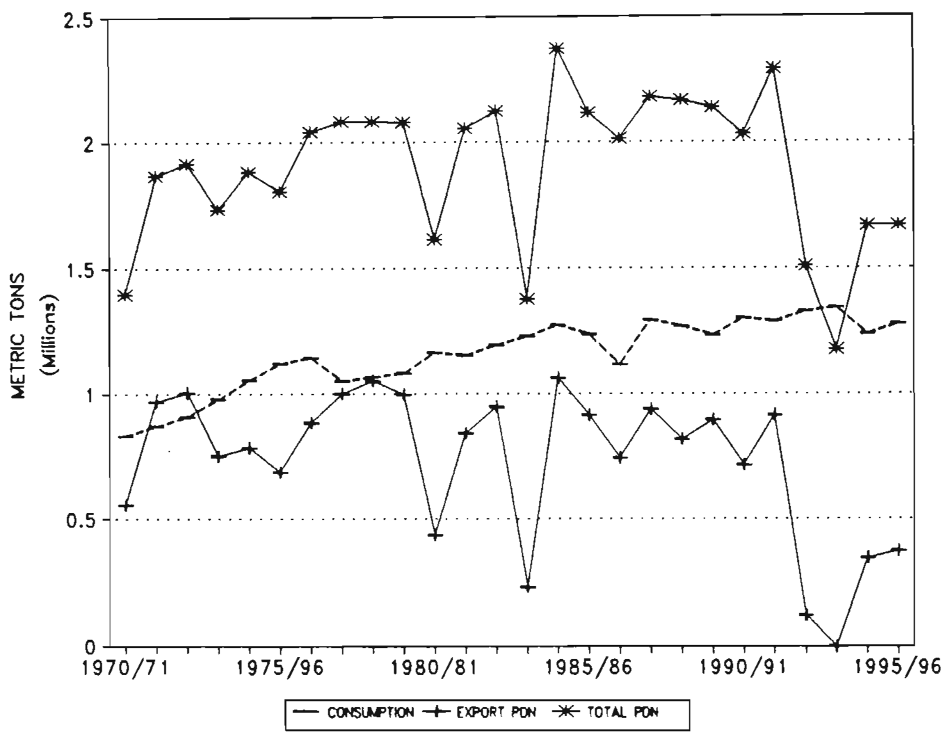

Figure 1.5 Production, exports & domestic consumption of sugar in SA
Source: SASA Yearbook. 1984/85 & SASA Industry Directory (1996).

The industry exports nearly one million tons of sugar (Table 1.4). Exports have been unstable (Figure 1.5), and export earnings per metric ton (expressed in 1990 prices) have been below domestic market equivalents (Figure 1.6).

Table 1.4 Total production, exports, domestic consumption, real export and domestic value (million Rands) of South African sugar, 1970/71 - 1995/96

Season	Production (Mt)	Exports (Mt)	Consumption (Mt)	Export value	Domestic value
1970/71	1398872	556229	835405	-	1407
1971/72	1864665	967921	870893	-	1270
1972/73	1914601	1004601	909052	-	1149
1973/74	1731575	750087	980802	-	1048
1974/75	1883195	783424	1053349	1916	882
1975/76	1801088	685585	1121431	2087	726
1976/77	2041520	882330	1145640	1327	853
1977/78	2083877	998511	1049600	1052	1388
1978/79	2082514	1047533	1064984	742	1457
1979/80	2078795	997097	1082714	798	1440
1980/81	1610868	436496	1165374	809	1392
1981/82	2055441	842185	1152027	1177	1364
1982/83	2125993	944609	1195244	501	1304
1983/84	1377718	232288	1225190	356	1283
1984/85	2369695	1061877	1271006	487	1293
1985/86	2117415	914298	1233672	458	1277
1986/87	2013836	744025	1114826	573	1251
1987/88	2179226	938847	1294393	461	1235
1988/89	2168142	819516	1267520	723	1230
1989/90	2137161	898159	1232531	890	1171
1990/91	2028472	713720	1302593	777	1179
1991/92	2289304	913123	1287291	499	1151
1992/93	1608297	123173	1326698	584	1155
1993/94	1171822	0	1345134	-	-
1994/95	1667920	347507	1235220	-	-
1995/96	1667315	375653	1278015	-	-

Source: South African Sugar Association (SASA) yearbook, 1984/85 & SASA industry Directory, 1996. (-) symbolizes unavailable data.

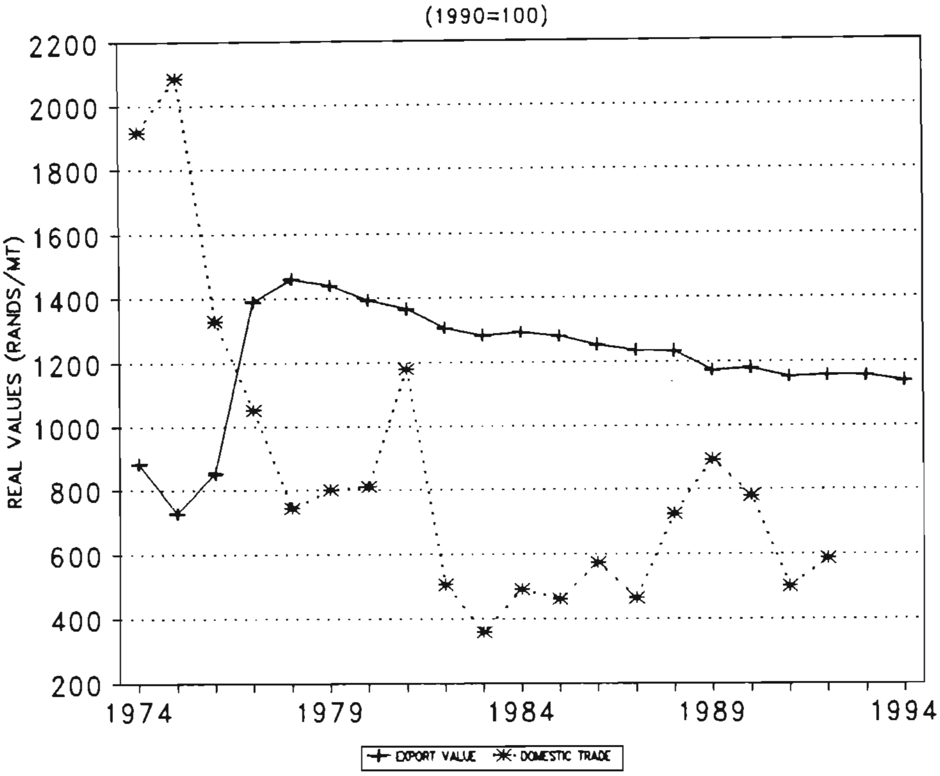

Figure 1.6 Domestic trade price & unit export value of sugar in SA

Source: SASA Year Book. 1984/85 & SASA industry Directory (1996).

Exports are considered important as they add to total profits from cane growing. Sugar cane is a long-term crop with a high capital investment, and a high proportion of fixed costs in growing and milling. Therefore, exporting sugar even at low prices has contributed towards covering the industry's fixed costs (Ardington, 1981/82: 53-59). Likewise, abandoning these markets would be a retrograde step for the industry because the loss of markets developed over many years would lead to losses of foreign exchange earnings of about R 525 million by 1991 (SASA, 1993/94).

CHAPTER 2

THE ANALYSIS OF FARM EFFICIENCY

Studies on efficiency in agriculture have occasionally related farm size to efficiency (Hallam 1991), with much debate on the relative merits of small and large farm strategies. The co-existence of large and small-sized farms in the agricultural sector may suggest that different sized farms can be efficient. Small farm strategists advocate a policy of breaking up large farms into smaller farms on the grounds that productivity per hectare is higher on a smaller farm. The emergency of small scale farms is supported because of the intensive utilization of labour and capital, therefore fulfilling employment and equity goals (Ellis, 1988: 192) which large farms do not meet. On the other hand, it is argued that some gains from agricultural innovations are scale dependent (Thomson and Lyne, 1991). Likewise, adoption rates are related to farm size (Welch, 1978; Feder *et al.*, 1982, Feder, 1985; Shaw and da Costa, 1985), therefore technology is more productive the larger the scale of activities to which it is applied.

In view of the intended land resettlement programme of small farms on formerly large scale commercial farm land in the SA sugar industry, aspects of farm size efficiency are studied based on information from small and large scale sugar cane farms in KwaZulu-Natal province. Studies on farm size efficiency relationships in SA show mixed evidence for the existence of scale efficiencies (Van Zyl, 1995). Empirical studies showing an inverse relationship between farm size and efficiency have a tendency to disregard the fact that the adoption and use of any technology involves fixed transaction and information costs (Lyne, 1996). Likewise many studies (Van Zyl, 1995) are based on information collected from "medium" and "large" commercial farms, thereby drawing conclusions in isolation of information from the very small farms. In this chapter, literature on theoretical consideration in the analysis of farm efficiency is reviewed, and sources of economies of scale on farm operations are discussed. The influence of human resource capital on farm performance is also investigated, given that the potential for increasing farm output indirectly relates to farmers' managerial qualities (Kalirajan and Shand, 1988).

2.1 Managerial proficiency and farm performance

This section provides a profile on measures of managerial adeptness among sugar cane farmers studied. Adoption of agronomic practices specific to sugar cane farming, is used to measure farmer managerial proficiency. High adoption rates of management practices by farm operators may reflect an individuals' ability to implement good management techniques (Sumner and Leiby, 1987). Improved technologies are often packaged in seeds, pesticides, fertilizers, equipment or resource-management schemes (Welch, 1978: 263). Different studies have used various measures to reflect management abilities which represent farmer knowledge, and level of adoption of recommended and appropriate practices. Feder and Slade (1984a), used; (i) knowledge of treating seeds with anti-fungi solution prior to planting, (ii) including the trace element of zinc sulphate in the basal fertilizer dose and, (iii) the adoption of pesticides and weedicides, as measures of management ability in a study on the acquisition of information and the adoption of new technology in irrigated rice production in India. Strauss *et al.*, (1991), used soil analysis on farms, use of certified rice seed or inoculated soybean seed, and action against rice blust as measures of adoption of new technology and cultural practices by farmers in Central-West Brazil.

In this study, soil testing to determine fertilizer application rates, and the adoption of certified *seedcane*, are used to measure adoption of improved farm practices among small and large scale sugar cane producers. The adoption of the two farm practices (soil analysis and certified seedcane) is also used to reflect on the managerial mastery of individual sugar cane farmers. Sugar cane is an efficient user of nitrogen (N), and the timing and placement of N is critical for the production of high yields of sugar. In addition, the highly variable crop requirements of potassium (K) and phosphorus (P) necessitate soil analysis to determine applications rates (Don *et al.*, 1994: 233). Fertilizer management practices that achieve sustained profitability, routinely focus on a prior knowledge of the nutrient status of the soil (Rehm, 1994: 185). Sugar cane is propagated using vegetative stem cuttings called "seedpieces" or "seedcane". These are either treated with heat and fungicide or cut from designated commercial fields to ensure that planting materials are certified as free of diseases (Don *et al.*, 1994: 232).

Adoption is taken to be the final outcome of exposure to some practice or innovation, and a variety of sources are used to communicate the message (Brien *et al.*, 1965). In the sugar industry, farmers have access to several sources of farm information. These include; (i) SACGA regional economists, (ii) field extension officers, (iii) the sugar association experiment research station (SASEX), (iv) farmer participation in field day-demonstrations and practical training workshops in cane growing, (v) interaction with other farmers, and (vi) the use of farm magazines.

Human capital capacities of farm operators are considered as important in influencing the adoption of improved farming practices among sugar cane farmers. Farmer education, personal, social and economic conditions play an important role in influencing the rate at which farmers adopt improved production processes or techniques (Brien, *et al.*, 1965; Jamison and Lau, 1982; Feder *et al.*, 1985; Strauss *et al.*, 1991). Farm operators with better access to information have higher levels of cumulative information, and will therefore adopt earlier than other farmers, *ceteris paribus* (Feder and Slade, 1984a). Better educated farmers can assimilate and interpret information at lower costs than less educated farmers. Similarly, farmers with better endowments of human capital will acquire higher levels of knowledge and adopt earlier than other farmers (Feder and Slade, 1984a). Therefore, farm operators' education significantly influences the adoption of better farming methods. Farmers who are visited regularly by extension agents adopt faster because they attain the critical level of knowledge (Feder and Slade, 1984a). Hiebert (1974), also indicates that the level of 'expertise' manifested by farmers with intensive extension contact is consistently higher than that of other farmers. Any advantages associated with additional schooling can be substituted for with an increase in extension activity (Huffman, 1974).

The incentive for managers to learn and adjust their activities comes from the expected losses arising from ignorance (Huffman, 1974). Increases in scale increase incentives for 'correct' decisions resulting not only in the 'purchase' of more education by operators with larger farms, but also in investments that enhance response (Welch, 1978: 274). Therefore farmers with higher education possess higher allocative ability and adjust faster to changes in technology (Feder *et al.*, 1982). Large farmers are often deeply committed to agricultural development, technologically sophisticated and dynamic, with technically efficient and high volumes of output (Binswanger, 1994). Huffman (1974), in a study of Midwestern U.S. maize farmers, empirically demonstrates that scale economies exist in using information, and shows that larger farmers have greater incentives to adopt new technology. Therefore, technical economies exist in information gathering about technology, marketing and credit (Binswanger, 1994).

Impeded adoption of new technology by smaller farms is related to fixed costs attached to implementation (Feder *et al.*, 1982). Nonetheless, smallholders are said to rarely lag more than a few years behind their larger counterparts in technology adoption (Binswanger, 1994). Lack of entrepreneurship, know-how, land tenure, access to product and factor markets, small farm size, and poor technology, remain as momentous bottlenecks to agricultural modernization in third world agriculture (Groenewald, 1993). However risk and uncertainty associated with weather variations can restrict adoption of innovations (Feder *et al.*, 1982).

2.2 Theoretical considerations in the analysis of farm efficiency

2.2.1 Measuring farm size

Obtaining a universally accepted definition of farm size has been one of the problems encountered in farm size and efficiency studies. A review of literature however, suggests that numerous definitions of farm size have been adopted, ranging from acreage, value of farm products sold, days worked off-farm (for small-scale farms), level of farm income, to the level of total family income, and many authors tend to combine two or more of these definitions. Farm size has commonly been taken to be synonymous with farm acreage. Area is generally used to indicate the size of a farming enterprise, because it can easily be ascertained and easy is to understand. However, when it becomes necessary to specify the criterion of size of a farm as a business, acreage is shown to be rather unsatisfactory indicator of business size (Britton and Hill, 1975: 15). This is because the proportions in which land and other factors (labour, capital and so forth) combine together in production vary principally between types of farming, but also between farms of the same type. In addition, acreage as a measure of farm size does not give an indication of the quality of the land (Britton and Hill, 1975: 17).

Farm acreage could be taken as an acceptable indicator of farm business size if one could be sure that all other factors of production were linked in an unvarying way with acreage. Nonetheless, output and acreage do not increase proportionally. A farm which is double the size in terms of acreage and all other inputs is often less than the size in terms of output (Britton and Hill, 1975: 16). With multiple product firms, output measures are often more appropriate as they enable comparisons across firms. The heterogeneous nature of output of most farms renders quantity of output as a measure of farm size impossible in practice.

Therefore the principal and most convenient measure of production, also adopted in this study, is the monetary value of agricultural output, that is, physical output (tons of sugar cane) multiplied by the respective price. The value of product sales is one such method which is widely used (Stanton, 1978). Measuring farm size by total value of farm output likewise, could lead to a bias in the economies of size measure, if the production mix varies between farms of different sizes (Vlastuin *et al.*, 1982). As sugar cane farms studied tend to produce a single crop, differences in production mix are not seen as a major problem in the study. Britton and Hill (1975: 15), argue that the 'best' unit of measurement of farm size, and size of enterprises within farms will depend on the purpose for which the measurement is to be used.

2.2.2 Farm size and tenure issues

Variants in forms of land tenure cause a range of optimal farm size in countries at various stages of economic development (Heady, 1971). Similarly, differences in tenure forms in the KwaZu-Natal region resulted in cane farms being operated under a wide variety of size and tenure conditions. While conditions of development and resource supplies or markets do relate to farm size, tenure conditions also pose differences in optimal farm size and lead to differences in the opportunity cost of capital for landowners (Heady, 1971). Tenancy and small-sized farms are generally related in terms of the problems that they generate (Medina, 1980). Communal land tenure creates incentive problems to invest in land improvements, and tenancy arrangements that restrict farm sizes and affect farm productivity (Lyne and Nieuwoudt, 1991).

High population pressure in the KwaZulu[5] sub-region is a major factor leading to scarcity of farming land, reducing farming activities to small-sized farm units (Lyne, 1989: 143). However, the lack of an active land market within this region, has limited the expansion of commercial farming in the region (Lyne, 1989: 143). Some economists (Johnson, 1972; Barrow and Roth, 1990) contend that traditional African system of "communal" land tenure

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[5]Kwazulu was a 'homeland' in the Natal region, with the majority of sugar cane farmers operation at small scale. The two regions have been merged to form the KwaZulu-Natal province.

has been empirically demonstrated by economists as inefficient when land has scarcity value. Since property rights are not clearly defined, costs and rewards are not fully internalized, and contracts are not legal or enforceable (Barrow and Roth, 1990). On the other hand, because owners are given incentives to use land most efficiently, individualized tenure (freehold) is viewed as superior and leads to the maximization of agriculture's contribution to social well-being (Barrow and Roth, 1990). Johnson (1972), further argues that in situations where individuals cannot sell land, the value of the investment to the farmer declines because of lost flexibility in converting a fixed-place asset into another asset form. Therefore the supply price of funds (loans) increases because the restriction on land sale lowers the collateral value of the parcel to the lender, resulting in lower investment under customary tenure than under individualized tenure. In this study, land tenure was one of the important considerations in the selection of the study sample. Farms under communal tenure system were excluded from the study as they do not have the same incentives to adopt better farming methods and to invest in land improvements.

2.2.3 Meaning of efficiency

Conventional definitions of efficiency are in terms of the optimality conditions associated with the perfectly competitive norm, that is, "the marginal rates of substitution between any two commodities or factors must be the same in all their different uses" (Pasour, 1981). This implies a comparison of the observed situation with a defined efficiency norm. The 'perfect market' norm is often used in agriculture as agricultural producers are almost always price-takers. However, this norm has three important assumptions; (a) perfect communication, (b) instantaneous equilibrium, and (c) costless transactions. Decision makers are thus assumed to have perfect knowledge about all relevant variables, including future occurrences. Wherever this fails to hold, there is a potential for optimum farm size to be specific to individual units of production. Therefore many economists (Friedman, 1962; Pasour, 1981), contend that it is difficult to measure efficiency, because individual decision makers have different cost functions as they value opportunity costs differently and display different attitudes to risk. Different managers' subjective evaluation of the cost value of time, managerial input as well as of revenue also vary (Bradford and Johnson, 1964). Such perceptual differences can also be expected to influence an individuals scale of operation, contributing to divergence in size of business (Groenewald, 1991).

The existence of specialized factors of production (Friedman, 1962: 141; Groenewald, 1991) introduces an additional reason why firms should differ in size. In any industry where resources used cannot be regarded as unspecialized, there will tend to be firms of different sizes, hence one could speak of an "optimum distribution of firm size" rather than "optimum" size of a firm (Friedman, 1962: 142). Individual farmers therefore each have an optimum farm size and there is no single optimum farm size for all farmers. In a market economy an optimum distribution of farm size may occur, and a study of optimum size is thus superfluous. However, in South Africa where government is encouraging small farm development, the question of efficiency and equity becomes relevant and it is not possible to simply abstract from this issue.

In this study the term 'efficient farm' refers to a farm utilizing less resources than other farms to generate a given quantity of output. Alternatively, for a given quantity of resources they generate a greater output. This superior performance is manifested in higher efficiency ratios (output per unit of input), and a lower cost per unit of production. Therefore, agricultural efficiency is attained when the greatest possible product is achieved from a given stock of resources, or conversely, when a minimum input of resources is used to produce a given level of output.

2.3 Sources of efficiency (economies of size or scale)

Experience in agriculture as well as in manufacturing industry has frequently confirmed that average costs per unit produced (or sold) decline as fixed costs are spread over a greater output, so that the small farm or firm with limited output with certain unavoidable costs finds itself at a disadvantage (Britton and Hill, 1975: 7). Fixed costs such as management, supervision, information and machinery can be used over more units of output (Krause and Kyle, 1970), resulting in reductions in cost per unit of output (increasing returns to scale or size). The expressions returns to *scale* and *size* are used almost interchangeably by some economists (Stanton, 1978). Returns to scale are defined as the proportionate change in output when all inputs are increased in the same proportion (Hallam, 1991).

In practice, inputs are rarely, if ever, increased in the same proportions (Stanton, 1978; Doll and Orazem, 1978: 219). Consequently the term 'economies of size' is used to describe the fall in total cost per unit of production found on larger farms. For example, an economy of size occurs when the average cost of sugar cane production per ton on a farm producing 6000 tons per crop season is lower than on one producing 3000 tons. Economies of size can arise either within the farming process itself (internal economies), due to better utilization of machinery, labour or other inputs (technical economies), or through business dealings with other firms (external economies) in its purchase of inputs or the sale of its products (marketing economies).

2.3.1 Technical economies

Technical economies of size are those which arise within the business itself through its more efficient use of land, labour, capital, and of the abilities of the entrepreneur - the farmer himself (Britton and Hill, 1975: 118). Lower operating costs per unit of capacity are often given as a major source of economies of size in the use of fixed capital (Britton and Hill, 1975: 121). Tractors and harvest machines reach their lowest cost of operation per unit at a much larger area, so optimum operational family farm sizes will increase with mechanization (Hall and LeVeen, 1978; Binswanger *et al.*, 1992: 24).

But Rao (in Binswanger and Elgin, 1988) argues that, economies of scale for machines do increase minimum efficient farm sizes but by less than expected, because of rental markets for machines. Rental markets for machines nonetheless, can circumvent the economies of scale inherent in machines only partly, because rental markets are often not feasible for time-bound operations, such as seeding in dry climate or harvesting where climatic risks are high (Binswanger and Elgin, 1988; Binswanger *et al.*, 1992: 21). The renting of machinery involves fixed transactions costs which introduces size economies that favour large farm operations (Lyne, 1996).

Binswanger *et al.*, (1992: 21), argue that in plantation crops like sugar cane, economies of scale arise from processing or marketing stage rather than in farm operation. Economies of scale in processing are transmitted to the farm because processing must occur within hours from harvesting[6] (Binswanger and Elgin, 1988). Binswanger *et al.*, (1992: 22), point out that where little co-ordination between harvesting and processing is required, markets (local and national) are supplied by family farms even in economies dominated by plantations[7]. This explanation, however disregards fixed management costs, and transaction and information costs incurred in the use of technology at farm level.

2.3.2 Labour, management and information costs

Management, like a machine, is an indivisible and lumpy input. Good management initially gives rise to economies of scale. The better the manager, the larger the optimal farm size. The quality of management affects returns to size and may also provide increasing returns to size (Groenewald, 1991). Therefore, optimal farm sizes will tend to increase with technical change under quality management (Binswanger and Elgin, 1988).

Although seen as a lumpy and indivisible input, some management skills can be rented. Private extension officers can be hired by the hour (Feder and Slade, 1984b). Likewise, contract farming where larger farmers can provide technical, financial and marketing advice to smaller farmers could be arranged (Binswanger and Elgin, 1988). Rental markets for management and alternative contractual arrangements can circumvent the lumpiness of management skills only partially. Actual farming decisions and the supervision of labour

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[6] Sugar cane harvesting and processing must be well co-ordinated, if cane is left unprocessed for more than 12 hours the sugar is lost to fermentation (Binswanger *et al.*, 1992:22)

[7] In Central America unrefined sugar (*muscovado*), is produced by family farms. This is cited by Binswanger *et al.*, (1992) as an example where processing does not involve economies of scale.

cannot be bought in the market, nor is there any substitution for the important plot-specific experience of a farmer or manager (Binswanger and Elgin, 1988).

Deininger and Binswanger (1992) believe that there is considerable empirical evidence to indicate that large-scale *unmechanised* agriculture is less efficient than small-scale farming based on the effort of labour. Bates (1996) studied very small scale communal sugar farmers in KwaZulu-Natal, who largely relied on non mechanized labour intensive technologies, and observed that the smaller farms, less constrained by the labour input were performing better. This was attributed to the fact that labour costs became a severe constraint on the small scale farms that are larger.

The use of family labour on small farms is thought to cost less than hired labour as there are no search and hiring costs (i.e., transaction costs are zero), and transaction and supervision costs may indeed be lower for family labour. However, in a situation where an active and diversified off-farm labour market prevails, such as in KwaZulu-Natal (Lyne and Ortmann, 1996), people with different skills command different wages. The opportunity cost of a family member used on the farm is therefore likely to approximate his or her expected wage rate (adjusted by the probability of employment).

Britton and Hill (1975: 45) recommend that any study of relative efficiency of different sizes of farm business must impute values of factors of production where no cash payment is involved. They suggest two principal methods of arriving at imputed costs: (1) to use what is paid to similar factors of production in similar occupations where actual payments are made; and (2) to consider what the inputs in question could earn in their best-paid alternative employment (their transfer earnings or opportunity costs). In this study family labour *shadow* price is imputed by costing operations performed by family labour based on what is paid to similar factors of production in similar occupations as suggested by Britton and Hill (1975: 50). Management costs were imputed considering what a farm operator could earn in his/her best paid alternative employment (opportunity cost).

The adoption and use of any technology involves fixed transaction and information costs. On large farms, these costs can be spread over large volumes of output (Lyne, 1996). Information costs are fixed and therefore introduce size economies (Huffman, 1974; Welch, 1978: 259). Therefore average cost curves vary among managers, with better managers having lower cost curves, due to lower information costs (Huffman, 1974). In this study, information costs were computed based on mean annual cash costs of farm information from private sources compiled in a study by Bullock *et al.*, (1995) on small and large commercial vegetable farmers in KwaZulu-Natal (Table 2.1). The cost of different sources of information listed in the study by Bullock et al. (1995) were adjusted by rankings of individual farmers (captured in this study) assessing the usefulness of similar sources of farm information in assisting farmers to improve their cane farm productivity.

Table 2.1 Mean annual cash costs of various sources of information for commercial vegetable farmers in KwaZulu-Natal (1993/94)

Information source[8]	Mean annual cost (R)
Farm magazine	229
Own farm records/budgets*	1067
Tax prepare/accountants*	743
Field days/conferences	98
Soil consultants	87
Agric. newspapers & newsletters	15
Technical bulletins	25
University specialists	44
Management consultants*	391
Extension service	24
Radio and TV reports	22
TOTAL	2745

Source: Bullock *et al*, (1995)

2.3.3 Costs of borrowing

Economies of size that stem from borrowing capital remain less documented (Britton and Hill, 1975: 110). Variability of production and 'informational imperfections' restrict the amount of credit available to small farmers as lenders seldom have enough information to determine which of the small farms are relatively productive and low risk borrowers (Carter, 1988). The cost of information required to determine the credit-worthiness may exceed the benefits to be gained from the relatively small loan amount. Transaction costs associated with many small loans act as a disincentive for lenders and the cost of credit to small farmers is likely to increase (Carter, 1988). In the presence of fixed transaction costs, the cost of

[8]Information sources marked by asterisk (*) were omitted in the computation of information costs for small farms, and are mainly observed to be important on large commercial farms.

borrowing in the formal credit market is therefore a declining function of the amount of owned land (Binswanger *et al.*, 1992: 26).

Nevertheless, Britton and Hill (1975: 113) in a UK farm credit market study, found that farm size alone did not appear to be an important factor in determining the cost of borrowed capital. Preferential charges for bank credit prevailed, but a large farmer was only likely to secure credit if size is accompanied by greater creditworthiness. As far as bank charges on interest were concerned (Britton and Hill, 1975: 113), the sums involved were related to the amount of work undertaken by the bank (i.e.,'arrangement fees' for loans and 'commitment fees'), and the commission on administering transactions in farm accounts levied on a 'cost per transaction' basis.

However, in the UK unlike in KwaZulu-Natal, information on borrowers is readily available which makes the assessment of borrowers rather easy to accomplish. The finding in the UK study by Britton and Hill (1975) that farm sizes were not important in cost of borrowing may be attributed to a sufficient lack in variation in farm size. For instance the same result may be observed if only the commercial farming sector in SA is studied.

Experiences from lending agencies (e.g KwaZulu Finance Corporation-KFC and Small Cane Growers Financial Aid Fund-FAF) regarding small scale farmers in SA are that costs of lending to small farmers are substantially higher than to large farmers (Bates, 1996). In the South African sugar industry, the actual cost of small loans during the survey was 14.5% which is highly subsidized. Total cost of borrowing (reflecting administration and transactions costs) on loans by small scale farmers ranged between 30% to 48% if there were no subsidy. Mortgage bond rates (unsubsidised) paid by large farmers ranged between 15% to 18.5% during the respective period (Table 2.2)[9]. The actual subsidised interest charged to small farmers was 12.5% in 1993/94 season (Bates, 1996). A shadow price of 30% on average, was used to cost funds lent to small borrowers in light of data (Table 2.2) supplied by Bates (1996). The opportunity principle was used in the credit and labour markets (own labour and management was priced at opportunity cost section 2.3.2 and Table 5.15 section 5.5). The purpose was to estimate costs and incomes in a situation where markets are not distorted.

Table 2.2 Actual and unsubsidised interest rates charged by the Small Growers Financial Aid Fund (FAF) in the SA sugar industry

Season	Actual interest	Subsidy dependence index (SDI)	Unsubsidised interest
91/92	13.5%	98.1%	29.7%
92/93	11.0%	142.5%	31.5%
93/94	12.5%	340.4%	48.4%
94/95	14.5%	73.2%	25.1%
95/96	15.5%	57.6%	24.4%

Source: Bates (1996)

[9]Formal borrowing is the main sources of credit in the SA sugar industry (Bates, 1996), as such the costing of credit in the study was based on information in the formal credit market.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Multivariate analysis

3.1.1 Linear discriminant analysis (LDA)

Multiple discriminant analysis was used to determine factors important in classifying 'small' and 'large' sugar cane farms, and to identify factors that influence the different degrees of adoption of appropriate farming practices among sugar cane farmers. Discriminant analysis attempts to separate two or more groups of individuals, given measurements for the individuals on several variables (Manly, 1994: 107). The objective of linear discriminant analysis (LDA) is to find a linear function which distinguishes between groups using discriminating variables which measure characteristics on which the groups are expected to differ. The discriminant function includes *n* variables, X_1, ..., X_n, that will separate the two groups as well as possible. The method employed in group separation is canonical variate analysis (Manly, 1994: 109). This is by analysis of variance that maximises the between-group variance, while minimising the within-group variance. The LDA model takes the form:

$$D_i = \sum_{j=1}^{n} B_j X_{ij} \quad (3.1)$$

The standardized weighting coefficient estimates ($\boldsymbol{B_j}$) are particularly important for policy analysis, since each shows the relative contribution of its associated variable ($\boldsymbol{X_j}$) to the linear function. Discriminant scores D_i estimated for each group are compared to the mean score for each classified group and group membership is classified into the group with the score most similar to his own. Success in discrimination between groups is assessed by observing the proportion of correct group classifications and the Wilk's lambda statistics (Klecka, 1980: 38).

3.1.2 Principal component analysis (PCA)

Principal component analysis (PCA) was used to condense the variables into fewer orthogonal variables. Perfectly correlated variables cannot be used in a discriminant function at the same time (Klecka, 1980: 9). The lack of correlation between explanatory variables is a useful property because it means that the indices are measuring different 'dimensions' in the data (Manly, 1986: 59). PCs can then be substituted instead of the original (**x**) variables in the derivation of a discriminant rule, thus reducing the dimensionality problem (Jolliffe, 1986: 157).

Variables studied were measured on varying scales, hence components were derived from the correlation matrix. Each variable is initially standardized to have a zero mean and unit variance. This caters for the differences in scales, and avoids any undue influence of scales on the components (Manly, 1986: 63). The object of component factor analysis therefore, is to economise on the number of explanatory variables X_1, X_2 ..., X_p (Crabtree, 1971; Nieuwoudt, 1977; Manly, 1986:58) by seeking linear transformations of the type:

$$PC_{ij} = \alpha_{1j}X_{i1} + \alpha_{2j}X_{i2} + \alpha_{3j}X_{i3} + \ldots\ldots + \alpha_{pj}X_{ip} \qquad (3.2)$$

In this approach new uncorrelated indices (components) PC_{ij} are constructed that explain as much of the variance in the original data as possible, in descending order. The *first* principal component is a linear function of highly correlated variables which accounts for the greatest possible part of total variance in the data (Ehrenberg, 1982: 207). The coefficients (α_{pj}) indicate the relative importance of each variable in the component.

3.2 Conceptual frame work in modelling farm size efficiency

The measurement of efficiency of enterprises has been undertaken in studies by the estimation of frontier functions. A frontier is taken to refer to a bounding function which represents the maximum output attainable from a given set of inputs (Coelli, 1995). The frontier function represents a best-practice technology against which the efficiency of firms within the industry can be measured. In terms of efficiency measurement, firms in the industry would be operating either on that frontier, if they are perfectly efficient, or beneath the frontier if they are not fully efficient (Farrell, 1957).

The history of efficiency measurement begins with Farrell (1957) who drew upon the work of Debreu (1951) to define a simple measure of firm efficiency. Farrell proposed that the efficiency of a firm consists of two components: (1) technical efficiency, which reflects the ability of a firm to obtain maximal output from a given set of inputs, and (2) allocative (price) efficiency, which reflects the ability of a firm to use inputs in optimal proportions, given their respective prices. The two measures of efficiency (technical and allocative) are then combined to provide a measure of total economic (overall) efficiency. The Farrell (1957) idea of technical, allocative and scale efficiency of production decisions has been adopted and extensively studied (Chavas and Aliber, 1993; Färe *et al.*, 1994; Chavas and

Cox, 1996). The Farrell concepts of technical and allocative firm efficiencies can be illustrated both algebraically and diagrammatically.

3.2.1 Graphical explanation of technical and allocative firm efficiencies

Figure 3.1 below illustrates firm technical and allocative efficiencies using a simple example involving firms which use two inputs (x_1 and x_2) to produce a single output (y), under an assumption of constant returns to scale.

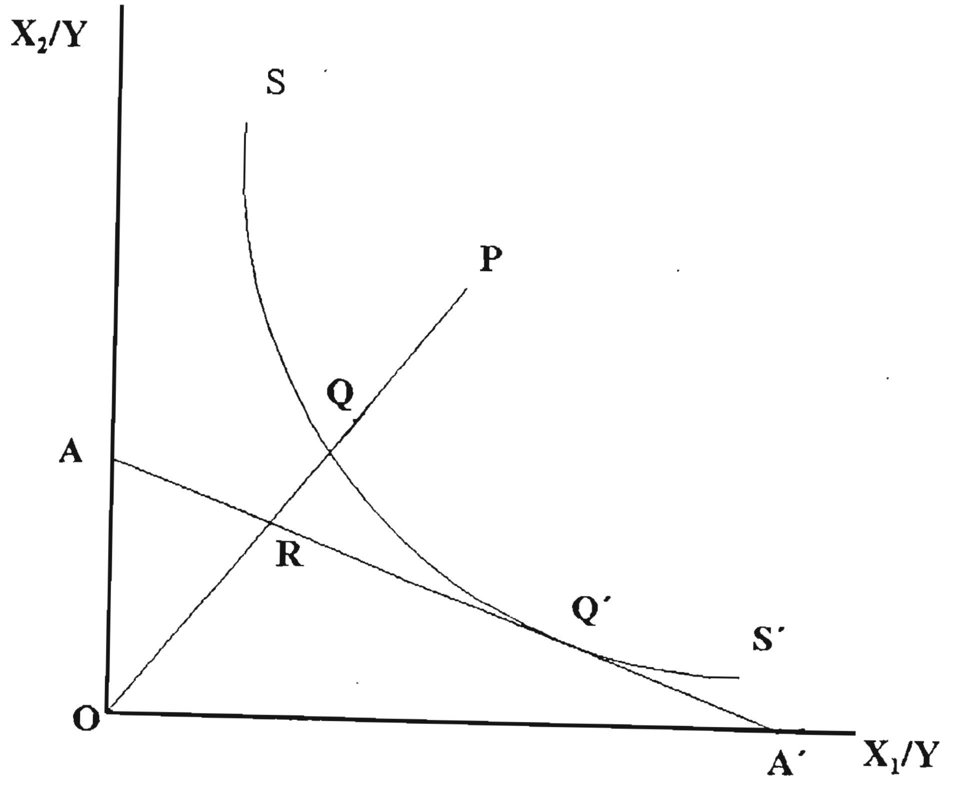

Figure 3.1 Technical and allocative firm efficiencies
Source: Coelli (1995).

Knowledge of the unit isoquant of the fully efficient firm, represented by SS' in Figure 3.1, permits the measurement of technical efficiency. If a given firm uses quantities of inputs, defined by the point P, to produce a unit of output, the technical efficiency of that firm is defined to be the ratio OQ/OP, which is the proportional reduction in all inputs that could theoretically be achieved without any reduction in output. The point Q is technically efficient because it lies on the efficient isoquant.

If the input price ratio, represented by line AA' in Figure 3.1, is also known, allocative efficiency may also be calculated. The allocative efficiency of the firm operating at P is defined to be the ratio OR/OQ, since the distance RQ represents the reduction in production costs that would occur if production were to occur at the allocatively (and technically) efficient point Q. The total *economic efficiency* is defined to be the ratio OR/OP, where the distance RP can be interpreted in terms of a cost reduction. Note that the product of technical and allocative efficiency provides the overall efficiency, (OQ/OP)(OR/OQ)=(OR/OP), and all three measures are bounded by zero and one.

However, the efficiency measures (as illustrated in Figure 3.1) assume the production function of the fully efficient firm is known. In practice this is not the case, and the efficient isoquant must be estimated from the sample data (Coelli, 1995). Farrell suggested the use of either (a) a non-parametric piecewise-linear convex isoquant constructed such that no observed point should lie to the left or below it (Figure 3.2), or (b) a parametric function, such as the Cobb-Douglas form, fitted to the data, again such that no observed point should lie to the left or below it.

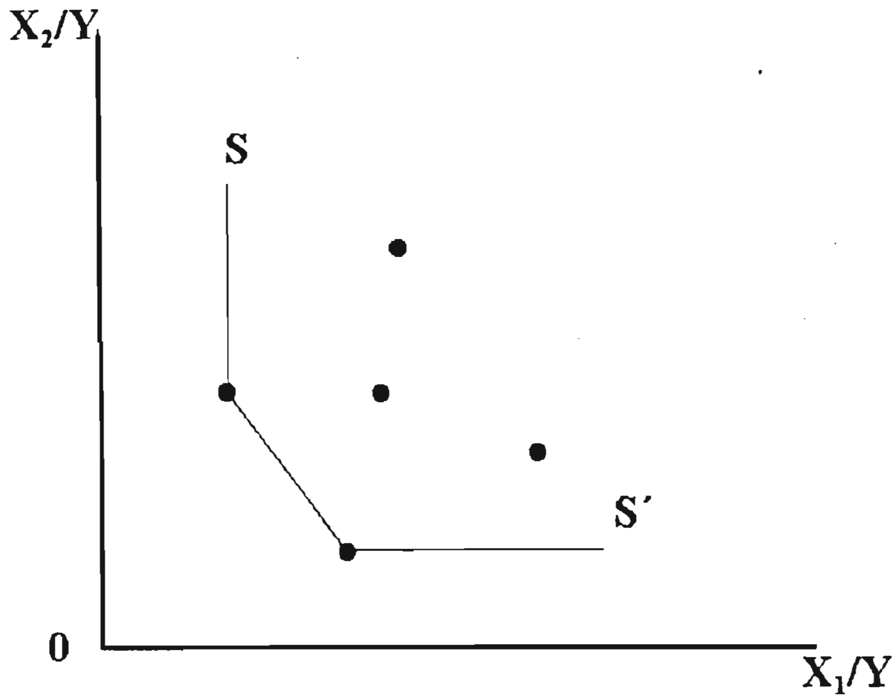

Figure 3.2 Piecewise linear convex isoquant
Source: Coelli (1995).

3.2.2 Algebraic conceptualization of firm technical and allocative efficiencies

The measurement of firm efficiency based on the work of Chavas and Aliber (1993) considers a firm using an (M x 1) input vector $x = (x_1, x_2, ..., x_M)' \epsilon \Re^{M+}$ in the production of an (N x 1) output vector $y = (y_1, y_2, ..., y_N)' \epsilon \Re^{N+}$, where $\Re^{N+}$ denotes n-dimensional space of a specified technology. The set of all technologically feasible production plans (firm's production possibilities set y) is a subset of $\Re^{N+}$, that is $y \epsilon \Re^{N+}$ (Varian, 1992:2). The underlying technology is characterised by the production possibility set T_v, where $(y, -x) \epsilon T_v$ is a non-empty, closed, convex, and negative monotonic set that represents a general technology under variable returns to scale (VRTS). Cone technology T_c defined as;

$$T_c = cl\{y,-x): (ky,-kx) \in T_v \forall\ k \in \Re^+\},$$

where; cl{•} denotes the closure of the set {•}, and k measures the proportion by which output changes given a change in inputs. Under constant returns to scale (CRTS), a proportional change in all outputs is associated with the same proportional change in all inputs (Chavas and Cox, 1996). T_c exhibits CRTS and satisfies $T_v \subseteq T_c$. The cone technology T_c generated by T_v is the smallest closed CRTS technology that contains T_v. Taking the (M x 1) vector $r = (r_1, r_2, \ldots, r_M)' \in \Re^{M+}$ to denote market prices for inputs x, the cost minimizing problem (under competition) can be expressed as:

$$C(r,y,T) = r'x^* = \min_x\{r'x: (y,-x) \in T, x \in \Re^{M+}\}, \tag{3.3}$$

where $x^* = \text{argmin}_x\{r'x:(y, -x) \in \Re^{M+}\}$ is the cost minimizing input demand functions under technology T.

For a firm choosing the output-input vectors (y, x), this corresponds to the Farrell technical efficiency index (TE):

$$TE(y,x,T_v) = inf_k\{k: (y, -kx) \in T_v, \in \Re^+\} \tag{3.4}$$

In general, $0 < TE \leq 1$, where $TE = 1$ implies that the firm is producing on the production frontier and is said to be technically efficient. Alternatively, $TE < 1$ implies that the firm is not technically efficient. In this case, (1-TE) is the largest proportion reduction in inputs (x) that can be achieved in the production of outputs(y).

Likewise, for a given input choice x, (Farrell and Fieldhouse, 1962), this generates the Farrell allocative efficiency index (AE):

$$AE(r,y,T_v) = C(r,y,T_v)/[r'(TE)x] \tag{3.5}$$

where $C(r, y, T_v)$ is the cost function under technology T_v, and $[(TE)x]$ is a technically efficient input vector from (3.4). In general $0 < AE \leq 1$, where $AE = 1$ corresponds to cost minimizing behaviour where the firm is said to be allocatively efficient. Alternatively, $AE < 1$ implies allocative inefficiency. In this case, $(1 - AE)$ measures the maximal proportion of cost the technically efficient firm can save by behaving in a cost minimizing way.

The two indexes ***TE*** and ***AE*** in (3.4) and (3.5) both depend on outputs y. Thus, they can be interpreted as being conditional on scale y (Seitz, 1970). ***TE*** and ***AE*** can also be combined into an *economic efficiency* index given scale y (Farrell, 1957), defined to be the product of the two indexes (3.4) and (3.5):

$$(TE\ AE) = C(r,y,T_v)/r'x \tag{3.6}$$

where $0 < (TE\ AE) \leq 1$. Then, $(TE\ AE) = 1$ implies that the firm is both technically and allocatively efficient. Alternatively, $(TE\ AE) < 1$ indicates that the firm is not efficient, $[1 - (TE\ AE)]$ measuring the proportional reduction in cost that the firm can achieve by becoming both technically and allocatively efficient.

3.2.3 Scale efficiency

While the indexes TE and AE in (3.4) and (3.5) are conditional on outputs y, the choice of y involves efficiency considerations as well. Whether a firm is producing optimally at y has been analyzed through the measurement of returns to scale S, expressed as $S(y, x, T_v)$.

According to Chavas and Aliber (1993), returns to scale can be characterised from the production function T_v as well as the cost function $C(r, y, T_v)$. Returns to scale can be expressed from the cost function in terms of the ray average cost (RAC):

$$RAC(k,r,y,T_v) = C(r,ky,T_v)/k, \tag{3.7}$$

where $k \in \Re^+$ and $y \neq 0$. Assuming differentiability, let the elasticity of the ray average cost function with respect to k (evaluated at k=1) be denoted by $e=\partial\ln(\text{RAC})/\partial\ln(k)$. Then under competition, the function $S(y,x,T_v)$ evaluated at the cost minimizing solution $\boldsymbol{x}^*$ (Baumol *et al.*, 1982: 55) can be expressed as:

$$S(y,x^*,T_v) = 1/(1+e) \tag{3.8}$$

Given the above definition of returns to scale in terms of S, it follows that returns to scale at the point y are increasing, constant, or decreasing whenever the elasticity of $\boldsymbol{e}$ is negative, zero, or positive, respectively. This implies that, when returns to scale are increasing, then the ray average cost $\text{RAC}(k,r,y,T_v)$ is a decreasing function of $\boldsymbol{k}$ (where a proportional increase in outputs leads to a less than proportional increase in cost). Similarly, when returns to scale are decreasing, then the ray average cost $\text{RAC}(k, r, y, T_v)$ is an increasing function of $\boldsymbol{k}$ (where a proportional increase in outputs leads to a more than proportional increase in cost). In the case where the RAC function has a U-shape, then constant returns to scale are attained at the minimum of the RAC with respect to k. This suggests the following index of scale efficiency:

$$SE(r,y,T_v) = AC(r,y,T_V)/C(r,y,T_V), \tag{3.9a}$$

where

$$AC(r,y,T_v) = inf_k\{\frac{C(r,ky,Tv)}{k}:k>0\}$$

denotes the minimal ray average cost function with respect to k. Clearly, $0<SE\leq 1$. Values of the vector ***y*** that satisfy SE(r, y, T_v) = 1 identify an efficient scale of operation corresponding to the smallest ray average cost. Alternatively, finding SE(r, y, Tv)< 1 implies that the value of the vector is not an efficient scale of operation. In this case (1-SE) can be interpreted as the maximal relative decrease in the ray average cost that can be achieved by proportionally rescaling all outputs toward an efficient scale of operation (where the output vector ***y*** exhibits locally constant returns to scale). SE(r, y, T_v) rises (declines) with a proportional augmentation in ***y*** under increasing (decreasing) returns to scale. According to Chavas and Aliber, (1993), AC(r,y,T_v) can alternatively be expressed as:

$$AC(r,y,T_v) = C(r,y,T_c).$$

Therefore scale efficiency index SE(r,y,T_v) can be alternatively written as

$$SE(r,y,T_v) = C(r,y,T_c)/C(r,y,T_v) \qquad (3.9b)$$

In this study more emphasis is placed on scale efficiency because of the importance of the farm size variable in the analytics of this study.

3.3 The measurement of farm efficiency

The estimation of production frontiers falls into two broad categories; parametric and non-parametric (data envelopment analysis-DEA). The parametric approach relies on a parametric specification of the production function, cost function, or profit function (Forsund *et al*, 1980; Bauer, 1990). The nonparametric (DEA) approach to frontier estimation involve mathematical programming models (Seiford and Thrall, 1990; Coelli, 1995).

The parametric production frontiers are stochastic or deterministic (Coelli, 1995). Deterministic is generally used to describe that group of methods which assume a parametric form for the production frontier along with a strict one-sided error term (Coelli, 1995). Work involving the use of deterministic methods of efficiency frontier analysis is found in Argner and Chu (1968), Afriat (1972) and Schmidt (1976). One of the primary criticisms of deterministic frontier estimates is that no account is taken of the possible influence of measurement errors and other data noises upon the shape and positioning of the estimated frontiers, since all observed deviations from the estimated frontier are assumed to be a result of technical inefficiency (Coelli, 1995).

Aigner *et al.*, (1977) and Meeusen and Van den Broeck (1977) proposed the estimation of a stochastic frontier production function, where sources of data noise are accounted for by adding a symmetric error term to the non-negative error. The parameters of this model are estimated by maximum likelihood (ML), given suitable distributional assumptions for the error terms. Agner *et al.*, (1977) assume that the symmetric error term has a normal distribution and the non-negative error term has either the half-normal or the exponential distribution. This stochastic model specification not only addressed the data noise problem associated with deterministic frontiers, but also permitted the estimation of standard errors and tests of hypotheses, which were not possible with earlier deterministic models because of the violation of certain ML regularity conditions referred to by Schmidt (1976).

The stochastic frontier is not, however, without problems. The main criticism is that there is no *a priori* justification for the specification form of the error term (Coelli, 1995). The specification of more general distributional forms of the error term, such as the truncated-normal (Stevenson, 1980) and the two-parameter gamma (Greene, 1990), has partially alleviated the problem, but resulting efficiency measures may still be sensitive to distributional assumptions.

A variety of functional forms have been used in the empirical estimation of frontier models. The Cobb-Douglas functional form has been the most commonly used. Its most attractive feature is its simplicity. This simplicity, however, is associated with a number of restrictive properties, most notably, returns to scale are restricted to take the same value across all firms in the sample, and elasticities of substitution are assumed equal to one. The other two most popular functional forms are; the translog used by Greene (1980), and the Zellner-RevanKar generalized production function used by Forsund and Hjalmarsson (1979), and Kumbhakar *et al.*, (1991).

The Zellner-Revankar form removes the returns-to-scale restrictions, while the translog form imposes no restrictions upon returns to scale or substitution possibilities (suffered in the Cobb-Douglas functional form), but has the drawback of being susceptible to multicollinearity and degrees of freedom problems. These problems however, can be avoided by jointly estimating the translog production function with the first-order conditions for profit maximisation, as suggested by Greene (1980), but this increases the complexity of the estimation of parameters (Coelli, 1995).

The nonparametric (DEA) procedure of analysing efficiency is adopted in this study. The

DEA approach to frontier estimation has been used in a small percentage of agricultural frontier applications (Fare *et al.*, 1985; Ray, 1985; Chavas and Aliber, 1993). However the method has the advantage of imposing no *a priori* parametric restrictions on the underlying technology (Färe *et al.*, 1985), while it handles disaggregated inputs and multiple output technologies. The mathematical models used in non-parametric methods of analysing farm efficiency are deterministic and provide estimates with no statistical properties. That is, there are no standard errors, or *t* ratios to facilitate statistical inferences. In contrast, econometric models are amenable to statistical tests on assumptions made about the parameters to establish the validity of a model (Forsund *et al.*, 1980). While the parametric approach relies on a relatively well developed set of statistical tools, it also requires very strong information and / or assumptions about technology and behaviour.

The DEA approach suffers from the same criticism as the deterministic methods, in that it takes no account of the possible influence of measurement errors and other noise in the data, therefore assuming that all deviations from the frontier are due to inefficiency. However none of the proposed methods (deterministic and stochastic) of measuring efficiency relative to an estimated frontier is perfect, and the answer to the question of which method of the frontier estimation (stochastic frontier or DEA) will often depend upon the application being considered (Coelli, 1995). The DEA method has the advantage of removing the necessity to make arbitrary assumptions regarding the functional form of the frontier and the distributional form of the error term. The DEA method of estimating frontiers therefore remains one of the frontier methods that could be utilized in agriculture to investigate the influence of farm size upon efficiency (Coelli, 1995).

3.4 The nonparametric (DEA) approach

Consider a sample of n observations on firms in a given competitive industry. Let y^i and x^i be the output vector and input vector, respectively, chosen by the ith firm, $i = 1, 2, \ldots, n$. The production possibility set of each firm in the industry is denoted by $\breve{T}$, with $(y^i, -x^i) \in \breve{T}$, $i = 1, \ldots, n$, where $\breve{T}$ is a non-empty, closed, convex, and negative monotonic set. The question then is: how to use the production data, (y^i, x^i) $i = 1, \ldots, n$, to provide a representation of the set $\breve{T}$. Following (Afriat, 1972; Färe, *et al*, 1985), consider the following nonparametric representation of $\breve{T}$.

$$T_v = \{(y, -x): y \le \sum_{j=1}^{n} \lambda_i y^i,\ x \ge \sum_{j=1}^{n} \lambda_i X^i,\ \sum_{j=1}^{n} \lambda_j = 1, \lambda_j \in \Re^+, \forall\ i\} \qquad (3.10)$$

The set T_v in (3.10) is closed, convex, and negative monotonic. Under variable returns to scale, it is the smallest convex set that satisfies the monotonicity property and includes all the observations (y^i, x^i), $i = 1, \ldots, n$. As such, it corresponds to the inner bound of the underlying production possibility set $\breve{T}$ (Banker and Maindiratta, 1988). Using T_v in (3.10) as a representation of technology, the measurement of the Farrell technical efficiency index TE in (3.4) for the ith firm is obtained form the following linear programming problem:

$$TE(y^i, x^i, T_v) = \min_{k,\lambda} \{k_i : y^i \le \sum_{j=1}^{n} \lambda_j y^j,\ k_i x^i \ge \sum_{j=1}^{n} \lambda_j X^j, \sum_{j=1}^{n} \lambda_j = 1, \lambda_j \in \Re^+, \forall\ j\} \qquad (3.11)$$

Then, based on T_v in (3.10), the measurement of the Farrell allocative efficiency index AE for the ith firm is obtained from (3.5), the cost function $C(r, y^i, T_v)$ being calculated from the following linear programming problem:

$$C(r, y^i, T_v) = \min_{x,\lambda} \{r'x : y^i \le \sum_{j=1}^{n} \lambda_j y^j,\ x \ge \sum_{j=1}^{n} \lambda_j X^j,\ \sum_{j=1}^{n} \lambda_j = 1, \lambda_j \in \Re^+, \forall\ j\} \qquad (3.12)$$

Where r is the price vector for x. Alternatively, under constant return to scale (CRTS), consider the following nonparametric representation of $\breve{T}$:

$$T_c = \{(y, -x): y \leq \sum_{j=1}^{n} \lambda_i y^i,\ x \geq \sum_{j=1}^{n} \lambda_i X^i, \lambda_i \in \Re^+, \forall\ i\} \tag{3.13}$$

Comparing (3.10) and (3.13), note that $T_c \subseteq T_v$ in (3.10). T_c is closed, convex, negative monotonic and exhibits CRTS (Afriat, 1972; Färe, *et al.*, 1985). It is the smallest cone that satisfies the monotonicity property and includes all the observations (y^i, x^i), $i = 1, \ldots, n$. As such, it corresponds to the CRTS inner bound of the underlying production possibility set T. Based on T_c in (3.13) as a representation of the CRTS technology, consider calculating $C(r, y^i, T_c)$ from the following linear programming problem:

$$C(r,y^i,T_c) = \min_{x,\lambda} \{r'x: y^i \leq \sum_{j=1}^{n} \lambda_j y^j,\ x \geq \sum_{j=1}^{n} \lambda_j X^j, \lambda_j \in \Re^+, \forall\ j\} \tag{3.14}$$

Then, the scale efficiency index SE for the ith firm can be obtained from (3.9b), where $C(r, y^i, T_v)$ and $C(r, y^i, T_c)$ are given in (3.12) and (3.14), (Chavas and Aliber, 1993).

CHAPTER 4

DATA SOURCES AND CHARACTERISTICS OF RESPONDENTS

4.1 Data collection

Sugar cane growing areas in the KwaZulu-Natal Sugar-belt differ in resource base, which leads to differences in technology adopted and costs of production (Ortmann, 1985). Sugar cane is mainly produced under dry land conditions (rainfed), while a reasonable amount of irrigation goes on in the industry. Large-scale sugar cane farms tend to specialize in a single crop enterprise, while small-scale farmers are known to operate farms with an enterprise mix of cane and some other food crops (Cobbett, 1984). Mills to some extent have control over the management of resources in the growing of sugar cane on small and large farms. Sugar mills own very large estates (known as mill-cum planters-MCP), and as a measure to ensure that more land is planted under cane, mills have supported and operated small cane farms on behalf of the farm owners. Such differences in cropping patterns and resource management decisions, expose farmers to different cost structures and economic conditions in the sugar industry. In order to cater for the differences in resource base, and peculiarities in economic and environmental conditions faced by farmers in the sugar industry, a three-stage research procedure was followed to collect data. The first stage involved breaking down (stratifying) the industry into relatively homogeneous sub-regions. This stratification was as recommended by the SACGA, dividing the sugar industry into *five* major regions, based on differences in resource endowment. The industry was therefore stratified into: (1) North irrigated region, which includes *Malelane* and *Pongola* areas; (2) Zululand region, which includes *Umfolozi*, *Felixton*, *Entumeni*, *Amatikulu*; (3) North Coast region, covering *Darnall*, *Gledhow*, *Glendale*, and *Maidstone* areas; (4) Midlands region covers areas of *Mt. Edgecombe*, *Illovo*, *Union Co-op* and *Noodsberg*; and (5) South Coast region covering *Sezela* and *Umzimukulu*. Frean (in Ortmann, 1985a) suggests a similar division of the sugar cane industry for policy formulation purposes. The North-Coast region was selected in this study because of the presence of both small and large-scale farm units operating in relatively homogeneous agro-climatic conditions, and under a similar land tenure regime (private ownership). The other reason was that sugar cane is the major crop enterprise in this region even on small-scale farm operations (Quantum, 1990: 47).

The second stage involved the drawing of a sample constituting both small and large scale *independent* sugar cane farms. Farmer independence in farm decision making was an important consideration in the selection of the sample (mill-cum planters and small-scale sugar cane farms where the mills influence decision making processes were excluded from the sample). The 'Indian' small-scale farmers were found to meet the two conditions, that is, operating under a free-hold land tenure system and were identified as independent in decision making as regards farm operations. The sample was stratified into small and large farm categories to maximize the variation of the farm size variable so as to study the effect of this variable on efficiency. Small scale farms were distinguished from large scale farms following the SACGA definition of small farms as farms twenty hectares and below under sugar cane. A list of addresses obtained from the SACGA, consisting of 380 North Coast region registered quota growers was used as a sample frame of large scale farmers. The North Coast region is divided into four zones along lines of the four sugar mills (Figure 4.1) that serve the region (Darnal, Gledhow, Glendale, and Maidstone). The sample in the large farm category included all 380 listed registered large scale farmers in the North-Coast region. Reasons for including all farmers in this category are; (a) large scale farmers were to be reached through a postal survey making it cheaper to mail questionnaires to all respondents, (b) questionnaires had to be mailed to as many farmers a possible to ensure a reasonable response rate (a response rate of about 30% was anticipated based on similar mail surveys conducted in the region)[10].

A list of small-scale sugar cane farmers in the North-Coast obtained from Tongaat Hulett (Sukumani Development Company)[11] was used to select a random sample of small scale farmers from the four strata in the North-Coast region. The third stage was the actual data collection. Data were collected by means of a survey designed in collaboration with the SACGA and Sukumani Development Company (PTY) during March-May 1995. Three hundred and eighty questionnaires were posted to the large-scale farmers. Ninety farmers responded to the survey (24% response rate), of which 64 (16.8%) returned usable questionnaires. Due to failure in having assess to postal addresses of small scale farms, farmers in this category were interviewed using a similar structured questionnaire (given in Appendix A). Of the 100 small scale farmers whose names were selected from the list of the small farm group, four could not provide useful information. Therefore information was collected from ninety six small scale independent commercial sugar cane farmers. Although two hundred respondents consisting of an equal number of small and large farmers were targeted, 160 respondents provided usable information.

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[10]Woodburn *et al.*, (1994) had a response rate of 46% of which 35% was usable; Bullock *et al.*, (1995) 37% of which 15.5% were usable; and Newman (1996) 34% of which 30% were usable.

[11]Sukumani Development Company provides private extension support to small-scale sugar cane farmers.

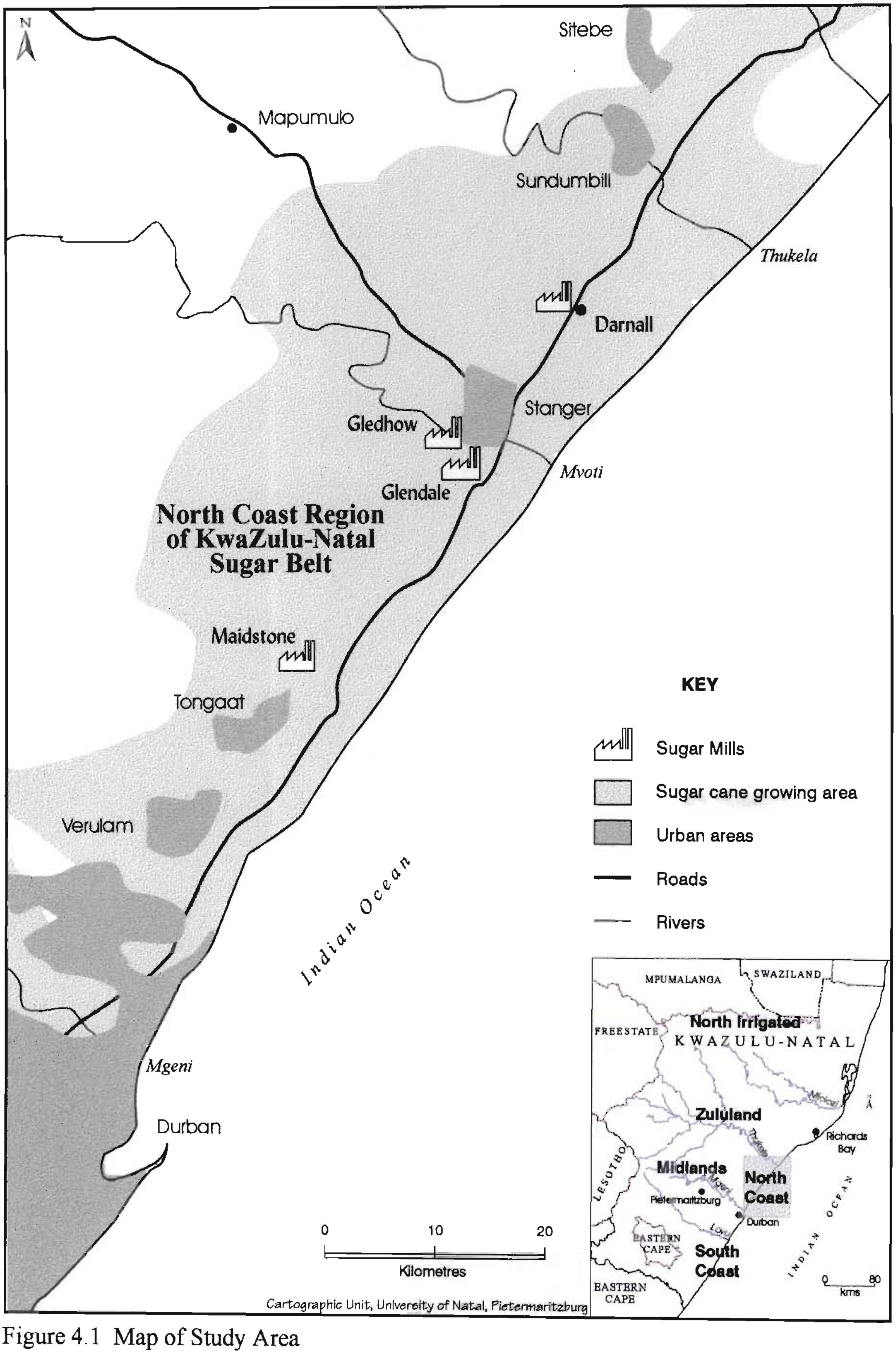

Figure 4.1 Map of Study Area

Data collected included information on farmers' personal, social and economic characteristics, and farm location used in the assessment of the agro-climatic farm attributes for the 1993/94 season. The low response rate affected the representativeness and reliability of sample data in the large scale farm category. However, some sample statistics (farm size, yield) were not significantly different from population data giving some credibility to sample data. The presence of both small and large-scale farm units in the region enabled the collection of information showing resource use for a wide range of farm sizes, operating in relatively homogeneous agro-climatic conditions, and under a similar land tenure regime (private ownership).

4.2 Descriptive statistics

A t-test of mean difference (Norussi, 1990a: 701), of selected characteristics on small and large sugar cane farms is presented in Tables 4.1, 4.2 and 4.3. Descriptive statistics illustrating a demographic profile of respondents in the sample are presented in Table 4.1. Table 4.2 illustrates characteristics specific to land use and performance indicators for small and large scale farms within the sample. Table 4.3 shows adoption rates of appropriate farm practices, and evaluation of sources of farm information by small and large scale farmers.

4.2.1 Demographic characteristics

From Table 4.1, no significant difference in the average age between small and large scale farm operators was recorded (50 years and 49 years, respectively). Similarly the mean years of farming experience were not statistically significantly different between the two groups (24 years for large-scale farmers compared to 22 years for small-scale farmers). As regards formal education, there is a significant difference between the two farm groups, with large-scale farmers recording an education level of above matric (Standard 10), compared to standard 6 to standard 9 in the small-scale farm group. Data on farmer's education were captured using the scale ranging from zero to four followed in Makary and Rees (1981) to symbolise; no education, standard 5 and below, standard 6 to 9, standard 10 (matric), 4 for tertiary education, respectively. Such categorisation in the different levels of education had to be followed due to difficulties experienced by respondents (especially in the small farm group) in stating the exact number of years taken to attain a certain standard of education. Farming is a full-time occupation to ninety two percent (58) of large-scale farm operators with eighty seven percent (54) having received practical training in cane growing, attending over two training sessions on average in two years. Eighty percent (76) of small-scale farmers are full-time farmers, and forty six percent (44) have been trained in cane growing with an attendance rate of one training sessions on average in two years.

Table 4.1 Mean difference in farmers' personal and demographic characteristics according to farm category

CHARACTERISTICS	SMALL	LARGE	t-VALUES
Age (years)	50 (95)	49 (58)	0.74
Farming Experience (years)	22 (96)	24 (62)	0.83
Education	2.3 (96)	3.5 (64)	8.09**
Training workshops attended in two years	1.2 (95)	2.9 (64)	2.44*
Full-time Farming	0.80 (96)	0.92 (64)	2.09*
Training	0.46 (96)	0.87 (63)	5.77**

*Significant at; **1 percent, and *5 percent level. Figures in parenthesis represent valid cases.*

4.2.2 Land use and performance indicators

From Table 4.2, significant differences in the means of selected land use characteristics and performance indicators are visible between small and large cane farms. Average farm size operated is 12.5 hectares and 263 hectares for the small and large scale groups, respectively. Average area under sugar cane for the small farm group is 8.3 hectares, and 197 hectares for the large scale farmers. Large farms have a relatively high percentage of land under sugar cane, utilizing 81.6% of operated land as compared to the 76.5% on small farms. The results of the small farmer group are consistent with those reported in the small grower development survey (Quantum research, 1990: 47), with over three quarters of the Asian (Indian) respondents claiming that 75% or more land is under cane compared to 76% in this study (Table 4.2). Sugar cane production contributed respectively, 91% and 98.3% of gross total farm income on small and large farms. This shows that sugar cane growing is the most important farm activity on farms studied (small and large), therefore the complication of different product mixes on the measurement of farm sizes is a relatively minor issue in the data studied (see section 2.2.1). The ratio of rented land for purposes of growing sugar cane is relatively higher on small farms 33%, compared to 25% in the large scale category. However the difference is not significant but demonstrates that the proportion of land rented for growing sugar cane falls with increase in size of farm operated. This is evidence on the other hand that land transactions take place in both strata, an indication that the sample was drawn from farmers possessing secure land tenure rights.

As regards measures of economic performance considered, the average yield on farms in the study area was relatively lower on small-scale farms (47.6 tons/ha), compared to large-scale farms (54.6 tons/ha). The average yield on large scale farms reported in the sample corresponds with the 55 tons/ha average yield for the North Coast region as observed by the SACGA. Net farm income per hectare is significantly higher on large farms (R 1519) compared to small holdings (R 438). The market related interest rates charged on borrowed capital are lower for large farms (15%), compared to small scale farms (23%).

Table 4.2 Mean difference in land use and performance indicators between small and large scale sugar cane farms.

LAND USE	SMALL	LARGE	t-VALUES
Farm size (Ha)	12.5 (96)	263.4 (63)	9.47***
Area under sugar cane (Ha)	8.3 (95)	197 (62)	8.44***
% of area under sugar cane	76.5 (95)	81.6 (61)	1.42
Sugar cane income per gross farm income (%)	91.0 (95)	98.3 (59)	2.65***
Rented land under cane per total area under cane (%)	33 (19)	25 (24)	0.44
PERFORMANCE INDICATORS			
Average Yield (Tons/Ha)	47.6 (95)	54.6 (61)	1.91*
Net Income (R/Ha)[a]	438 (87)	1519 (51)	2.69***
Interest on borrowed capital (%)	23 (85)	15 (32)	13.22***
Input costs (R/Ha)[b]	1036 (92)	635 (57)	3.71***
Labour cost per (R/Ha)[c]	1995 (87)	1147 (57)	3.25***
Quantity of fertilizer (Ha)	0.55 (91)	0.49 (35)	0.72
Agro-climatic potential	2.9 (96)	2.8 (57)	0.28

*Significant at; ***1 percent and *10 percent respectively level. Figures in parenthesis represent valid cases.* [a]Net income reflects returns to management, rent earned on land and other fixed inputs. [b]Includes farm variable costs [c] Includes imputed family and hired labour costs.

Quantity discounts on bulk purchase of inputs like fertilizers and herbicides may explain the lower input costs per hectare on large scale farms. Labour costs per hectare on small scale farms (including imputed family labour costs) are higher (R 1995) on small farms compared to large farms (R 1147). There was no significant difference in the quantity of fertilizer used per hectare in either farm groups. There is no significant difference in the measured agricultural potential between the two farm groups studied. This is attributed to the fact that the sample of farms was from a region (the North Coast of the sugar cane belt) with a relatively homogeneous agro-climatic conditions. The agro-climatic potential between regions in the study area was captured on a scale ranging from one to four to represent regions with; poor, average, good and very good potential. The scale is based on four of the agro-ecological zones which provide a broad framework for evaluating land productivity and rainfall reliability in regions at the SA Sugar Experiment Station (SASEX).

Table 4.3 shows significant differences in mean adoption rates of appropriate farm practices, and evaluation of farm information sources between small and large farm operators. Data on farm information sources available in the SA sugar cane industry (i.e., ECAD, EXOF, SASEX, DEMON, OHFRM, MGZ) were captured on a likert-type scale ranging from zero to four representing rankings; not useful, less useful, useful, and very useful respectively, indicating the importance of a range of extension facilities to individual farmers (Table 4.4). This reflects the relevances of issues discussed when farmers seek external extension assistance (Zinnah *et al.*, 1993). INFRM is the average score of the ratings for all the farm information source data.

Table 4.3 Mean difference in adoption rates of appropriate farm practices, and farmers' evaluation of sources of farm information.

FARM PRACTICE		SMALL	LARGE	t-VALUES
Adoption of soil analysis	(SOIL)	0.87 (93)	1.68 (62)	7.49**
Adoption of certified seedcane	(CERTF)	0.27 (93)	0.65 62	4.98**
Adoption of farming practices	(ADOPT)[a]	1.13 (93)	1.48 (62)	4.57**
FARM INFORMATION SOURCES				
Visits by field extension officer	(VST)	2.46 (94)	1.05 (62)	6.58**
SACGA economists	(ECAD)	0.91 (93)	1.97 (60)	5.45**
Extension officers	(EXOF)	2.65 (93)	2.34 (60)	2.19*
Experiment research station	(SASEX)	1.92 (92)	2.30 (60)	2.30*
Field day-demonstrations	(DEMON)	0.75 (92)	1.83 (60)	6.25**
Other farmers	(OHFRM)	1.99 (94)	2.02 (60)	0.17
Farm magazines	(MGZ)	1.15 (93)	1.55 (60)	2.46*
Information	(INFRM)	1.53 (94)	2.01 (60)	4.72**

(a)ADOPT is derived from combining the response scores on the rate of soil analysis and use of certified seedcane by each farmer (see section 5.3 for details). *Significant at; ** 1 percent and * 5 percent level, respectively. Figures in parenthesis represent valid cases.*

VST measures frequency of visits by field extension officers on a farm in a season, captured on a scale as ranging from zero to four (i.e., none, 3 times; 4-6 times; 7-9 times; and 10+ times, respectively). The categories of the variable VST were determined after a means test showed significant changes in adoption of farm practices and farm visits by extension officers at the above intervals.

The adoption rate of improved farm practices is relatively higher amongst large-scale cane growers. Overall, large scale farmers turn to a relatively wider source of farm information

Table 4.4 Variable definitions and measurements

Farm size (FMSZE):	Hectares
Area under sugarcane (ASC):	Hectares
Education (EDUC):	scale ranging from zero to four to symbolise; no education, standard 5 and below, standard 6 to 9, standard 10 (matric), 4 for tertiary education, respectively
Experience (EXPNC):	years
Training (TRNG):	Dichotomous (1,0) one for training, zero otherwise
Workshops attended in two years (XTRNG):	continuous number
Farming occupation:	Dichotomous (1,0) one for full-time, zero otherwise
Agro-climatic potential (NAP):	scale ranging from one to four depicting areas' potential as; poor, average, good and very good respectively.
Soil analysis (SOIL):	scale ranging from zero to two, representing farmers who never have farm soils tested, those who test soils only when planting a new crop, and who conduct soil tests seasonally,
Use of certified seedcane (CERTF):	dichotomous, equal to one if certified seedcane is used, and zero otherwise.
Field extension officer visits (VST):	scale ranging from zero to four (i.e., none, 3 times; 4-6 times; 7-9 times; and 10+ times, respectively).
Assessment of farm information sources: (1) regional economists (ECAD) (2) field extension officers (EXOF) (3) research experiment station (SASEX) (4) field demonstrations (DEMON) (5) other farmers (OHFRM) (6) farm magazines (MGZ)	likert-type scale ranging from zero to four representing rankings; not useful, less useful, useful, and very useful respectively,

CHAPTER 5

EMPIRICAL ANALYSIS AND RESULTS

5.1 Characteristics of small and large farms

Multiple discriminant analysis was used to determine factors affecting small and large sugar cane farms. The main objective was to 'discriminate' between small and large sugar cane farms, on the basis of some set of characteristics, evaluate how well the two groups discriminate, and to determine which characteristics are the most powerful discriminators. The variable categorising farms as small and large was captured as dichotomous, equal to one if a farm is classified as large, and zero if a farm is small. The postulated function to classify small and large farms took the form:

$$\begin{aligned} Z_i = {} & a_1AGE + a_2EXPNC + a_3EDUC + a_4XTRNG + a_5TRNG + a_6VST + a_7ADOPT \\ & + a_8INFRM + a_9MG + a_{10}INPTC + a_{11}LABOR + a_{12}YIELD + a_{13}NAP \end{aligned} \tag{5.1}$$

Where; Z_i is the discriminant score for each farm, and a_1 ,..., a_n are the weighing (standardized discriminant function) coefficients of variables; age of farm operator (AGE), farming experience (EXPNC), education (EDUC), number of training workshops attended (XTRNG), agricultural training status of farm operator (TRNG), visits by field extension officer (VST), level of adoption of appropriate farming practices (ADOPT), use of farm information (INFRM), input costs per hectare (INPTC), labour costs per hectare (LABOR), average sugar cane yield (YIELD), and natural agro-climatic potential of a region (NAP). Details of variables in function 5.1 are given in Tables 4.1, 4.2, and 4.3. The weighting given to each of the original characteristics must be determined so that the resulting composite score Z_i will have maximum usefulness for classifying the two farm groups (Dunn and Frey, 1976). While these weights may be positive or negative, their relative contribution centres on the absolute value, that is, the coefficients identify the variables which contribute most to differentiating between the two farm groups (Klecka, 1980: 29).

Due to the intercorrelations between variables (Table 5.1), principal component analysis (PCA) was performed to condense the variables into fewer orthogonal variables. The extracted components are given in Table 5.2. Variables with factor loadings greater than 0.5 were used to interpret the PCs. PC_1 has high loadings on field extension staff farm visits (VST), hired management (MG), farmers' formal education level (EDUC) and market related interest rate on borrowed capital. PC_1 is a contrast between farm human resource capital, and market related cost of borrowed capital (i.e., PC_1 will be high if MG and EDUC are high but RATER and VST are low, and vice versa). The index shows that education is a substitute for extension services. PC_2 has high loadings on training (TRNG) in agriculture particularly cane growing, use of farm information (INFRM), number of times the farmer participated in agricultural training workshops (XTRNG), and adoption of appropriate farm practices on a sugar cane farm, that is, soil analysis and use of certified seedcane (ADOPT). PC_2 can be interpreted therefore as a *knowledge index*. PC_3 with heavy loadings for net farm income per hectare (NFI), labour (LABOR) and input (INPTC) costs per hectare is a *financial index*, and measures labour and input costs per hectare contrasted to net farm income (i.e., farmers with large positive values of PC_3 face high labour and input costs relative to their income, likewise farmers with lower values of PC_3 face lower labour and input costs relative farm income). PC_4 captures the interrelationships between farming experience another form of training (Stefanou and Saxena, 1988) and age of farm operator.

Table 5.1 **Correlations matrix of social and economic characteristics of sugar cane farms studied**

		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
Education (EDUC)	X_1	1.0																
Age (AGE)	X_2	-.22**	1.0															
Farming experience(EXPNC)	X_3	-.14	.73**	1.0														
Training (TRNG)	X_4	.16*	.06	0.5	1.0													
Training workshops (XTRNG)	X_5	.14	-.06	-.12	.34**	1.0												
Extension visits (VST)	X_6	-.44**	.11	-.14	-.13	-.06	1.0											
Farm practice adoption(ADOPT)	X_7	.28**	.03	.10	.36**	.14	-.10	1.0										
Farm information (INFRM)	X_8	.28**	.05	.02	.46**	.25**	.06	.41**	1.0									
Area under sugarcane (ASC)	X_9	.44**	-.01	.07	-.25**	.11	.30**	.39**	.18*	1.0								
Average yield (YIELD)	X_{10}	.11	-.04	-.01	.03	.07	-.13	.04	.06	.20*	1.0							
Agricultural potential (NAP)	X_{11}	-.05	.02	.03	-.01	.03	-.10	-.05	.06	.09	.23*	1.0						
Hired manager (MG)	X_{12}	.33**	-.00	.02	.06	.03	.28*	.23*	.08	.54**	.06	.10	1.0					
Input cost/ha (INPTC)	X_{13}	-.08	.00	-.12	-.26**	-.03	.13	-.14	-.08	-.21*	.07	-.00	-.08	1.0				
Labour cost/ha (LABOR)	X_{14}	-.38**	-0.07	.01	-.15	-.11	.09	-.15	-.16	-.18*	.10	.00	-.11	.21*	1.0			
Interest rate (RATER)	X_{15}	-.47**	.08	-.01	-.40**	-.16*	.45**	-.37**	.14	-.55**	-.18*	-.06	-.38**	.34**	.30**	1.0		
Gross farm income (GFI)	X_{16}	.39**	.05	.15	.22**	.13	-.28**	.35**	.13	.92**	.22**	.09	.42**	-.15	-.10	-.53**	1.0	
Net farm income/ha (NFI)	X_{17}	.13	.11	.13	.17*	.15	.11	.12	.18*	.18*	.17	.21*	.04	-.31**	-.70**	-.28**	-.28**	1.0

**Significant at 1% and * Significant at 5%, (2-tailed)

Component PC_5, measures the extent to which the natural agricultural potential of a region is related to the average sugar cane yield.

Table 5.2 Interrelationships between social and economic characteristics of sugar cane farms studied

VARIABLE	EIGENVECTOR FOR COMPONENTS				
	PC_1	PC_2	PC_3	PC_4	PC_5
Farm visits by field extension officers (VST)	-.715				
Hired manager (MG)	.709				
Education of farm operator (EDUC)	.685				
Interest rates (RATER)	-.678				
Training (TRNG)		.769			
Information (INFRM)		.767			
Training workshop (XTRNG)		.607			
Adoption of farming practices (ADOPT)		.589			
Net farm income/ha (NFI)			-.870		
Labour cost/ha (LABOR)			.865		
Input costs/ha (INPTC)			.515		
Farming experience (EXPNC)				.919	
Farmers age (AGE)				.889	
Average yield (YIELD)					.756
Agricultural potential (NAP)					.743
Eigenvalue	3.32	1.98	1.48	1.40	1.25

Components PC_1, PC_2, PC_3, PC_4, and PC_5 were included in the estimated discriminant model. PC_4, a farming experience index and PC_5, a natural agricultural potential index were excluded from the model as they had F-values of less than 1 and statistically non-significant. This may be due to the fact that both small and large farms studied do not differ in farming experience, and are located in a relatively homogenous agricultural potential region. The results are presented in Table 5.3.

Table 5.3 Estimated discriminant functions for 'small' and 'large' sugar cane farms

Explanatory variable	Standardised coefficient	t-value	Component score group means		
			Small	Large	F value
PC_1	1.032	8.40*	-0.578	0.577	70.61*
PC_2	0.848	5.21*	-0.326	0.637	27.15*
PC_3	-0.499	2.75*	0.161	-0.381	7.55*
PC_4	-	-	-0.087	-0.212	0.51
PC_5	-	-	-0.067	-0.035	0.27E-01
Number of valid cases			82	38	

*significant at 1% level

F value	118.84*
Wilk's lambda	0.36
Canonical correlation	0.80
Classifications:	
Small scale	90.20%
Large scale	89.50%
Total	90.00%

From Table 5.3, a Wilk's lambda value of 0.36, and 90% overall correct classification of farms indicates an effective classification ability of the estimated discriminant function. This conveys information that variability (or variance) between groups far exceeds variability within groups, therefore the classification appears valid.

The two groups of farm sizes (small and large) seem to differ greatly on lines of human resource capital and cost of borrowed capital (market related), as PC_1 (combining extension, use of hired management, education, and interest rates on borrowed capital) is the main discriminator with the highest standardized coefficient (1.032). The positive sign on the coefficient of PC_1 implies that large farms are better equipped in human resource capital, and face lower market related interest rates, compared to small farms. PC_2 which is an interaction index of training, use of farm information, number of training workshops attended, adoption of appropriate farm practices (an indicator of managerial proficiency) emerged as the second most important discriminating variable with a standardized coefficient of 0.848. The positive sign on the coefficient of PC_2 shows that large farms have high incentives to acquire more knowledge, and are in a better position to adopt appropriate farming methods than smaller farms.

The negative sign on PC_3, the third most important discriminating variable (with a standardized coefficient of -0.499), shows that large farms have high incomes relative to labour and other input costs. The revers is true, small farms face large labour and input costs relative to their income. Frequency distributions of the discriminant scores are shown in Tables 5.4 and 5.5 along with their accompanying histograms (Figures 5.1 and 5.2). Both small and large farms studied have an approximately univariate normal distribution, the estimates therefore can be accepted with reasonable confidence.

Table 5.4 Frequency distribution of discriminant scores estimated for the small farm group

Code	Discriminant score range	Frequency	Frequency as percentages
1	-3.043 to -2.464	4	5
2	-2.464 to -1.885	10	12
3	-1.885 to -1.305	11	13
4	-1.305 to -0.726	19	23
5	-0.726 to -0.146	20	24
6	-0.146 to 0.433	10	12
7	0.433 to 1.012	5	6
8	1.012 to 1.592	3	4
		82	100

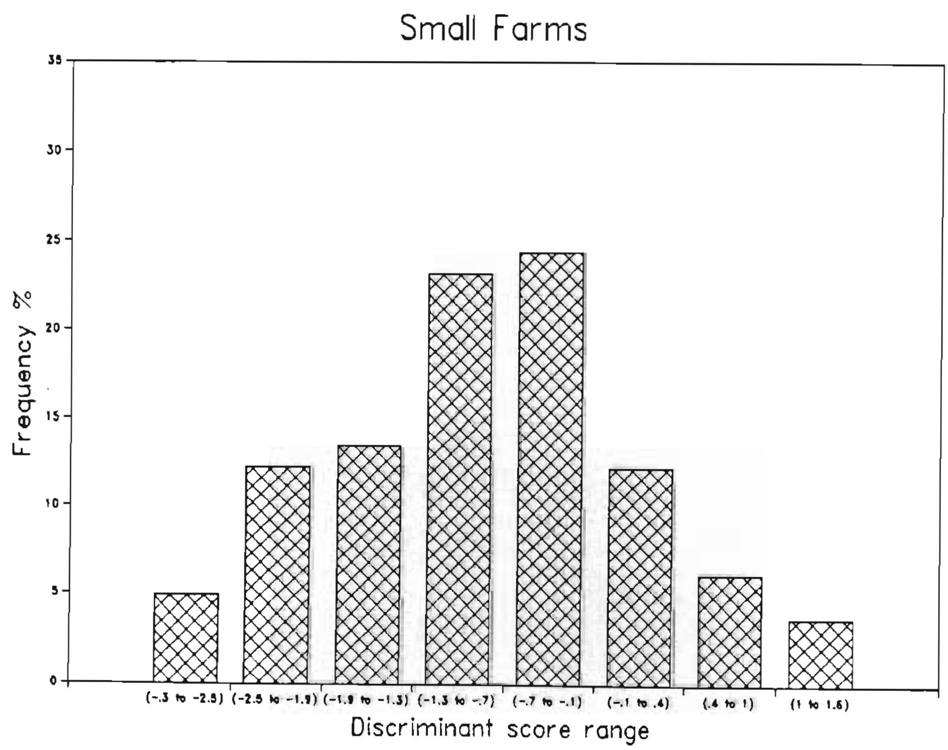

Figure 5.1 Histogram for discriminant scores of the small farm group

Table 5.5 Frequency distribution of discriminant scores estimated for the large farm group

Code	Discriminant score range	Frequency	Frequency as percentages
1	-0.090 to 0.526	4	5
2	0.526 to 1.142	5	12
3	1.142 to 1.759	11	13
4	1.759 to 2.375	8	23
5	2.375 to 2.992	6	24
6	2.992 to 3.608	4	12
		38	100

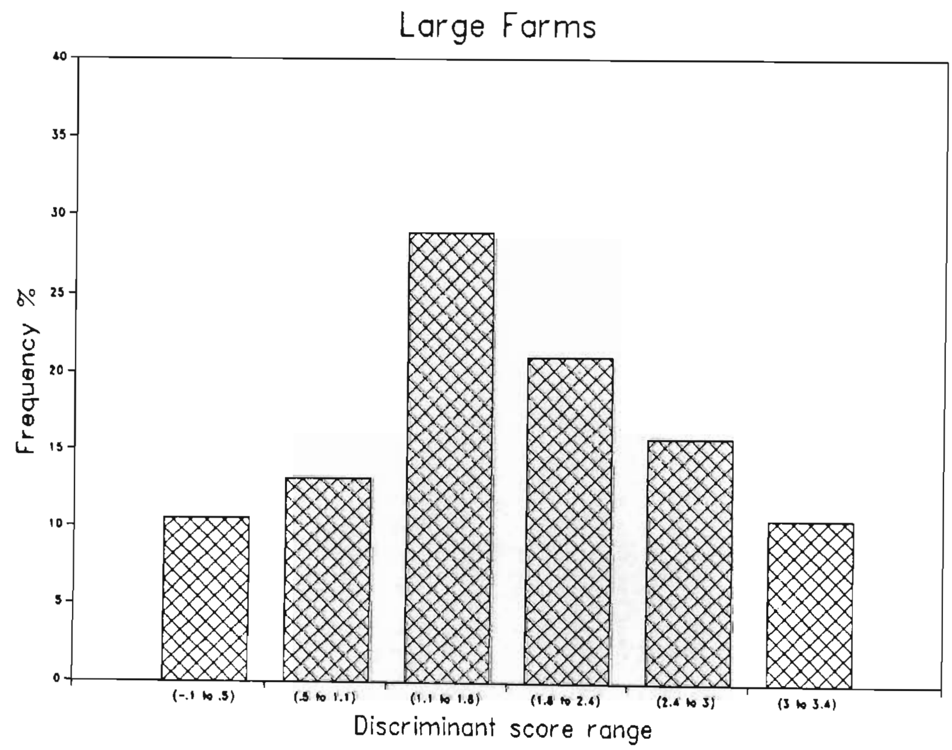

Figure 5.2 Histogram for discriminant scores of the large farm group

5.2 Factor relationships in sugar cane production

Interrelationships between social and economic farmer characteristics, and environmental factors on sugar cane farms of different sizes were analysed using principal component and factor analysis (Norusis, 1990b: 318-323). Principal component and factor analysis methods have been used in previous studies to analyse interrelationships between observable variables (Crabtree, 1971; Nieuwoudt, 1977; Horton, 1979; Prince *et al.*, 1991; Robertson and Nieuwoudt, 1992; Odulaja and Kiros, 1996). Its appropriate use involves the study of interrelationships among variables in an effort to find a new set of variables that are fewer in number than the original variables, yet still express what is common among the original variables (Foltz *et al.*, 1993).

From Table 5.1, it is evident that area under sugar cane (ASC), is positively correlated to farm operators' education (EDUC) and training (TRNG), farmers' rate of consultation with various sources of farm information (INFRM), and the average sugar cane farm yield (YIELD). Welch (1978), found farm size and educational levels of farm operators, systematically positively related. ASC is also negatively (and significantly) correlated with market related interest on borrowed capital. The frequency of contact with extension officers is negatively (VST) correlated with farm operators' education (EDUC). EDUC likewise, is positively related to the adoption of improved farm practices (ADOPT) that is, soil testing, and the use of certified seedcane. Agricultural Training (TRNG) of farm operators is positively correlated with both net farm income/profitability (NFI), and the rate of consultation with different sources of information (INFRM). TRNG is also positively correlated with adoption of improved farm practices.

Principal component analysis (PCA) was performed to examine interrelationships between variables. PCA generated five principle components (PC's) that accounted for the variability between farmers on the 16 variables used to reflect the production structure in the SA sugar cane industry. Kaiser's criterion was used whereby only PC's with eigenvalues greater than one (1.0) are retained (Stevens, 1986:341; Norusis, 1990b:319). The value of 1.0 represents the variance of the original variables (Johnston, 1980: 190). Hence, a PC with an eigenvalue of less than 1.0 accounts for less of the total variance than any of the original variables. The criterion was followed in this study because it is particularly accurate when the number of variables is small (Stevens, 1986: 341).

Five components accounting for 62% of the total variation were retained to best describe the structure of the SA cane industry from the 16 measured variables. Components were rotated using *varimax* rotation to more easily define groups of related dimensions (Rummel, 1970). Factor loadings, analogous to correlation coefficients, represent the degree and direction of the relationship between the original variables measured and the newly defined factors. Generally, variables with loadings greater than 0.5 were used to interpret the factor components. The objective is to attach an economic interpretation to the PC's (Stevens, 1986:339). If the PC's can be meaningfully interpreted, this leads to a greater understanding of the variation in the data (Crabtree, 1971). Table 5.6 shows extracted PCs.

Table 5.6 Factor pattern showing production relationships in studied sugar cane farms

VARIABLE	EIGENVECTOR FOR COMPONENTS				
	Z_1	Z_2	Z_3	Z_4	Z_5
Area under cane (ASC)	**0.772**	0.175	-0.102	0.111	0.090
Hire manager (MG)	**0.748**	-0.057	0.019	0.100	0.011
Interest rates (RATER)	**-0.677**	-0.375	0.292	0.029	-0.041
Education (EDUC)	**0.656**	0.215	-0.061	-0.256	0.068
Extension visits (VST)	**-0.621**	0.032	0.111	0.205	-0.130
Information (INFRM)	0.129	**0.769**	-0.042	0.045	0.034
Training (TRNG)	0.124	**0.764**	-0.145	0.068	-0.063
Training workshops attended (XTRNG)	-0.083	**0.610**	-0.089	-0.211	0.172
Adoption of farming practices (ADOPT)	0.388	**0.561**	-0.016	0.159	-0.160
Net farm income (NFI)	0.040	0.106	**-0.868**	0.077	0.295
Labour costs/ha (LABOR)	-0.088	-0.086	**0.864**	0.030	0.050
Input costs/ha (INPTC)	-0.206	0.100	**0.517**	-0.096	0.223
Farming experience (EXPNC)	-0.007	0.005	-0.054	**0.916**	0.018
Age of farm operator (AGE)	-0.109	0.022	-0.063	**0.888**	0.032
Average yield (YIELD)	0.160	0.090	0.101	-0.112	**0.753**
Agricultural potential (NAP)	0.060	-0.046	-0.091	0.050	**0.744**
Latent root	3.74	1.99	1.52	1.48	1.23

From Table 5.6, the first component Z_1 appears to be a contrast between area under sugar cane in hectares (ASC) and use of hired management (MG), market related interest rates on borrowed capital (RATER), and formal education of the farm operator (EDUC). That is, Z_1 will be high if ASC, MG, and EDUC are high but RATER and VST are low. Likewise Z_1 will be low if ASC, MG, EDUC, and ADOPT are low but RATER and VST are high. Therefore Z_1 can be interpreted as a measure of *scale*. The second component Z_2, measures the extent to which farmers search for farm information (INFRM), have practical agricultural training (TRNG) and attend training workshops (XTRNG) specifically in sugar cane growing, and adopt improved farm practices. Z_2 can be interpreted as an *index of progressive management*, The third component Z_3 can be regarded as a *financial index* and measures labour and input costs per hectare contrasted to net farm income (i.e., farmers with large positive values of Z_3 face high labour and input costs relative to their income). Z_4 captures the interrelationships between farming experience another form of training (Stefanou and Saxena, 1988) and age of farm operator. Component Z_5, measures the extent to which the natural agricultural potential of a region is related to average sugar cane yield.

5.3 Managerial proficiency and farm performance

5.3.1 Cross-tabulation analysis between soil testing and use of certified seedcane

A measure of association between soil analysis and use of certified seedcane was performed in a cross-tabulation analysis. The tested hypothesis postulates that a farmer who adopts soil analysis is most likely to make use of certified seedcane on his farm (thus assuming a relationship between the two farm practices). A test of *independence* between the two farm practices was performed with an objective of assessing if the two farm practices could be combined into a single variable as a measure of farmer managerial proficiency.

In cross-tabulations, two variables are by definition independent if the probability that a case falls into a given cell is simply a product of the marginal probabilities of the two categories defining the cell. To construct the statistical test of the independence hypothesis, the probability (P) of an observation falling into cell (ij) is estimated (Norusis, 1990b: 129) by:

$$P(row = i \ and \ column = j) = \left\{\frac{count\,in \ row\,i}{N}\right\}\left\{\frac{count\,in \ column\,j}{N}\right\} \qquad (5.2)$$

To obtain the expected number of observations (E_{ij}) in cell (ij), the probability is multiplied by the total sample size (N), that is;

$$E_{ij} = \frac{(count\ in\ row\ i)(count\ in\ column\ j)}{N}$$

A statistic often used to test the hypothesis that the row and column variables are independent is the *Pearson chi-square* (Norusis, 1990b: 130), calculated by summing over all cells the squared residuals divided by the expected frequencies

$$X^2 = \sum_i \sum_j \frac{(O_{ij}-E_{ij})^2}{E_{ij}} \tag{5.3}$$

Where; O_{ij} are the observed frequencies and E_{ij} expected frequencies. The *chi-square* statistic itself is not a good measure of the degree of association between two variables because it is sensitive to sample size, degrees of freedom, and scale measurements of variables studied (Norusis, 1990b: 132). But its wide spread use in tests of independence has encouraged the use of modified measures of association like the *phi-coefficient* which modifies the *Pearson chi-square* by dividing it by the sample size and taking the square root of the result.

The rate of testing soils on a sugar cane farm was measured on a scale ranging from zero to two, categorizing farmers who never have farm soils tested, test soils only when planting a new crop, and ones who conduct soil tests seasonally, respectively. Adoption of certified *seedcane* was classified as dichotomous, equal to one if certified seedcane is used, and zero otherwise. Results of the cross-tabulation are as given in Table 5.7.

Table 5.7 Cross-tabulations of soil testing by use of certified seedcane

	Use of certified seedcane		
Soil analysis	0	1	Row Total
0	26 16.8%	7 4.5%	33 21.3%
1	39 25.2%	20 12.9%	59 38.1%
2	25 16.1%	38 24.5%	63 40.6%
Column Total	90 58.1%	65 41.9%	155 100%

Chi-Square:	Value
Pearson	16.1*
Statistic:	
Phi	0.3226*

**significant at 1% level*

From Table 5.7, a *Phi-coefficient* of 0.3226 and *Pearson chi-square* value of 16.1 (both statistically significant at an observed significance level of less than 1%), indicated that the *chi-square* test showed a strong association between the two practices, therefore the hypothesis that the use of certified seedcane and adoption of soil testing on a sugar cane farm are independent was rejected, implying that a farmer who tests soils on his farm is most likely to use certified seedcane.

The cross-tabulations (Table 5.7) yielded ***six*** group combinations on the two farm practices analysed (soil testing and use of certified seedcane). Of the 155 valid cases analysed; (i) twenty six (16.8%) neither had soils tested nor used certified seedcane, (ii) seven (4.5%) reported as users of certified seedcane but never adopted soil analysis, (iii) thirty nine

(25.2%) had farm soils tested only when planting a new crop, and never used certified seedcane, (iv) twenty (12.9%) reported as users of certified seedcane and analysed farm soils only when planting a new crop, (v) twenty five (16.1%) reported as none users of certified seedcane but had soils tested seasonally on their farms, and lastly (vi) thirty eight (24.5%) reported as using certified seedcane and tested farm soils on a seasonal basis. The six groups were re-classified into three groups, that is of; (1) *non-adopters*, group one respondents, classifiable as a group reflecting low managerial aptitude, (2) *partial adopters* (in group two, three, four and five), classified as a group of average managerial ability (3) *full-adopters* (in group six) of high managerial ability. The characteristics of the three farm groups with different magnitudes of adopting improved and appropriate farm practices were then analysed using the SPSS test of means procedure (Norusis, 1990a: 457). Averages of some of the social and economic farmer characteristics studied within the three defined groups were calculated. The results are presented in Table 5.8.

From Table 5.8, significant increases are observable in the mean area under sugar cane (farm size), education and agricultural training of farm operators, and use of farm information between groups of *non-adopters*, *partial adopters* and *full-adopters*, respectively. Table 5.8 reveals a reduction in contact with field extension staff, as managerial proficiency increases among sugar cane farmers. However no significant differences were recorded between groups of *non-adopters*, *partial adopters* and *full-adopters* on age and farming experience, and number of training workshops attended by a farm operator on average in two seasons. As regards farm performance indicators (i.e., labour costs, input cost, and net farm income per hectare), no significant differences between group means appear on input cost and net farm income per hectare between *non-adopters*, *partial-adopters* and *full-adopters*.

Table 5.8 Social and economic characteristics of sugar cane farmers broken down by magnitude of managerial proficiency

Variable	Managerial proficiency potential			
	non-adopters Low potential	*partial-adopters* Average potential	*full-adopters* High potential	F-Value
Area under sugarcane (ha) (ASC)	13.40 (25)	39.56 (90)	242.11 (37)	30.51***
Age of farm operator (AGE)	50.19 (26)	48.79 (85)	51.32 (37)	0.66
Farming experience (EXPNC)	21.04 (37)	21.93 (91)	26.43 (26)	1.90
Education (EDUC)	2.31 (26)	2.70 (91)	3.42 (38)	9.64***
Agricultural training (TRNG)	0.31 (26)	0.61 (91)	0.89 (38)	13.3***
Training workshops (XTRNG)	0.62 (26)	2.11 (90)	2.42 (38)	1.44
Extension visits (VST)	2.23 (26)	2.06 (89)	1.45 (38)	3.00*
Farm information (INFRM)	1.22 (25)	1.77 (90)	1.97 (38)	13.00***
Labour costs/ha (LABOR)	2066.82 (25)	1732.42 (81)	1262.67 (32)	2.04*
Input costs/ha (INPTC)	1075.94 (25)	891.57 (87)	733.52 (34)	1.88
Net farm income/ha (NFI)	395.56 (25)	771.21 (81)	1359.66 (31)	1.26
Average yield (tons/ha) (YIELD)	49.01 (25)	50.31 (82)	53.45 (35)	.51

*Significant at ***1%, **5% and *10%. Figures in parenthesis represent valid cases.*

However the difference in means between the three groups reveals that as managerial potential increases, labour costs per hectare decreases that is, from R 2066, R 1732 to R 1262, respectively. Likewise, although the mean group differences on input costs per hectare are statistically non-significant that is, R 1076, R 892 and R 733, respectively between the three groups, input costs per hectare decrease as managerial proficiency increases. The between group means on net farm income per hectare as an indicator of farm performance were not statistically significant, it is however evident that as managerial proficiency improves, net farm incomes increase (i.e., from R 396, R 771 to R 1360) between groups respectively. Average yield per hectare is relatively high in the group of adopters compared to the other two groups. This tends to support the conclusion of Sumner and Leiby (1987), that high adoption rates of management practices by farm operators may reflect an individuals' ability to implement good management techniques.

5.4 Factors affecting the adoption of improved farm practices

Factors that influence the different rates of adoption of recommended farm practices that is, soil analysis and use of certified seedcane as illustrated in section 5.3 are examined. Focus is placed on soil analysis and use of certified seedcane because varying degrees of adoption of the two seasonal farm practices on a sugar cane farm reflects different management abilities amongst farmers (section 2.1). Identifying factors that influence adoption of appropriate cultural practices by sugar cane farmers may also help to explain productivity differences between small and large sugar cane farms, given that the potential for increasing farm output through appropriate farming practices, indirectly relates to farmers' managerial qualities (Kalirajan and Shand, 1988). The underlying hypothesis postulates managerial behaviour as a function of abilities, skills and capacities of the farmer, socio-economic situation, and the natural conditions in which a farmer operates. Linear discriminant analysis (LDA) is employed to test the hypothesis.

5.4.1 Linear discriminant analysis (LDA)

Discriminant analysis was used to identify factors that influence the different degrees of adoption of appropriate farming practices among sugar cane farmers. The dependent variable was derived from combining the response scores on the rate of soil analysis and use of certified seedcane by each farmer in a cross-tabulation analysis explained in section 5.3. The LDA model was formulated on the basis of a dependent variable classified into three groups (*non-adopters*, *partial adopters* and *full-adopters*). Variables used to distinguish between *non-adopters*, *partial-adopters* and *full adopters* of appropriate farm practices on a sugar cane farm are given in Table 5.9.

Table 5.9 Potential discriminating variables.

Farm size (FMSZE):	Larger farmers probably have greater incentives to adopt new technology (Huffman, 1974).
Education (EDUC):	Education is an important determinant of production efficiency and technology diffusion (Jamison and Lau, 1982; Feder, *et al*, 1985; Strauss, *et al*, 1991).
Experience (EXPNC):	Management experience, is a form of training (Stefanou and Saxena, 1988), and influences production decision making. It plays an important role in influencing the ability to acquire and sort technical information in an efficient manner (technical efficiency).
Training (TRNG):	A farmer with training in agriculture is better equipped to understand the benefits of adopting appropriate farm practices.
Extension (VST):	Extension visits and participation in workshops are positively related to adoption by exposing farmers to 'new information' (Feder and Slade, 1984a; Adesina and Baidu-Forson, 1995).
Wealth (WLTH):	Wealthier farmers are more likely to adopt appropriate cultural practices (Strauss *et al*, 1991)
Agro-climatic potential (NAP):	A more favourable environment increases the expected utility of net income, hence increasing the probability of a farm adopting modern production methods (Hiebert, 1974).

Factors associated with adoption of appropriate farm practices are estimated by the LDA model specified as:

$$Z_i = a_1 FMSZE + a_2 EDUC + a_3 EXPNC + a_4 TRNG + a_5 VST + a_6 WLTH + a_7 NAP \qquad \textbf{(5.4)}$$

Where; Z_i is the discriminant score for each group category of *non-adopters* and *partial-adopters* and *full adopters*, and a_1 ,..., a_n are the weighting (standardized discriminant function) coefficients.

5.4.2 Results of the farm practices LDA adoption model

Factors that could influence the different degrees of adoption and non-adoption of improved farm practices on a sugar cane farm were included in the discriminant function as independent variables. A problem of intercorrelation between variables measuring the likely sources of farm information in the sugar industry was detected in the data (Table 5.10). Principal component analysis PCA (Norusis, 1990b) was therefore used to condense variables into fewer orthogonal variables,. and also to examine interrelationships between variables. The extracted components (Table 5.11), portray differences between information sources within the sugar industry that reflect extra initiatives to improve farm productivity, and passive information sources accessible by way of interaction with field extension personnel during routine farm visits. Variables with factor loadings greater than 0.4 are used to interpret the PCs. PC_1 captures information accessible to farmers from extension support institutions, loading heavily on farm magazines (MGZ), regional SACGA economists (ECAD), and the experiment station (SASEX). The second component (PC_2), with heavy loadings for training (TRNG), number of times the farmer participated in agricultural training workshops (XTRNG), and field-day demonstration (DEMON), separates information acquired by training from other sources. PC_3 has high loadings on the following variables; rating of usefulness of information disseminated by field extension officers (EXOF) in helping a farmer to improve farm productivity, extension visits (VST), and education (EDUC). PC_4 is strongly associated with farming experience.

Table 5.10 Correlations matrix of sources of farm information in the SA sugar industry

		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
Farm magazine	X_1	1.000										
SACGA regional economists	X_2	0.404**	1.000									
Experiment station	X_3	0.209**	0.333**	1.000								
Training workshops	X_4	0.018	0.254**	0.133	1.000							
Training	X_5	0.184*	0.369**	0.248**	0.335**	1.000						
Field demonstrations	X_6	0.357**	0.449**	0.262**	0.264**	0.597**	1.000					
Other farmers	X_7	0.160*	0.041	0.080	0.144	0.163*	0.313**	1.000				
Visits by extension officer	X_8	-0.166*	-0.262**	0.080	-0.056	-0.129	-0.240**	0.068	1.000			
Field extension officer	X_9	0.075	0.161*	0.206*	0.075	-0.043	0.026	0.068	0.350**	1.000		
Education of farm operator	X_{10}	-0.186*	0.282**	0.143	0.145	0.160*	0.365**	0.118	-0.436**	-0.177*	1.000	
Farming experience	X_{11}	-0.058	0.106	0.078	-0.122	0.054	-0.043	-0.027	0.135	-0.040	-0.138	1.000

**Significant at 1% and * Significant at 5%, (2-tailed)

Table 5.11 Interrelationships between sources of farm information

VARIABLE	EIGENVECTOR FOR COMPONENTS			
	PC_1	PC_2	PC_3	PC_4
Farm magazines	0.755			
Regional SACGA Economists	0.700			
Experiment Station	0.615			
Training workshops		0.759		
Training		0.719		
Field Demonstrations		0.618		
Other farmers		0.481		
Farm visits by field extension officers			0.833	
Field extension officer			0.701	
Education of farm operator			-0.622	
Farming experience				0.897
Eigenvalue	2.93	1.65	1.14	1.07
Percentage variability	26.7	15.0	10.3	9.7

Components PC_1, PC_2, PC_3, PC_4, in addition to variables NAP (measuring the agro-climatic potential of regions), WLTH (measuring the total value of farm and non-farm assets), and gross farm income from cane GFI (a measure of farm size), were included in the estimated discriminant model. Initially the discriminant analysis was based on the three groups of classified adopters (i.e., non-adopters, partial adopters, and full adopters). The separation between the three groups was poor, better results could be obtained if only the two extreme groups of *non-adopters* and *full-adopters* are used. The variable classifying groups of adopters and non-adopters was captured as dichotomous, equal to one if a respondent is categorised as an adopter, and zero for non-adopters. The discriminant function was therefore estimated based on 64 respondents from the two extreme groups. The estimated LDA model results are presented in Table 5.12.

Table 5.12 Estimated discriminant functions for non-adopters and full adopters of improved farm practices on sugar cane farms

Explanatory variable	Standardised coefficient	t-value	Group means *non-adopters*	Group means *full-adopters*	F value
PC_1	0.765	4.67**	-0.808	0.316	21.80**
PC_4	0.555	2.40*	-0.285	0.331	5.77*
PC_2	0.543	3.69**	-0.473	0.322	13.65**
PC_3	-0.540	3.02**	0.382	-0.380	9.14**
GFI	0.163	3.51**	21594	687929	12.13**
WLTH	0.161	3.56**	209141	2656107	12.69**
Number of valid cases			24	29	
F value		50.1**			
Wilk's lambda		0.35			
Canonical correlation		0.80			
Classifications:					
	non-adopters	87.5%			
	full-adopters	93.1%			
	Total	90.6%			

significant at **1% and *5% level

The LDA model correctly identifies 87% of *non-adopters* and 93% of *full-adopters*. A high 90.6% overall classification accuracy, and a low Wilk's lambda of 0.35 indicate a good discriminant function. All signs agree with *a priori* reasoning. Variable NAP was not statistically significant and excluded from the final model. Frequency distributions of estimated discriminant scores (Figure 5.3 and 5.4), show that both groups (non-adopters and adopters) display approximately normal distributions suggesting that the significance tests can be accepted with reasonable confidence. The estimated LDA model could perhaps be further improved by incorporating more information into the model, for example farmers' subjective perceptions and assessments (Nowak, 1992; Adesina and Baidu-Forson, 1995), on soil analysis and the use of certified seed, and structural constraints experienced by farmers in securing certified seedcane, and having farm soils tested.

Table 5.13 Frequency distribution of estimated discriminant scores for non-adopters

Code	Discriminant score range	Frequency	Frequency as Percentages
1	(-2.970 to -2.225)	5	21
2	(-2.225 to -1.480)	9	38
3	(-1.480 to -0.735)	2	8
4	(-0.735 to 0.010)	6	25
5	(0.010 to 0.755)	2	8
		24	100

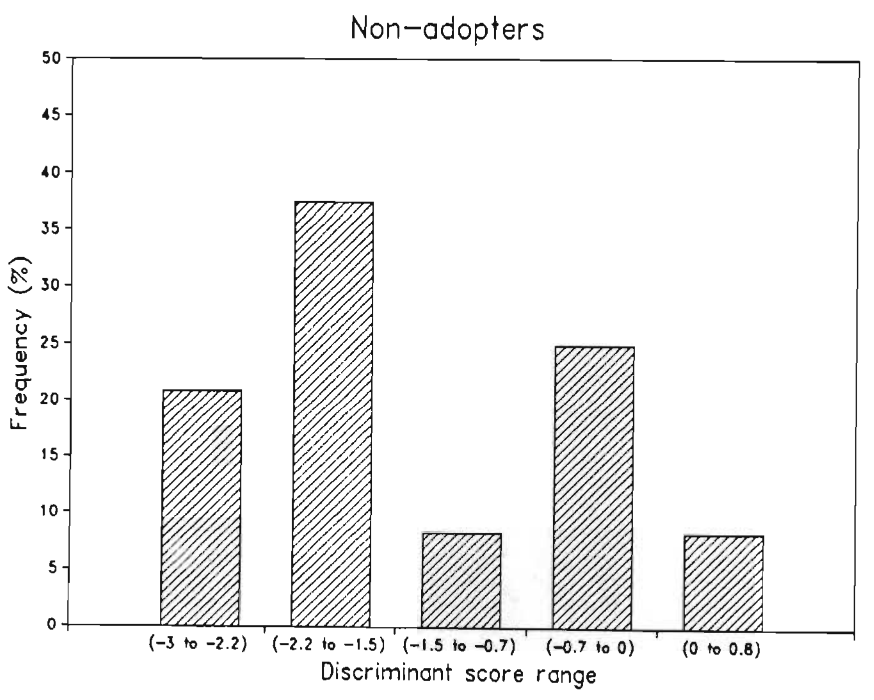

Figure 5.3 Histogram for discriminant scores for non-adopters

Table 5.14 Frequency distribution of estimated discriminant scores for adopters

Code	Discriminant score range	Frequency	Frequency as Percentages
1	(-1.352 to -0.566)	1	3
2	(-0.566 to 0.219)	4	14
3	(0.219 to 1.0005)	6	21
4	(1.005 to 1.790)	13	45
5	(1.790 to 2.575)	3	10
6	(2.575 to 3.164)	2	7
		29	100

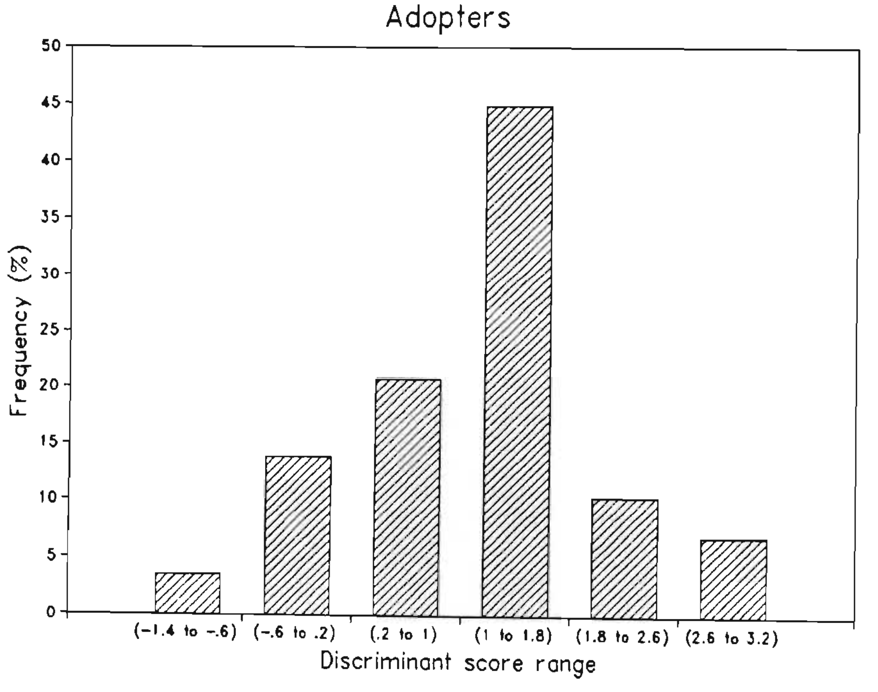

Figure 5.4 Histogram for discriminant scores for adopters

Based on the standardised coefficients, PC_1 capturing information (accessible to farmers by liaising with extension and research institutions) is the major factor associated with adoption of soil testing and use of certified seedcane on sugar cane farms. This is likely because the SA sugar experiment station serves the entire sugar industry in provision of improved sugar cane varieties, control of pests and diseases, effective extension services and cultivation practices (Chadwick and Sokhela, 1992). Likewise Cane Growers' Association regional economists play a crucial role in providing extension support and advice to sugar cane farmers. PC_4 (strongly associated with farming experience) is the second most important discriminating factor, this tends to support Stefanou and Saxena (1988) contention that experience plays an important role in influencing the ability to acquire and sort technical information.

PC_2 (strongly associated with agricultural training), shows that agricultural training of farm operators is important in the adoption of farm practices. The negative sign on PC_3 implies that better educated farmers who rely less on support from field extension staff are more likely to adopt soil analysis and use of certified seedcane on sugar cane farms. The positive sign on GFI (gross farm income) suggests that sugar cane farms with a high gross turnover (large farms) have a high probability of adopting improved farm practices. Likewise, wealthier farmers are more likely to adopt improved farm practices, as reflected by the positive sign on the WLTH variable coefficient.

5.5 Sources of economies of size

Data used in the non-parametric efficiency analysis of sugar cane farms include: sugar cane output and inputs such as: (a) hired and family labour; (b) management; (c) fertilizers; (d) herbicides, seeds, and other chemicals; (e) operating and machinery maintenance costs; (f) miscellaneous (rent, supplies and utilities); (g) cost of borrowed capital; (h) information cost (i) machinery (intermediate-run assets); and (j) land and buildings (long-run assets). The measurement of the effect of size on overall economic efficiency requires valuing all inputs so that the relative proximity of each farm to the cost frontier can be determined (Hall and LeVeen, 1978). All inputs are therefore valued at their opportunity cost. This included the imputed value of family and farm operator labour (management)[12], and the opportunity cost for land and capital. Quantity measurements are annual flow variables. A 6% interest rate (real rate) was used to transform machinery and tools[13] (intermediate-run capital inputs) to service flows. After adjusting farm size for differences in land quality within regions by using land values to normalize area, a 5% interest rate (real rate) on the value of land was used as a measure of the flow resource of land. The rental rate of return for land in SA agriculture is about five percent (Nieuwoudt, 1987).

Tests of the difference in means on major factor costs, which could be sources of economies of size in sugar cane farming are presented in Table 5.15 The data indicate significant differences in per ton average cost of labour, operator labour services, information, interest on borrowed capital, input costs (fertilizer and herbicides), and investment in machinery, on

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[12]The opportunity cost of management time was measured as wage income in alternative employment (refer to questionnaire in Appendix A, section 4e).

[13] Machinery and tools were valued at market prices to account for cost of depreciation.

small and large farm units studied, with small farms recording higher costs than large farms.

Table 5.15 Mean differences in economic characteristics of sugar cane farms in KwaZulu-Natal, 1993/94 season

		Small	Large	t-value
Area under cane (ha)				
	Mean	8.3	197	6.81***
	SD	5.75	218	
	n	(95)	(62)	
Labour costs/ton (Rand)				
	Mean	78.7	33.3	3.37***
	SD	121.6	21.6	
	n	(87)	(51)	
Management costs/ton (Rand)				
	Mean	250	22.8	6.10***
	SD	359.6	24.2	
	n	(93)	(59)	
Information costs/ton (Rand)				
	Mean	2.20	1.07	2.29**
	SD	4.10	1.42	
	n	(85)	(32)	
Interest on borrowed capital (%)				
	Mean	23	15	13.22***
	SD	3	3	
	n	(85)	(32)	
Fertilizer & herbicide costs/ton (Rand)				
	Mean	32.9	20.6	2.61***
	SD	38.6	16.9	
	n	(93)	(56)	
Machinery Investment/ton (Rand)				
	Mean	166.9	41.4	2.65***
	SD	350	49.4	
	n	(56)	(43)	

Significant at; *** *1 percent,* ** *5 percent, and* * *10 percent level.* Figures in parentheses represent valid sample cases. All inputs presented in this table are valued at their opportunity cost.

The combined expenditure reported for fertilizers and herbicides shows that large farms have a significantly lower average costs for these items. This supports the contention by Hall and LeVeen (1978) that the combined factors of pecuniary economies of size may account for at least as much of the cost advantages of large units as do technical economies of size. However, it cannot be determined from the data collected if cost savings derive from lower input prices or from more efficient use of the inputs. Per ton investment in machinery is about 303% greater on small farms than on large farms, while per ton investment of labour is 136% higher on small farms.

5.6 Long-run technical, allocative and scale efficiency indices

As illustrated in chapter 3, for each farm, the optimal objective function for 3.11, 3.12, and 3.14 was calculated from the linear programming problems using the GAMS computer program. The long-run (LR) estimate of the Farrell technical efficiency index **TE** is given by 3.11, where all inputs are rescaled toward the frontier isoquant[14]. The LR estimate of the Farrell allocative efficiency (**AE**) index is given by 3.5 and 3.12. Treating all inputs as variable, the scale efficiency (**SE**) indexes are obtained from 3.9b. The indexes; TE, AE and SE estimated for each farm range between zero and one, with 100% efficiency indicated by a score of one. A summary of the results is presented in Table 5.16.

The 0.71 mean technical efficiency **TE** within the small-scale farm group, and 0.81 for the large farms (Table 5.16 and Figure 5.5) shows that, the average technical efficiency score of the small farms is lower than the average score of large farms. This is also reflected by the difference in percentages of technically efficient farms (with **TE**=1) between the small and large farms. The mean allocative efficiency of 0.52 and 0.60 for small and large farms respectively (Table 5.16 and Figure 5.6), suggests that price or allocative inefficiency contributes more in causing farms to fall short of achieving the LR economic efficiency (**TE AE**) than technical inefficiency. The low percentage of price efficient farms (with **AE**=1) namely 2.4% among the small farms and the 9.4% for large farms, indicates that improving allocative efficiency can reduce production costs on both large and small farms.

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[14]A single production frontier was assumed for both small and large farms in the analysis based on the fact that technology employed in sugar cane production in the two farm groups studied does not differ much, that is, both small and large farms are mechanised in most farm operations, sugar cane is produced in rainfed conditions, and both farm groups use almost similar levels of fertilizers (refer to Table 4.2).

Table 5.16 Long-run efficiency indexes of small and large scale sugar cane farm studied

INDEX		SMALL-SCALE (n=85)	LARGE-SCALE (n=32)	t-value
Technical Efficiency (TE)				
	Mean	0.71	0.81	1.95*
	SD	0.28	0.24	
	% 1's	35.3	46.9	
Allocative Efficiency (AE)				
	Mean	0.52	0.60	1.79*
	SD	0.18	0.20	
	% 1's	2.4	9.4	
Economic Efficiency (TE AE)				
	Mean	0.37	0.49	2.69**
	SD	0.21	0.24	
	% 1's	1.2	9.4	
Scale Efficiency (SE)				
	Mean	0.46	0.88	11.80***
	SD	0.25	0.13	
	% 1's	0	3.1	

*significant at; ***1 percent, **5 percent, and *10 percent level.*

The mean scale efficiency SE index of 0.46 and 0.88 for the small and large farms respectively, suggests that while there are inefficiencies (technical and allocative) for small scale farms, they are not as wide as inefficiencies which are related to size (Table 5.16 and Figure 5.7). The inverse of scale efficiency index (**1/SE**) is plotted against output and farm size (Figures 5.8 and 5.9). Following the discussion in section 3.1.3, this inverse measure can be interpreted in a similar way to an average cost function (Chavas and Aliber, 1993). **1/SE** is a declining function of output/farm size under increasing returns to scale, and an increasing function of farm size under decreasing returns to scale.

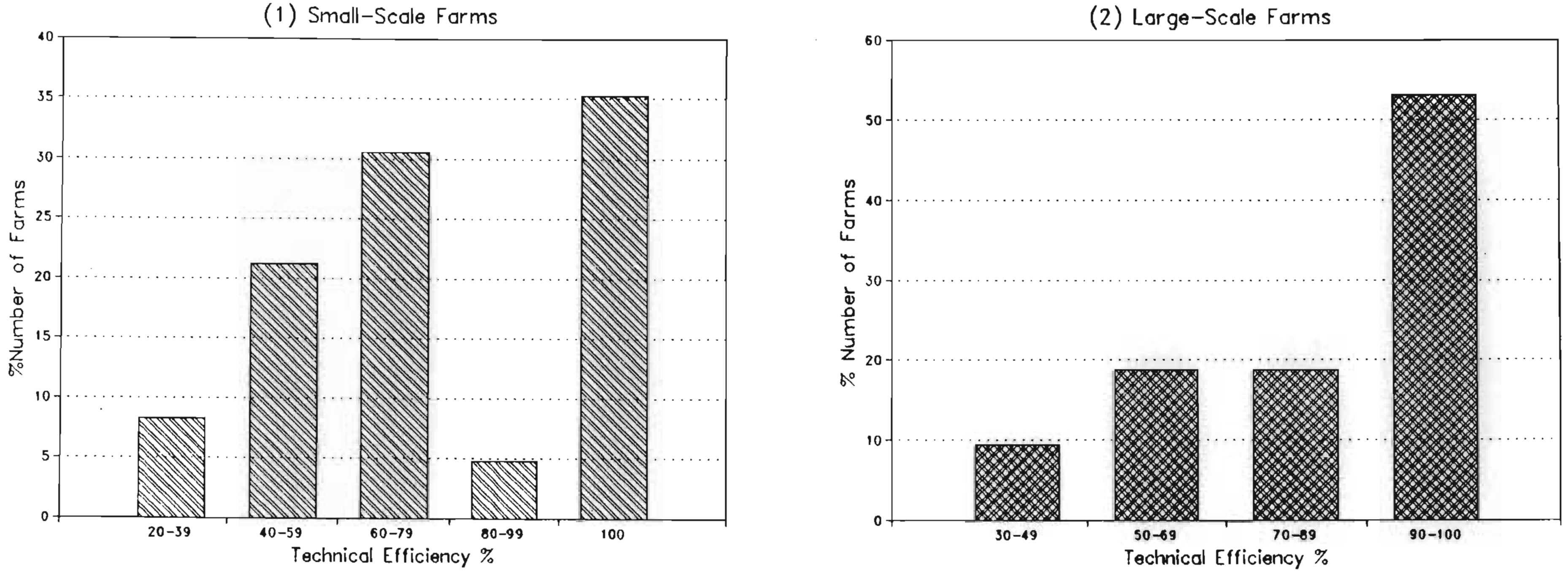

Figure 5.5 Distribution of technical efficiency among small and large sugar cane farms studied

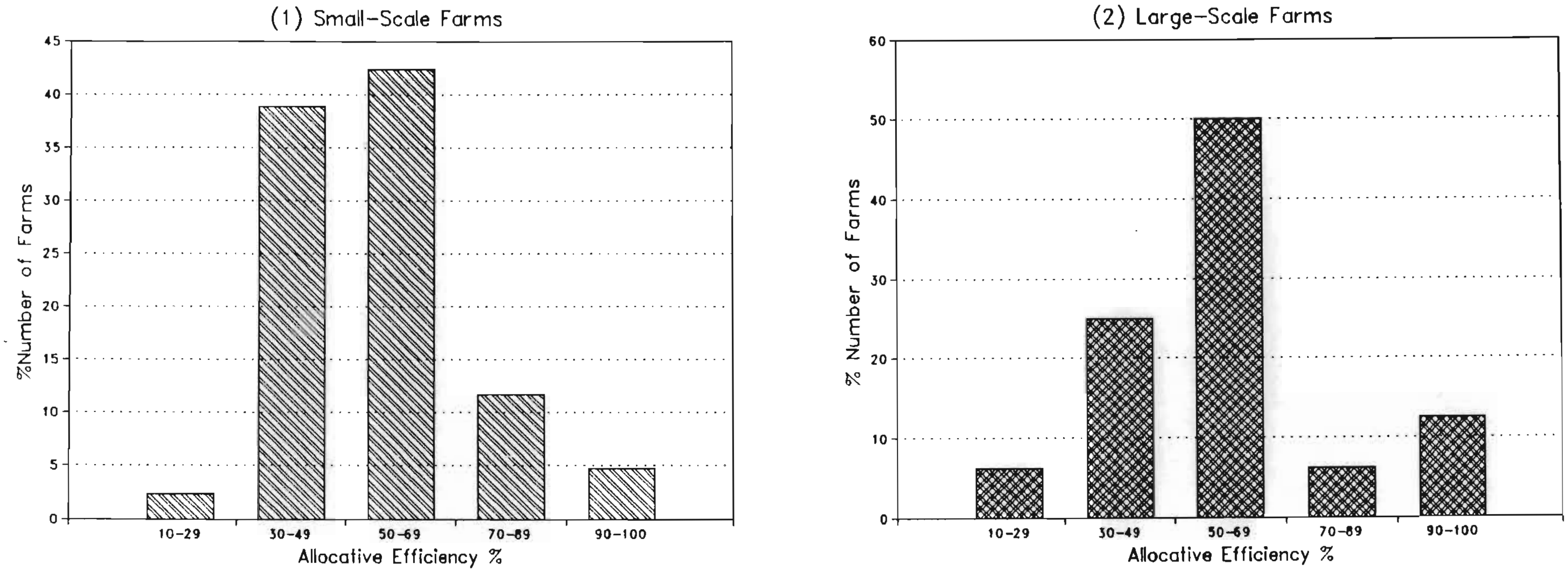

Figure 5.6 Distribution of allocative efficiency among small and large sugar cane farms studied

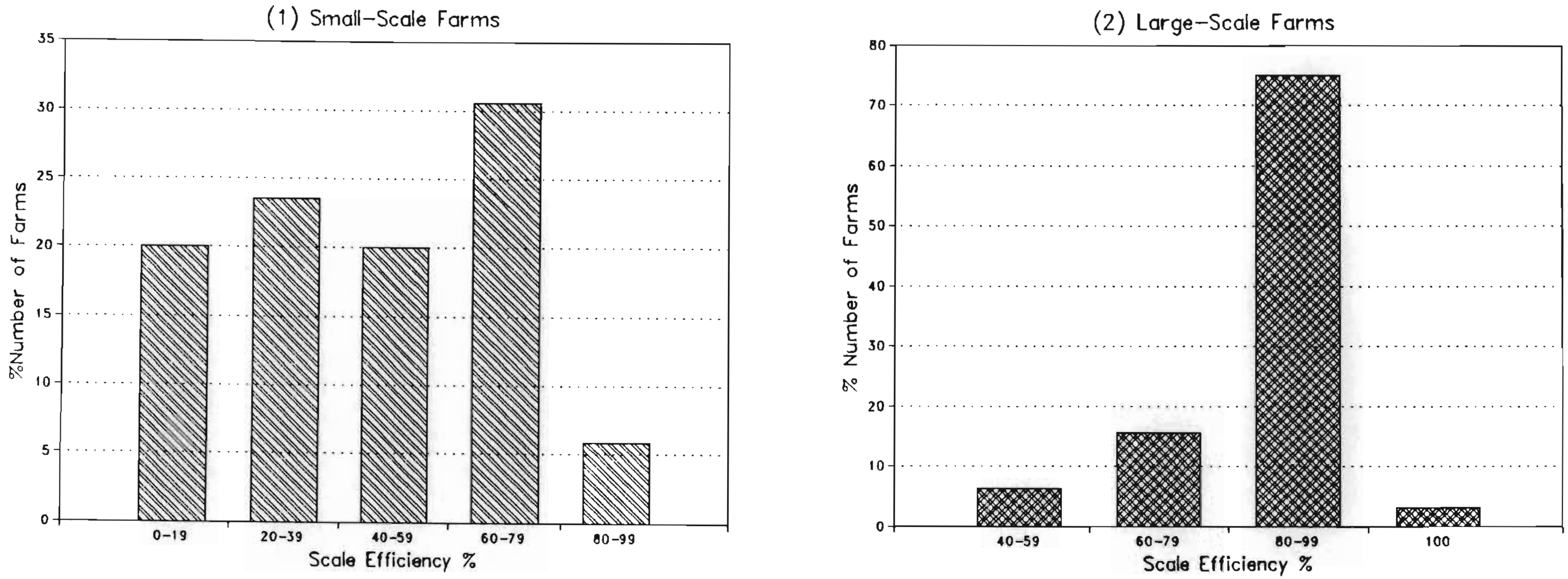

Figure 5.7 Distribution of scale efficiency among small and large sugar cane farms studied

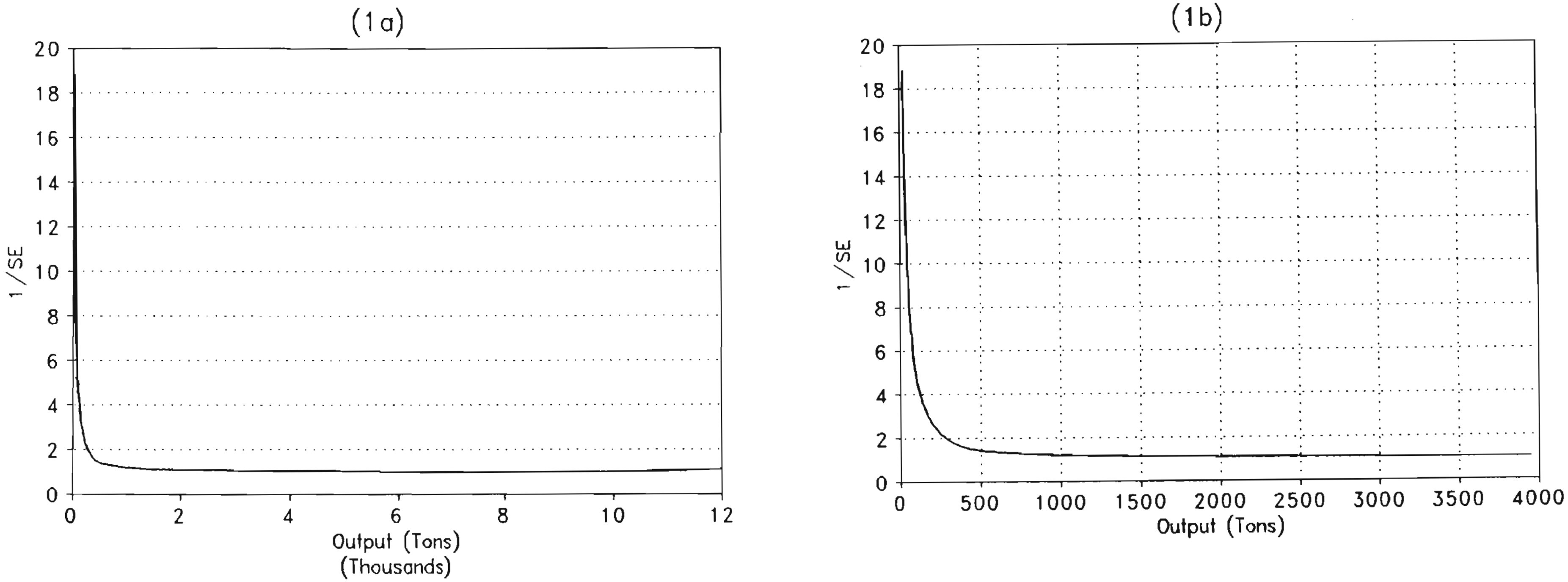

Figure 5.8 Economies of size in sugar cane production

Note: In Figure 5.8, graph (1b) provides more detail of graph (1a) for a smaller output.

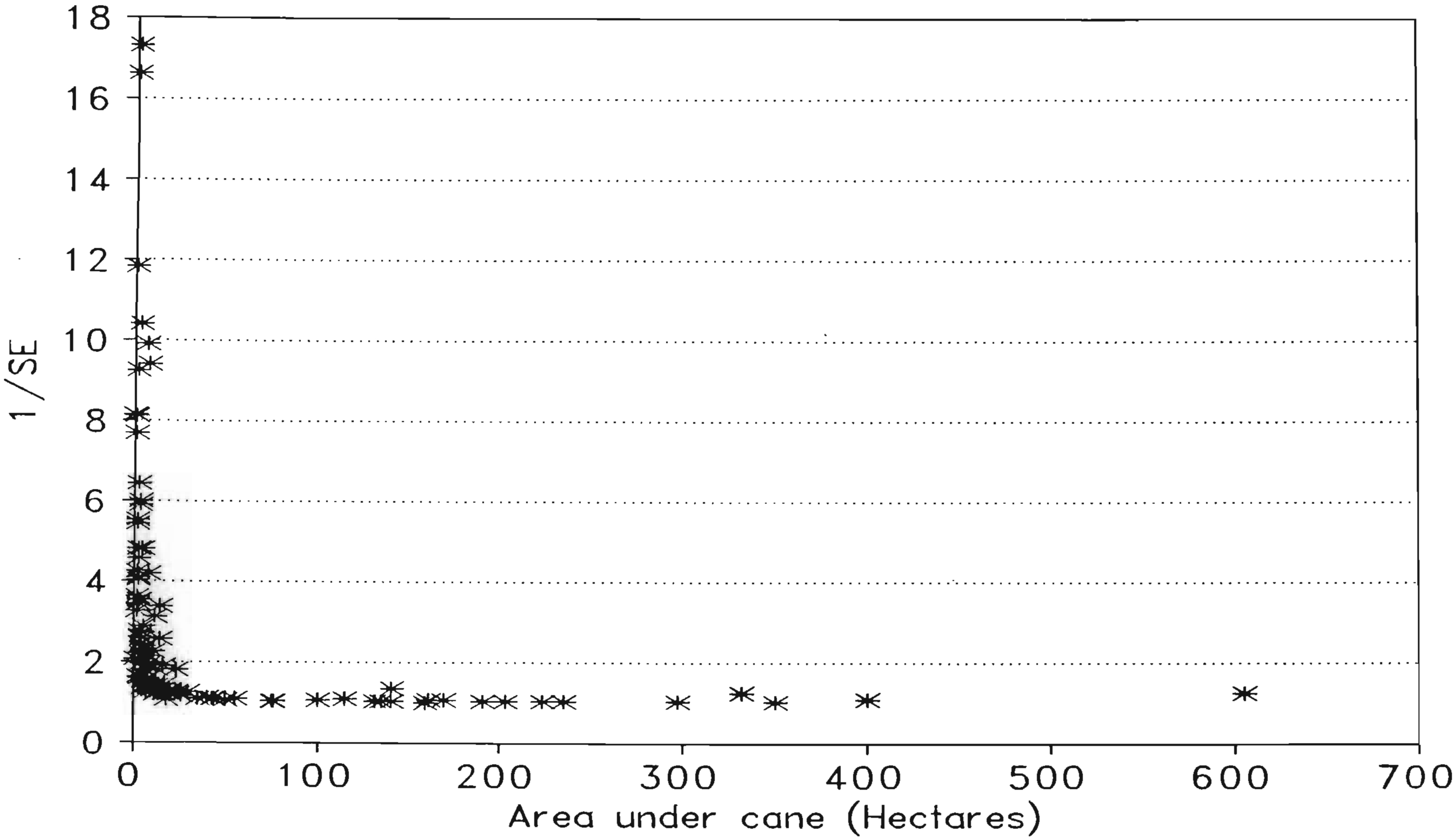

Figure 5.9 Economies of size in sugar cane production

Figures 5.8 and 5.9 show that the cost structure of sugar cane farms studied is "L"- shaped, indicating substantial economies of scale on very small farms producing less than 500 tons of cane (Figure 5.8). At an observed yield of 50 tons per hectare recorded between small and large farms studied (Table 4.2), 500 tons are equal to ten hectares. If yields per hectare are different, then acreage must be adjusted accordingly.

According to Figure 5.8, cost per ton falls sharply with increased output between 0 and approximately 500 tons. Costs per ton keep falling with increased output to about 2500 tons (50 hectare of land under sugar cane) after which costs per ton level of for farms producing an output larger than 2500 tons (50 hectares).

5.7 Further interpretations of sugar cane farm efficiency analysis

Non-physical inputs, for example; farming experience, information, and supervision tend to influence the ability of a producer to use the available technology efficiently (Parikh *et al.*, 1995). In this study, variation in scale efficiency recorded among farms prompted a further investigation of factors associated with differences in efficiency levels. Available data provided an opportunity to examine possible linkages between farm characteristics and farm efficiency by estimating an econometric model whereby scale efficiency indexes were regressed on a set of explanatory variables. With the largest possible value of SE indexes being 1, this generates the following Tobit model (McDonald and Moffitt, 1980; Chavas and Aliber, 1993; Gujarati, 1995: 572).

$$SE_i = X_i\mathrm{B} + e_i \qquad if\ X_i\mathrm{B} + e_i < 1 \qquad (5.5)$$
$$= 1 \qquad otherwise$$

where SE_i is the scale efficiency index of *ith* farm, X_i is a vector of explanatory variables, β is a parameter to be estimated, and e_i is an error term $\sim N(0,\sigma^2)$. Explanatory variables in the tobit model were selected on the theoretical basis that the level of education of a farm operator improves efficiency performance of outputs as well as inputs in a production process (Kumbhakar and Bhattacharya, 1992). Likewise increased education and extension services improve allocative efficiency of farmers (Ram, 1980; Huffman, 1977; Parikh *et al.*, 1995). However, age of household head has negative effects on efficiency (Parikh *et al.*, 1995), because older farmers are constrained in resource utilization to attain scale efficiency.

Ten variables measuring sources of farm information represented by three PCs, and a variable ADOPT[15] measuring farmer managerial proficiency, farm size FMSZE, and age of farm operator AGE were regressed on the scale efficiency index. The details of the PCs are given in Table 5.17, and results of the estimated model are presented in Table 5.18.

Principal component PC_1 reflects farm information obtained by farmers from training, participation in training workshops and field demonstrations, and interactions with other farmers. PC_2 is mainly associated with information accessible to farmers by liaising with extension and research institutions. PC_3 is a contrast between farmers' formal education level and the extent to which field extension officers render extension assistance to a farmer. PC_3 will be high if a farmer is less educated and is visited relatively more by field extension

[15] The variable ADOPT is derived from combining the response score on the rate of soil analysis and use of certified seedcane by each farmer (see section 5.3).

staff, therefore having a high rating to the usefulness of such assistance.

Table 5.17 Details of principal components included in the efficiency model

Principal component Label		Variables with component loadings greater than 0.5
PC_1	=	0.776*TRNG + 0.687*XTRNG + 0.649*DEMON + 0.641*OHFRM
PC_2	=	0.776*SASEX + 0.657*ECAD + 0.569*MGZ
PC_3	=	0.855*VST - 0.654*EDUC + 0.642*EXOF

EDUC	=	Formal education of farm operator (variable measurement as given in Table 4.4).
TRNG	=	Dummy variable, scoring one if farmer had received agricultural training, zero otherwise.
XTRNG	=	Number of training workshops attended by a farm operator on average in two seasons
VST	=	Number of times a farmer was visited by field extension staff in a season

Units of measurement in the assessment of the usefulness of the different sources of farm information are based on a likert-type scale of zero (not useful) to four (very useful) refer to Table 4.4.

SASEX	=	Farmer ratings of the usefulness of the SA Sugar experiment Station
ECAD	=	The assessment of the usefulness of SACGA regional economists in assisting farmers to improve farm productivity.
EXOF	=	The assessment of the usefulness of field extension officers in assisting farmers to improve farm productivity.
DEMON	=	Farmer assessment of the usefulness of field demonstration
OHFRM	=	Farmer assessment of usefulness of assistance obtained from other farmers as a source of farm information
MGZ	=	Farmer assessment of the usefulness of farm magazines

Table 5.18 Factors influencing scale efficiency on a sugar cane farm

Explanatory Variable	Dependent Variable (SE)		
	Coefficient	Std. Error	t-Stat
Intercept	0.6030	0.0965	6.3***
PC_1	0.0407	0.0244	1.7*
PC_2	0.0299	0.0249	1.2
PC_3	-0.0481	0.0299	-1.6$^{\circledast}$
AGE	-0.0033	0.0016	-2.0**
ADOPT	0.1529	0.0558	2.7***
FMSZE	0.0003	0.0001	2.1**

n = 117
Log-likelihood Function = 4.803

*Significant at; ***1%, **5% * 10% ⊛15%, respectively.*

The tobit model coefficients are estimated by the method of maximum likelihood (Breslaw, 1993:159). The value of a Tobit coefficient does not represent the expected change in the dependent variable given a one unit change in an explanatory variable (Norris and Batie, 1987). Rather, the Tobit model estimates a vector of normalized coefficients which can be transformed into the vector of first derivatives. Nonetheless, where such a decomposition is not relevant, beta coefficients are directly usable (McDonald and Moffitt, 1980) as in this study.

Coefficients of all variables (PC_1, PC_3 AGE, ADOPT, FMSZE) have *a priori* expected signs and are statistically significant (Table 5.18). PC_2 has the correct sign but is only significant at 20% level. The positive signs on coefficients of variables PC_1, FMSZE, and ADOPT respectively, imply that high levels of knowledge attained by farmers through attending training programmes are associated with scale efficiency on a sugar cane farm. Large farms are more scale efficient, and farm operators demonstrating higher managerial abilities attain high level of scale efficiency on their farms. PC_3 has a negative sign, implying that educated farmers can attain high levels of scale efficiency inspite of having less external support from field extension staff. The negative sign on AGE implies that older farmers are less able to utilize farm resources to attain an optimal level of scale efficiency. The estimates from the tobit model show that human resource factors influence efficiency in farm resource use, supporting the results of Britton and Hill (1975: 8).

CHAPTER 6

CONCLUSIONS AND POLICY IMPLICATIONS

The sugar cane sector in South Africa (SA) has a dualistic distribution of farm size, with small farm units co-existing alongside large scale operations. The sector consists of 45270 cane farmers of whom 43510 (96%) are small-scale farmers (South African Cane Growers Association, 1994). The dilemma in the SA agriculture in general and the sugar cane sector in particular is about the skewed distribution of present land ownership, and the uncertainty that remains about the viability of farms of various sizes. The SA government intends to resettle small scale farmers on about 30% of large scale commercial farm land. Although the intended resettlement is necessary to reduce the present unfair distribution of land ownership, the land reform process should ensure that the country's limited and fragile agricultural resources are utilized on a sustainable, efficient and productive basis.

In this study, resource use and farm efficiencies on small and large farms are examined, and information is provided on efficiency implications if large sugar cane farms are subdivided into smaller units under the land redistribution programme. This is based on information collected from a sample of 160 small and large privately owned sugar cane farms in the North Coast region of KwaZulu-Natal sugar Belt. Farms studied ranged from one to six hundred hectares. The sample was stratified to maximize the variation of the farm size variable in order to study the effects of this variable on efficiency.

Investigations of characteristics of sample farmers using discriminant analysis revealed that small and large farms studied differ significantly on lines of human resource capital and cost of borrowed capital (market related). The findings of the study show that large farms are better equipped in human resource capital, and face lower market related interest rates compared to small farms. This is in line with the Groenewald, (1991) and Binswanger *et al.*, (1992: 25) concept that "the better the manager the larger the optimal farm size". The results also support the finding of Binswanger *et al*, (1992: 26) that cost of borrowing in the formal credit market due to fixed transactions costs is a declining function of farm size.

An interaction index of training, use of farm information, number of training workshops attended, and adoption of appropriate farm practices (an indicator of managerial proficiency) is the second important discriminating variable in classifying farms as small and large. The analysis shows that large farms have a higher incentive to acquire more knowledge, thus supporting the findings of Huffman (1974) and Welch (1978: 274). The results also reveal that large farms are in a better position to adopt appropriate farming methods than smaller farms as found by Huffman (1974) for U.S maize farmers. The third and final most important discriminating variable, shows that large farms have high incomes relative to labour and other input costs.

The low human resource capital capacities, and low incentives to acquire more farm information have far reaching policy implications for the ability of small farms to adopt new technology which is important in the growth and development of the sugar cane sector. On the other hand, the high interest cost on capital on small farms due to transaction costs tends to imply that very small farms can not compete favourably for credit with large farms in the credit market. The transfer of land to people previously excluded from the land market is crucial for the long term political and economic stability of the country, nevertheless, the low levels of net farm income on very small farms is bound to jeopardize the objective of having meaningful economic empowerment of the rural poor.

The analysis of adoption of soil analysis and use of certified seedcane as measures of managerial proficiency shows that, the intensity of adopting appropriate and improved farming practices (managerial proficiency) significantly increases with increase in area under sugar cane (farm size), education and agricultural training of farm operators, and use of farm information. The results reveal some evidence of reductions in contact with field extension staff as managerial proficiency increases among sugar cane farmers. However no significant differences is recorded on age and farming experience, and number of training workshops attended by a farm operator on average in two seasons with changes in managerial proficiency.

As regards farm performance indicators (i.e., labour costs, input cost, and net farm income per hectare), results show no significant statistical differences between groups with different managerial ability on input cost and net farm income per hectare. However labour costs per hectare was noted to decrease from R 2066, R 1732 to R 1262 as managerial proficiency ascended from the group of non-adopters, partial-adopters and full-adopters, respectively. Likewise, decreases in input cost per hectare from R 1076, R 892 to R 733 are evident between the three groups respectively. It is also evident that as managerial potential increases net farm income per hectare improves from R 396, R 771 to R 1360 between non-adopters, partial adopters, and full-adopters, respectively. Therefore the adoption of agronomic practices (soil analysis and use of certified seedcane) specific to sugar cane farming as measures of farmer managerial proficiency show that high adoption rates of management practices by farm operators may reflect an individuals' ability to implement good management techniques as pointed out by Sumner and Leiby (1987).

Study results on factors influencing the adoption of recommended and appropriate cultural practices on sugar cane farms reveal that, farm information (gathered through liaising with experiment station, contact with SACGA regional economists and intensive use of farm magazines) was the most important factor influencing the adoption of soil testing and use of certified seedcane on sugar cane farms. Experienced sugar cane farmers tend to adopt improved and appropriate cultural practices on their farms. Information acquired by farmers (through training in agriculture, particularly cane growing, and participation in information transmitting activities like seasonal field training workshops) is important in influencing the adoption of appropriate cultural practices on a sugar cane farm. Better educated farmers were more likely to have soils analysed and used certified seedcane inspite of having received less external from field extension personnel. Finally the results reveal that size of operation and wealth, significantly influence the farmers ability to adopt better farming methods. These conclusions are consistent with the evidence concerning the adoption of appropriate cultural practices on farms in (Feder and Slade, 1984a; Strauss *et al.*, 1991; Adesina *et al.*, 1995).

Adoption of improved farm practices on sugar cane farms points towards a policy direction of designing extension provision strategies that will target farmers of varying resource base (human and capital) in order to improve the current productivity levels in the sugar industry. Emerging and inexperienced farmers in the business of sugar cane growing must be provided with adequate training to improve their capacity to cope with the understanding of better sugar cane farming methods. Therefore, rural development policy implications of low rates of adoption of improved and appropriate farm practices on small farms, indicate that emphasis on small sugar cane farms will certainly require more resources to be invested in the improvement of human capital capacities because small scale farms are less able to attract high quality management, which will definitely involve intensive extension support and training.

Results highlight the importance of the Sugar Experiment Station (SASEX) and the economic division of the South African Cane Growers' Association (SACGA) in shaping managerial capabilities of sugar cane farmers. This indicates that proper training and extension support services aimed at increasing farmers' managerial ability should form part of the agricultural restructuring process in the SA agricultural sector. The findings of this study point towards the need for a strong collaborative link between SASEX and the SACGA economic division with field extension staff who are mainly in close contact with small farmers to facilitate the dissemination of relevant information on better farming methods that is lacking in the majority of small growers.

In the study, a nonparametric (DEA) frontier method of estimating technical, allocative and scale efficiencies was used. The method is flexible in the sense that it does not impose a functional restriction on technology as is typical in a parametric approach. The procedure provides firm-specific information on sources, and magnitude of production efficiency by solving appropriately formulated linear programming models.

Farm-specific indexes for technical, allocative and scale efficiencies are estimated. Study results show that technical inefficiencies are rather limited among small and large sugar cane farms, with these farms attaining on average 71% and 81% level of technical efficiency, respectively. This indicates that economic losses are more generated by allocative inefficiencies, implying that most farms can find ways of reducing production costs. Small farms exhibit relatively high scale inefficiencies attaining on average 46% scale efficiency level, compared to 88% among large farms. The size of a farm operation therefore appears to affect the level of efficiency attainable in a sugar cane farm operation.

Economies of size, whereby large farms reduce costs by spreading fixed machinery, labour and management, information, and transaction costs in the credit market over more output are evident in the data. Results show that the long-run average cost structure on farms studied is relatively flat after initially declining rapidly over a range of farms producing less than 500 tons of sugar cane (i.e., operating approximately less than ten hectares under sugar cane). This shows evidence of important economies of size in sugar cane production, with strong economies of size on farms producing less than 500 tons of sugar cane.

A number of agrarian policy implications for the SA sugar cane sector can be drawn from the findings. The most substantive is that small farms producing less than 500 tons (operating approximately ten hectares under sugar cane) require significantly more resources to produce a rand's worth of output than larger farms. Therefore if commercial farms are subdivided in the land resettlement programme, significant efficiency loss may occur if the resettled farms produce less than 500 tons. Little efficiency loss is expected if resettled farms produce more than 2500 tons (i.e., approximately 50 hectares under cane). Therefore permitting the subdivision of commercial farm land into farms producing more than 2500 tons may not lead to a loss in efficiency, provided that land is individually owned. This requires the repeal of Act 70 of 1970 which forbids the subdivision of agricultural land into 'non viable' farms. Sugar cane producing regions in the SA sugar industry are of different agricultural potential which means that the acreage needed for minimum cost will differ. It is important to note that if yields per hectare are different, then acreage must be adjusted accordingly, as costs are expressed per ton.

As part of the land reform process in the sugar cane sector, Illovo Sugar company settled 20 small scale farmers on 1600 hectares of prime sugar land (Natal Witness, June 1996). Farm sizes on resettled land varied between 50 and 100 hectares. The results from the study indicate that the Illovo sugar company resettled farms are sufficiently large from an efficiency point of view. Experience in the credit market on the other hand shows that KFC a parastatal lending institution - is not willing to finance the purchase of sugar cane farms smaller than 52 hectares in size on grounds that smaller units will not generate sufficient cash flow to meet (subsidized) debt obligations (Simms, in Lyne and Ortmann, 1996).

Results of the tobit (econometric) model indicate significant linkages between scale efficiency and farmer characteristics, institutional factors and size of farm holdings. This suggests that the shape of the agricultural structure may not solely be responsible for differences in efficiency but rather that a whole range of other factors associated in different degrees with small and large farms are also important (for example, level of education, training, age and managerial proficiency of individual farm operators). The research findings also suggest that efficiency of very small scale sugar cane farms (producing less than 500 tons) can be enhanced by land consolidation, improved farm operators' education, additional training and extension services for expansion and propagation of modern techniques of cane production. This supports the suggestions by Groenewald (1991), that flexibility in farm size and farm size structure developments must be promoted, not controlled. Such flexibility, accompanied by purpose - directed farmer training and farmer support, will be of utmost importance in the agricultural adjustment process in SA. However, returns to investment in better education, training and extension may be extremely poor if farm sizes are very small.

Economies of size have broad implications for the structure, performance, and growth of an industry. Overall efficiency of an agricultural system largely depends on the performance of its farming system. Having a broader understanding of the structures and operations of specific cropping systems within the SA agricultural sector will enable policy makers to assess the likely usefulness of reform policies from an efficiency point of view, and to design programs that will direct change towards desired ends. This study is important to individual sugar cane farmers by providing an understanding of their economic position in relation to the sizes of farms they operate. It could enhance management decision making processes of cane growers by enabling farmers to determine probable areas that could be restructured to increase efficiency in cane production. It could be very useful if similar studies are extended to other crop sectors such as the maize industry which is important in the country's agricultural economy.

CHAPTER 7

SUMMARY

The need for a rapid transfer of land to people previously excluded from the land market is crucial for the long term political and economic stability of South Africa (SA). The dilemma in SA agriculture however, lies with uncertainty about the viability of farms of different sizes, and the need to ensure that the country's extremely limited and fragile agricultural resources are used on a sustainable, efficient and productive basis. Such considerations have posed a challenge to policy makers in the choice of an agrarian structure to achieve the dual goals of growth and equity.

The sugar industry is very important in the agricultural economy of KwaZulu-Natal. The industry consists of both small and large farms, however yield (a measure of productivity) is lower on small farms than on large farms, which implies efficiency losses if more emphasis is placed on very small scale sugar cane farming.

The study examines efficiency in resource utilization on small and large sugar cane farms, and the implications this might hold for the reallocation of resources between farm size-groups in pursuit of land redistribution. The analysis is based on data collected in a survey conducted in the North Coast region of KwaZulu-Natal sugar belt during March/April 1995 from a sample of 160 commercial farmers of which 96 were small farms and 64 large farms. The study shows that small farms as compared to large farms; are deficient in human resource capital, less competitive in the credit market, have low incentives to acquire more

farming knowledge, are of less capacity to adopt better farming methods, and face high input costs relative to farm income. These factors play a significant role in the level of farm efficiency attainable in the two categories of farm operations.

The influence of human resource capital in the adoption of better farming methods is investigated. The adoption of agronomic practices specific to sugar cane farming (i.e., soil analysis and use of certified seedcane) taken as a measure of managerial proficiency of farm operators supports the hypothesis that high adoption rates of management practices by farm operators are not direct indicators of *ability*, but reflect the capacity to implement good management techniques on a farm. The results show increases in farm income relative to labour costs and costs inputs (like herbicides, fertilizer, and seedcane), as managerial proficiency of farm operators improves. Managerial proficiency is observed to significantly improve with increases in farm size, education and training, and use of farm information.

Adequate information is necessary to facilitate the adoption of better farming methods. This shows that a mechanism of transmitting relevant information through training of farmers on better farming methods will improve the managerial capabilities of farmers. Farming experience (another form of training) is associated with adopting better farming practices. Education of farmers is equally important in the implementation of better farming methods. Results show that adoption of better farming methods are not scale neutral, as farm size and wealth, significantly influence the farmers ability to adopt better farming methods in sugar cane farming.

In the analysis of farm efficiency, all inputs were valued at their opportunity cost. This included the imputed value of family and farm operator labour (management), and the opportunity cost for land and capital. Quantity measurements of fixed assets (land and machinery) were converted into annual flow variables. A shadow price of 30% on average, was used to cost funds lent to small borrowers based on information from lending agencies in SA (e.g KFC and FAF). Lending agencies express the view that lending costs are substantially higher for small farmers than large farmers. Unsubsidised interest rates (reflecting administration and transactions costs) on loans to small farmers ranged between 30% to 48%, as opposed to the 14.5% (subsidized) rate charged on small farm loans during the survey period. Mortgage bond rates paid by large farmers ranged between 15% to 18.5% during the respective period. Information costs were computed based on mean annual cash costs of farm information from private sources compiled in a study by Bullock, *et al.*, (1995).

Economies of size, whereby large farms reduce their costs by spreading fixed machinery, labour and management costs, information, and transaction costs in the credit market over more output are evident in the data. The data indicate significant differences in per ton average cost of labour, operator labour services and information costs on small and large farm units studied, with small farms recording higher costs than large farms. The combined expenditure reported for fertilizers and herbicides showed that large farms had a significantly lower average costs for these items. Average yield is high on large farms, suggesting the possibility that resources are better utilized (as a result of better management on large farms). Per ton investment in machinery was about 303% greater on small farms than on large farms, while per ton labour investment was 136% higher on small farms.

The effect of farm size on efficiency was analysed based on a non-parametric (DEA) method of production frontier estimation. Given the importance of the farm size variable in the study, more emphasis was placed on scale efficiency (SE) of production decisions. The SE indices estimated for each farm ranged between zero and one, with 100% efficiency indicated by a score of one. The inverse of scale efficiency index (1/SE), comparable to an average cost function, is a declining function of output/farm size under increasing returns to scale, and an increasing function of farm size under decreasing returns to scale (Chavas and Aliber, 1993). The inverse of SE (1/SE) was plotted against sugar cane output and farm size.

The results show that the cost structure of sugar cane farms studied is "L"- shaped, indicating substantial economies of scale on very small scale farms producing less than 500 tons of cane (i.e., operating approximately less than 10 hectares under sugar cane). Costs per ton fall with increased output to about 2500 tons (approximately 50 hectares of land under sugar cane) after which costs per ton level of for farms producing an output larger than 2500 tons (50 ha). This implies that small farms producing less than 500 tons (ten ha of sugar cane) require significantly more resources to produce a rand's worth of output than larger farms. If yields per hectare are different then acreage must be adjusted accordingly.

The policy implications of the results are that, if commercial farms are subdivided in the land resettlement programme, significant efficiency loss may occur if the resettled farms produce less than 500 tons. Farms producing more than 2500 tons of cane (i.e farms with more than 50 hectares of area under sugar cane) are large enough from an efficiency point of view, and competitive enough to guarantee worthwhile economic returns to capital and management. Other issues such as debt service ability of small versus large farms and viable income were not researched.

Non-physical inputs, for example; farming experience, information, and supervision influence the ability of a producer to use the available technology efficiently. Results of a tobit (econometric) model indicate significant linkages between scale efficiency and farmer characteristics, institutional factors and size of farm holdings. The research findings therefore suggest that efficiency of very small scale sugar cane farms (producing less than 500 tons) can be enhanced by land consolidation, farm operators' education, training and extension services for expansion and propagation of modern techniques of cane production, and by promoting the use of farm information.

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APPENDIX A

SURVEY QUESTIONNAIRE

APPENDIX A

FARMER QUESTIONNAIRE

FARM SIZE AND ECONOMIC EFFICIENCY QUESTIONNAIRE (KWAZULU-NATAL SUGAR CANE GROWERS)

TO BE COMPLETED BY THE PRINCIPAL FARM DECISION-MAKER OF THE FARM BUSINESS

This questionnaire attempts to relate how different economic and demographic conditions faced by farmers influence farm efficiency. The objective is to highlight factors that need to be considered when formulating land and agricultural policies.

In order to foster agricultural development in SA, polices must specifically account for the different factors that farmers face in a farming environment, which in turn affect the nature and size of farm operations.

The study is undertaken by the Department of Agricultural Economics, University of Natal (PMB) in collaboration with the South African Cane Growers' Association (SACGA).

All survey responses will be kept strictly confidential.

The questionnaire consists of Eleven major questions. Please answer all questions as accurately as possible. **Even if you don't answer all questions, please return the questionnaire.**

Farm location

Please Specify ________________

1. BACKGROUND INFORMATION

(a) Code........... (b) Age _____ (c) Male _____/Female____

(*tick, were appropriate*)

(d) Education *(tick, were appropriate)*

No Education	☐
STD 5 and Below	☐
STD 6 to 9	☐
STD 10 / Matric	☐
Diploma	☐
Degree	☐

(e) Are you a **FULL-TIME** or **PART-TIME** farmer?

Full-time ☐ Part-time ☐

(f) For how long have you been growing sugar cane?

_________ years.

(g) Have you ever had **PRACTICAL TRAINING** (i.e attending ***field day demonstrations***, ***mill group meetings***, or ***any other form of training***) relating to sugar cane growing?

Yes ☐ No ☐

If **YES**,

(h) State the number of times you have attended such **TRAINING PROGRAMMES** (i.e *field days demonstrations* and *other of forms training*) in the last **TWO** seasons __________ times.

(i) Please <u>rank</u>, **HOW USEFUL** you have found the following in assisting you to <u>**improve the productivity**</u> of your sugar cane farm? Please <u>circle</u> the number that best indicates your judgement as indicated by the scale below.

Not Useful	Less Useful	Useful	Very Useful
0	1	2	3

Economic advisors from the Cane Growers' Association	0	1	2	3
Extension officer(s)	0	1	2	3
Sugar Cane Experiment Station(s)	0	1	2	3
Training during Field Days-Demonstrations	0	1	2	3
Other Farmers	0	1	2	3
Farm Magazines	0	1	2	3

(j) Approximately, **HOW MANY TIMES** did the extension officer(s) visit your sugar cane farm in the last **TWO** seasons?

- 10+ ☐
- 7-9 ☐
- 4-6 ☐
- 1-3 ☐
- None ☐

(k) How do you **RATE** your <u>Field lay-out plan</u> (i.e ***contouring*** & ***strip cropping practices***) on your sugar cane farm relative to other farmers in your district?

- Very Good ☐
- Good ☐
- Satisfactory ☐
- Fair ☐
- Uncertain ☐

(l) Please **indicate**, how often you have Farm soils tested on your sugar cane farm by circling the number that best indicates the **rate of implementation** as shown by the scale below.

Never	when planting a new crop	Every season
0	1	2

(m) Do you use of Heat treated or certified Cane Seed on your farm

Yes ________, No ________

(m) What would you comment about your sugar cane growing **under normal weather conditions** relative to other farmers in your district?; *(tick where appropriate)*

Very successful	☐
Successful	☐
Not successful	☐
Failure	☐

2. FARM SIZE, LAND TENURE AND UTILIZATION (1993/94 SEASON)

(a) What is the **TOTAL** size of your farm? ________ hectares

(b) Crop production (1993/94 SEASON)

CROP	HECTARES	TOTAL HARVESTED	QUANTITY SOLD	GROSS INCOME (R)
Sugar cane				
Vegetables				
Maize				
Madumbes				
Avocados				
Grazing		***********	***********	********
Forestry				
Other (Specify)				

(c) Livestock & Poultry production (1993/94 SEASON)

LIVESTOCK	NUMBER OWNED	NUMBER SOLD	GROSS INCOME (R)
Oxen			
Cows			
Bulls			
Goats			
Pigs			
Chicken			

(d) Of the cane that was harvested in 1993/94 season,

How much was;

Used as seed _______ Tons

Sold as seed _______ Tons

(e) What was the <u>average Price</u> paid for each Ton of cane? (R)______

(f) Over the last years, what has been the <u>average yield</u> on your cane farm?

_________ Tons/Hectare.

(g) From your <u>personal judgement</u>, what size of cane farm can you <u>operate</u>

efficiently, with your present resources? ________ Hectares.

(h) How many Tons of cane would you have to cut to lead a **decent life**?

_____________Tons/Season

(i) What is the next **ALTERNATIVE CROP ACTIVITY** you would consider investing in if are to **SWITCH** farm resources from sugar cane production?

____

(j) Who owns the land that you farm? *(tick where appropriate)*

Myself	☐	Nkosi	☐
Family	☐	Government	☐
Company (CC/PTY)	☐	Financial Institution	☐

(k) Do you rent land for the purposes of growing sugar cane?

Yes ☐ No ☐

If ***YES***

(l) How many hectares do you rent? ___________

(m) What is the cost of renting this land per annum? R __________

(n) Please indicate what you think are the major **LIMITING FACTORS** to sugar cane farm expansion, by circling the number that **BEST** expresses your judgement as indicated by the scale below.

Not Limiting	Limiting	Quite Limiting	Very Limiting
0	1	2	3

Lack of Land to expand on Farm operations	0	1	2	3
Lack of capital to purchase inputs	0	1	2	3
Lack of Labour	0	1	2	3
Lack of Extension Services	0	1	2	3
Low prices paid for surplus (B pool) cane	0	1	2	3

4. LABOUR AND MANAGEMENT

(a) Who makes the decisions about farming matters (i.e ***WHAT TO DO, WHEN TO DO IT, & WHAT FARMING PURCHASES TO MAKE***)?

(tick where appropriate)

Myself ☐

Hired Manager(s) ☐

Wife ☐

Son/Daughter ☐

(b) Do you hire manager(s) on your farm?

Yes ☐ No ☐

If YES,

(c) How many managers are hired on your sugar cane farm? _______

(d) Level of <u>education</u> and <u>work experience</u> of hired managers

MANAGER CATEGORY	LEVEL OF EDUCATION	WORK EXPERIENCE IN YEARS
1st Manager		
2nd Manager		
3rd Manager		

(e) If you were to be **HIRED AS A FARM MANAGER ELSEWHERE**, what would be an acceptable payment for your services?

R _______ per month.

5. LABOUR UTILIZATION ON FARM

Number of permanent Farm workers? Men_____ Women ______.

(a) Sugar cane Production (1993/94 SEASON)

TYPE OF OPERATION	NUMBER: [MEN/WOMEN] EMPLOYED	HOURS WORKED/DAY	DAYS TAKEN TO COMPLETE TASK	DAILY WAGE
Ploughing	Hired:-			
	Family:-			
Planting	Hired:-			
	Family:-			
Weeding	Hired:-			
	Family:-			
Fertilizer Application	Hired:-			
	Family:-			
Harvesting	Hired:-			
	Family:-			

(b) Vegetables

TYPE OF OPERATION	NUMBER: [MEN/WOMEN] EMPLOYED	HOURS WORKED/DAY	DAYS TAKEN TO COMPLETE TASK	DAILY WAGE
Ploughing	Hired:-			
	Family:-			
Planting	Hired:-			
	Family:-			
Weed Control	Hired:-			
	Family:-			
Fertilizer Application	Hired:-			
	Family:-			
Harvesting	Hired:-			
	Family:-			

(c) Other Crops (please specify) ....

TYPE OF OPERATION	NUMBER: [MEN/WOMEN] EMPLOYED	HOURS WORKED / DAY	DAYS TAKEN TO COMPLETE TASK	DAILY WAGE
Ploughing	Hired:-			
	Family:-			
Planting	Hired:-			
	Family:-			
Weed Control	Hired:-			
	Family:-			
Fertilizer Application	Hired:-			
	Family:-			
Harvesting	Hired:-			
	Family:-			

(d) Livestock

TYPE OF OPERATION	NUMBER: [MEN/WOMEN] EMPLOYED	HOURS WORKED / DAY	DAILY WAGE
Animal Feeding	Hired:-		
	Family:-		
Milking	Hired:-		
	Family:-		
Animal Health/Vet	Hired:-		
	Family:-		
Other (specify)	Hired:-		
	Family:-		

(c) Cane Transportation Costs/Ton in 1993-94 Season

________ Rand/Ton.

(d) What is the distance to your nearest sugar mill? ________ Km.

6. FARM EXPENSES ON INPUTS (1993/94 SEASON)

(a) Sugar cane production

INPUTS	QUANTITY PURCHASED	QUANTITY USED	TOTAL COST
Fertilizer	/(50 Kg Bags)	/(50 Kg Bags)	
Herbicides	/Litres	/Litres	
Chemicals	/Litres	/Litres	
Cane seed	/Tons	/Tons	

(b) Vegetable production

INPUTS	QUANTITY PURCHASED	QUANTITY USED	TOTAL COST (R)
Fertilizer	/(50 Kg Bags)	/(50 Kg Bags)	
Chemicals	/Litres	/Litres	
Vegetable seed			
Other seed			

(c) Livestock

INPUTS	QUANTITY PURCHASED	QUANTITY USED	TOTAL COST (R)
Animal Feeds: (i) Livestock			
(ii) Poultry			
Vet services	*************	************	
Drags			
Other Chemicals			

8. **TOTAL EXPENDITURE ON INTEREST ON FARM LOANS 1993-94 SEASON**

Loan Category	Amount paid as Interest (Rand)	Interest Charged as %
Bonds		
Loans		
Bank overdrafts		
FAF *(Small growers' Financial Aid Fund)*		
TOTAL		

9. **VALUE OF FARM & NON-FARM ASSETS & MAINTENANCE AND RUNNING COSTS 1993-94 SEASON**

CATEGORY OF ASSETS	TOTAL VALUE	MAINTENANCE & RUNNING COSTS
Motor Vehicles		
Lorries		
Tractors		
Equipments/implements		
Land & Improvements		
Buildings		
Other (specify)		

10. FARM OVERHEAD EXPENSES/SUNDRIES (RAND) 1993-94 SEASON

DETAILS	TOTAL FARM COSTS	NON-CANE COSTS	**CANE COSTS**
Farm Staff (i) Salaries			
(ii) Wages			
(iii) Other Labour Costs			
(iv) Rations			
Administration (i) Audit/Secretarial/ Legal Expenses			
(ii) Phone/ Radio			
(iii) Levies (Mill Group/Planters)			
Electricity/Gas/Coal & Water			
Insurance (i) Crop			
(ii) Vehicles			
(iii) Buildings			
Licences			
General Transport			
Rental (i) Rent			
(ii) Leases			

11. FARM FINANCIAL CHARACTERISTICS OF YOUR SUGAR CANE FARM (1993/94 SEASON)

(a) What was the Debt [Instalments, Accounts Payable, Overdraft, Mortgage Bond] ***to*** Asset [Cash in hand + Bank, Values of Vehicles & Machinery + Equipment, Land + Buildings ***{i.e Debts/Assets x 100}*** _____ %

(d) Approximately what is the ratio of NON-FARM INCOME **to** TOTAL FARM INCOME? {i.e ***Non-farm Income/Total Farm Income*** x 100}
________ %

****

EVEN IF YOU HAVE NOT ANSWERED ALL QUESTIONS, PLEASE RETURN THE QUESTIONNAIRE.

Would you be interested in the results of the study?

Yes ☐ No ☐

Your survey responses will be kept strictly confidential.

THANK YOU FOR PARTICIPATING IN THIS STUDY