# THE FARM SIZE-EFFICIENCY RELATIONSHIP IN SOUTH AFRICAN COMMERCIAL AGRICULTURE[1]

Johan van Zyl
*Dean Faculty of Biological and Agricultural Sciences, University of Pretoria. Presently on sabbatical with the World Bank*

*This paper briefly discusses the sources of economies of scale, with some international evidence. It provides a picture of the structure of South African agriculture, detailing distributions of farm size as well as some results of previous studies analysing farm size efficiencies. An analysis of farm size-efficiency relationship in commercial farming is done by utilising representative farm level survey data on the six major grain producing areas and an irrigation area over the period 1975-1990. The role of policy in explaining these relationships is discussed, while some conclusions are also drawn.*

*The findings have specific implications for land reform. The inverse farm size-efficiency relationship, which is also present in South African agriculture despite a history of policies favouring relatively large mechanised farms, implies that significant efficiency gains can be made if farm sizes in the commercial sector becomes smaller. An important element in such a process would be the removal of all policies and distortions favouring larger farms relative to smaller farms.*

## 1. Introduction

At least two questions related to the productivity relations in South African agriculture, which have not been adequately addressed in South Africa before, are important when considering land reform:

- Are large mechanised farms and the present commercial white farms economically efficient relative to smaller holdings?
- What is the role of past policies in determining these observed productivity relations?

If larger farms are not efficient relative to smaller farms, then smaller farms and equalising the ownership distribution would enhance both efficiency and equity, and if policy created artificial economies of scale, they should be adjusted.

This paper has as objective to explore these issues by briefly reviewing the sources of economies of scale and international evidence on these issues, as well as analysing representative farm-level data in both the South African commercial sector. These analyses are conducted against the policy environment and changes therein, as well as other factors which influence farm production.

Section 2 briefly discusses the sources of economies of scale, with some international evidence. Section 3 provides a picture of the structure of South African agriculture, detailing distributions of farm sizes as well as some results of previous studies analysing farm size efficiencies. In section 4, an analysis of farm size-efficiency relationship in commercial farming is done by utilising representative farm level survey data on the six major grain producing areas and an irrigation area over the period 1975-1990. The role of policy in explaining these relationships is discussed in section 5, while some conclusions are also drawn.

## 2. Economies of Scale[2]

*Sources of Economies of Scale*

Lumpy inputs: Farm machinery -threshers, tractors and combine harvesters- are lumpy inputs, and reach their lowest cost of operation per unit at relatively large areas. With the advent of agricultural mechanisation many people believed that the economies of scale associated with it are so large that it makes the family farm obsolete. Small owners would sell or lease their land to larger operators. However, it became quickly apparent that machine rental can permit small farmers to circumvent the economies of scale advantage associated with machines in all but the most time-bound of operations, such as ploughing and planting (seeding) in dry climates or harvesting where climatic risks are high. In those situations farmers compete for early service and therefore prefer to own their own machines. Thus, economies of scale associated with machines do increase the minimum efficient farm size, but by less than expected because of rental markets. The use of lumpy inputs leads to an initial segment of the production function that exhibits increasing returns with operational scale, but these technical economies vanish when farm size is increased beyond the optimal scale of lumpy inputs or when rental markets make the lumpiness of machines irrelevant.

Management skills and information, like machines, are indivisible and lumpy inputs, so the better the manager, the larger the optimal farm size. Technical change strengthens this tendency. The use of fertilisers and pesticides, and arranging the finance to pay for them, require modern management skills. So does the marketing of high-quality produce. In an environment of rapid technical change, acquiring and processing information becomes more and more important, giving better managers a competitive edge in capturing the innovator's rents. Therefore, optimal farm sizes tend to increase with more rapid technical change. However, some management and technical skills, like machinery, can be contracted from specialised consultants and advisory services or can be provided by publicly financed extension services. Contract farming for processing industries or bulk marketing companies often involves the provision of technical advice.

Access to credit and risk diffusion: Land, because of its immobility and robustness, has excellent potential as collateral, making access to credit easier for the owner of unencumbered land. On the other hand, rural credit markets are difficult to develop and sustain. There is therefore often severe rationing of credit, which can be partly relieved by the ability to provide land as collateral. The high transaction

costs of providing formal credit in rural markets implies that the unit costs of borrowing decline with loan size. Many commercial banks do not lend to small farmers because they cannot make a profit. Raising interest rates on small loans does not overcome this problem, since it eventually leads to adverse selection. For a given credit value, therefore, the cost of borrowing in the formal credit market is a declining function of the amount of owned land. Providing funds to overcome emergencies is a common function of informal rural credit markets. However, the amounts small farmers can borrow for consumption are usually tiny, and often only at high interest rates. Investigations into how farmers and workers cope with disaster show that credit finances only a small fraction of their consumption in disaster years. Access to formal commercial bank credit therefore gives large modern commercial farmers a considerable advantage in risk diffusion over small farmers without access. Establishment of a viable credit function for the family farm is a *conditio sine qua non* of modern commercial farming. Hence emphasis is needed for all efforts to develop rural credit, including co-operative banking and other savings-mobilisation mechanisms.

Economies of scale in processing: Wage-based plantations continue to exist for typical plantation crops, for example sugarcane, bananas and tea. This is not because of inherent economies of scale in producing these crops, rather economies of scale arise from the processing or marketing stage rather than from the farming operation and are transmitted to the farm. However, economies of scale in processing alone are not a sufficient condition for the explanation of the existence of plantations. The sensitivity of the timing between harvesting and processing is crucial as well, sugarcane, tea or the fruits of the oil palm have to be processed within hours of harvesting. Plantation style production has never been established for easily stored products such as wheat or rice which can be bought at harvest time in the open market and stored for milling throughout the year. Even sugarcane can be contracted for by millers with small farmers (e.g. in South Africa) as long as the logistics of harvesting and transportation can be solved. Thus, the superiority of the plantation depends *on a combination of economies of scale in processing with a co-ordination problem*. Plantations do not arise, or do not survive once labour coercion is abolished, unless both these conditions exist. In many cases, even where there is an even labour demand over the year, the plantation mode of production has therefore declined sharply at the expense of smallholder production. This applies to commodities as diverse as sugarcane, tea, coffee, bananas, rubber and oil palm, as well as tobacco and cotton.

Wage plantations survive in areas where they were first established under conditions of low population density and with a large land grant. Where the same crops were introduced into existing smallholder systems, contract farming prevails. Processors seem not to have found it profitable to form plantations by buying out smallholders and offering them wage contracts. This suggests either that the co-ordination problem associated with plantation crops can be solved at a relatively low cost by contract farming, or that imperfections in the land sales markets are so severe that it is prohibitively expensive to create large ownership holdings by consolidating small farmers.

*Evidence on the farm size - productivity relationship*

The literature clearly demonstrates that a systematic relationship between farm size and productivity is the result of market imperfections, and then only when more than a single market is imperfect. For example, if credit is rationed according to farm size, but all other markets are perfect, land and labour market transactions will produce a farm structure that equalises yields across farms of different operational size. But if there are imperfections in two markets, land rental and insurance, or credit and labour, a systematic relationship can arise between farm size and productivity.

In countries, like South Africa, where markets facing small farmers for any combination of labour, land, credit, land rental, insurance, etc., are often imperfect or missing (at least for some farmers, in general those who are small), this may give rise to real economies of scale over the short-term. However, these economies of scale are 'false' in the sense that they are only temporary, and the result of deliberate elimination of, or restrictions on, these markets.[3] With development of these markets economies of scale diminish and eventually disappear. The issue thus is *not to pursue* a farm structure that over the short-term captures these benefits, but over the longer-term gets a country locked into an inefficient and inequitable structure centring on large-scale mechanised farms.

Even without economies of scale, the question remains: Does size matter? Are larger farms more productive and/or profitable than smaller ones even if an argument cannot be made for superior technical efficiency? The answer clearly is yes. Policies are rarely scale neutral and external economies of scale is a reality. While these tend to favour larger farms, there are considerable transaction costs in the labour market, as well as supervision costs, which favour smaller farms. The issue is: What is the net effect of these factors?

Many studies on the farm size-productivity relationship reported on in the literature suffer from severe shortcomings such as not accounting for differences in land quality or labour productivity, using physical yields, and not accounting for differences in operational holding size and ownership holding size. Proper measures of efficiency are the difference in total factor productivity between small and large farms, and the difference in profits, net of the cost of family labour, per unit of capital invested. Studies which apply these measures typically support the following generalisations (Binswanger, *et al.*, 1993):

- *the productivity differential favouring small farms over large farms increases with the differences in size*, implying that it is largest where inequalities in landholdings are the greatest, in the relatively land-abundant countries of Latin America and Africa, and smallest in land-scarce Asian countries where farm size distributions are less equal;
- the highest output per unit area is often achieved not by the smallest farm size category but by the second smallest farm size class, suggesting that the smallest farms may be the most severely credit constrained.

However, most of the empirical work on the farm size-productivity relationship has been flawed by methodological shortcomings, and has failed to adequately deal with the complexity of the issues involved. In general, studies which

come to grips with some of the problems consistently show the superiority of smaller farms over large farms.

Numerous studies provide empirical evidence at the micro-level of the existence of an inverse relationship between farm size and the efficiency of resource use - as farm size increases, efficiency declines. This relationship is basically due to higher efficiency of family labour as compared to hired labour, in combination with commonly observed imperfections in credit and land rental markets (Binswanger, *et al.*, 1993). Berry and Cline (1979) found that the value added per unit of invested capital for the second smallest farm size group (10 to 50 ha) exceeded that of the largest farm size groups (200 to 500 ha) in a majority of zones that did not specialise in plantation groups.

A World Bank study (World Bank, 1983) on the higher efficiency of small versus large farms in Kenya, found that output per hectare was 19 times higher and employment per hectare was 30 times higher on holdings under 0.5 hectare than on holdings over 8 hectares. At the national level, this meant that a 10% reduction in average farm size would increase output by 7% and employment by over 8%. Binswanger, *et al.* (1993) report similar results for many other countries. Chavas and Aliber (1993) found virtually no scale economies in dairy production in Wisconsin, and the very limited initial scale economies they observed were attributable to lumpiness of certain inputs.

Evidence is also available at the macro-level, but only in terms of physical yields - an imperfect indicator of efficiency. Prosterman and Riedinger (1987) using data from 117 countries, show that 11 of the top 14 countries in terms of grain yields per hectare are countries in which small-scale, family farming is the dominant mode of production.

However, studies by Feder (1985) and Carter and Kalfayan (1989) demonstrate that the existence of market imperfections which tend to favour large farms (e.g. capital and insurance markets) may negate the inverse relationship between farm size and productivity. Carter (1994) finds that certain financial market disadvantages may render small farms non-competitive. Hence, whereas the small-scale farming strategy holds considerable promise from an efficiency perspective, this does not mean that its implementation is easy or can afford to ignore critical policy issues, such as resolving the usually constrained access of small farmers to credit markets.

*Related Issues: Mechanisation, Labour Organisation and Farm Size*

Also underlying the establishment and maintenance of large-scale farms is the misguided perception that there is a relationship between mechanisation and large farms. This has been clarified in the literature (see Johnson and Ruttan, 1994). Capital intensity is explained by the substitution of capital for labour because of high wages. This substitution process, brought about by changes in relative factor prices (Peterson and Kislev, 1991), indirectly caused larger farms. Machinery allows farmers to work progressively larger units of land (Hayami and Ruttan, 1985).

In this respect, the work of Brewster (1950) on the influence of machinery on farm size is enlightening: Mechanisation in industry involves stationary machinery, which implies that the number of workers can be increased substantially without increasing labour supervision costs. In agriculture, labour and machines are both mobile, making supervision expensive and increasing management costs. In addition, agricultural tasks are sequential in nature due to the annual cycle of production. This limits the opportunities for specialisation and division of labour, which creates few advantages to expansion beyond the size of owner-operator. The literature clearly demonstrate (*cf.* Berry and Cline, 1979; Binswanger and Rosenzweig, 1986; Binswanger and Kinsey, 1993; Binswanger and Elgin, 1992; Binswanger, *et al.*, 1993) that family farms are generally more efficient and superior to other types of farming because of the way in which labour relations are organised. Family farms are by definition farms where the owner is the operator and where his/her family provides the large bulk of the regular labour requirements throughout the year. While the definition of family farms does not exclude the hiring of other people, especially in a part-time capacity when related to seasonal labour, it tends not to rely too much on such behaviour. In addition, in countries where capital is relatively scarce and expensive, the relationship between labour and capital should reflect this. Over-emphasising modernisation, restructuring, mechanisation and other similar concepts implying the use of more capital to labour than that dictated by economic realities should be discouraged. This all implies farm sizes on the smaller side of the spectrum rather than larger sizes for family farms.

## 3. Structure of South African agriculture: issues related to size

*Farm Sizes in South Africa*

Farm sizes in South Africa began to increase in the 1950s and continued to increase until the 1980s. After steadily increasing until 1971, black farm employment began to decline. Consequently, it can be argued that scale efficiencies appeared after 1950, and in particular after 1970, and were a main factor behind the steady decline of employment in agriculture (Van Zyl, *et al.*, 1987). Agriculture was the only major economic sector that experienced an absolute decline in employment between 1951 and 1985 -- despite the fact that wages were rising at a slower rate in agriculture than in other sectors. This history suggests that in South Africa, a number of interventions in the markets for land, labour and capital produced a structure of incentives which induced scale efficiencies, in particular since the 1970s.

From the beginning of the century until the 1950s, the number of farms and the total area cultivated increased, but the average farm size declined. After 1950 this trend is reversed; and farm size grew consistently, accelerating in the 1970s before levelling off in the late 1980s. Because the cultivated area remained the same, the number of farms declined -- from 116 848 units in 1950 to 62 084 units in 1990 (RSA, 1994). The pattern seems to continue until the late 1980s, although there is some evidence of an increasing differentiation in farm sizes below the 100-hectare minimum which (in some areas) defines a farm in official statistics (World Bank, 1994).

Average farm size increased from 738 hectares per farm in 1953, to 867 hectares in 1960, to 988 hectares in 1971, and to 1 339 hectares in 1981, but declined to 1 280 hectares per farm in 1988. From 1955 to 1988,

average farm size by province increased from 1 284 to 2 663 hectares per farm in the Cape Province; 471 to 998 hectare per farm in the Orange Free State; 403 to 629 hectare per farm in the Transvaal, and 390 to 609 hectare per farm in Natal. These data show that the national average hides significant regional variations. In 1988, the median farm size was about 500 hectares, with farms in the high-potential areas significantly smaller. Such qualifications should not distract, however, from the fact that large-scale farms dominate South African agriculture, and that the average size of these farms is extraordinary by international standards.

*Evidence of Economies of Scale*

At present, there is mixed evidence for the existence of scale efficiencies in South Africa's commercial farm sector:

- The distribution of gross farm income in commercial agriculture is highly unequal: In 1988, 3% of the farmers earned 41% of the total gross farm income; 26% earned 81%, while the remaining 74% of farmers earned a mere 19% of total gross farm income (calculated from the 1988 agricultural census, CSS, 1993).

- Hattingh (1986) reports evidence of a direct relationship between farm size and efficiency in sheep farming in the Karoo and in cattle ranching in north-western Transvaal. He also reports that efficiency increased between small and medium-sized irrigated farms at Vaalharts and dryland grain farms in the Orange free State, before decreasing again on the larger farms (size ranges are not specific);

- Analysing the Department of Agriculture's Production Cost Surveys, Moll (1988) finds no significant economies of size[4] both in maize-cattle regions (Western Transvaal, North-West Orange Free State and the Transvaal Highveld) and in wheat-sheep regions (Swartland). Using re-tabulated 1983 census data, however, Moll (1988) finds economies of size, but only in the maize areas and for 50-300 hectare range.

Conversely, there exists empirical evidence from South Africa to suggest an inverse relation between farm size and efficiency. Statistics from the 1988 census of agriculture (CSS, 1993) show that 50% of farming units owning only 6% of the farmland, with farm sizes of less than 500 hectares, were responsible for 30% of gross farm income, 23% of net farm income, 32% of capital investment, and 29% of farm debt. The larger farms (1000 ha +) comprising a third (33%) of all farming units, collectively owed more than 50% of the total farm debt. However, these farms were responsible for 53% of total gross farm income.

*Evidence on Causes of Scale Efficiency*

The official definition of the viable farm in terms of size has had a profound negative effect on the relative profitability of farms smaller than the viable size. Given the high levels of official assistance and subsidies to farmers, the viability definition became almost a self-fulfilling prophecy, because under the Agricultural Credit Act all farms below the viable size were excluded from assistance. Moreover, under the Subdivision of Agricultural Land Act of 1970, it is not possible to subdivide an existing title deed without ministerial approval. Permission is granted only with proof that a reasonable net farm income can be obtained with "average" management. The subjectivity of this requirement, together with the lending criteria of the official funding agencies, precludes systematic empirical analysis of small farms in South Africa. Yet, it is interesting to observe that despite the lack of assistance for small farmers, official records of deed transfers show that the prices of small parcels of land increased more rapidly than the prices of large parcels since the 1960s.

Ironically, the benchmark for determining farm viability --farm size-- has changed over time; during the 1960s and 1970s, expansion and mechanisation were considered the solution to remain competitive with non-farm incomes. However, in the 1980s, the high debt loads from capital and land purchases reduced farm profitability and decreased returns to capital-intensive investment. Thus many farms once thought to be viable by the criteria set in the 1970s were exposed as not viable in the financial crisis of the 1980s.

Farmers themselves seem to view consolidation of farms as a rational economic reaction capturing economies of scale. For instance, Moll (1988) reports that of 55 farmers surveyed in Bredasdorp and Malmesbury regions who had bought land during the previous decade, 35 (or 64%) indicated that they had done so partly to take advantage of size economies.

De Klerk (1991) attributes the process of farm consolidation to technical change, *viz.* mechanisation. Consolidation has generally also caused a reduction in farm employment, because the new mechanised farm did not need to employ of the workers from the more labour-intensive smaller farms that were acquired. While seasonal workers bore the brunt of mechanisation, permanent workers were most directly affected by consolidation (De Klerk, 1985).

Sartorius von Bach, Koch and Van Zyl (1992) constructed an index of managerial ability based on indicators such as budgeting and the keeping of records and found it to be highly correlated with both farm size and total farm income. By evaluating Cobb-Douglas production function coefficients with the managerial ability index included as an input, the authors found significantly increasing returns to scale among 34 farmers in Vaalharts Irrigation Area. When managerial ability is excluded from the regression, however, results indicate constant returns to size. These results are confirmed by Van Schalkwyk, Van Zyl and Sartorius von Bach (1993) using non-parametric procedures to analyse the same sample and adjusting land size for quality differences. The same patterns hold true for a sample of 100 farmers in North-eastern Orange Free State.

Groenewald (1991) suggests that even beyond the indivisibility of capital and managerial inputs, economies of scale may result from scale efficiencies induced by the existing agricultural marketing system through volume discounts on the purchase of inputs and volume premiums on the sale of outputs. However, he ascribes most of the perceived economies of scale to management, with larger farms having better managers.

Roth, *et al.* (1992) econometrically tested a number of models explaining the reduction in the number of farms between 1972 and 1988. They found the number of farms to be positively correlated with the ratio of real machinery costs to real gross revenue, but negatively correlated with the ratio of farm requisites (mainly non-labour inputs) to output prices. This suggests that scale efficiencies in agriculture are strongly associated with a decline in machinery cost and an increase in the profitability of non-labour inputs. Both correlations suggest that the appearance of scale efficiencies in South African agriculture is rooted in the policy distortions that led to the reduction of the real cost of capital in the agricultural sector.

Chavas and Van Zyl (1993), using non-parametric analysis and accounting for quality differences in land, found a highly significant negative correlation between farm size efficiencies and debt burden, while size efficiency and managerial ability were positively correlated. The results show that the issue of scale efficiency is a complex one and is influenced by a variety of factors, of which managerial ability—the basic indivisible input in agriculture—seem to be dominant. A whole range of farm sizes both extensive and intensive commercial farming, was found to be scale efficient, depending on how farmers organise their specific variable and fixed input mix, as well as the combination of outputs they produce. Their results are consistent with the findings of Sartorius von Bach and Van Zyl (1992), who conclude that better managers have larger farms. It should be noted, however, that small farms will in general require less sophisticated management than large farms, which would explain why Chavas and Van Zyl (1993) found efficient farms in all size categories. On the other hand, these results can be interpreted to mean that farm size is not really the central, but rather managerial ability.

*Synopsis*

The evidence on the farm size-efficiency relationship in South African agriculture is mixed. However, much of the evidence on scale efficiencies in South African of farms, and in some cases inappropriate analytical methods and measurement variables were used.

## 4. Economies of scale in commercial agriculture

As noted above, the majority of the previous studies on the farm size-efficiency relationship in South Africa are flawed due to a variety of reasons, and the results are therefore not reliable. In particular, the studies generally suffer from the following shortcomings: only a minority of the studies adjust farm size for quality differences in land and other inputs; most of the studies use physical yields of specific crops or the value of agricultural output per unit of operated area , both imperfect (and at best only partial) measures of efficiency; differences in operational holding size and ownership holding size are sometimes not accounted for; and managerial inputs from the farmer and his/her family, and family labour, have not been included.[5]

In this section, total factor productivity differences between small and large farms are determined.

The data used in these analyses come from farm surveys conducted by the Department of Agriculture's Directorate of Agricultural Economics over the period 1974/75 to 1990/91. Farm surveys, covering a representative sample of between 65 and 85 individual farmers, were conducted in each of the six major grain production areas of South Africa. Two regions were surveyed per annum, implying that each region was surveyed every three years. These six areas involve rainfed agriculture; subsequently, an irrigation area was also included in the analysis. The regions included in the analysis are representative of the relatively medium and high potential agricultural areas of South Africa, excluding perennial crops. More than 80 percent of all maize, wheat and other grain are produced in these areas, while livestock (dairying, beef cattle and woollen sheep) is also important in most areas. Table 1 provides more information on the surveys included in the analyses. They were selected to represent all the regions; poor, normal and good rainfall years; thus, selected years during the period 1974 to 1991.

The data from these surveys specifically allow for the elimination of the problems with previous studies. In particular, farm size is adjusted for differences in land

**Table 1: Surveys included in the farm size-efficiency analyses of commercial farming**

| Region | Type of Farming (Predominant) | Year Covered by Survey | Number of Farmers Surveyed |
|---|---|---|---|
| Eastern Free State | Summer-rainfall (mixed): maize, wheat, cattle, sheep | 1979/80<br>1982/83<br>1985/86<br>1988/89 | 92<br>83<br>76<br>72 |
| Transvaal Highveld | Summer-rainfall (mixed): maize, sorghum, cattle, sheep | 1974/75<br>1983/84 | 71<br>77 |
| Western Transvaal | Summer-rainfall (grain): maize, sunflower, cattle | 1981/82 | 78 |
| North-western Free State | Summer-rainfall (grain): maize, wheat, sorghum | 1979/80 | 87 |
| Ruens | Winter-rainfall (mixed): Wheat, sheep, dairying | 1978/79<br>1987/88 | 69<br>77 |
| Swartland | Winter-rainfall (mixed) Wheat, sheep, dairying, beef | 1983/84 | 82 |

quality within regions by using land value to normalise areas; differences in operational holding size and ownership holding size are incorporated into the analysis; and family labour is considered. Another important point is that, within a specific region, all farmers essentially face the same prices because they buy from the same input suppliers and output markets for most commodities were controlled. This implies that monetary values of outputs and inputs (revenues and costs in the relevant categories) can be treated as quality adjusted quantities[6], which greatly enhances the reliability of the analysis as it also normalises input and output quantities by eliminating the effect of quality differences. The opportunity cost approach was used to derive the value of family labour.

All analyses were conducted separately for each region/survey. Because the analysis implicitly neglects possible production uncertainty (for example due to weather effects), the underlying assumption is that all farmers within each survey face similar production uncertainty. This seems to be appropriate given that the analysis is conducted for a given production year and one relatively homogeneous region at a time.

Table 2 provides a summary of the size characteristics of the farms in each of the surveys. From this information it is clear that the surveys cover a relatively large range of farm sizes. While relatively small farms are also part of the data set, the average farm size indicates that the farms are in general large, specifically relative to world standards. The median farm size is smaller than the average in all the data sets, indicating a positively skewed size distribution.

The final data for each farm in the different samples involve inputs and outputs. These were aggregated to give two output series -- crops and livestock -- and seven input series --land, buildings, livestock and machinery represented the stock inputs, while labour, management (including family labour) and variable inputs[7] represented flows. All quantity measurements used in the analysis were annual flow variables. The stock variables were transformed into flow variables by calculating the equivalent annuities based on the relevant interest rate for that period and region, the average useful life of the particular assets, and the applicable tax rate.[8] Thus, the analysis presented below measures all inputs and outputs as annual flows expressed in monetary values.

*Total Factor Productivity by Farm Size Category*

Total factor productivity (TFP) for different farm size categories is clearly a superior indicator of the farm size-efficiency relationship when compared to partial indicators, such as physical output or value of agricultural output per unit of operated area, as it fully accounts for differences in labour and input use. In this sub-section, TFP values for different farm size categories are compared for each of the surveys in Table 1. The Tornquist-Theil Index was used to calculate the comparative TFP index, while the farm with the highest TFP --the most efficient farm-- was used as reference point in these calculations.[9] The methodology in constructing the TFP index is described in detail in Thirtle, *et al.* (1993). Table 3 presents the results.

Both the results on total factor productivity and the labour/machinery ratio per farm size category are enlightening when considering land reform (Table 3). Within the sample of relative large commercial farms, covering a range of farms sizes which all depend heavily on hired labour, the results are clear:

- It establishes that the negative relationship between farm size and efficiency also applies to South African commercial farming areas, in spite of a history of distortions and privileges to these farmers which particularly benefited the larger ones. Without exception, the relative TFP index of the smallest third farms is higher than that of the largest third farms. Efficiency gains are highest in the Eastern Free State for 1988/89 and 1985/86, where the small farms performed respectively 29 percent and 19 percent better than the large farms, and the Ruens for 1987/88, where small farms fared 28 percent better. While these differences are in most cases not statistically significant at the 10 percent level (with the exception of the three cases cited above) due to the wide variation of results between farms within a particular region, smaller farms are in general more efficient than larger farms.

- Furthermore, it seems that this negative relationship became more accentuated after 1985, when the movement towards the removal of distortions and abolishment of privileges to larger farms started taking effect. The three data sets covering the period after 1985 all yielded statistically significant differences (at the 10

**Table 2: Summary of the size characteristics of farms analysed (adjusted ha)**

| Region | Year | Farm Size Characteristics (ha) - Adjusted for quality differences | | | |
|---|---|---|---|---|---|
| | | Average | Median | Maximum | Minimum |
| Eastern Free State | 1988/89 | 993.2 | 763.0 | 3418 | 32 |
| | 1985/86 | 1375.4 | 943.7 | 9221 | 108 |
| | 1982/83 | 1154.8 | 885.5 | 4287 | 41 |
| | 1979/80 | 1019.5 | 860.4 | 2504 | 162 |
| Transvaal Highveld | 1983/84 | 1101.2 | 933.7 | 3394 | 178 |
| | 1974/75 | 663.4 | 464.9 | 3716 | 107 |
| North-western Free State | 1979/80 | 865.4 | 767.8 | 2355 | 158 |
| Western Transvaal | 1981/82 | 474.6 | 361.5 | 1461 | 118 |
| Ruens | 1987/88 | 1501.0 | 1167.3 | 6638 | 230 |
| | 1978/79 | 1435.3 | 1054.2 | 4706 | 187 |
| Swartland | 1983/84 | 793.4 | 704.5 | 2675 | 259 |

**Table 3: Relative total factor productivity and labour/machinery indices for different farm size categories***

| Region | Year | Total Factor Productivity** | | | Labour/Machinery Ratio** | | |
|---|---|---|---|---|---|---|---|
| | | Small | Medium | Large | Small | Medium | Large |
| Eastern Free State | 1988/89 | 129 | 126 | 100 | 192 | 113 | 100 |
| | 1985/86 | 115 | 107 | 100 | 136 | 116 | 100 |
| | 1982/83 | 104 | 101 | 100 | 115 | 106 | 100 |
| | 1979/80 | 102 | 99 | 100 | 129 | 98 | 100 |
| Transvaal Highveld | 1983/84 | 111 | 104 | 100 | 138 | 128 | 100 |
| | 1974/75 | 113 | 110 | 100 | 115 | 110 | 100 |
| North-western Free State | 1979/80 | 117 | 111 | 100 | 135 | 95 | 100 |
| Western Transvaal | 1981/82 | 103 | 91 | 100 | 122 | 91 | 100 |
| Ruens | 1987/88 | 128 | 110 | 100 | 125 | 97 | 100 |
| | 1978/79 | 112 | 110 | 100 | 132 | 92 | 100 |
| Swartland | 1983/84 | 106 | 102 | 100 | 118 | 104 | 100 |

Notes: * Three farm size categories were defined for each data set: small represents the smallest third of the farms; medium represent the middle third of the farms; and large represents the largest third of the farms.

** TFP index and labour capital ratio of large farms are the norms (100) against which the other size categories were compared.

percent level) in efficiency between small and large farms, while all the data sets covering farm operations before 1985 yielded statistically insignificant differences (at the 10 percent level).

This aspect needs further investigation to fully confirm these observations. However, the result is fully compatible with prior expectations

- Smaller farms consistently have a higher labour/machinery ratio than larger farms in all the areas for all the periods covered, indicating that they are relatively more labour intensive. Differences between these ratios are statistically significant between small and large farms for most of the areas at the 10 percent level of significance (with Eastern Free State in 1982/83, Transvaal Highveld in 1974/75, and Swartland in 1983/84, being the exceptions).

The conclusion thus is that, in general, smaller farms are not only more efficient than their larger counterparts, but are also relatively more labour intensive in their mode of production. However, these general results derived from averages within groups mask the wide variability between specific farms. Using market prices to measure productivity assesses differences in private efficiency, while the use of social opportunity costs as a measure eliminates the impact of distortion and measures differences in social efficiency. Few studies, none of them in South Africa, has made this distinction in the analysis of the farm size-efficiency relationship. During the period under consideration, the price of capital was distorted by several factors, including tax benefits and interest rate subsidies. This contributed, amongst other things, to over-capitalisation of specifically larger farms (see table 3). On the other hand, output prices were also distorted due to protection and market price support.[10] Most of these privileges went to relatively large farms. Accounting for these distortions is thus important when looking at farm structure and production relations from a social point of view.

Social efficiency estimates were calculated for four of the data sets analysed above, namely Eastern Free State (1988/89) and Ruens (1987/88), as well as Western Transvaal (1981/82) and Eastern Free State (1979/80). These four surveys respectively represent those with the two largest differences and two smallest differences in average TFP between small and large farms in Table 3. Alternatively, they can also be regarded as representative of the beginning and the end of the decade of the 1980s – thus pre-reform and just after the

**Table 4: Social relative total factor productivity for different farm size categories***

| Region | Year | Average Social/Private TFP ratio | Social Total Factor Productivity** | | |
|---|---|---|---|---|---|
| | | | Small | Medium | Large |
| Eastern Free State | 1988/89 | 0.86 | 138 | 133 | 100 |
| Ruens | 1987/88 | 0.91 | 135 | 108 | 100 |
| Western Transvaal | 1981/82 | 0.78 | 118 | 85 | 100 |
| Eastern Free State | 1979/80 | 0.75 | 121 | 97 | 100 |

Notes: * Three farm size categories were defined for each data set: small represents the smallest third of the farms; medium represent the middle third of the farms; and large represents the largest third of the farms.

** TFP index and labour capital ratio of large farms are the norms (100) against which the other size categories were compared.

first reforms started taking effect. They are also representative of all the areas in the analysis.[11] Social opportunity costs for capital, labour, variable farm inputs and farm outputs (both crops and livestock) were obtained from previous studies and were incorporated into the analysis. The TFP analysis of each farm was repeated using these social opportunity costs rather than the actual private costs. The results of these social efficiency estimates are summarised in Table 4.

The results from the social TFP analysis should be interpreted with care. Farmers react to the incentive structure facing them, and if capital are relatively cheaper, they should use more of it, and vice versa. For this reason the social TFP calculations are more indicative of the distortions than the actual social costs or efficiency losses. Strictly, changing the values from private to social prices does nothing to the physical input and output ratio, and TFP stays essentially the same, although the weighting of the inputs and outputs change. However, the point here is to determine to what an extent farm size influences the farmer's ability to capture benefits and use the structure of incentives. The results obtained from the social TFP analyses, which are summarised in Table 4, indicate that:

- Average social TFP is lower than average private TFP in all the regions. The difference is much more accentuated at the beginning of the 1980s than later in the decade when some of the privileges were already removed. The reason for this is that because all farmers face the same prices, the value of outputs and inputs can be treated as quality adjusted quantities. While these differences are meaningless in terms of efficiency, they indicate to what an extent policies have been distorted.

- Larger farms are less efficient relative to smaller farms when social opportunity costs are used to determine the value of output instead of actual market prices. The reason for this stems mainly from the differences in the relative importance of labour and capital in the input mix of large and small farms (see Table 3). The value of output of small and large farms are generally affected in a similar manner because the ratio of livestock to crops does not differ significantly between these groups, but the input mix varies considerably, with large farms being relatively more capital intensive and small farms being relatively more labour intensive. Because the social opportunity cost of labour is lower than the actual wage rate (due to massive rural unemployment), and the higher social opportunity cost for capital than the subsidised prices farmers face, the total value of inputs increase more for large farms than for small farms.

- The positive effects of removal of distortions on small farms (or negative effects on large farms) are relatively greater where the distortions have been large. For example, the analysis show that small farms gain more in relative efficiency (compared to the private analysis in Table 3) under such situations.

## 5. Explaining the results : Policy, technology and management

The different analyses of the farm size-efficiency relationship in the grain producing areas (which represent approximately 60% of all cultivate areas) in South Africa yield consistent and complementary results from which it can be concluded that:[11]

- There is an inverse relationship between farm size and efficiency in the commercial farming areas for the range of farms analysed, regardless of the methodology used.

- This inverse relationship in commercial farming seems to become stronger and more accentuated as policy distortions, which largely favour large farms relative to smaller farms, are removed.

- Large farms use relatively more capital intensive methods of production, while smaller farms are more labour intensive.

From these results it is clear that the policy framework is crucial as it has an important impact on the farm size-efficiency relationship. However, even in South Africa where a small group of large commercial farmers have captured most of the benefits from the extremely distorted policy regime which heavily supported them, these were not enough to off-set the disadvantages brought about by higher labour supervision costs and transaction costs associated with labour, and imperfect labour markets. In addition, for the range of commercial farms analysed, advantages large farms have in access to inputs, credit, services, marketing and distribution opportunities were also negated. The conclusion is that even a policy environment favouring large farms over small ones, resulting in huge social opportunity costs, was not enough to make large farms more efficient than relative smaller farms.

These results apply to the existing technologies used on South African farms. These technologies essentially originated in the United States, where labour is relatively expensive and capital abundant, and were adapted to the local situation (Van Zyl and Groenewald, 1987; Van Zyl, *et. al*, 1987). In addition, research and extension concentrated on encouraged the adoption of such technologies, many of which are inappropriate given South Africa's factor endowment. The argument is that small farms, even smaller than the range of farm sizes evaluated in the analyses presented in this paper, will be even more efficient than larger farms if there were more appropriate technologies available, these technologies were properly supported by research and extension, and the policy environment in general was more friendly towards small farmers.

Finally, the results provide some insights on how to think about the farm size-efficiency relationship in general. It supports the idea that economies of scale arise because of missing or imperfect markets, or distortions and pecuniary economies favouring large farms over small farms. It shows, however, that the costs

associated with labour supervision, and other labour-related transaction costs, are huge, and outweigh many of the advantages of being large. Even in the South African commercial farm sector, where relatively larger farms have benefited substantially more from a comprehensive range of policies and privileges, it was not enough to compensate for these costs, and an inverse farm size-efficiency relationship is observed. However, markets do exist in these areas and they function fairly well, for even the smaller commercial farmers. On the other hand, where they are missing or imperfect, for example in the homelands where the situation is further compounded by a lack of support systems and infrastructure, small farms are less efficient than the larger farms, although all farms are relative small due to over-population and often extreme fragmentation of use-rights.[12]

The farm size-efficiency relationship thus seems to be determined by the relative importance of the factors benefiting smaller farms and those benefiting larger farms. On the balance, how these factors impact on the relationship, and the net outcome of their effects, are influenced by several factors, both individually and together. These include the production relations and technology utilised on the farms, relative factor endowment facing the broader society and managerial ability of the farm manager. For example, managerial ability seems to be have a smaller impact where there are other factors which are more restrictive, or where there are no alternative technologies available. In addition, in an economy where the factor endowment (and relative prices) favour the use of labour, farm size should be smaller because the disadvantages of using labour kick in at smaller farm sizes. Thus, production relations and factor endowment (which includes management) together determines the impact of pecuniary economies and distortions on farm size-efficiency the one hand, and supervision and transaction costs associated with labour on the other.

These findings have specific implications for land reform. The inverse farm size-efficiency relationship, which is also present in South African agriculture despite a history of policies favouring relatively large mechanised farms, implies that significant efficiency gains can be made if farm sizes in the commercial sector become smaller. An important element in such a process would be the removal of all policies and distortions favouring larger farms relative to smaller farms. The basic principle should be to make markets work by removing distortions and privileges favouring large farmers, and creating markets to service small farmers in areas where they are missing without entrenching new privileges. Imperfect markets should be made to work better.

Although the efficiency argument cannot be a judge of the present distribution of land rights given the history of how these rights were acquired,[13] it does provide a powerful argument for some restructuring in the farm sector in light of the inverse farm size-efficiency relationship observed in South African commercial agriculture. However, a precondition is the removal of all privileges to the farm sector as they tend to favour large farms over smaller ones, as well as the addressing of missing and imperfect markets for small farmers. Thus, the playing field should be levelled.

**Notes:**

1. A more detailed version of this address can be found in Van Zyl *et al.* (1996).

2. This section is based on the work of Binswanger *et al.* (1993) and Van Zyl (1996).

3. Under certain circumstances, such as those in South Africa, there are external economies of scale (Johnson & Ruttan, 1994). It occurs when, as firms or farms increase in size, they experience advantages in terms of access to inputs, credit, services, storage facilities, or marketing and distribution opportunities relative to smaller farms. This gives large farms real advantages relative to small farms due to pecuniary economies or policy distortions rather than to greater efficiency. On the other hand, diseconomies of scale may also occur, for example when the labour market fails or do not exist, when transaction costs in the labour market are high, or when the effort of hired labour is significantly affected by supervision (De Janvry, 1987).

4. Moll (1988) measures economies of size (all factors but operator labour changing) as opposed to economies of scale (all factors changing).

5. See Binswanger, *et al.* (1993) for a discussion of these problems, as well as appropriate measures of farm size efficiency.

6. This amounts to assuming that the corresponding implicit price indexes are unity. This approach has the advantage of being empirically tractable. Although it allows for price variation across years and areas, it has the disadvantage of neglecting price variations across farms within any particular survey. While the intuition is that these variations are small or even negligible, they cannot be ruled out. The "rule of one price" (Chavas and Aliber, 1993) does, for example, not take into account different transaction costs or market failures. However, the assumption that all farmers within a survey face the same prices seem to reasonable given the nature of the farm support system in these areas. An additional, but related point is that the "rule of one price" implicitly accounts for commodities which are not of homogeneous quality. Different farmers may face different prices because they purchase inputs or sell outputs of different quality. By using the monetary values of input and output as quantities, there is an adjustment for these quality differences, with and implicit assumption that the markets work fairly well.

7. Variable inputs represented all the other inputs, including seed, fertiliser, purchased animal feed, chemicals, etc.

8. To convert the stocks, namely land, buildings, livestock and machinery, into annual flows, discount rates for these inputs based on the economic rate of depreciation (5 years for machinery and 20 years for buildings), the national price indices, the interest rate on the relevant annuities and the pertinent tax rate were calculated and multiplied by the market value of each asset.

9. See Ball, Bureau and Butault (1994) for a review of the properties and recommendations on the selection of different index numbers based on the axiomatic and economic approaches. Following from this, the Tornquist-Theil methodology is appropriate for this analysis.

10. See Kirsten and Van Zyl (1996) for a synopsis of these policies and their effects.

11. See for example, Helm and Van Zyl (1994), Van Heerden and Van Zyl (1992) and Meyer and Van Zyl (1993).

12. See Piesse *et al.* (1995) for a detailed analysis of size-efficiencies in homeland agriculture.

13. See Van Zyl (1996) for a summary of the arguments presented by Bromley (1989), Calabresi (1991) and Schmid (1987; 1992; 1994) in this respect.

**References**

BALL, V.E., BUREAU, J.C., & BUTAULT, J.-P. (1994). Intercountry comparisons of prices and real values. Unpublished Paper, Economic Research Service, USDA, Washington, D.C.

BERRY, R.A. & CLINE, W.R. (1979). Agrarian structure and productivity in developing countries. Baltimore, Johns Hopkins University Press.

BINSWANGER, H.P., DEININGER, K. & FEDER, G. (1993). Power, distortions, revolt and reform in agricultural land relations. Discussion Paper, World Bank, Washington, D.C. (forthcoming in: Srinivasan, T.N. and J. Behrman (Eds.). Handbook of development economics, Vol III).

BINSWANGER, H.P. & ELGIN, M. (1992). What are the prospects for land reform? In: Maunder, A. and Valdes, A. (Eds.). Agriculture and governments in an interdependent world. Buenos Aires, International Association of Agricultural Economists.

BINSWANGER, H.P & KINSEY, B. (1993). Characteristics and performance of resettlement programs : A Review. World Development, Vol 21(9):1477-1494.

BINSWANGER, H.P.& ROSENZWEIG, M.R. (1986). Behavioral and material determinants of production relations in agriculture. Journal of Development Studies, Vol 22(3):503-539.

BREWSTER, J.M. (1950). The machine process in agriculture and industry. Journal of Farm Economics, Vol 32(1):69-81.

BROMLEY, D. (1989). Economic interests and institutions. New York : Basil Blackwell.

CALABRESI, G. (1991). The pointlessness of Pareto: Carrying coase further. Yale Law Journal, Vol 100:1211-1237.

CARTER (1994 ). Sequencing capital and land market reforms for broadly based growth. Paper No. 379, Department of Agricultural Economics, University of Wisconsin.

CARTER, M.R. & KALFAYAN, J. (1989). A general equilibrium exploration of the agrarian question. Unpublished Research Paper, Department of Agricultural Economics, University of Wisconsin.

CHAVAS, J-P. & ALIBER, M. (1993). An analysis of economic efficiency in agriculture: A nonparametric approach. Journal of Agricultural Resource Economics, Vol 18(1):1-16.

CHAVAS, J-P. & VAN ZYL, J. (1993). Scale-efficiency in South African grain production : A non-parametric analysis. Unpublished Research Paper, World Bank, Washington, D.C.

CSS (1993). Census of agriculture, 1988. Central Statistical Services, Government Printer, Pretoria.

DE JANVRY, A. (1987). Farm structure, productivity and poverty. Working Paper No. 432, Department of Agricultural and Resource Economics, University of California, Berkeley.

DE KLERK, M. (1985). Technological change and employment in South African agriculture: The case of maize harvesting in the Western Transvaal, 1968-1981. Unpublished MA Economics dissertation, University of Cape Town.

DE KLERK, M. (1991). The accumulation crisis in agriculture. In: Gelb, S. (Ed.) South Africa's Economic Crisis. David Philip, Cape Town.

FEDER, G. (1985). The relation between farm size and productivity : The role of family labour, supervision, and credit constraints. Journal of Development Economics, Vol 18:297-313.

GROENEWALD, J.A. (1991). Returns to size and structure of agriculture: A suggested interpretation. Development Southern Africa, Vol 8(3):329-342.

HATTINGH, H.S. (1986). The skew distribution of income in agriculture. Agricultural Outlook Conference. February 1986, Pretoria.

HAYAMI, J. & RUTTAN, V.W. (1985). Agricultural development : An international perspective. Johns Hopkins University Press, Baltimore.

HELM, W.E. & VAN ZYL, J. (1994). Quantifying agricultural support in South Africa. Agrekon, Vol 33(4).213-219.

JOHNSON, N.L. & RUTTAN, V.W. (1994). Why are farms so small? World Development, Vol 22(5):691-706.

KIRSTEN, J.F. & VAN ZYL, J. (1996). The contemporary policy environment: Undoing the legacy of the past. In: Van Zyl, J., Kirsten, J.F. and Binswanger, H.P. (Eds.) Agricultural Land Reform in South Africa Policies, Markets and Mechanisms. Oxford University Press, Cape Town (forthcoming).

MEYER, N.G. & VAN ZYL, J. (1993). Comparative advantages in Region G : An application of a sectoral linear programming model. Agrekon, Vol 31(4):307-312.

MOLL, P.G. (1988). Economies of size in 'White' South Africa : Implications for land reform. Unpublished Research Paper, University of Cape Town.

PETERSON, W. & KISLEV, Y. (1991). Economies of scale in agriculture : A re-examination of the evidence. Staff Paper P91-43, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul.

PIESSE, J., SARTORIUS VON BACH, H., THIRTLE, C. & VAN ZYL, J., (forthcoming). Agricultural efficiency in the Northern Transvaal homelands, Journal of International Development.

PROSTERMAN, R.L. & RIEDINGER, J.M. (1987). Land reform and democratic development. Baltimore and London, The Johns Hopkins University Press.

ROTH, M., DOLNY, H. & WIEBE, K. (1992). Employment, efficiency and land markets in South Africa's agricultural sector: Opportunities for land policy reform. Unpublished review paper, Land Tenure Centre, University of Wisconsin.

RSA (1994). Abstract of agricultural statistics, 1994. Department of Agriculture, Republic of South Africa, Pretoria.

SARTORIUS VON BACH, H.J. & VAN ZYL, J. (1992). Comment: Returns to size and structure of agriculture - A suggested interpretation. Development Southern Africa, Vol 9(1):75-79.

SARTORIUS VON BACH, H.J., KOCH, B.H. & VAN ZYL, J. (1992). Relating perceptions and associated economic criteria to economic survival in commercial dryland farming in South Africa. Agrekon, Vol 31(4):210-215.

SCHMID, A.A. (1987). Property, power and public choice. New York, Praeger.

SCHMID, A.A. (1992). Legal foundations of the market: Implications for formerly Socialist Countries of Eastern Europe and Africa. Journal of Economic Issues, Vol 26:707-732.

SCHMID, A.A. (1994). Institutional law and economics. European Journal of Law and Economics, Vol 1:33-51.

THIRTLE, C., SARTORIUS VON BACH, H.J. & VAN ZYL, J. (1993). Total factor productivity growth in South African agriculture, 1947-1991. Development Southern Africa, Vol 10(3):301-318.

VAN HEERDEN, W.R. & VAN ZYL, J. (1992). The aggregate measure of support for maize in South Africa. Unpublished Research Paper, University of Pretoria, Pretoria.

VAN SCHALKWYK, H.D., VAN ZYL, J. & SARTORIUS VON BACH, H.J. (1993). Management and returns to farm size: Results of a case study using parametric and non-parametric methodology to measure scale efficiencies. Agrekon, Vol 32(4):252-256.

VAN ZYL, J. (1995) The farm size-efficiency relationship in South African Agriculture. In: Van Zyl, J., Kirsten, J.F. and Binswanger, H.P. (Eds.) Agricultural land reform in South Africa : Policies, markets and mechanisms. Oxford University Press, Cape Town (forthcoming).

VAN ZYL, J., KIRSTEN, J.F.& BINSWANGER, H.P. (Eds.) (1996) Policies, markets and mechanisms for agricultural land reform in South Africa. Oxford University Press, Cape Town (forthcoming).

VAN ZYL, J., FENYES, T.I. & VINK, N. (1987). Labour-related structural trends in South African maize production. Agricultural Economics, Vol 1(3):241-258.

VAN ZYL, J. & GROENEWALD, J.A. (1987). Economical farm technology for different levels of managerial ability : The case of maize cultivar selection. Quarterly Journal of International Agriculture, Vol 26(1):46-57.

WORLD BANK (1983). Kenya: growth and structural change. Basic Economic Report, Africa Region, Washington, D.C.

WORLD BANK (1994). South African agriculture: Structure, performance and options for the future. Discussion Paper 6, Informal Discussion Papers on Aspects of The Economy of South Africa, Southern African Department, The World Bank, Washington, D.C.