COMPARISONS OF THE TRENDS IN SUGAR YIELDS IN LEADING BEET AND CANE PRODUCING COUNTRIES

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Abstract

This paper analyses the technological advances which have taken place on both the field and factory sides of sugar production in the past 30 years. It focuses on three leading sugar producers; Australia, France and South Africa. It finds that the greatest technological gains have been made in the beet sector (France). All three countries have improved the efficiency of their factory operations and it is unlikely that further significant gains can be made in these areas. The greatest differences between these countries lie in the performance of their field operations. The French industry has made great strides in beet yields, while advances in cane yields, by comparison, have been unimpressive. The paper concludes that one important reason for the difference between the field performances of the beet and cane sectors is the ownership of seed research and development (R&D) in the two sectors. Beet seed R&D is typically undertaken by private companies, while cane R&D is carried out by public bodies which are sponsored by the cane industry.

Introduction

During the past 30 years there have been considerable technological advances on both the field and factory sides of sugar production. Technical progress in the beet sector during this period has far outstripped the gains achieved by the cane industry. Indeed, sugar yields in the most efficient beet producing regions now rival those in the most efficient cane growing regions. Until recently, it used to be considered to be virtually a law of nature that efficient cane producers enjoyed much higher yields of recovered sugar per hectare than their beet counterparts, and that this was translated into lower costs of production. After the advances made by the European Community (EC) since the 1960s, this view is very hard to sustain.

This paper analyses the changes in sugar yields in three of the most dynamic and efficient sugar industries in the world, two of which are cane based – Australia (Queensland) and South Africa, and one of which is beet based – France. The analysis focuses on the changes which have taken place in the field and factory and considers the developments in technology and farming/factory practice which have been largely responsible.

Discussion

The starting point for this analysis is to determine the trend in aggregate sugar yields in the three featured countries. The next step is to divide this broad measure into its component parts: agronomic (field) yields and final (factory) recoveries. This analysis is carried out for sugar yields per harvested area (i.e. excluding immature plant cane), as well as per cultivated area, with surprisingly different results.

Sugar yield

The most common measure of aggregate sugar yield is the quantity of sugar which is produced per hectare of harvested beet or cane. Throughout this paper, sugar yields refer to the amount of recovered sugar per hectare and, thus, include a measure of the intrinsic (sucrose) content of the cane or beet in addition to a measure of the efficiency of the factory in recovering that sugar. For France, sugar output is expressed in 96° pol; for Australia it is expressed in 94 net titre; and for South Africa it is tel quel. For comparative purposes the measures of 94 net titre and 96° pol are broadly similar. In the case of the tel quel basis used for South Africa there should be some upward adjustment to reflect the fact that throughout this period most of the sugar supplied by South Africa has been white. Figure 1 compares sugar yields in Australia, South Africa and France since 1960 using a five year moving average of yields. (Five year moving averages are used to iron out year-to-year fluctuations caused by climatic variation). The most striking feature of Figure 1 is the strong upward trend in French beet sugar yields, which contrasts sharply with the stagnant, and even downward, trend in cane sugar yields.

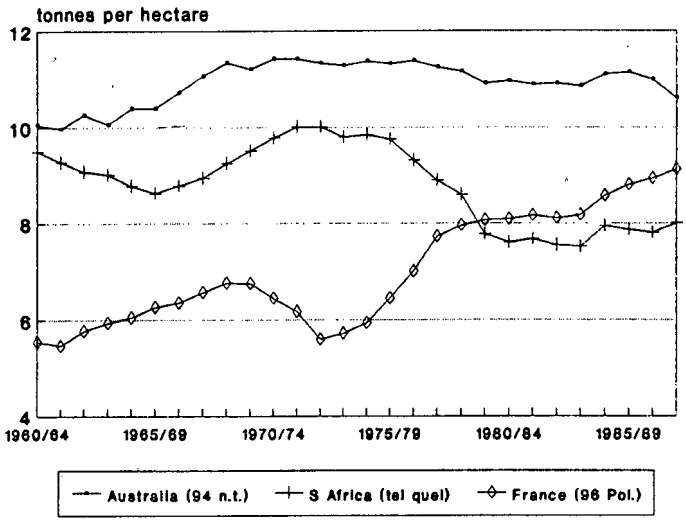

FIGURE 1 Recovered Sugar per Harvested Hectare 5-Year Moving Average: 1960/64 to 1986/90 Crop Years

Between 1960/64 and 1986/90, sugar yields in France rose by a remarkable 61%, from 5,6 to 9,0 tonnes per harvested hectare. (The dip in the mid-1970s was caused by severe drought, which lowered both beet yields per hectare and the sugar content of beets). For most of this period, Australian yields hovered close to 11,0 tonnes per harvested hectare, although a discernable downward trend is evident since the mid-1970s. Meanwhile, South African yields fell to 8,0 tonnes per harvested hectare by the late 1970s, from close to 10,0 tonnes/ha at the beginning of the 1960s.

This stagnation in cane sugar yields is a relatively recent phenomenon. Immediately before the period shown in Figure 1, yields were on a rising trend. In Australia, the sugar yield averaged 8,3 tonnes per harvested hectare between 1950/1 and 1954/5. Ten years later this had risen to 10,2

tonnes per harvested hectare, an increase of over 22%. In South Africa, the gains made in sugar yields were even more impressive, rising by 36% during the same period.

The field and factory components of sugar yields

Overall yields of sugar per hectare depend upon both field and factory performance. Within both categories, significant advances have been recorded in some countries. In the case of field operations, the two key components of sugar yields are beet or cane yields (measured as tonnes of beet or cane/hectare) and beet or cane quality (measured as percent sucrose content). The development of new varieties, changes in cultivation practices and increased mechanisation have all influenced field performance although, as will be seen, not always to the advantage of yields.

Once the sugar crop is harvested, factory operations come into play, and the attention devoted to improving factory performance (measured as factory recovery rate) has been no less intense. The scope for massive changes may appear to be much smaller than in field operations, but sugar industries, particularly in more developed countries, have managed to make significant progress in reducing processing losses. (Higher recovery rates are not the only area of interest to processors. In order to improve processing economics, great attention has been devoted to the attainment of scale economies in factories, as well as to technological advances that reduce labour and energy use. This last component of factory operations has been of particular relevance to the beet industry, where all fuel has to be purchased).

The field and factory components of overall sugar yields cane be summarised as:

Sugar Yield = Beet or Cane Yield * Sucrose Content * Factory Recovery Rate

Developments in field operations

Field and factory performances can be separated, and are treated separately in this paper. Figure 2 summarises for each country the average annual percentage change in agricultural sugar yields and its two component parts, namely yields of cane or beet/ha and sucrose content. The data are limited to the period since 1965 because of the absence of data on the sucrose content of cane in Australia prior to that time. The annual average percentage changes are derived by fitting an exponential growth trend to the data.

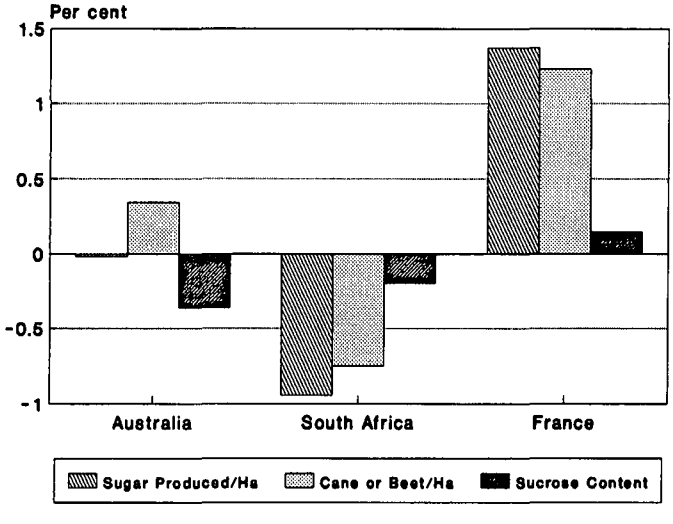

FIGURE 2 Percent change in agricultural yields per harvested hectare: average annual percentage change: 1960 to 1990 crop years

It is apparent from Figure 2 that the most dynamic component of agricultural sugar yields in the past 25 years has been beet and cane yields. In each case, the changes in beet and cane yields have far exceeded the change in sucrose content. Thus, it is beet and cane yields that have determined the direction, as well as the pace, of changes in overall sugar yields in each country.

The strong upward trend in French beet yields underpins the impressive gains in sugar yields, while in South Africa declining cane yields per harvested hectare have been the major factor behind falling sugar yields.

The increases in EC beet yields, and in sucrose content, are more creditable than they may appear to be at first sight, since they have occurred during the period when the industry was making the switch from multigerm to monogerm seeds. The primary motive behind developing these seeds was to remove the need for hand thinning of crops and so make mechanised planting easier. Although monogerm seeds cut down on labour costs, early varieties, introduced in the 1960s and early 1970s (when the fall in yields was compounded by a serious drought), were associated with a distinct drop in yields. However, it appears that improved crop establishment, better pest and weed control and the more judicious use of fertilizers have helped to offset this drawback. Furthermore, European beet seed companies have developed higher yielding monogerm seeds which have sustained the upward trend.

Returning to the cane sector, Figure 2 indicates that since the mid-1960s the yields of cane per hectare have not mirrored the strong upward trend that has occurred in the beet sector although, as with sugar yields, improvements up until the late 1960s were impressive. As with the development of monogerm beet seeds, not all efforts at developing new technology have been made with yield increases as a primary target. The reduction of labour costs was the main incentive behind the introduction of mechanical harvesting, but in many instances this has been achieved at the expense of cane yields, with significant cane tonnages being left behind in the fields. To the extent that producers have succeeded in offsetting the losses associated with the introduction of mechanical harvesting, their variety breeding programmes must be adjudged successful. However, it is almost 20 years since mechanical harvesting and loading became universal in Australia, and little further progress can be discerned in cane yields since then. Furthermore, increasing mechanisation has coincided with declining cane yields in South Africa.

As was stressed earlier, not all technological developments are aimed at raising yields; lowering costs is another key objective. Perhaps, therefore, by focusing on sugar yields alone one will miss the more important trends which are taking place. For example, by concentrating on sugar yields per harvested area, no account is taken of the considerable changes that have taken place in planting and ratooning practices in many cane industries to improve land utilisation. One important difference between beet and cane cultivation is that the former is an annual crop while the latter is a perennial crop. Thus, each year beet farmers harvest all the land which they dedicate to beets, while cane farmers must dedicate part of their cane area each year to immature plant cane. Since cane farmers incur a cost on non-harvested land, there is an incentive to minimise the area under immature plant cane. Not surprisingly, therefore, considerable attention has been paid to increasing the proportion of the total area which is harvested each year. This has certainly been the case in South Africa, and to a lesser extent Australia, since the early 1960s (Figure 3).

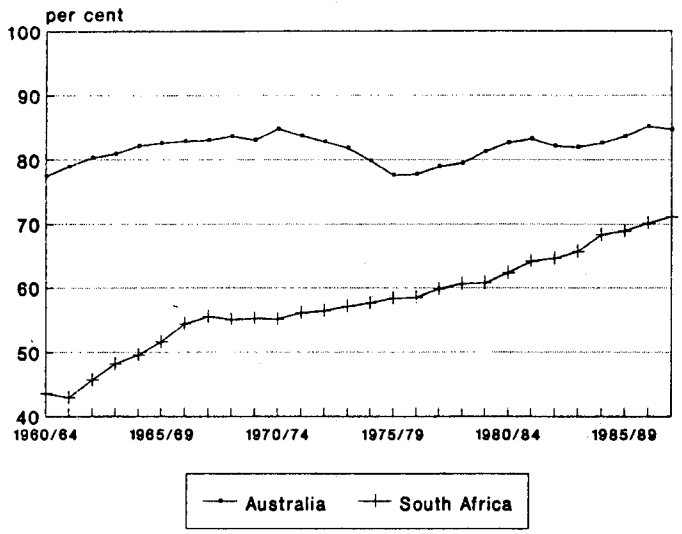

FIGURE 3 Percentage of cultivated area harvested 5-year moving average: 1960/64 to 1986/90 crop years

An increase in the proportion of cultivated land which is harvested each year can be achieved by two means. One is to reduce the average time between planting and harvesting plant cane; the other is by extending the average number of ratoons. However, both of these will tend to depress the sucrose content of the cane and the quantity of cane harvested per hectare unless advances in cane technology and farming practices are sufficiently great to offset this tendency. Harvesting immature plant cane within a year, rather than waiting the 18 months or so until it reaches maturity, reduces both the cane yield per hectare and the sucrose content of the cane. Furthermore, since the sucrose content of cane declines as the number of ratoons increases, lengthening the average number of ratoons also lowers the average quality of the cane crop. Thus, increasing the proportion of the cultivated area which is harvested each year will tend to depress average sugar yields per hectare.

Given the remarkable increase in the proportion of the total cane area harvested each year in South Africa in the past 25 years, it is hardly surprising that the yields in field operations have declined over this period. In Australia, the proportion of the cane area harvested each year has barely changed during this period and has not, therefore, had a significant impact on field operations. Thus, the virtual stagnation of yields in Australian field operations cannot be attributed primarily to changes in time between planting and harvesting plant cane, or the average length of ratoons. The improvement in yields in French field operations are attributable wholly to advancements in management and in seed technology.

It is evident from this discussion that the comparison of sugar yields presented above conceals a considerable change in farming practice in South Africa and, to a much more limited extent, in Australia. Arguably, therefore, one is not comparing like with like when comparing sugar yields on the basis of harvested area. Ideally, a comparison of technological change would be done by measuring sugar yields on the assumption that the time between planting and harvesting plant cane and the number of ratoons had been held constant.

In the absence of such hypothetical data, an alternative approach can be adopted. Instead of comparing yields per harvested hectare, they can be compared per cultivated hectare. While this still does not constitute a measurement of technological change in field operations, it does provide a basis for comparing the efficiency of land utilisation. As Figure 4 illustrates, this alternative measurement of yields dramatically alters the picture painted earlier. Although French sugar yields are unchanged (because the cultivated and harvested areas are the same), there is now a discernable upward trend in South African sugar yields. In Australia, this alternative measurement has minimal impact because of the negligible change which has taken place in the share of the cane area which is harvested each year.

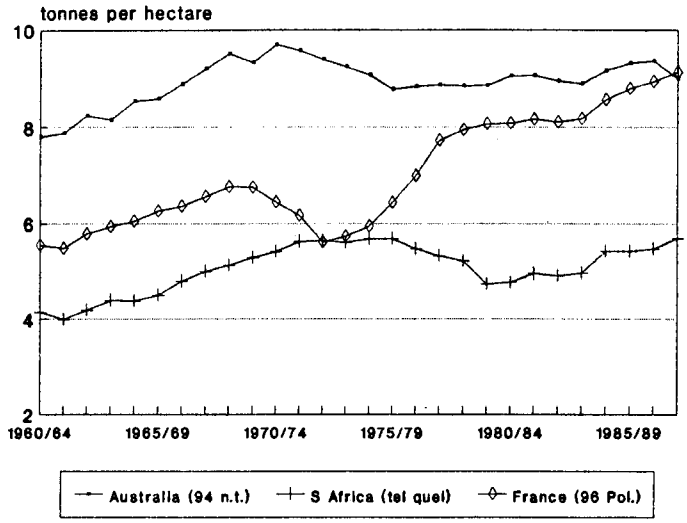

FIGURE 4 Recovered sugar per cultivated hectare 5-year moving average: 1960/64 to 1986/90 crop years

When sugar yields are compared on the basis of cultivated area, it transpires that French yields now match those of Australia and that both are significantly higher than in South Africa. However, the South African industry should derive some satisfaction from the fact that its sugar yields have risen over the past 30 years, and they are still rising.

As before, the trends in sugar yields can be divided into their component parts. These are depicted in Figure 5. The sucrose content has not changed from that shown in Figure 2 because its calculation is independent of the measurement of land area. Instead, all the change is in the other component: beet or cane output/ha.

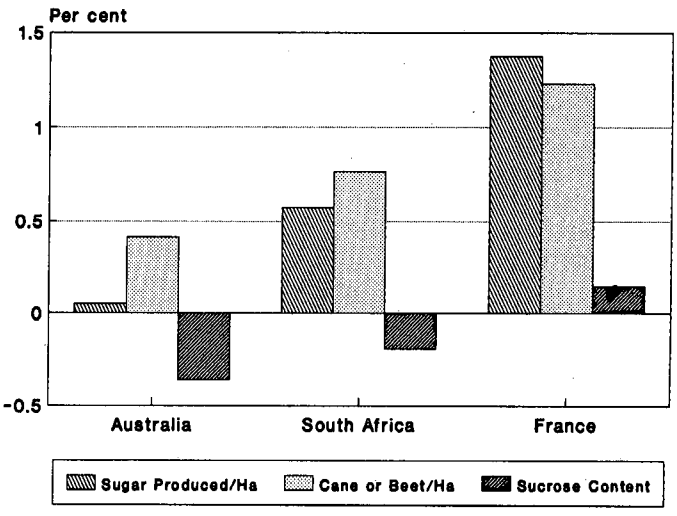

FIGURE 5 Percent change in agricultural yields per cultivated hectare: average annual percentage change: 1960 to 1990 crop years

The two most interesting results to emerge from this analysis concern South Africa. The first is that (agronomic) sugar yields per cultivated hectare have risen by 0,6%/year since 1965, compared with the fall of 0,9%/year when the yields are calculated per harvested hectare. The second is that this increase has been attributable principally to an increase in cane yields, although this has been at the expense of sucrose content. Overall, however, this change in farming practice has raised the output of sugar per hectare of cultivated land, despite the offsetting tendency caused by reducing the time between planting and harvesting plant cane.

Developments in factory operations

Turning to the processing of sugar crops, significant progress has been made in a number of areas by both the beet and cane industries. In contrast to field performances, the technical advances which have been made in factory operations are remarkably similar in all three countries, although the beet sector has again made the greatest strides (Figures 6 and 7).

French processors have achieved remarkable reductions in losses over the past twenty years, raising recorded recovery rates from an average of 88,7% in 1966-70 to their current level of approximately 92%. The efficiency of by-product operations in the beet sector has also been improved. The industry in France provides the most striking example of this, where efforts have concentrated upon upgrading pulp presses. This has resulted in a significant reduction in beet pulp water content.

Within the cane sector, millers in Australia have been particularly successful in reducing losses, and have raised recovery rates from an average of 88,5% in 1966-70 to approximately 90% today. Over the same period the South African sugar industry increased average recovery rates from 83,2% to 86%. Although molasses typically accounts for the largest proportion of sugar lost during crushing, the area which has seen the greatest improvement in the cane sector is bagasse. In Australia, the sucrose loss to bagasse averaged 4,7% between 1965-69. Fifteen years later this had been reduced to 3,8%.

These gains have not been made without incurring some extra costs. Much of the increase in recovery rates in South Africa has been achieved through the use of diffusers. This in turn has increased imbibition rates from around 42%, as a percentage of cane, in the mid-1960s to well over 50%. Significantly more steam is therefore required for evaporation. Losses to bagasse in South Africa have fallen from 5,6% to 3,0% since the late 1960s.

Changes in overall sugar yields

Figures 6 and 7 bring together the analysis of the technological changes in operations. In each figure the change in the recovered sugar per hectare is depicted alongside its field and factory components: changes in agronomic yields and changes in factory recovery rates. Figure 6 summarises the changes in field and factory performance per harvested area, while Figure 7 illustrates these changes per cultivated hectare.

The changes in factory recovery rates are identical in both diagrams because its measurement is independent of whether yields are calculated per harvested or cultivated area. However, the changes in factory recovery rates have been positive in all three countries, and fall within a narrow range of 0,1% to 0,5% per annum. This is in sharp contrast to developments in agronomic yields, which have differed greatly between the countries.

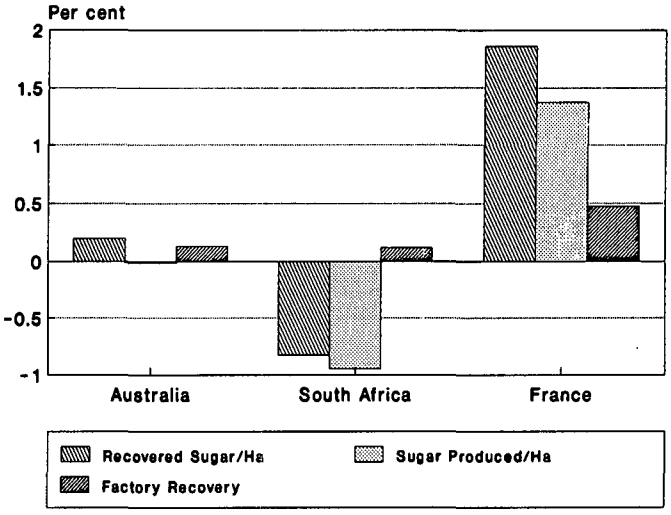

FIGURE 6 Percent change in recovered sugar per harvested hectare: average annual percentage change: 1960 to 1990 crop years

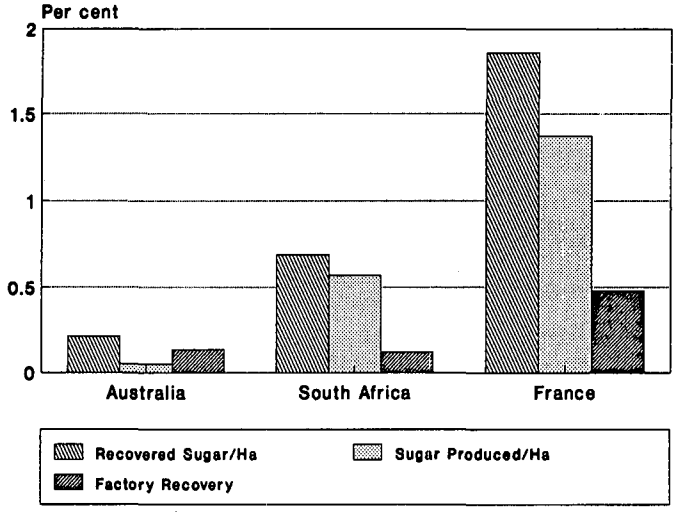

FIGURE 7 Percent change in recovered sugar per cultivated hectare: average annual percentage change: 1960 to 1990 crop years

Conclusions

The most striking finding of this analysis is that the increase in the recovered sugar per hectare in France has been far greater than in either Australia or South Africa, which are considered to be among the most efficient cane sugar producers in the world. It was also found that the differences in overall yield performances are attributable primarily to developments in field operations.

This observation brings one back to a question raised earlier: why have beet producers made such rapid progress over the last two decades while the cane industries have effectively marked time? Are cane yields approaching their technical limits and is it becoming increasingly difficult for plant breeders to push yields up further with new varieties?

One possible explanation for the divergent trends between beet and cane yields is that the improvements made by the cane industry in the immediate post-war years resulted in a large technical gap opening up between it and the beet sector.

In the last twenty years, beet producers have made great strides in catching up with cane producers, who have been held back by technical limitations on further progress. An important corollary to this argument is that, at some point in the future, beet sugar yields will be held back by the same limitations.

A second possible explanation lies in the totally different processes by which improved varieties of beet and cane are developed. The research and development of new cane varieties is normally undertaken by experimental stations funded by the sugar industry. Once new varieties have been bred and proven to be useful they are propagated and released to growers. Thereafter, growers use their own crops to supply cane points for planting. The contrast between this and the development of new beet varieties could not be more pronounced. Most important research in undertaken by privately owned beet seed companies. These seeds are then sold to growers, and the developer of a popular new variety can be assured that commercial success will follow fairly rapidly, since new beet seeds have to be purchased for each crop year. This provides beet seed companies with a strong incentive to invest as heavily as possible in the research and development of improved varieties.

Within the cane industry, however, the economic signals are less clear cut. Perhaps one way forward for the cane industry is, therefore, to introduce a system of royalty payments for the use of new cane varieties. In many countries the varieties which are delivered to mills are monitored and this would enable the basis for payments to private cane breeders. For the so-called free rider obstacle to be overcome, strict controls would have to be implemented to prevent farmers avoiding payment. However, if this is indeed a major reason why cane yields and the sucrose content of cane is failing to keep pace with development in the beet sector, perhaps it is necessary to tackle this undoubtedly difficult option.

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