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EFFICIENCY OF TRANSPORT, MILLING AND HANDLING IN THE SUGAR INDUSTRY

BUREAU OF AGRICULTURAL ECONOMICS

OCCASIONAL PAPER 96

EFFICIENCY OF TRANSPORT, MILLING AND HANDLING IN THE SUGAR INDUSTRY

A CASE STUDY OF THE MACKAY REGION

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Foreword

The purpose of this paper is to present the findings of a study evaluating the effects of regulations on costs in the off-farm sector of the Australian sugar industry. The main findings are that substantial cost savings can be made in transporting and milling cane; that expanding the productive capacity of the industry could be profitable, at least in the off-farm sector; and that the existing regulation of cane pricing and cane supply to mills must be changed to allow these benefits to be achieved.

These findings will be valuable in the continuing debate on regulation of the sugar industry. Previous reports have established a clear case for regulatory change and these have been extensively debated inside and outside the sugar industry. This report will help to focus the debate on the magnitude of the net benefits of deregulation.

While the economic gains highlighted in this report remain untapped, the economic potential of the sugar regions of coastal Queensland will remain unrealised. And Australia will be less competitive than it should be in the world market. The outlook for the sugar industry remains uncertain in the short term, while in the longer term it is dominated by the ability of the industry to remain internationally competitive. Australia exports 80 per cent of its sugar, and policy changes are required if the industry is to take full advantage of the world market.

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August 1986

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CONTENTS

Summary 1

1 Introduction 5

2 Background 6
- 2.1 The policy environment of the Australian sugar industry 6
- 2.2 Policy issues: transport, processing and handling 9

3 A regional model of the Mackay sugar processing sector 12
- 3.1 Nature of the model 12
- 3.2 Physical constraints 12
- 3.3 Costs 15
- 3.4 Effects of regulations 15
- 3.5 The model and its solution 15
- 3.6 Data 16

4 Application of the model 19
- 4.1 The existing situation 19
- 4.2 Transport cost savings 19
- 4.3 Weekend milling 25
- 4.4 Expansion 32
- 4.5 Industry-wide savings 35
- 4.6 Overall evaluation 35

5 Policy implications and conclusions 37

Appendixes

A Potential for decline in net miller revenue with increases in the sugar content of cane 39

B Long run elasticity of demand for Australian raw sugar 43

C Mathematical formulation of the problem 45

D Inputs to the model: combinations of quantities, costs and constraints 47

E Features of the mixed integer formulation 49

F Data 51

References 59

List of figures and tables

Figures

A	Variation of sugar content of cane through growing season	10
B	Regions of the Australian sugar industry	13
C	The transport, processing and handling network	14
D	The Mackay sugar region	17
E	Existing mill areas	20
F	Optimal allocation of cane: existing supply locations	23
G	Reallocation of cane production	24
H	Allocation of cane to mills with weekend milling	27
I	Sensitivity of mill costs to share of costs fixed	28
J	Allocation of cane to mills with weekend milling and added tramline linkages	30
K	Allocation of cane to mills with a 17-week season	31
L	Sensitivity of profitability to share of costs fixed, for various weekend milling strategies	32
M	Allocation of cane to mills with a 27-week season	33
N	Effects of changes of sugar content of cane on the revenues of growers and their miller for an average Queensland mill, 1984-85	40
O	Cost curves of the model	47
P	Operational procedure	49
Q	Minimum haul-out cost by distance	55
R	Road transport cost by distance	55
S	Road and rail sugar transport costs	56

Tables

1	Present net differences in marginal value of sugar cane between growing areas	21
2	Differences in the marginal value of sugar cane between growing areas, with optimum allocation of cane to mills, given existing supplies	22
3	Differences in the marginal value of sugar cane between growing areas, with optimum allocation of cane to mills, given a reallocation of land to sugar	25
4	Annual transport and milling costs, and potential transport cost savings	26
5	Differences in the marginal value of sugar cane between growing areas, with weekend milling	28
6	Average unit costs of transport, milling and handling, with increases in cane production	34
7	Millers' marginal revenue for No. 2 pool sugar sales, net of cane purchases	35
8	Pattern of consumption, production and elasticities	44
9	Sugar cane production estimated in raw sugar equivalents	52
10	Permitted mill sugar production	53
11	Adjusted fixed and variable costs of three surveyed mills	54
12	Fixed and variable costs of milling	58

SUMMARY

The Australian sugar industry has for many years been governed by an extensive set of controls and regulations enforced under Queensland legislation. Many controls and regulations were implemented in 1915 as wartime measures and survive today. Tight controls over planting and harvesting and inflexible rules about pricing and delivery terms for sugar cane have limited the ability of cane growers and millers to adjust to changing economic conditions and to exploit profitable opportunities. Several recent reports claim that existing regulations impose substantial costs on the industry.

The primary aim of this study is to estimate the benefits and costs from changing some of these regulations. The estimates obtained are for changes in transporting and milling sugar cane and raw sugar in the Mackay region of Queensland. The findings are:

- **large cost savings can be made in transporting and milling cane;**
- **expansion of the productive capacity of the industry could be highly profitable, at least in the off-farm sector; and**
- **these economic gains can be achieved only if the regulation of cane pricing and of cane supply to mills are fundamentally changed.**

Effects of regulations in the off-farm sector

Regulations in the transport, processing and handling sector preclude weekend milling and changes to the length of the milling season. They also prevent expansion of cane production and milling throughput, which would reduce unit processing costs. And they stop the redirection of cane from farms to mills and the reallocation of cane growing areas, which would minimise transport costs.

The system of cane payment arrangements, land assignments and delivery quotas effectively prevents mills from profiting from adopting weekend milling. Land assignments and delivery quotas prevent growers from expanding cane production. **So millers cannot attract more cane to take advantage of weekend milling capacity.**

Weekend milling would allow a given volume of cane to be milled in a shorter crushing season. This would result, in turn, in the production of more raw sugar from the same volume of cane, because cane quality varies markedly with time of year. But under the present cane payment formula, over 90 per cent of the value of this additional sugar would accrue to growers, while millers, who receive less than 10 per cent of the benefit, would incur the majority of extra costs in overtime and sugar transport. Further, with a shorter crushing season and when the No. 1 pool sugar price exceeds the No. 2 pool sugar price by a small margin the miller has to pay more for all cane purchases. The extra payment for cane alone can cause overall mill profitability to be reduced. Therefore, even if weekend milling is potentially profitable for the industry as a whole, **there is no incentive for mills to practise weekend milling.**

Regulation may also prevent millers from expanding their capacity by extending the length of the milling season. **A longer season would allow more efficient use of milling resources** and could therefore lower average milling costs. It would require growing extra cane. But under the cane payment formula all benefits would accrue to millers, while net revenue to growers would decrease due to the lower average yield of sugar from the cane. **Growers have no incentive to agree to supply additional cane** beyond the existing season length, and millers cannot attract extra throughput, despite the fact that this option might be more profitable for the whole industry.

The cane payment arrangements do not encourage growers to minimise transport costs, as mills are required to pay (virtually) the same price for cane irrespective of its distance from the mill. And the system of land assignments and delivery quotas can divert cane away from the closest mill, and can exclude land close to mills from growing cane. As a result, the production of cane on least cost sites and its transport by least cost routes is inhibited.

Measuring the effects of regulation

The approach taken in this study was to construct **an economic model of the off-farm (transport, milling and handling) sector** in the Mackay region. The basis for the structure of the model is the set of mills and transport links which currently exists in the region, though allowing for some modifications of the tramway system. Information on transport and milling costs was obtained from three mills. Existing and potential patterns of sugar cane production were considered.

The model can be used to estimate the potential for increasing profitability in the industry from changes in particular off-farm practices. To a lesser extent, the model can also be used to identify broadly how regulation could best be modified to facilitate change. **Estimates of potential benefits and costs were calculated** for the three major changes in current practice given in the previous section. One of the main values of this particular model is that it can be used to study the economic interactions of changes in one part of the industry on the operations of another.

Estimated economic gains

It is estimated that the costs of transporting and processing cane in the Mackay region could for the current level of production be reduced by 15 per cent. This would be a saving of about $9.5m a year. Further, it is estimated that additional off-farm profits of $15m a year could be earned by expanding cane and sugar production. **The same increase in profitability industry-wide would result in net gains of $130m a year.** Any on-farm profits from increased cane production or cost savings arising from harvesting economies in the expanded industry would be additional to this $130m.

The economic model on which the estimate of potential gains in the Mackay region is based necessarily involves a degree of simplification. As well, there must be some element of inaccuracy introduced by extrapolating the Mackay region results to the industry as a whole. The gains which are actually attainable could be greater than or less than the estimated $130m. **On balance, the estimate seems quite robust.**

The estimates of cost savings possible on existing production are not very sensitive to changes in the underlying assumptions on input costs. In contrast, estimates of profits available from expanded production are sensitive to the assumption made about the future world price. The price used in this paper was the average No. 2 pool price for the period 1973-74 to 1984-85. Given the volatility of the world price, the realised price in any year could be much greater or less than this average. However, as there is no detectable long term trend in world price, the average is the best estimate available. Further, Australia accounts for only a small proportion of world production and so is not likely to influence world price strongly. Even if it were able to do so, **restricting Australian production in a growing world market would only leave open an opportunity for expansion by other exporters.**

Potential gains in other regions will not exactly match those anticipated for the Mackay region. **Some regions will have**

considerably greater scope for expansion and rationalisation than will others. For the industry as a whole the potential for expanded production is considerably greater than the 30 per cent allowed for Mackay in this study. Thus, there is a possibility of greater gains than those estimated in the paper.

There are also some reasons for believing that, even within the Mackay region, **attainable gains from industry rationalisation may be greater than those estimated in the study.** Because of the level of aggregation in the model, potential gains from rationalising the transport of cane are probably underestimated. Also, the estimates apply only to cost savings which are possible with existing capital and technology. In the longer term, regulatory and structural change might lead to better use of new technology. The estimates of increased profit do not take any account of the value of by-products such as electric power and molasses.

The issue is not that the realisable gains could vary from the $130m estimated here (whether because realised world prices settle at a level different from that used in this analysis or because opportunities in other regions differ in degree from those in Mackay). Rather, the issue is that regulations and controls have at least the same types of restrictive effects industry-wide on the ability of growers and millers to realise cost savings and exploit world market opportunities as they have in the Mackay region. The results from the regional model at least indicate how great the gains could be for the industry as a whole. At the very least they establish a prima facie case for believing that large gains are possible and that **there is likely to be a high payoff from further investigating ways of realising those gains.**

Policy implications

Because of the centralised decision making processes of the sugar industry, the resources of individual growers and millers tend to be allocated collectively. This centralisation does not provide an efficient mechanism for allocating resources, as it deprives individuals of the flexibility they need to specialise and pursue their own geographic, managerial or other production advantages. **Millers and growers must receive appropriate incentives to seek individually, rather than collectively, the benefits of opportunities such as weekend milling and rationalising cane transport.** Under present production and marketing controls millers, for instance, have little incentive to mill at the weekend; this is largely because they cannot effectively negotiate with growers, individually or by mill area, on price, quantity or delivery terms for cane.

Provided that free negotiation between growers and millers places neither party in a superior bargaining position, **cane prices determined by a competitive market will give the incentives required for transport and milling to be rationalised.** Safeguards already exist to deal with imbalances of market power under sections of the Trade Practices Act dealing with monopoly, and through the process of civil arbitration. If necessary, stronger safeguards can be devised by using a specific industry policy, with the single objective of correcting instances of excessive market power.

The policy implications of the findings of this study are important. A movement away from the current centralised controls on the industry, toward a market with freedom of negotiation on price, quantity, location, timing and transport terms between growers and millers, seems essential if gains of the sort estimated in this paper are to be obtained. **To achieve these gains it would be necessary to allow greater flexibility in the production of sugar sold at the going price (No. 2 pool) on the world market.** It would also be necessary to permit more flexible payment arrangements, both for millers producing No. 2 pool sugar and for growers supplying cane for that purpose.

Quantity restrictions on the production of cane and sugar used to make No. 2 pool sales would have to be removed to provide the flexibility needed. **Arrangements to allow effective negotiations between growers and millers on price, quantity and delivery terms for cane would also**

need to be developed. For this to occur, amendments would be required to the Regulation of Sugar Cane Prices Act. These would need to permit incentives for growers and millers to make and uphold supply contracts independently of the appeal and enforcement powers of the Central Sugar Cane Prices Board. And to gain the full benefits of rationalisation and expansion it would be necessary to replace the present land assignments and farm and mill peaks affecting No. 1 pool sales with a system of freely negotiable market entitlements.

1. Introduction

The structure of the Australian sugar industry and the behaviour of the participants in it have for many years been governed by an extensive web of controls and regulations. Many of these controls and regulations were implemented in 1915 as wartime measures and have never been revoked (Sieper 1982). Borrell and Lawrence (1984) concluded that government regulations have distorted economic incentives in the industry and have, as a result, produced an inappropriate industry structure and size.

Four recent major reports (BAE 1983; Industries Assistance Commission 1983; Sugar Industry Review Committee 1984; Savage et al. 1985) have recommended substantial revision of the nature and degree of government regulation of the industry. In all cases their recommendations have been based on evidence that current regulation imposes hefty costs on the industry. The purpose of this study is to estimate the size of some of these costs, and to indicate the likely gains from particular policy changes.

It is difficult to estimate the gains from changes in government regulations. The existing regulations have direct and indirect effects on the way cane transport, sugar milling and sugar handling are structured. As a means of estimating the effects on the off-farm sector of a number of changes in the structure and the regulation of the industry, an economic model which broadly represents the full extent of off-farm activities in the Mackay region was developed. The reason for selecting Mackay is discussed later.

In the model, regulations are represented as constraints on particular activities or sets of activities. Some regulations are represented as constraining particular activities directly, while for others such constraints are indirect. For example, there is no explicit prohibition of weekend milling, but it is argued (in chapters 2 and 4) that the regulation of millers' and growers' shares in the revenue from sugar sales discourages mills from maintaining continuous production. The fact that regulatory constraints cannot always be modelled directly places some limits on how far the model can be used to evaluate specific policy changes.

This paper provides detailed documentation of the model and a discussion of some important results from its application. Chapter 2 contains a discussion of the general structure and policy framework of the industry as well as a qualitative summary of the effects of that policy and structure. A detailed description of the Mackay regional model, its structure and operation, is contained in chapter 3; related to this section are five appendixes which outline the sources, nature and limitations of the data, and the assumptions used in the model. Applications of the model are discussed in chapter 4. These involve relaxing policy constraints to allow for weekend milling, rationalising the transport, milling and location of cane production, and expanding the industry. Chapter 5 discusses the policy implications of these results.

2. Background

2.1 The policy environment of the Australian sugar industry

The present industry arrangements do not allow commercial markets to operate in the normal way, particularly at the mill or grower level. Regulations prevent competitive offers by individuals to buy and sell cane. The regulations control the price paid for cane, the quantity of cane grown and the sugar produced from it. Revenues from sales of cane are divided between individual growers and millers in set proportions determined by a formula; rigid conditions apply to the delivery, transport and scheduling of cane; and a system of delivery quotas (farm and mill peaks) and land assignments is used to regulate cane production. These controls are enforced under two Queensland Government Acts — the Sugar Acquisition Act and the Regulation of Sugar Cane Prices Act. (For details of these controls, see Industries Assistance Commission 1983.) Under these controls, growers and millers cannot effectively negotiate on the price, quantity or terms of delivery for sugar cane. As a result, neither party can gain the full benefit of any comparative advantage in growing or milling cane.

Land assignments and delivery quotas

Delivery quotas and land assignments prevent resources from being freely transferred within the industry and between the industry and the rest of the economy. Quotas and assignments are set by the Central and Local Sugar Cane Prices Boards. These are statutory authorities set up under the Regulation of Sugar Cane Prices Act and empowered to make a wide range of decisions affecting the operation of the industry. The compulsory acquisition powers of the Sugar Board, which was set up under the Sugar Acquisition Act, help the Central Board enforce quotas and assignments. As part of the system of delivery quotas and assignments, a mill is legally obliged to process all cane delivered to it, up to a specified level, and to pay at least a set minimum price for the cane. The price depends on sugar content. Moreover, mills may take cane only from their assigned areas, and growers accordingly may supply it only to designated mills.

Under the land assignment system, only cane grown on designated or assigned land is priced according to the cane payment formula. Any sugar produced from cane grown on unassigned land cannot be sold for more than $1/t, which is unprofitable. So delivery quotas and land assignments limit the size of the industry. The industry can expand only if the Central Sugar Cane Prices Board increases quotas and assignments. Such increases have been intermittent. This is because in the past increases have only followed periods of very high world prices, which themselves have been intermittent. However, mill closures and rezoning assigned land have also led to some adjustment. The system of land assignment and quota allocation has itself remained intact since 1915.

The Central Sugar Cane Prices Board reviews quotas each year and takes into account the views of millers and growers about whether to alter allocations. When the Board has allowed expansion it has generally allocated the increase by offering to raise all quotas proportionally, and then reallocating on a similar basis any capacity not taken up. Quotas are allocated to specific land assignments by the Local Sugar Cane Prices Board of each mill area.

Expansions have generally been resisted by those growers and millers who have no expansion potential and who fear bigger price risk. The system of averaging ('pooling') returns over the whole industry helps to spread the price risks for sales to markets where Australia does not hold fixed term contracts. Growers and millers who cannot expand, and tend to be risk averse, worry that expansion in other areas will increase the proportion of 'risky' sales in the pool, and oppose it (Borrell and Lawrence 1984). When world prices have been high, such producers generally resist less, making it easier for the Central Board to authorise an expansion. But at other times, growers who could profitably expand will be stopped from producing more.

Terms and conditions on the sale and delivery of cane

The Central Sugar Cane Prices Board also has considerable powers over the terms and conditions of the sale and delivery of sugar cane by growers to millers. The important components of these arrangements are: a two-pool pricing system; awards by Local Cane Prices Boards; and an industry-wide formula to share the proceeds from sales of sugar and sugar cane.

The two-pool pricing system, which applies to both cane and raw sugar, is managed largely by the Sugar Board. However, because the Central Prices Board is involved in setting the quotas applying to each pool, it too plays a part in managing the system. The two pools distinguish between returns from sales to less secure markets and those from sales to reasonably secure ones. The No. 1 pool is made up of returns from domestic market sales, long term contract sales and sales to certain preferred markets. The No. 2 pool is made up of spot sales on the world market. In ten of the past sixteen years, the No. 1 pool price has exceeded the No. 2 pool price. Pool prices for cane are closely related to pool prices for sugar and are determined under the awards of Local Cane Prices Boards.

Local awards — which cover all conditions of sale, including the arrangements for determining date of delivery — are made under the Regulation of Sugar Cane Prices Act. All local awards are currently based on a rigid cane payment formula which fixes the price of cane and disallows negotiation on other terms. The Act requires that base pool prices for cane be specified, with a system of premiums and discounts to take account of quality variations, particularly in the sugar content of the cane. Provision is also made under the Act for growers and millers to negotiate their local awards annually by mill area. But in practice, as outined below, the scope for negotiation is limited and prices for cane are effectively determined by the State-wide cane payment formula established by the Central Board.

This formula is incorporated in all local awards. The details of the formula (see also appendix A) are given in Industries Assistance Commission (1983). Under the payment formula and related arrangements, millers and growers conduct business on terms which are common throughout the industry. Without scope for negotiation on these terms, millers and growers are unable to trade in a way that would enable them to specialise and exploit individual soil, climatic, managerial or other production advantages. As a result, economic opportunities are overlooked.

There are several reasons why individual millers and growers cannot negotiate mutually beneficial improvements to local awards. These are:

- the quantity of cane which a grower can sell is largely fixed by production controls;
- the support of about 90 per cent of growers is required to change a local award;
- the powers of the Central Prices Board to override private contracts, and the regulation of the scheduling of cane harvesting and crushing, make it virtually impossible for individual growers and millers to negotiate a separate contract;
- the ease of access to the Central Board and the industry-wide pooling of any legal costs involved lessen the incentive for effective negotiation at the local level; and
- variations to an award must be 'fair and just', so that outcomes of appeals tend to protect existing equities and industry arrangements. But they undermine the

confidence of millers and growers in change through negotiation at the local level in the first instance.

There is virtually no scope for negotiation on price and delivery terms because land assignments explicitly limit production, and cane from each assignment is directed to a specific mill. Millers can therefore neither compete for the cane of other mills nor pay assigned growers to supply more cane. Only if technological or regulatory change gives clear financial gains to all parties covered by a local award does a basis for negotiation exist. Even then, as long as the quantity remains non-negotiable, the scope and number of opportunities for rationalisation and expansion of the industry are greatly restricted.

As has been stated, even when highly profitable opportunities exist for renegotiation, around 90 per cent of grower support is required to change a local award. Moreover, any change in the terms of an award can be overturned on appeal to the Central Prices Board by either the miller or a group of 20 or more growers (that is, about 10 per cent of growers in a mill area). Unless it can be demonstrated that change to an award benefits virtually all suppliers to the mill, there is little chance of achieving a change, as a very small minority can prevent all other growers from realising profitable opportunities.

It is not viable to negotiate a separate contract between particular growers and a miller. The Central Prices Board has the power to override any contract negotiated privately. The effect of this is that a separate contract is not binding if it prevents the growers concerned from obtaining at least the level of benefits available under their local award. And the provisions in the Act about the breach of an award allow growers to appeal to the Central Prices Board against separate contracts between other growers and a mill which impinge on the equities of any grower. This is a particular problem in scheduling harvesting.

The timing of the harvest influences growers' exposure to the risks of wet weather and variability in cane quality. To deal with this problem, harvesting arrangements are established under mill area awards with the aim of treating all growers as nearly equally as possible, regardless of the economic costs and benefits of doing so. As a consequence, harvesting is scheduled as frequently and evenly as practicable across all harvesting groups and throughout the harvesting season, to reduce and equalise among growers the individual risks of wet weather and low quality. Separate arrangements between particular growers and millers can interfere with overall harvesting arrangements and therefore with the equities of other growers, and this can constitute a breach of award by the mill. In this way, equity considerations in the scheduling of harvesting are another constraint on individual negotiation.

Other constraints on the scope for negotiating separate contracts include the ease of access to the Central Prices Board and the predictability of results of appeals to the Board on changes to awards. Appeals are determined by a judge of the Queensland Supreme Court and the elected grower and miller representatives on the Board. Variations are allowed only if Board members are satisfied that circumstances have so changed as to make a variation 'fair and just' (Government of Queensland 1983). In fact, despite enormous change in market circumstances and occasional attempts by growers and millers to change cane payment arrangements, mill awards have remained broadly unchanged since 1915. The requirement to protect the existing equities of *all* current stake holders in the industry — regardless of whether the potential economic gains in aggregate outweigh the costs — makes appeal outcomes predictable and undermines the ability and incentive for individual millers and growers to negotiate changes in arrangements between themselves.

The cane payment arrangements persist because there are many obstacles stopping millers and growers from negotiating to change them. There is no way of negotiating separate contracts. And the emphasis on protecting existing equities prevents change through centralised negotiation. The cane payment formula itself has also stood in the way of change.

The formula was derived on the principle that each party should recover its costs, and is reviewed annually on this basis. Thus, an opportunity apparently exists to adjust the formula regularly. But the following observation is relevant:

> 'Although a good deal of time and effort and money has gone into progressively refining the measurement of costs and assets, it seems that the effort has done little except to successfully establish how many unknowns and unmeasurables there really are in an exercise to establish an industry's costs and assets. The cane payment formula has not been altered for 30 years.' (Searle and Ferguson 1984, p.6)

Due to the basis on which the cane payment formula is reviewed, its terms may be perpetuated by the influence it has on investment patterns. Given that the formula is based on the relative capital invested by the milling and growing sectors in 1915, and that the pattern of returns will affect the pattern of investment in the sectors, the formula may have tended to damp down any movements in capital and operating costs of the sectors away from their original relativities. Therefore, viewed against industry-wide costs the formula may at any time appear reasonably equitable to both sectors. However, over the longer term it has probably reinforced an enduring distortion in investment between them.

This self-perpetuating nature of the formula, together with the centralised decision making processes, helps to explain why the structure of the sugar industry has changed so little in the past 70 years. Within the web of government regulation affecting the industry, incentives are distorted so that growers and millers are discouraged from expanding, competing or adopting innovations as fast as possible.

2.2 Policy issues: transport, processing and handling

Production and marketing controls in the sugar industry effectively limit both the possibility and the incentive for growers and millers to bring about structural and organisational changes which might increase the industry's overall profitability. This subsection describes specific practical options for change which these controls impede. In particular, controls in the transport, processing and handling sector of the industry could discourage growers and millers from adopting the following responses to changes in product and input prices:

- milling at the weekend and adjusting the length of the milling season;
- expanding the production of cane, or of the raw sugar from it; and
- rearranging the transport flows of cane to the mills.

As these opportunities can affect the use and allocation of transport and milling resources, the economic impacts of sugar industry controls are important policy issues.

Weekend milling

At present, Australian mills generally crush cane 24 hours a day, Monday to Friday, over a season of 20-25 weeks. Weekend milling is rare in Australia. But it is standard practice in all other major sugar cane producing countries which supply the world market (Noble 1983). Several ways in which the increase in effective capacity resulting from weekend milling could be efficiently used are discussed below. How desirable those options are depends on the levels of costs and sugar prices, which are discussed in more detail in chapter 4.

Weekend milling could reduce the length of the harvesting and crushing season, for a given cane throughput. The sugar content of cane varies systematically over the traditional five-month harvesting and crushing season. As figure A shows, it rises to a peak in mid-season. More raw sugar could be produced from a given quantity of cane if the season were shortened by milling at weekends.

As harvesting and transporting cane costs the same regardless of its sugar content, profitability could be increased if season length were reduced. Weekend overtime costs and the extra variable costs of transporting the additional raw sugar from mills to ships must be set against the potential increase in revenue from raw sugar. However, even where overall revenue from the extra raw sugar exceeded the costs involved, under the current cane payment formula the benefits would not necessarily provide any incentive for mills to reduce the length of the crushing season.

Under the cane payment arrangements the extra costs to a miller from reducing the length of the harvesting season can outweigh the miller's share of the extra revenue. As well as the additional costs of overtime and transport, under certain conditions millers must pay the growers more for cane as its sugar content increases. The result can be that growers' revenue increases at a greater rate than millers' gross revenue (the returns from sugar sales). This is clearly a case of overpayment for cane: increased sugar production causes millers' profitability to decline. Appendix A demonstrates this graphically and mathematically.

The cane payment formula can thus provide a financial disincentive for millers to reduce season length or do anything to increase the sugar content of cane. This has been the case for six of the past ten years. Moreover, when the overtime and transport costs are also taken into consideration, there have probably been very few years when it would have paid millers to mill at weekends and thus reduce season length — despite the fact that such a practice is likely to have been profitable for the industry as a whole.

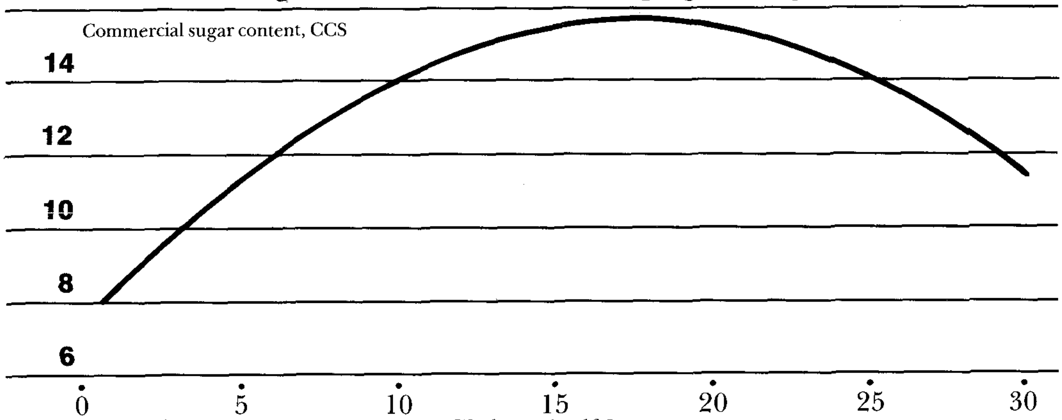
Prohibiting competition between mills for cane also discourages millers from operating at weekends. The system of delivery quotas stops millers buying cane grown outside their designated mill areas. In the absence of this restriction, cane currently available for milling could be crushed in fewer mills operating continuously. This would reduce the fixed costs of milling per unit of output, and weekend milling would be profitable if this reduction exceeded the extra overtime costs.

The existing volume of cane could be crushed in still fewer mills, with potential savings in average milling costs, if the season were lengthened rather than shortened. This change would be accompanied by a reduction in average sugar content and hence in sugar output. Though extension of the season would be profitable if the cost savings exceeded the revenue forgone as a result of reduced sugar output, under the cane payment formula all the savings would in this case accrue to millers while the costs would be borne by the growers. Accordingly, growers have no incentive to agree to such an increase in the length of the season.

Expansion

If controls did not limit the total supply of sugar cane, all mills would have the

A Variation of sugar content of cane through growing season



Source: Ryland (1975) BAE chart

opportunity to spread their fixed operating costs over a larger volume of cane by operating continuously, and possibly over a longer season. The potential to produce additional cane at current or lower costs might be considerable. Savage et al. (1985) reported that large areas of suitable land are currently excluded from the industry through the system of land assignments and delivery quotas. Prices of assigned land are higher than those of unassigned land (Belcher and Dalton 1983), suggesting that easing production controls could lead to increased cane production. It can also be inferred from this land price differential that production controls have limited profitable expansion within the industry. Given that there is scope for achieving economies of scale and other on-farm cost savings (Savage et al. 1985), industry expansion represents a profitable opportunity for some growers and millers, even at current low prices.

Cane transport

The cane payment arrangements and production and marketing controls on the industry also remove incentives for efficient transport. As already mentioned, mills are required by law to accept and process a specified amount of cane delivered from specified growers at a set minimum price. Under this arrangement, mills must pay virtually the same price to growers regardless of their location and the cost of transport of their cane to the mill (which is met mainly by the millers). This constraint effectively removes any economic incentives for growers to minimise transport costs when making location and harvesting decisions. Furthermore, the primary criterion used by the Central Prices Board to allocate land to cane production is equity of opportunity. That is, all growers are given the same opportunity to participate in any expansion of the industry. Economic considerations, such as transport costs to mills and which producers can grow cane most cheaply, are only secondary determinants of current decision making.

The responsibility for transporting cane from tramway sidings to mills currently rests with mill owners. But mill owners cannot choose among growers or vary their prices according to these transport costs. If millers and growers were free to negotiate directly on price and delivery terms, transport costs would be likely to be given greater weight in determining where cane is to be grown and milled. And there would be stronger incentives to reduce those costs wherever possible.

3. A regional model of the Mackay sugar processing sector

As figure B shows, there are several cane growing regions along the north-eastern coast of Australia. Transport costs are high relative to the value of the cane, and the sugar content of cane falls rapidly after harvest, so it is generally not economically feasible to transport cane between the major cane producing regions. Production and processing in a region is therefore independent of activities in other regions. From a modelling standpoint, this regional independence is convenient as it allows regions to be modelled separately. For this study the Mackay region was selected because it is a major sugar region and the data available on it are better than for other regions.

The model, although based on Mackay, has been developed in such a way that inferences can be drawn about the effects of changes at the industry level. Changes in regulations and controls can be expected to have comparable effects in all sugar regions. In developing the Mackay model to measure the broad economic impacts of changes in industry regulations and controls, the study has focused on policy analysis and development. The study has not aimed to develop a management tool that can be used to determine the optimal rationalisation and expansion strategy for farms and mills in the Mackay region, and the results should not be interpreted in this way. Rather, they indicate how much could be gained economically from changes in industry regulation.

In the Mackay region there are about 1200 cane farmers growing around 5 Mt of cane a year on 75 000 ha. Harvesting of cane, which is a perennial crop, begins in June and ends in December each year. Most of the cane is transported to mills along narrow gauge railways (tramways), although some from the more remote areas is hauled by road. Delivery from paddock to rail siding is by a variety of machinery, ranging from tractor and trailer equipment to highly specialised vehicles. Haul-out and rail transport are usually in 4 t bins known as 'canetainers'. More than a million and a half canetainer loads of cane are transported in the Mackay region each year, over distances of up to 60 km, using a system of approximately 500 km of track. Clearly, transporting cane is a big logistical problem.

There are six mills in the Mackay region of which four each process approximately 1.0 Mt of cane a year and the other two about 0.6 Mt each. Extracting raw sugar from cane involves a number of energy intensive and capital intensive processes. Since the sugar content of cane begins to fall immediately after harvest, there are potential gains from crushing as soon after harvesting as possible. Cane is generally crushed within 16 hours of harvesting.

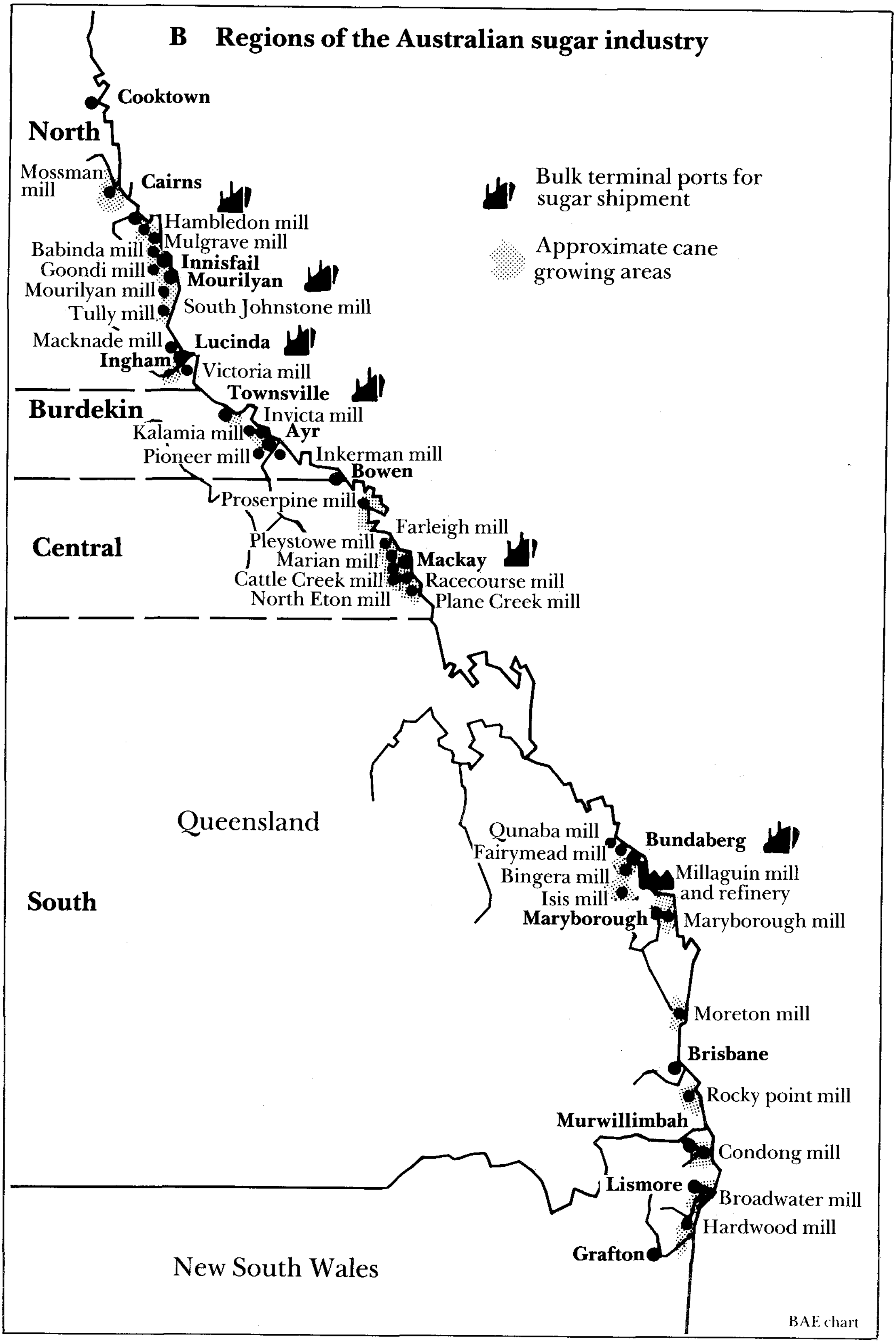
The raw sugar is transported either by road or rail from the mills to the bulk terminal, where it is stored before loading on to ships for export. Approximately 1.0 Mt of raw sugar is handled at the Mackay bulk terminal each year.

3.1 Nature of the model

The basic economic problem of the sugar processing sector can be viewed as that of minimising the costs of processing available cane to raw sugar ready for export. This means choosing the cheapest way of transporting cane and raw sugar between the farms, mills and the bulk export terminal. This network problem is represented in figure C. The links represent the sequence of off-farm activities.

3.2 Physical constraints

The volume of cane or raw sugar that can pass along links of the network at any time will be physically constrained by such factors as the capacities of the mills and of the transport systems. Any feasible



B Regions of the Australian sugar industry
Bulk terminal ports for sugar shipment
Approximate cane growing areas
Cooktown
North
Mossman mill
Cairns
Hambledon mill
Mulgrave mill
Babinda mill
Goondi mill
Innisfail
Mourilyan
Mourilyan mill
South Johnstone mill
Tully mill
Macknade mill
Lucinda
Ingham
Victoria mill
Townsville
Burdekin
Invicta mill
Kalamia mill
Ayr
Pioneer mill
Inkerman mill
Bowen
Proserpine mill
Farleigh mill
Central
Pleystowe mill
Marian mill
Mackay
Cattle Creek mill
Racecourse mill
North Eton mill
Plane Creek mill
Queensland
Qunaba mill
Bundaberg
Fairymead mill
Bingera mill
Millaguin mill and refinery
Isis mill
Maryborough
Maryborough mill
South
Moreton mill
Brisbane
Rocky point mill
Murwillimbah
Condong mill
Lismore
Broadwater mill
Hardwood mill
Grafton
New South Wales
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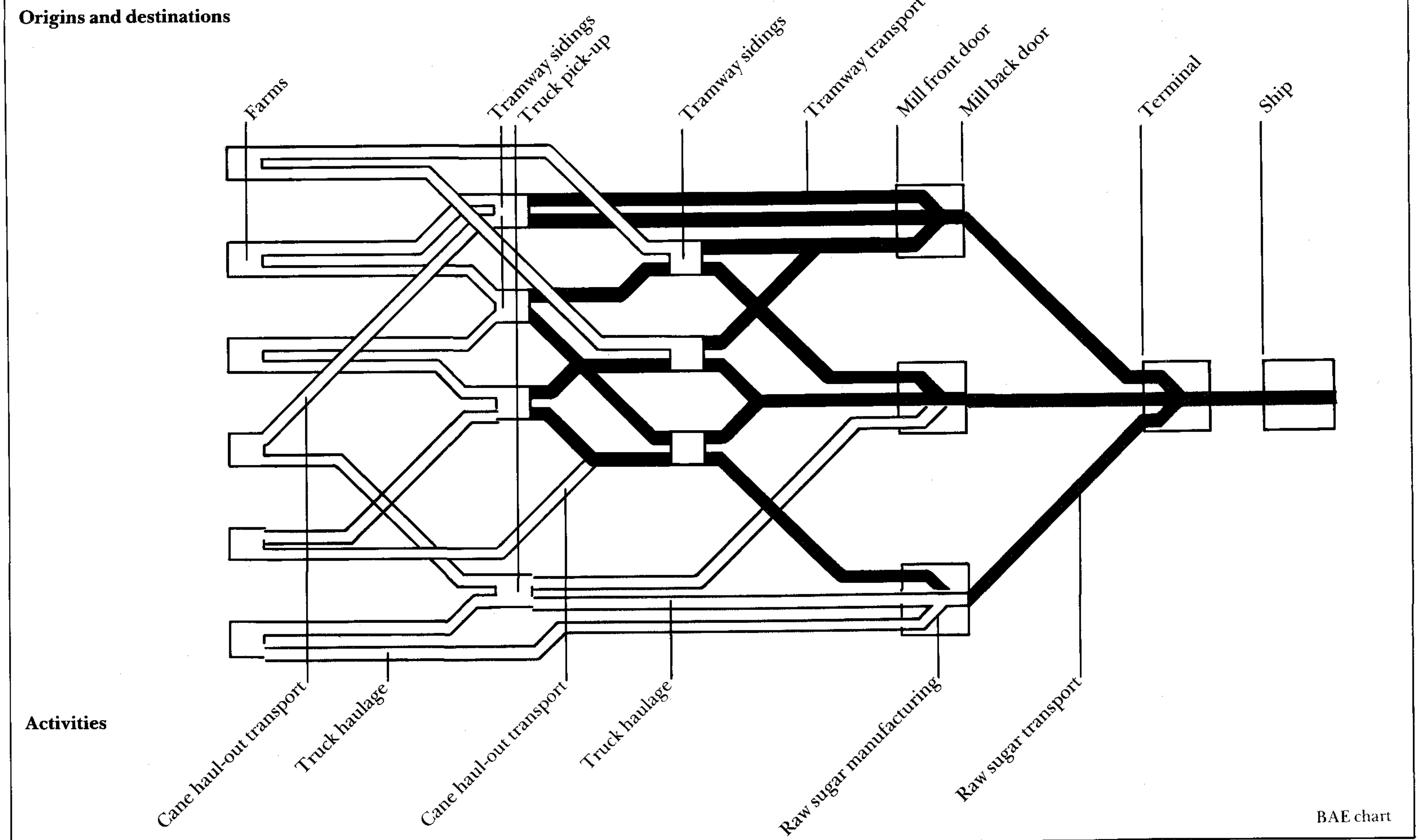
C The transport, processing and handling network



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solution to the network problem must satisfy all these constraints. Within these constraints there are many feasible ways of transporting all available cane on farms through the links of the network to the ship. The economic problem is to choose that solution with the lowest economic cost.

Given that Australia is a price taker in the world sugar market (see appendix B), it is reasonable to assume that all available cane could be sold as raw sugar at the going world price, and therefore that demand at this price equals total available supply.

3.3 Costs

Within a season, some costs such as those associated with activating and maintaining an existing mill or transport facility will be fixed and some will vary with throughput. The relationship between the latter costs and throughput may be quite complex. Labour costs, for example, can increase more than proportionately with throughput due to overtime arrangements.

The importance of distinguishing between fixed and variable costs can be illustrated by the magnitude of the cost trade-offs that exist between activities or links in the network. For instance, if there were three mills in a region each operating five days a week, it might be possible to close one and operate the other two continuously. This would lead to additional overtime charges and possibly to higher costs of transporting cane, but would eliminate the fixed costs of activating and operating one mill. If the savings in fixed costs were larger than the additional overtime and transport costs, closure of a mill would be an economic solution.

While it may be clear from such an analysis that closure of a mill is economically desirable, there may be no clear advantage in closure of one particular mill rather than others; that is, there may be no unique economic solution, and the model could not be used to identify which mill should be closed. Rather, the model only illustrates the benefits available from a change in policy that would facilitate rationalisation within the industry.

3.4 Effects of regulations

The regulations and controls discussed in chapter 2 limit the structure and operation of the industry. In modelling the Mackay region, the effects of regulations may be thought of as additional constraints on the activities of growers and millers. Modelling alternative policies is very much a matter of respecifying the constraints of the model in different ways.

Some regulations represent explicit constraints on particular activities: for example, the system of land assignments and delivery quotas restricts the availability of cane and limits the output of each mill. The location of cane growing, the quantity delivered and the mill to which it is delivered are specified. The representation of these regulations in the model can therefore be quite exact.

The effects of some other regulations can be represented only indirectly. For example, although there is no explicit prohibition of weekend milling, the regulation of millers' and growers' shares in sugar revenue creates a disincentive for millers to mill at weekends. Regulations on the scheduling of harvest and on labour, work and payment conditions provide further disincentives for weekend milling. The point is that what is represented in the model as a single constraint on weekend milling is actually the result of a complex interaction of the effects of a number of regulations. Analysis of the effects of groups of regulations on miller incentives, therefore, is an important precursor to specification of the model. This problem of representation also places some limits on the ease with which any modelling approach can be used to evaluate specific policy changes.

3.5 The model and its solution

The economic and policy problems were specified and solved as indicated in the mathematical specification in appendix C. A review of the general class of mathematical programming models to which this model belongs is contained in French (1977) and Fuller, Randolph and Klingman (1976). The problem is specified with the objective of minimising the costs of transporting, processing and handling sugar cane and raw sugar, subject to a set of constraints relating to the physical and policy environment. The mathematical form of the model is complicated by the need to represent whether specific mills and the transport and handling facilities open or close. The model is specified to deal with a single homogeneous product, and on this basis all cane is expressed in raw sugar equivalents, with 7 t of cane equal to 1 t of raw sugar.

Ryland (1971) developed a programming model of a sugar producing district. It was a model of the Mackay district, designed to work out how much could be saved by rationalising only the allocation of cane to mills. Ryland's results, which imply potential savings of 2.7 per cent of total costs, were based on cost data and mill capacities for the 1966 milling season. The experimentation conducted did not extend to issues of mill rationalisation and expansion. However, Ryland and Guise (1975) extended this work to determine the best schedule of milling cane and the optimal length of the cane harvesting season, given the variations in quality of sugar cane over time and space. They showed that large increases in net revenue could be achieved by exploiting these quality differences. These results, however, were generated assuming that much of the existing regulatory framework was retained. The current study develops a model which can analyse a range of policy alternatives, including quite fundamental changes to the regulations.

Solving the model provides estimates of the lowest cost flows of sugar cane (expressed in sugar equivalents) and sugar, from growing areas through mills to the export terminal. This set of flows is known as the 'primal' solution. In solving the primal problem, a second problem, the 'dual', is solved automatically: the dual solution shows how costs change in response to a unit change in the level of any of the constraints in the model. For example, if the supply constraint in one area were relaxed by one tonne, the dual solution would indicate the extra costs of transporting, milling and handling the additional tonne from farm to ship (assuming no other changes were allowed). From the dual it is possible to estimate, for any given set of regulations, the relative value of producing an extra tonne of cane in each of the growing areas the model covers.

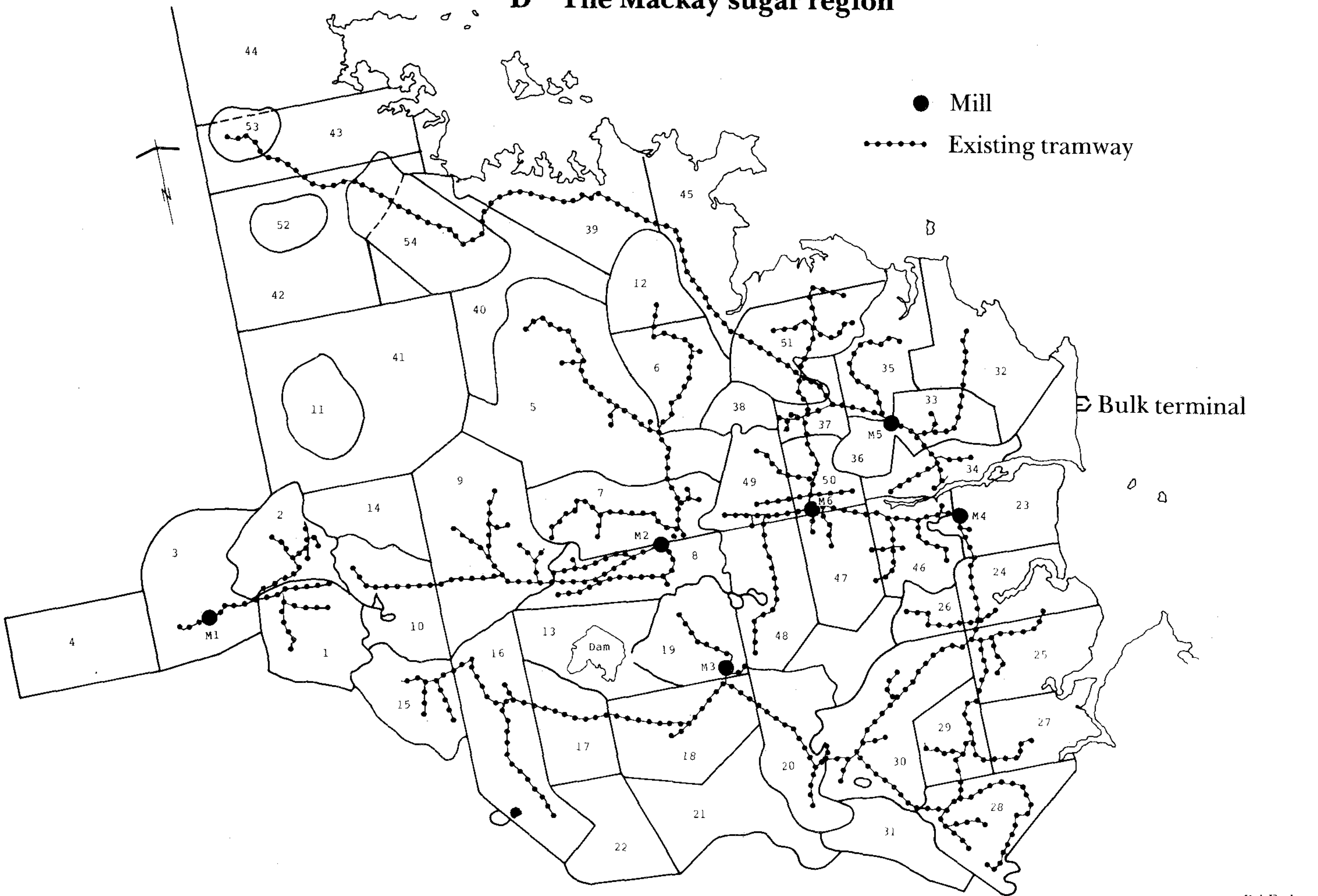
In a perfectly competitive market for the production, transport and milling of cane, variations in relative values would be reflected in differences in the price of cane from different growing areas, and the forces of competition would lead to a redistribution of cane between mills. When the cane price differential between any two mill areas exceeded the transport costs between the areas, there would be a profit to be made in moving cane to the mill area where the net returns were highest. By taking account of the differences in cane values between growing areas, the model can be run to reallocate the passage of cane through the transport and milling system to minimise transport and processing costs. In this way, the effects of removing the regulations and other constraints on the system can be analysed. Appendix D discusses the feasible combinations of costs in the model and appendix E discusses its operational features.

3.6 Data

Potentially, this modelling approach can be used to examine the economic effects of both long and short term policy changes and structural changes. The cost data used in the current formulation of the model were primarily concerned with operating costs. In this application, however, no allowance was made for expansion or rationalisation of milling capacity by constructing new facilities, and in this sense the model provides only a short term solution.

French (1977) has outlined three methods for estimating processing cost relationships — descriptive analysis of accounting data; statistical analysis of accounting data using econometric techniques; and economic engineering, estimating cost relationships from engineering data.

D The Mackay sugar region



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This study uses the method most closely related to the first approach, the least complicated of the three. It involved averaging accounting costs for the 1982-83 financial year for three mills in the Mackay region which are close to the average size for the industry. These cost data were supplemented and adjusted after interviews with management personnel from the three mills. This approach has the advantages that it is cheap compared to the other two approaches, it is easily understood by the industry and it will be regarded as commercially relevant. However, it has limitations. Accounting techniques, managerial efficiency, scale and production methods may vary greatly between mills. Variability may make it difficult to classify and allocate costs correctly and to establish the relationships between costs. Another limitation is that the cost relationships will represent those applying under current (regulatory) conditions, whereas different technologies, and therefore cost relationships, might be introduced as a result of regulatory change.

Of these limitations, the interpretation and classification of costs as either fixed or variable posed the greatest difficulty in this study. Although the statistical analysis and economic engineering approaches mentioned can be used to overcome these difficulties, the large amount of data required to do so successfully limits their applicability.

Using cost relationships which cannot reflect technological opportunities will lead to underestimating potential economic gains. Such an approach does not capture the additional savings which might arise from opportunities for technological changes and associated new investment made possible by structural and institutional change.

In addition to cost data, the quantity and location of existing and potential supplies of cane were also required. These were derived from a study of land use and land suitability in the Mackay region conducted by Holz and Shields (1985*a,b,c*). The region was partitioned into 54 cane growing areas, with the existing location of the six mills and the export terminal taken as given (see figure D). Detailed discussion of data sources and definitions is contained in appendix F.

Despite limitations on the data and on the approach used to derive cost relationships, the estimates obtained enabled the theoretical concepts discussed earlier to be embodied in the model in a comprehensive and operational way. The complex economic interrelationships of the industry were broadly represented, and the effects of changes on the structure of the industry could be analysed consistently. New information could be easily incorporated in the model and so the cost estimates provided a good starting point in the modelling exercise. Further consultation with the industry, sensitivity testing and additional evaluation of the data may allow these estimates to be refined.

4. Application of the model

The cane payment arrangement and the system of land assignments and delivery quotas were briefly discussed in section 2, where it was argued that these controls effectively prevent competition between mills. It was further argued that the relationship between millers and growers individually and collectively is constrained by these arrangements to the point where neither has much incentive nor capacity to seek changes which increase the industry's overall profitability.

In this section the Mackay sugar model is used to assess the opportunities for increased profitability through weekend milling, expansion of the industry and rationalisation of cane transport. The performance of the model is then discussed.

4.1 The existing situation

From the modelling standpoint, weekend milling and liberalising controls constraining expansion and cane transport will affect milling capacities and transport flows in the network. To use the Mackay model to evaluate these effects it is necessary to analyse how costs change as capacity constraints change. First the model must be run to replicate the actual structure and costs of the industry; this is the 'baseline simulation'.

To create the baseline simulation the model was run under the assumptions: that the existing legally imposed mill peaks were constraining the activities of mills; current legally imposed farm peaks were constraining the supply of sugar cane; cane from legally designated mill areas had to be supplied to legally designated mills; and the use of cane equalled the production.

Under these assumptions, the total annual costs from farm to ship generated by the model amounted to $63.6m, or approximately $100/t of raw sugar. Transport costs for the cane accounted for $14.24m of the total. The distribution of cane from farms to mills was that reported by Holz and Shields (1985*a,b,c*) and is shown in figure E. These figures provide the reference points from which the significance for industry profitability of weekend milling and other changes in practices can be assessed.

As discussed in chapter 3, the dual estimation to the baseline simulation provides an indication of the net differences in values of cane grown at various locations in the Mackay region. These estimates are shown in table 1. As can be seen, cane from area 53 is of least value, due mainly to the high road transport costs incurred in delivery to its assigned mill, and cane from other areas is worth up to $58/t more.

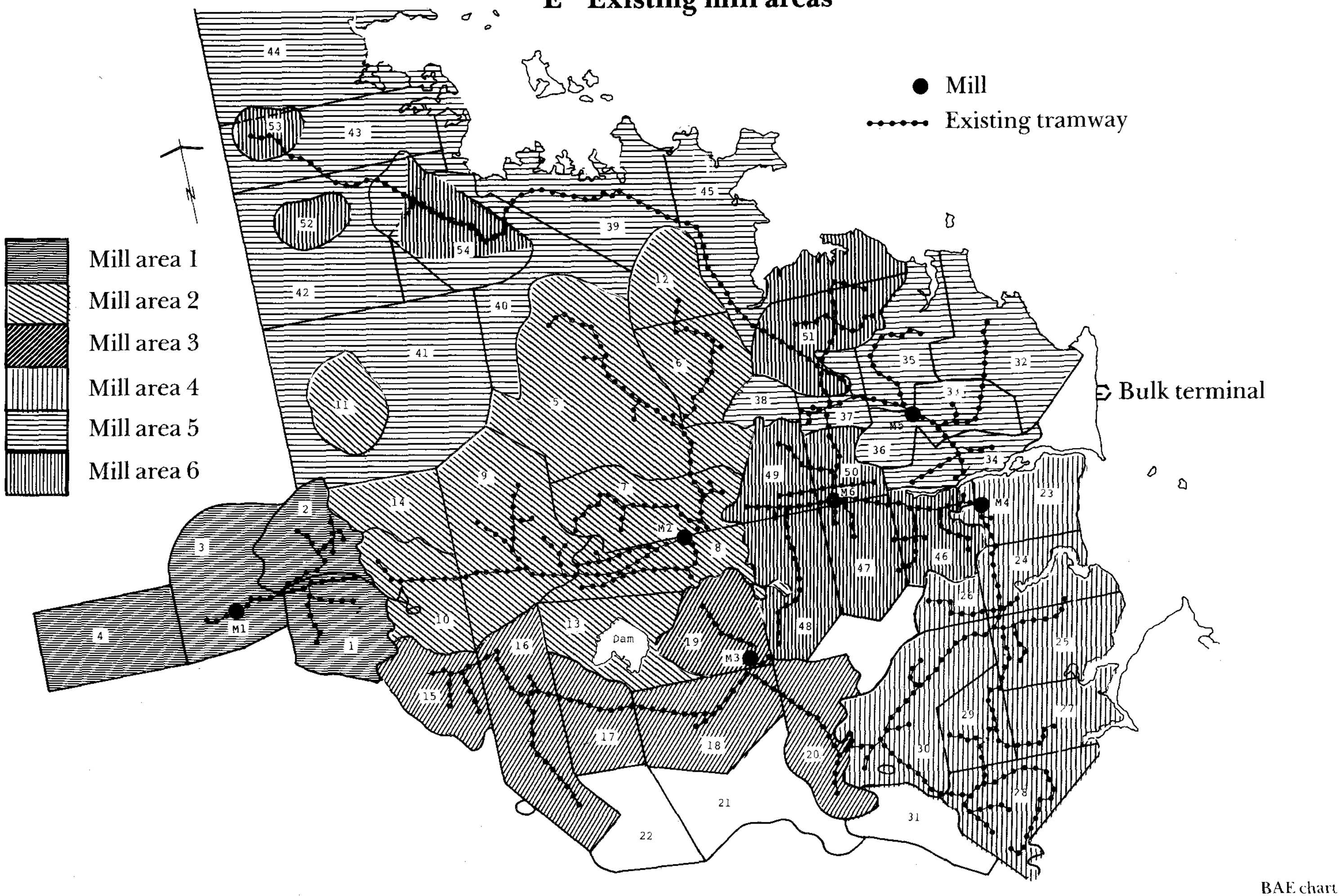
With existing arrangements, these differentials are not reflected in cane prices paid to growers, and therefore do not influence growers' location decisions. Neither can these differentials influence the distribution of cane between mills, because growers have no choice about where to send their cane for milling. If cane prices were based on such differentials, there would be incentives to redistribute the cane among the various mills, to grow cane on currently unassigned land and to increase yields on land close to mills, so as to minimise transport costs.

4.2 Transport cost savings

Reallocation of cane from existing growing areas to mills

To begin to model the potential transport cost savings, the constraint included in the baseline simulation that each growing area must supply to a designated mill is dropped. The physical capacities of the existing tramways and trucking routes were assumed to be large enough not to be limiting. Moreover, allowance was made

E Existing mill areas



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for new links between existing tramways. This is discussed in more detail in appendix F.

The least cost allocation of cane from farms to mills without the designation constraint on growing areas is broadly represented by the shaded mill areas of figure F. With this allocation total annual costs are estimated at $62.2m — a reduction of $1.4m from the baseline simulation. These estimated cost savings comprise reductions of 8.5 per cent in haul-out costs and 12.0 per cent in trucking and tramways costs, reducing total transport costs by 10 per cent. The bulk of the savings arise from transporting cane to mills closer to growing areas and by cheaper modes of transport. In some cases, savings are achieved by closing lightly used lines and eliminating the associated fixed costs.

Rationalising cane transport in this way would have a substantial effect on the relative values of cane grown in different areas. The new values are shown in table 2. The most significant effect is a reduction in the range of differentials from $58/t to $20/t. This reflects, primarily, more rational sourcing of cane by mills, along with some changes in transport mode. For example, producers in area 53, who currently move their cane by road, could gain by using the tramway to haul it to a different mill.

These estimates of transport cost savings are likely to be understated. The model involves aggregating many farms within each of the 54 growing areas, and hence of the transport flows from these farms to their mill. It is assumed that the unit transport cost for all farms in each growing area is the same. Since rationalising the aggregate transport flows used in the model suggests there could be large cost savings, it is likely that a more disaggregated model would detect even more cost savings.

1 Present net differences in the marginal value of sugar cane between growing areas[a]

Growing area	Difference	Growing area	Difference	Growing area	Difference
	$/t		$/t		$/t
1	44	19	47	37	54
2	41	20	45	38	50
3	49	21	*na*	39	48
4	51	22	*na*	40	41
5	44	23	58	41	34
6	41	24	56	42	37
7	51	25	51	43	40
8	47	26	50	44	36
9	40	27	47	45	48
10	38	28	36	46	49
11	26	29	49	47	57
12	40	30	49	48	48
13	45	31	*na*	49	50
14	34	32	49	50	55
15	37	33	56	51	45
16	42	34	49	52	8
17	47	35	54	53	0
18	51	36	57	54	19

a The net difference in marginal value of cane (in sugar equivalent tonnes) indicates the amount by which the value of cane in one area exceeds that in the base area, area 53. ***na*** Not applicable.

Reallocation of land

Cane prices do not reflect transport costs and so do not affect growers' decisions about where to grow cane. Further, given the way in which land is assigned and peaks are allocated, many growers have little option but to grow cane at great distances from the mills. And millers are forced to transport cane great distances by road, while land close to mills and tramways remains unassigned. Deregulation would therefore provide the opportunity to grow cane closer to the mills and thereby reduce transport costs.

In the model, removing the constraint that cane can be grown only on assigned land would reduce transport costs by a further $1.4m a year. This and the policy change examined in the previous section, would reduce total cane transport costs by around 20 per cent a year, comprising a 14 per cent reduction in haul-out costs and a 29 per cent reduction in trucking and tramway costs. These savings arise from a greater centralisation of cane production near mills (see figure G). The range of net differences in the marginal values of cane among growing areas declines to $14/t (table 3).

It is possible that the on-farm costs of production could be increased by the centralisation of cane production indicated in figure G. Holz and Shields (1985*c*) indicate that unassigned land in the Mackay region is less attractive than the assigned land, on average, and therefore costs of production may be higher. However, as reallocation is small relative to the total amount of unused suitable land in the region, any consequent increase in cost could be insignificant.

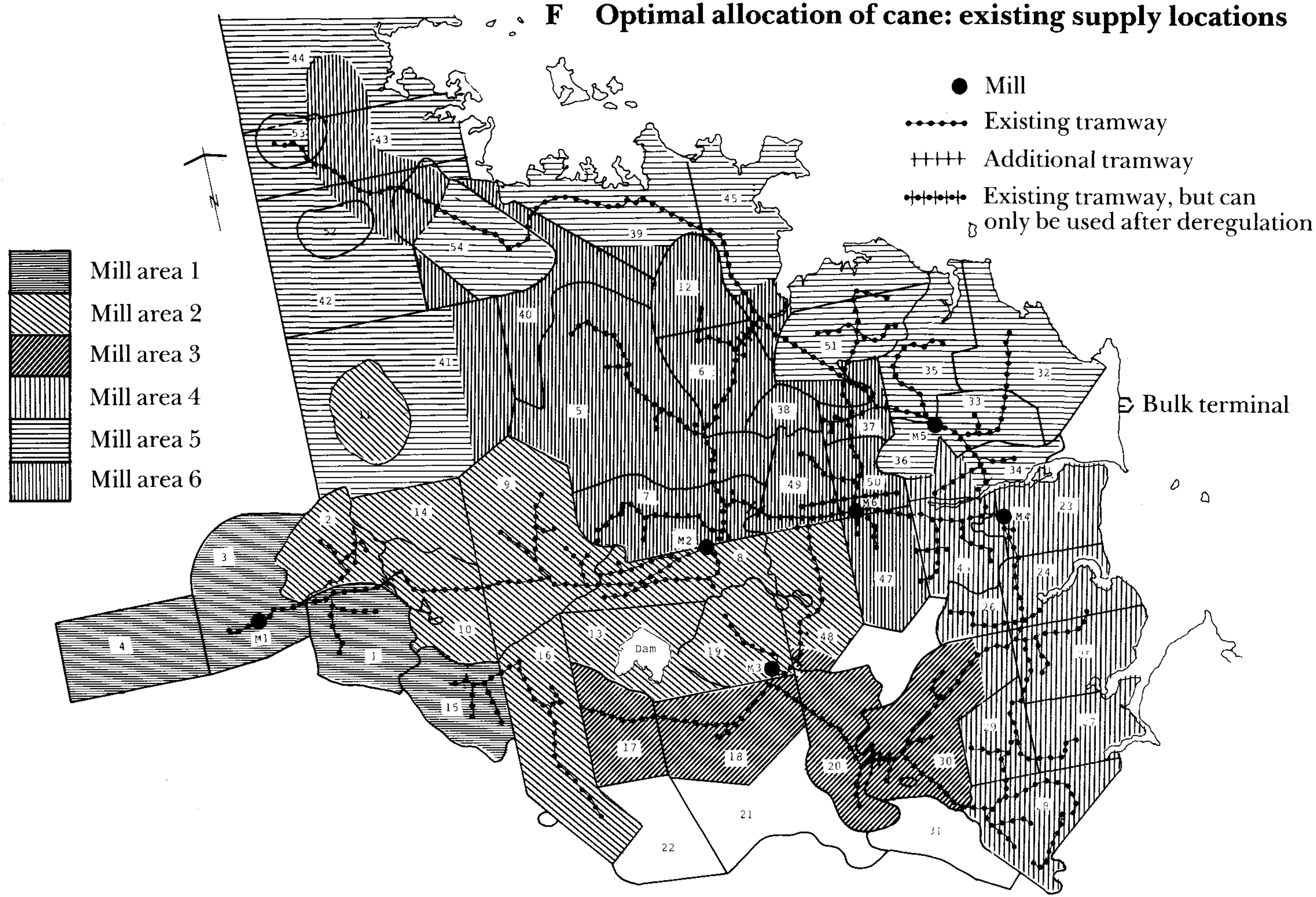
The cost savings discussed so far are summarised in table 4. These results have been obtained assuming current (five days a week) milling arrangements. It may be better to allocate cane differently if weekend milling were adopted, because there would be an increase in effective milling capacity. Though this allocation

2 Differences in the marginal value of sugar cane between growing areas, with optimum allocation of cane to mills, given existing supplies[a]

Growing area	Difference	Growing area	Difference	Growing area	Difference
	$/t		$/t		$/t
1	10	19	10	37	13
2	4	20	6	38	10
3	12	21	*na*	39	9
4	13	22	*na*	40	7
5	8	23	20	41	3
6	10	24	19	42	6
7	12	25	14	43	3
8	11	26	18	44	11
9	8	27	16	45	9
10	7	28	12	46	12
11	0	29	15	47	17
12	6	30	10	48	6
13	15	31	*na*	49	13
14	11	32	10	50	15
15	2	33	15	51	10
16	1	34	9	52	2
17	4	35	12	53	1
18	9	36	15	54	6

a The net difference in marginal value of cane (in sugar equivalent tonnes) indicates the amount by which the value of cane in one area exceeds that in the base area, area 11. ***na*** Not applicable.

F Optimal allocation of cane: existing supply locations



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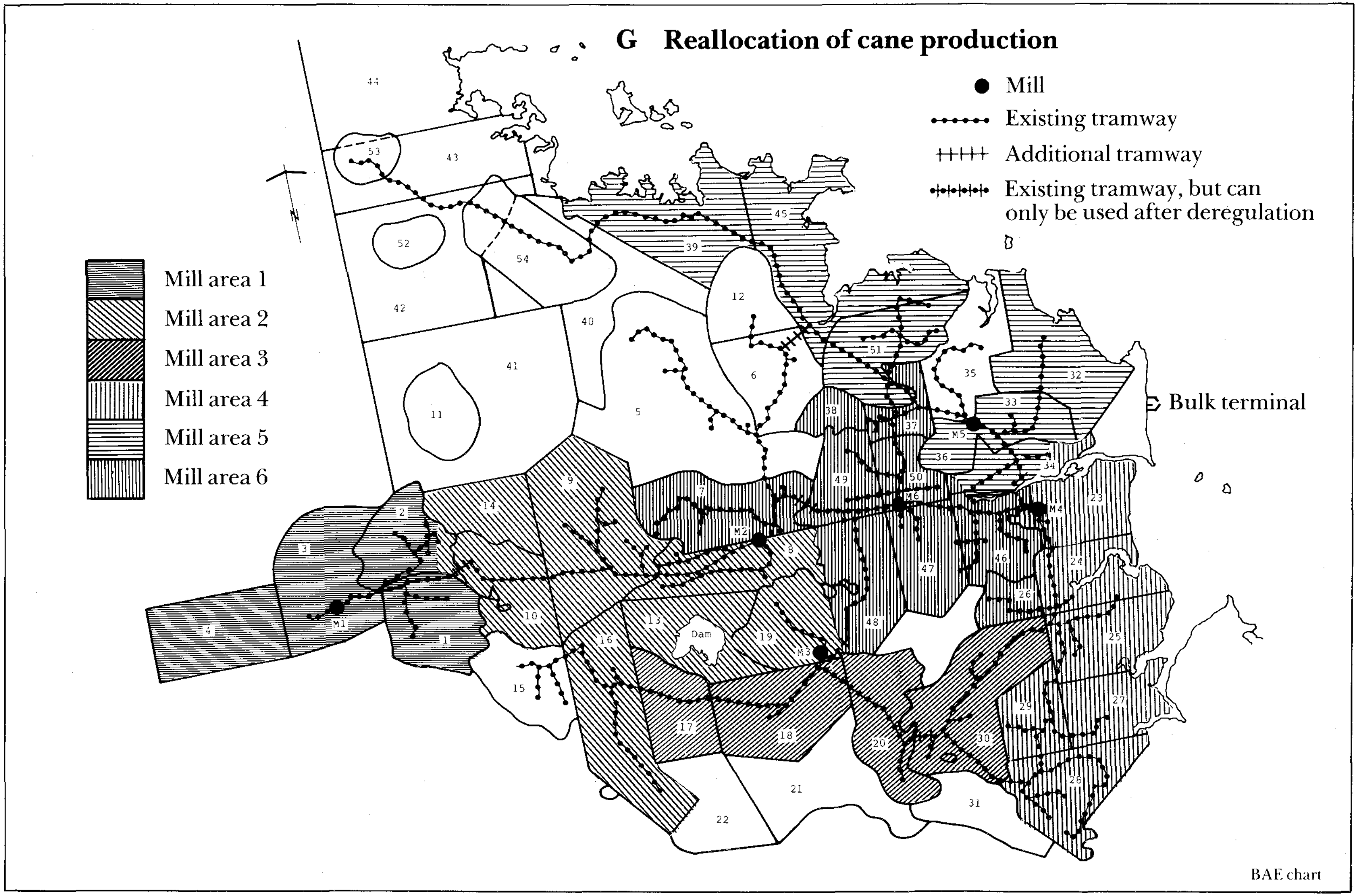
G Reallocation of cane production



may increase transport costs, it is possible that any such increase would be more than offset by lower unit milling costs.

4.3 Weekend milling

An extra two days' milling a week would increase notional milling capacity by 40 per cent. However, in practice it is necessary to shut down each mill for approximately one eight-hour shift a week for repairs and maintenance, so the effective capacity increase would be 33 per cent. Such an increase in mill capacity would present a number of opportunities. One option is to crush the current supply of cane in fewer mills. Other options are to shorten the harvesting and milling season or expand total cane production to occupy the capacity of *all* mills.

Fewer mills

To analyse the effect on annual operating costs of operating fewer mills, changes were made to two components of the baseline simulation. First, mill capacities were increased by 33 per cent to allow the use of capacity which is currently idle at weekends. Second, as for the simulation described in section 4.2, the constraint that each growing area can supply only a specified mill was dropped. However, no provision was made for adding links between the present tramways. The total cane throughput was assumed to be unchanged.

On this basis, total annual costs were estimated at $57.0m. This represents an annual saving of $6.6m (10 per cent) in aggregate, or $10/t of raw sugar. Underlying this saving is a substantial reallocation of sugar cane flows and the closure of the two smallest mills. The shaded mill areas of figure H provide some indication of the reallocation. As no modification was made to the tramway system, the redistribution results in greater haul-out distances and costs in some

3 Differences in the marginal value of sugar cane between growing areas, with optimum allocation of cane to mills, given a reallocation of land to sugar[a]

Growing area	Difference	Growing area	Difference	Growing area	Difference
	$/t		$/t		$/t
1	8	19	9	37	9
2	3	20	0	38	6
3	10	21	0	39	1
4	13	22	0	40	0
5	0	23	12	41	0
6	0	24	11	42	0
7	6	25	6	43	0
8	10	26	5	44	3
9	7	27	8	45	1
10	7	28	4	46	10
11	0	29	7	47	13
12	0	30	4	48	7
13	14	31	0	49	8
14	10	32	2	50	11
15	0	33	7	51	2
16	0	34	1	52	0
17	0	35	4	53	0
18	3	36	7	54	0

a The net difference in marginal value of cane (in sugar equivalent tonnes) indicates the amount by which the value of cane in one area exceeds that in the base areas, such as area 5.

growing areas, particularly those closest to the two closed mills. For these areas (for example, areas 1–4), the total cost of transporting cane by road to the remaining four mills increases, as the lower marginal values of cane from these areas reflect (table 5). However, the total estimated transport cost of $13.78m in this solution is still less than the $14.24m estimated for the baseline simulation.

The remaining cost savings arise from the elimination of the fixed costs of operating the two small mills. However, these savings are offset to some extent by the overtime costs associated with weekend milling at the other four mills.

Sensitivity testing

In interpreting the estimates of cost savings at the mill level, it should be appreciated that these estimates are sensitive to the division of mill operating costs into fixed and variable components. On the basis of data collected by the BAE, approximately 70 per cent of total operating costs were assessed to be fixed. However, in view of the difficulties of correctly classifying costs (see section 3.5), it is important to test how much changes in the proportion of fixed milling costs affect the results. To do this the model was run under the same set of assumptions described in section 4.3 and the ratio of fixed to total costs at mills was varied from 0.8 down to 0.4. The sensitivity of the estimated percentage cost savings to this variation is illustrated in figure I. Over the most likely range of 0.6 to 0.8, the savings due to weekend milling and the use of fewer mills ranged from around 9 per cent to 11 per cent of total costs. Despite the difficulties in classifying costs as fixed or variable, the results of the model appear to be reasonably robust in terms of the assumptions on costs.

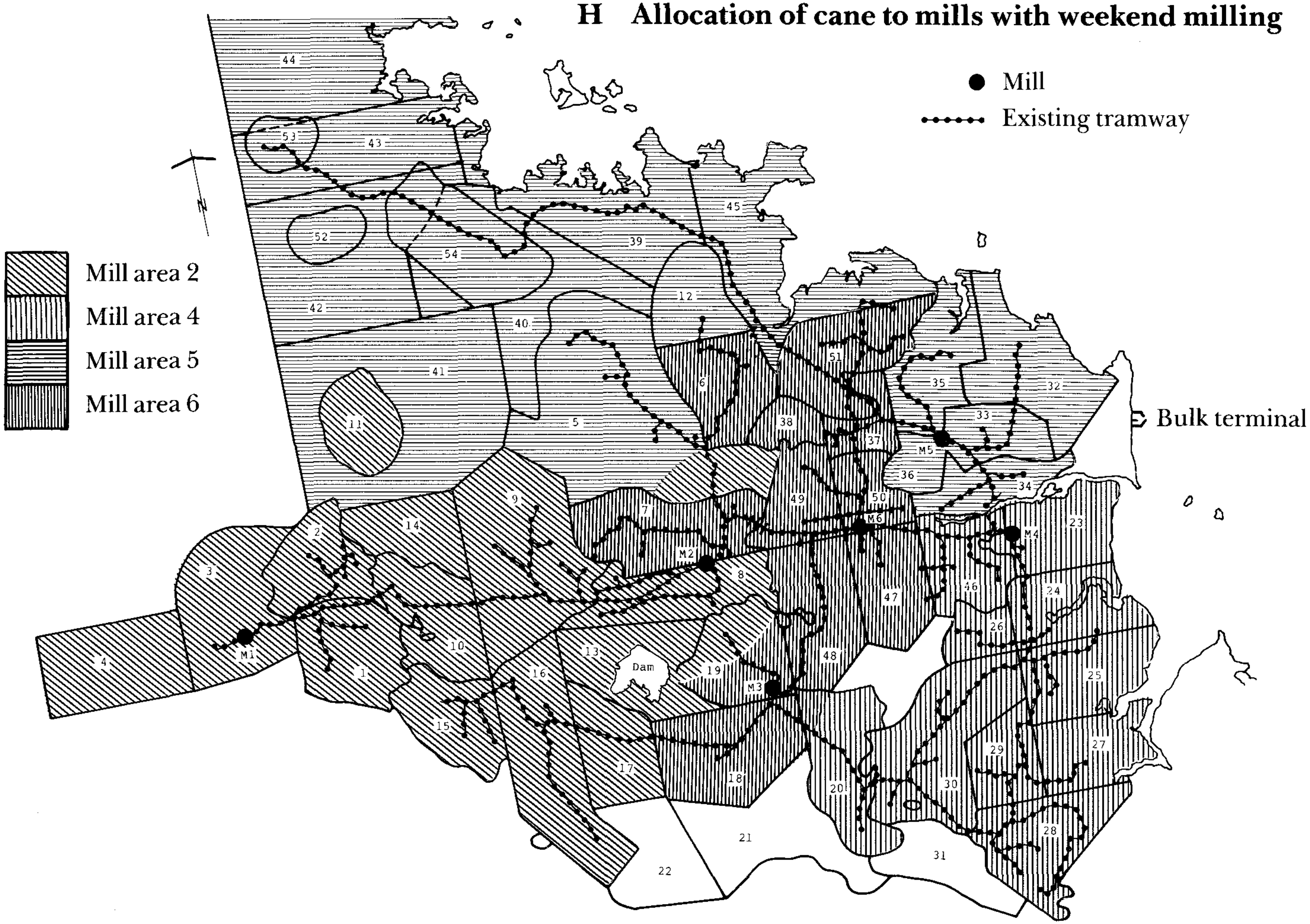
As tramways also have a high fixed cost component, similar sensitivity tests were conducted by varying the proportion of tramway costs regarded as being fixed. Estimated cost savings were quite insensitive to these variations due to the clear cost advantage of tramway over road

4 Annual transport and milling costs, and potential transport cost savings

Solutions	Cane transport costs: Haul-out	Cane transport costs: Truck and tramway	Cane transport costs: Total	Milling, sugar transport and handling costs	Total
	$m	$m	$m	$m	$m
Solution 1					
Baseline	8.716	5.524	14.24	49.36	63.6
Solution 2					
Optimal allocation of cane, with existing allocation of supplies	7.977	4.863	12.84	49.36	62.2
Cost savings over the baseline solution	0.739	0.661	1.40	0	1.4
	(8.5)	(12.0)	(9.8)	(0)	(2.2)
Solution 3					
Optimum allocation of cane, with reallocation of supply	7.523	3.917	11.44	49.36	60.8
Cost savings over the baseline solution	1.193	1.607	2.80	0	2.8
	(13.7)	(29.1)	(19.7)	(0)	(4.4)

***Note*:** Numbers in parentheses are percentages of baseline costs.

H Allocation of cane to mills with weekend milling



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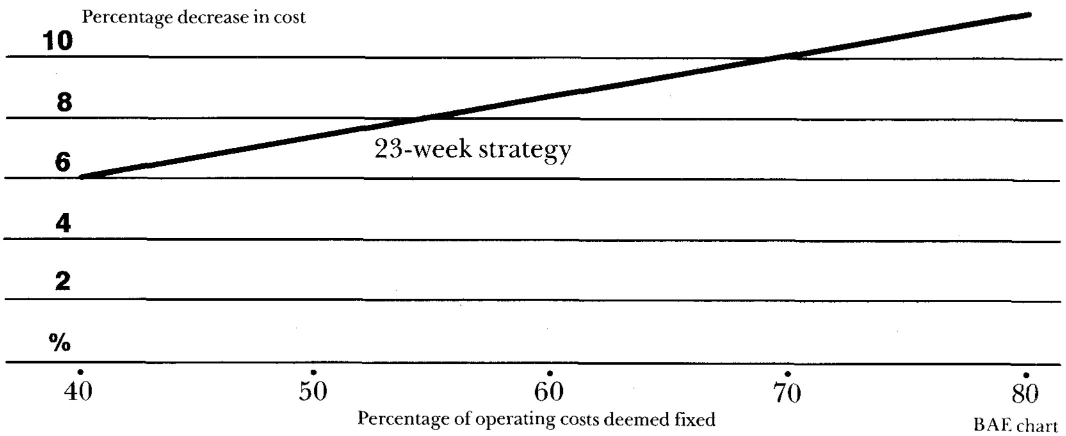
transport for most regions in the model. (This advantage may be due to the large sunk costs in the existing tramway system, and would not necessarily hold for investment in new tramway facilities.) The only tramways it would be economical to close would be those with low ratios of traffic to fixed costs. As such instances are rare, there are few opportunities to achieve savings by closing tramways.

5 Differences in the marginal value of sugar cane between growing areas, with weekend milling[a]

Growing area	Difference	Growing area	Difference	Growing area	Difference
	$/t		$/t		$/t
1	15	19	26	37	32
2	16	20	21	38	29
3	3	21	*na*	39	27
4	0	22	*na*	40	21
5	16	23	31	41	21
6	27	24	30	42	23
7	29	25	26	43	21
8	32	26	29	44	28
9	29	27	27	45	26
10	26	28	23	46	24
11	16	29	27	47	36
12	23	30	28	48	30
13	37	31	*na*	49	31
14	23	32	27	50	34
15	10	33	32	51	33
16	22	34	24	52	20
17	22	35	30	53	19
18	23	36	32	54	23

a The net difference marginal value of cane (in sugar equivalent tonnes) indicates the amount by which the value of cane in one area exceeds that in the base area, area 4. ***na*** Not applicable.

I Sensitivity of mill costs to share of costs fixed



BAE chart

Changes in harvesting costs

The cost savings estimated using the model do not account for changes which could be made outside the transport, processing and handling sectors. Because the sugar content of cane begins to decline immediately after harvest, it is current practice to store cut cane for no more than 16 hours, and milling must generally take place on the same day as harvesting. For this reason, consideration needs to be given to allowing harvesting on overtime as a result of weekend milling work.

Page, Couchman and Bathgate (1985) show that there is potential to reduce harvesting costs by extending harvesting hours by paying overtime. Extended harvesting hours could lead to better use of harvesting resources and increase economies of scale. In one example, Page et al. reported that a harvesting group could cut 30 kt of cane a year without overtime, at a total wage cost per tonne cut of $0.91. By working an additional hour a day at overtime rates the group could increase its output to 36 kt a year. The total wage cost per tonne cut would increase to $0.93, but the cost of capital (interest and depreciation) per tonne cut would be reduced from $1.16 to $0.91, leading to an overall saving in costs.

Such savings in the capital costs of harvesting would be realised when specialised harvesting and haul-out equipment is bought or replaced. Thus, full realisation could take a number of years, and in the short term there would be additional harvesting costs from weekend milling. However, it is unlikely that the latter would be big enough to eliminate the economies achievable in other operations with weekend milling.

Tramway linkages

The considerable redistribution of cane between mills implied by the above analysis, and the additional costs of road transport in some cases, make the provision of new tramway links between adjacent mill areas economically possible. When the new tramway linkages mentioned in section 4.2 were added to the 'weekend milling' model, a small additional transport saving of around $0.3m was achieved. The allocation of cane to mills under this solution is shown in figure J.

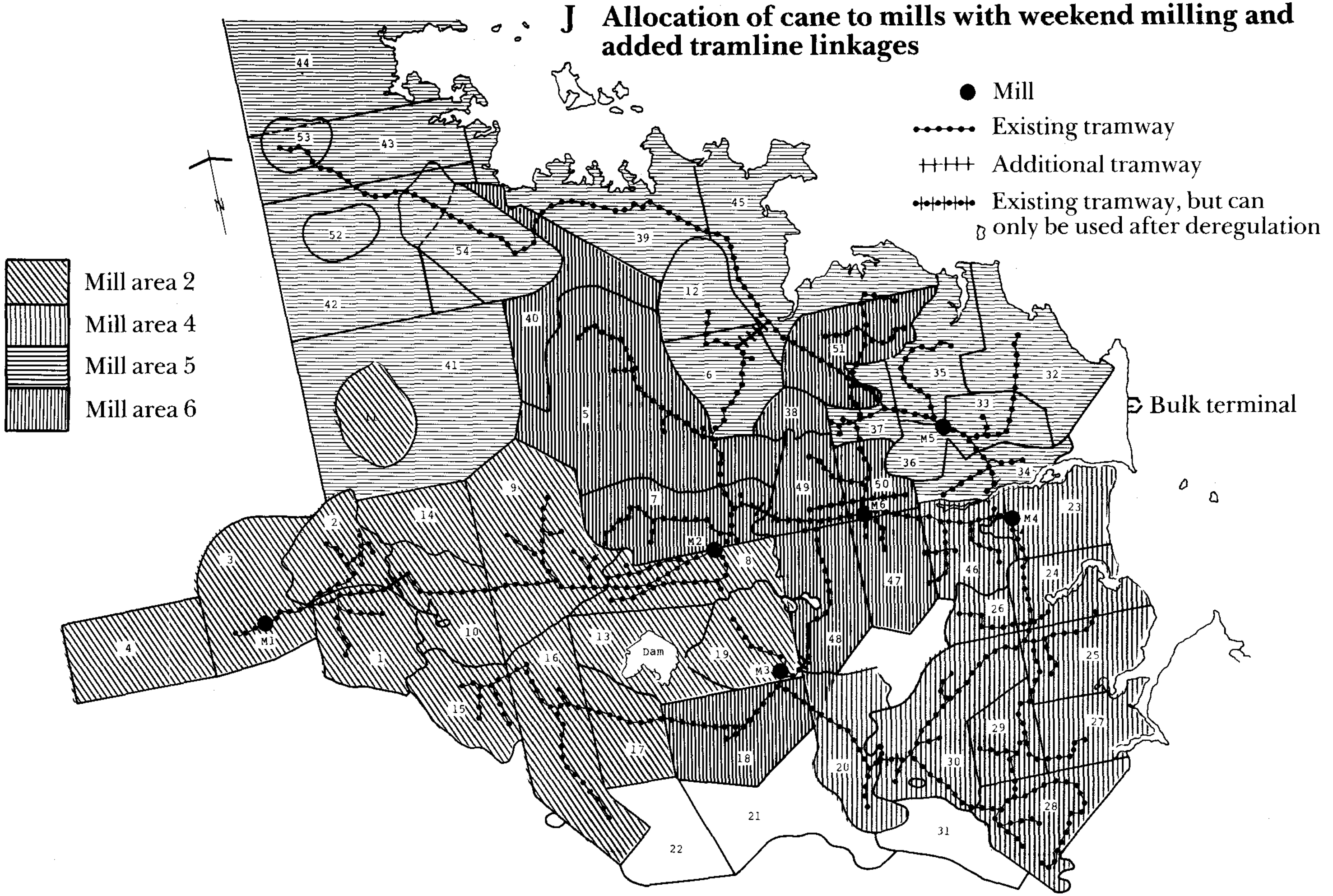
Alternative season lengths

Weekend milling would make it possible to shorten the season. As mentioned above, the sugar content of cane varies systematically over the existing five-month harvesting and crushing season (figure A), rising to a peak in mid-season. So shortening the season through weekend milling would enable more raw sugar to be obtained from a given quantity of sugar cane. This could allow greater profits, since there is no extra cost in transporting cane with a higher sugar content. The profitability of a given season length essentially depends on the cost of overtime relative to the price of raw sugar. The model cannot be used to estimate the best season length. But it can be used to work out the effects of particular variations in length of season.

There is sufficient standard time and overtime capacity in the existing six mills in the Mackay region to crush all available cane, under current mill peaks and land assignments, over a 17-week season. A 17-week season was simulated in the model by altering assumed milling capacities. This option, under the other assumptions outlined in section 4.3, is estimated to cost $63.2m. This is a saving of $0.4m over the baseline simulation. It indicates that the overtime costs of weekend milling and the costs of transporting the additional sugar to the export terminal are more than offset by the savings in cane transport costs arising from rationalising transport flows (see figure K). However, the main benefit of reducing season length is the value of additional sugar produced.

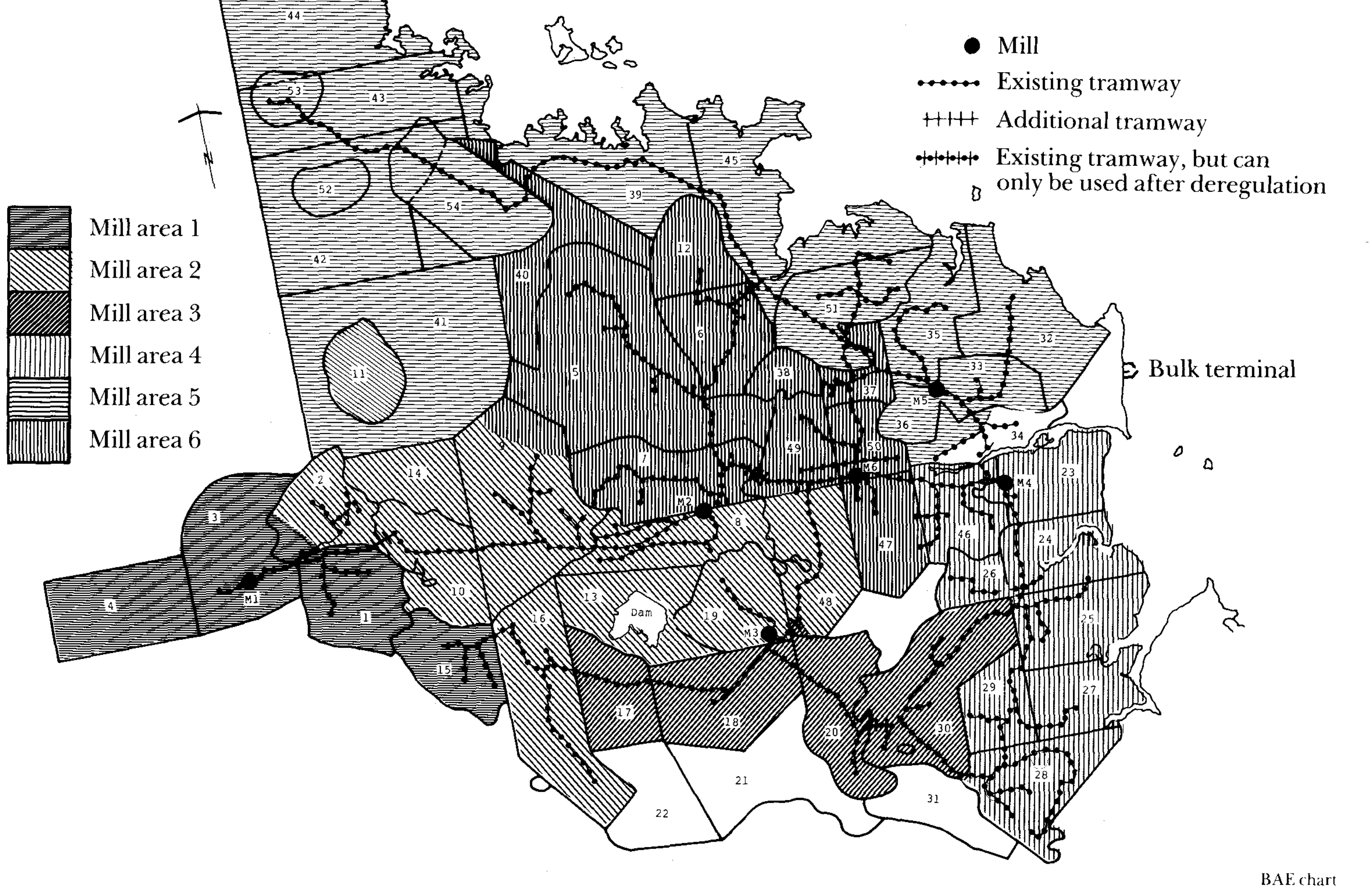
The average sugar content of cane is measured as the percentage weight of sugar which can be commercially extracted from the cane. Based on the work of Ryland (1975), the sugar content of cane is expected to rise from 14.14 per cent for a 23-week season to 14.88 per cent for a 17-week season. Sugar production would increase by 5 per cent, or 31 kt, for the Mackay region. Valued at a No. 2 pool price (the price obtained for marginal production of sugar) of $100/t, this would

J Allocation of cane to mills with weekend milling and added tramline linkages



BAE chart

K Allocation of cane to mills with a 17-week season



add $3.1m to industry revenue. On that basis, the change to a 17-week season would lead to an overall increase in industry profitability of $3.5m, the equivalent of a 5 per cent reduction in costs.

A comparison of weekend milling options

The results in the previous section indicate that with weekend milling industry profitability could be increased without closing any mills. However, if reduced season length is to be more profitable than closing two mills (see section 4.3) the No. 2 pool price would need to average more than $200/t over the long term. If the proportion of mill operating costs which is fixed were less than 70 per cent a reduction in the length of the season would be more profitable than mill closures at a lower No. 2 pool price. This relationship is illustrated in figure L which is a graphical summary of the effects on profitability of different weekend milling options for a range of assumptions about fixed costs.

Figure L also includes an illustration of the effects on industry profitability of a 19-week season with closure of one small mill. This option can be seen to be more profitable than a 17-week one for all assumptions about fixed costs and sugar prices. Furthermore, it can be inferred from figure L that a 19-week option is more profitable than a 23-week one if the No. 2 pool price exceeds about $125/t; below $175/t, the 27-week option is the most profitable and yields cost savings of around 13 per cent overall as it allows one large and one small mill to be closed, albeit at the expense of reduced sugar output (see figure M).

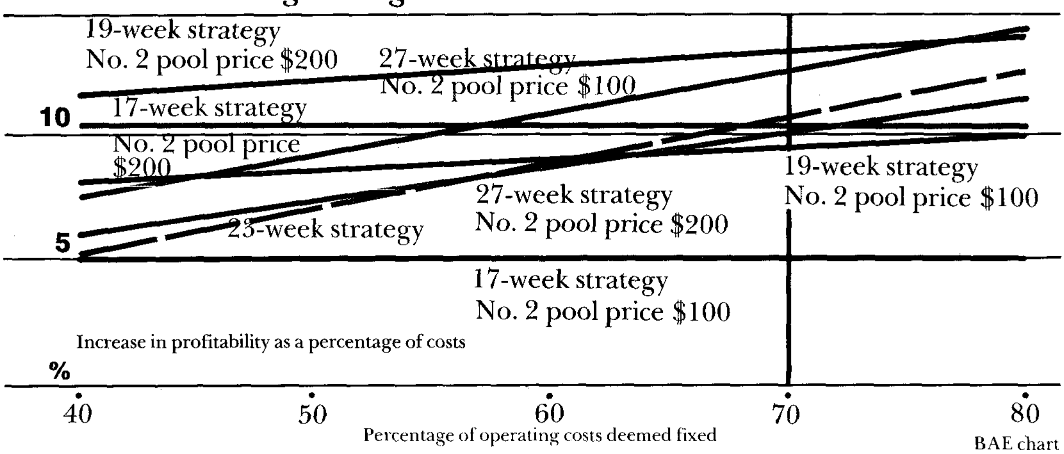
4.4 Expansion

The preceding results show how much industry profitability could be increased through more efficient use of transport and milling resources. An even better use of resources could be achieved, with increased throughput at *all* facilities, given a quite feasible expansion of the size of the sugar industry (see section 2.2 and appendix F).

To estimate the benefits of increased production, a series of analyses was conducted under the assumption that the full complement of suitable land in Mackay was available for cane production. Production was raised by successive increments of 5 percentage points up to a level equivalent to 130 per cent of current production. The full complement of standard time and overtime milling capacity was also assumed to be available, and tramways were linked as required.

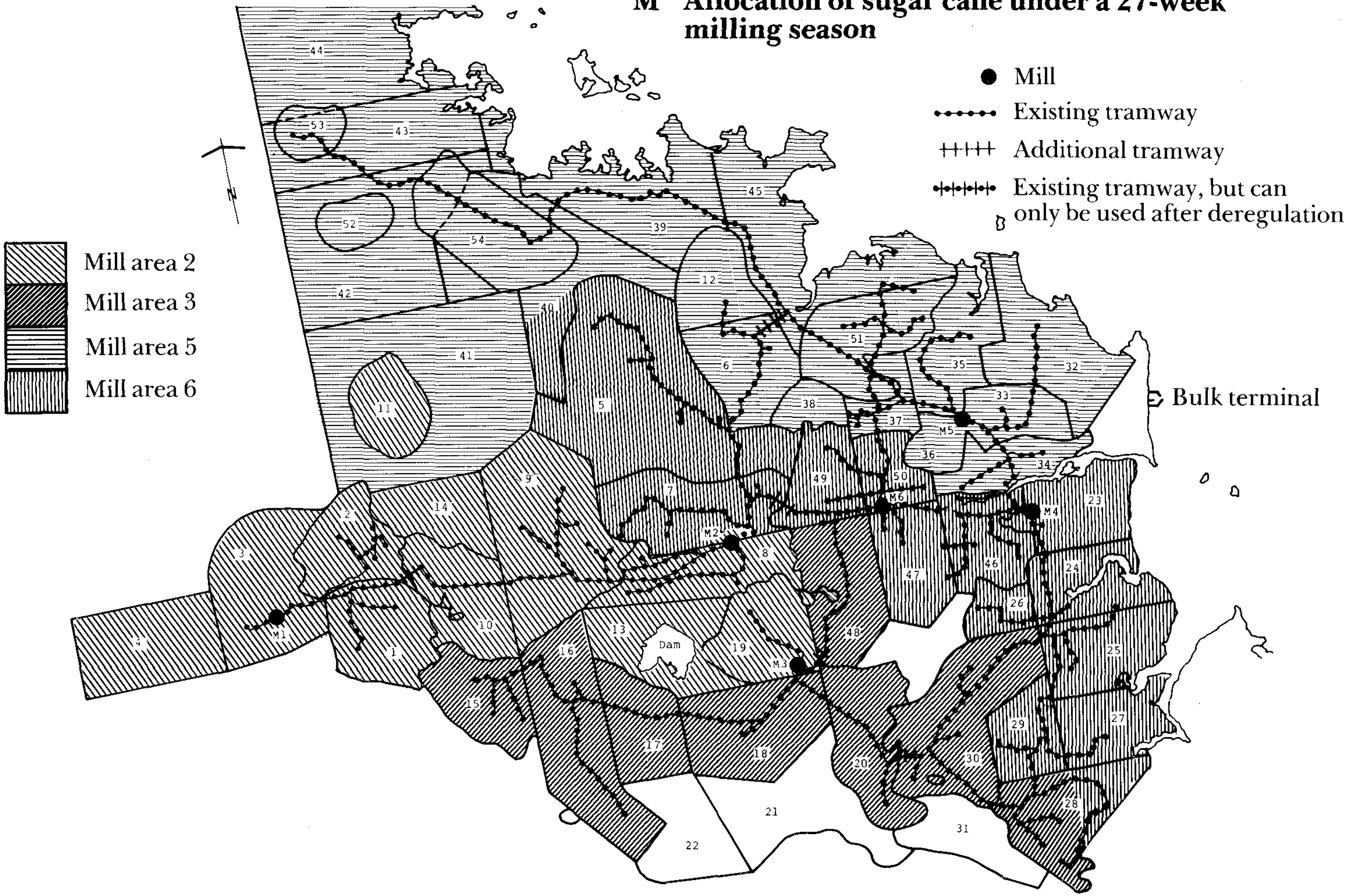
The average costs of transport, milling and handling arising from these analyses

L Sensitivity of profitability to share of costs fixed, for various weekend milling strategies



BAE chart

M Allocation of sugar cane under a 27-week milling season



BAE chart

are summarised in table 6. With a 30 per cent increase in production, six mills in the Mackay region would use most of their available standard time and overtime milling capacity. The average total cost in the off-farm sector was estimated to be around $85/t, a saving of 15 per cent over the baseline simulation. The marginal cost to mills of tramway transport, milling and delivery was estimated to be within the range $29/t to $41/t. This is small compared with the marginal revenue (net of cane purchases) received by mills from sales of No. 2 pool sugar in the past twelve years (table 7). Provided the net revenue from additional sales from the No. 2 pool exceeded $41/t, the profitability of all mills would be raised by increasing cane throughput.

If the average marginal net revenues received in the past can be realised in the future, all mills could be much more profitable if the industry were expanded. Costs in the off-farm sector of the Mackay region associated with current sugar production could be reduced by $9.5m and profits from the sale of the extra 190 kt of raw sugar would be around $15m. These figures do not include any profits due to improved economies of scale on farm or to additional sugar cane production which may be profitable at existing sugar prices on the world spot market.

The estimated profits from the sale of extra sugar are sensitive to the assumptions made about future price. The future world price is uncertain, but the estimated profits are based on the long term average and, therefore, most probable price.

The world sugar price is more volatile than all other commodity prices, and is cyclical. In June 1985 it averaged US2.8c/lb, which contrasts dramatically with the US56c/lb paid for sugar in November 1974. However, there is no statistically detectable long term trend in sugar prices. The market is characterised by a reasonably steady growth rate in consumption, but growth in production fluctuates. Changes in production are usually a direct result of government quota changes or other intervention, and consumption is influenced by regulated domestic sugar prices. Government intervention, in almost all producing and consuming countries, has long been the dominant feature of the sugar market and it is likely to remain the key influence in the future. The basic character of the market will therefore remain much the same as at present. Although certain structural changes are occurring, some are working to stabilise price while others have a destabilising effect; the net effect is therefore difficult to assess, and the historical average price seems the best unbiased estimate of the expected long term future price.

Although Australia is among the largest exporters, with around 9 per cent share of total world trade but only about 3 per cent of world consumption, it is too small to have a strong influence on world price.

6 Average unit costs of transport, milling and handling, with increases in cane production

Production	Percentage of existing production	Average unit cost	Number of mills open
kt	%	$/t	
635 (baseline)	100	100.61	6
635	100	86.60	4
668	105	84.98	4
699	110	87.07	5
731	115	85.50	5
763	120	84.26	5
795	125	86.54	6
827	130	85.47	6

Further, if Australia does not expand sales competing countries will increase their share of the growing world market: regardless of which country expands, the effect on world price will be the same. It is, therefore, quite reasonable to assume that the average world price can be realised for an expanded Australian production.

4.5 Industry-wide savings

While the potential for expansion varies among the regions of the industry, it can be inferred that the existing regulatory constraints on the industry will have qualitatively similar effects in all regions. At the very least the option to reduce the length of the milling season is available in every region. Further, Dawson, Berndt and Venk (1983) indicate that there is considerable potential for expanding the industry in nine of the twelve Queensland milling regions, equivalent to an increase in production of more than 50 per cent. Thus, both options are open to the majority of mill areas.

The mill closure option is not feasible in the five geographically isolated mills in Queensland, nor in the one region where there are only two mills. Nevertheless, for the industry as a whole, if the economic gains suggested by the Mackay model were achieved industry-wide, this would result in net annual savings of around $130m. This figure does not include the benefits from improved economies of scale on the farm or from extra production of sugar cane.

Not all regions will face potential gains equivalent to those for Mackay; some will have considerably more scope to expand, others will have less. However, for the industry as a whole the potential for expansion is greater than the 30 per cent allowed for Mackay in this study. Thus, gains may be greater than indicated.

4.6 Overall evaluation

The applications of the model presented in this section provide a great deal of useful information on the effects of regulations and controls which constrain the off-farm sector of the sugar industry. One of the main features of the model is that it takes account of economic interactions between mill areas over the whole Mackay region. So it is possible to study how changes in one area affect another part of the region. In this way the model can be used to assess economic gains for the whole region. This is important because gains available to the

7 Millers' marginal revenue for No. 2 pool sugar sales, net of cane purchases

Season	Marginal revenue in actual dollars	Consumer price index	Marginal revenue in constant 1984 dollars
	$/t		$/t
1973	49	32.73	150
1974	110	37.70	292
1975	101	43.40	233
1976	89	49.23	181
1977	47	55.30	85
1978	51	59.68	85
1979	162	65.09	249
1980	148	71.72	206
1981	88	78.63	112
1982	73	87.40	84
1983	52	96.24	54
1984	36	100.00	36
Average			147

Source: Estimated from Sugar Board (1984).

region as a whole are greater than those available to each subregion considered in isolation.

Although the model necessitates some degree of simplification of the structure of the Mackay industry, this does not weaken the results or the conclusion to be drawn from them. The results are not very sensitive to changes in the cost data used and, although they are sensitive to the assumption about future prices, the assumption used is unbiased. Therefore, although the results could be either overestimated or underestimated, there is no reason to favour either one of those possibilities.

Some of the other simplifying assumptions used may have led to the results being underestimated. As already discussed, the level of aggregation in the model probably has this effect. The potential gains indicated are only those that could be achieved with present technology and capital. They do not take account of additional savings which might arise, in the longer term, following technological changes and investments made profitable by structural and institutional change. Nor do they take account of economies obtained producing by-products such as electric power and molasses. That the gains are probably underestimated obviously does not weaken the conclusion that regulations and controls directly prevent growers and millers achieving cost savings and exploiting opportunities in the world market.

5. Policy implications and conclusions

It was argued earlier in this paper that the present controls on cane prices, production and marketing substantially reduce the incentives for millers to crush at the weekend or for growers to minimise cane transport costs. The results presented above support the contention that a number of different milling, transport and industry expansion options have the potential to increase industry profitability. Given that the economic gains computed are likely to be conservative, the benefits could be quite substantial.

The benefits of a particular milling option for any mill area will depend on a number of variables, and choosing the best one is a complex task. The best will vary from region to region, as it depends on the number of mills, seasonal conditions and production, processing and transport costs, which can all vary between regions. To determine and implement the best strategy for every region would be extremely difficult to achieve by the central decision making processes which currently exist in the industry. These tend to be cumbersome, and lack the flexibility needed by individual producers to exploit their differing advantages in producing and marketing cane.

If the economic gains from weekend milling and a reallocation of cane to mills were allowed to be reflected in the terms and conditions of the sale of cane, millers and growers would be able to and would be encouraged to negotiate mutually satisfactory milling and transport arrangements. In aggregate, this process would maximise the net benefits to the industry. For instance, given that milling on weekends would increase the amount of sugar obtainable from a given quantity of cane, and provided millers are reimbursed for at least the traditional milling costs involved, millers and growers would have an incentive to ensure that weekend milling was adopted whenever it was economic to the industry. The BAE (1983), the Industries Assistance Commission (1983), the Sugar Industry Review Committee (1984) and Savage et al. (1985) have all proposed that the current revenue sharing arrangements and other impediments applying to the production of overpeak (or No.2 pool) sugar be removed. This would leave growers and millers free to negotiate terms and conditions attached to the sale, transport and processing of cane.

From the model results presented in this paper, it is evident that the present revenue sharing arrangements and system of production and marketing controls impede the exploitation of profitable opportunities. Though the model can indicate the source and broad magnitudes of some of these opportunities, it does not predict exactly how the pricing and negotiating behaviour of growers and millers might change. The market structures and organisation implied by the various results are not necessarily consistent with those of a perfectly competitive market. For instance, each mill has some limited market power and therefore some limited potential to act like a monopoly. So removing those regulations and controls represented as constraints in the model may not independently lead to a rationalised industry structure that allows total industry profits to be maximised. Some government safeguards may be necessary.

Nevertheless, the potential benefits of more flexibility in negotiation between growers and millers should not be overlooked. Under the recommendations of the four reports listed above there would at least be opportunities for growers and millers to change to their mutual benefit the terms and conditions for delivering and processing cane. As in most Australian industries where there is free negotiation between various producers in the marketing chain, safeguards exist to limit the market power of any firm or group. The provisions for restrictive trade practices in the Trade Practices Act, and the process of civil arbitration would help to guard against growers or millers obtaining strong market power. These safeguards are discussed further in Industries Assistance Commission (1983) and Savage et al. (1985). If these safeguards did not work, a specific industry policy for correcting instances of excessive market power in the industry should be favoured over current policies. Current policies severely constrain the normal workings of decentralised markets and distort prices. They make equity more important than efficiency.

Movement toward a more decentralised and flexible decision making environment seems essential if the economic gains outlined here are to be obtained. To achieve these gains would require at least permitting greater flexibility in producing sugar sold at the going price on the world market (No. 2 pool). This would mean removing all quantity restrictions on the production of cane and sugar used to make up such sales. It would also mean removing obstacles to effective negotiation between growers and millers: in particular, removing or greatly changing controls over contracts made between millers and growers outside the mechanisms laid down by the Regulation of Sugar Cane Prices Act. It would also mean replacing the current system of land assignments and mill peaks with a system of freely negotiable market entitlements for producing No. 1 pool sugar.

Appendix A

Potential for decline in net miller revenue with increases in the sugar content of cane

The cane payment formula tends to discourage millers financially from doing anything to increase the average sugar content of cane crushed. This appendix gives a mathematical and graphical analysis of the nature of this disincentive.

For there to be an incentive for a miller to adopt costly changes in operations, such as weekend milling, the miller's revenue must increase, as sugar production increases, by more than the increase in mill costs. What is demonstrated below is that, for many likely sets of price and production conditions, revenue to millers is actually lowered by such increases in sugar production.

Graphical representation

The effects of changes in the sugar content of cane on the revenues of growers and millers are illustrated in figure N. The relationships shown are those which, in 1984-85, would have applied to a mill with cane throughput and No. 1 pool sugar quota equal to the Queensland mill averages. These averages in 1984-85 were 797 kt of cane and 106 kt of sugar, respectively. A commercial sugar content of cane of 13.31 per cent would therefore have been required to fill the mill's No. 1 pool quota exactly.

The slope of the miller's net revenue curve against sugar content decreases after the level needed to fill the miller's No. 1 pool quota (13.31 in this case), because the No. 2 pool price ($100/t) is less than the No. 1 pool price ($235/t). In the case illustrated, the payments which the miller is required to pay to growers under the formula increase more rapidly than the miller's gross receipts for sugar, so the miller's net revenue declines. This situation can be called 'overpayment'.

In 1984-85 the average commercial sugar content of cane was 13.62 per cent. On average, millers were operating in the range where increasing the sugar content of the cane would have reduced their revenue. If it had been possible, they would have been better off reducing sugar content toward 13.31 per cent.

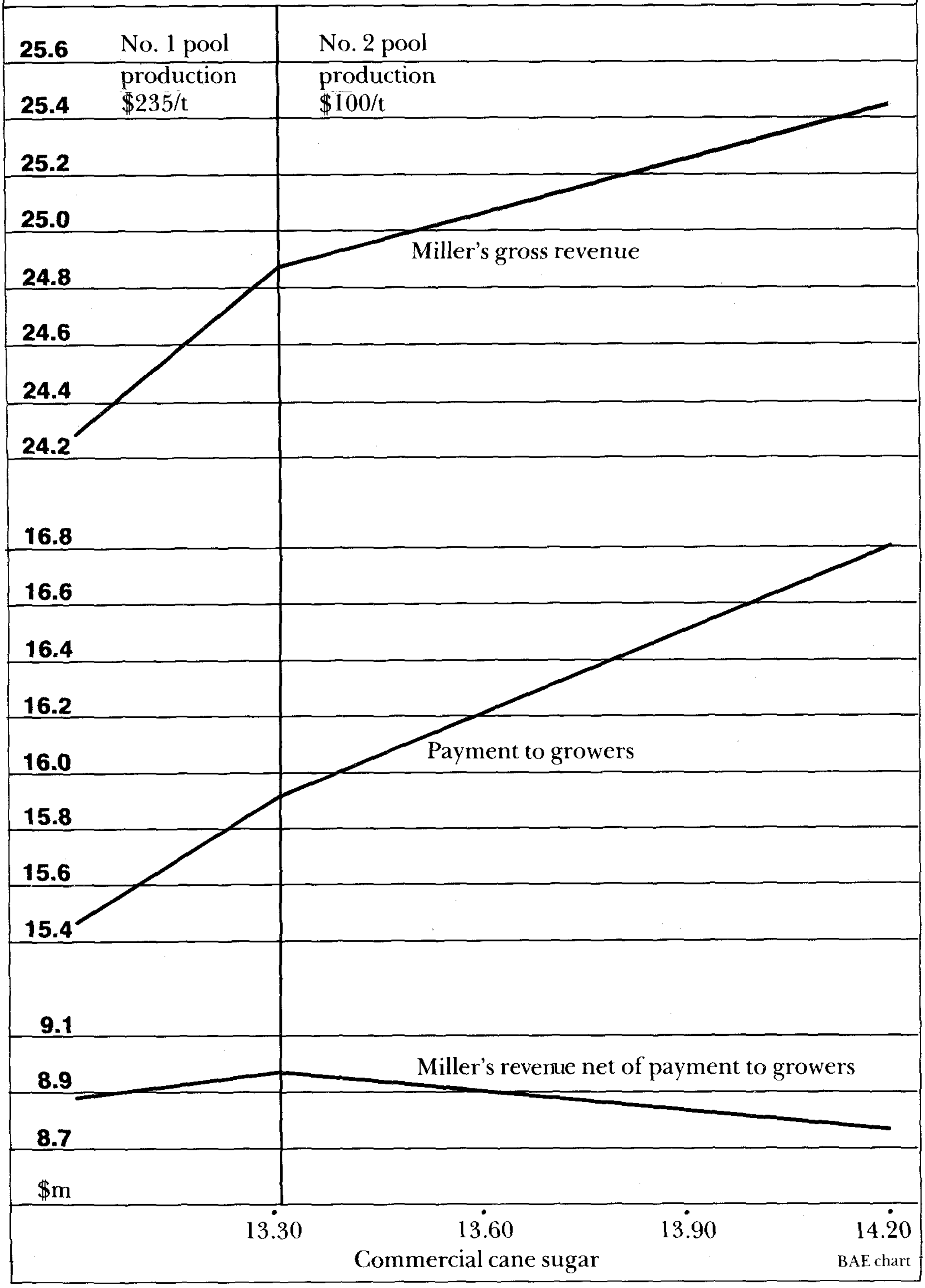
The main factors which influence the gains or losses to growers and millers with changing sugar content are: the two-pool pricing system; the price levels for No. 1 and No. 2 pool sales; the miller's No. 1 pool sugar quota; and the nature of the cane payment formula. These were all discussed in chapter 2.

Under the two-pool pricing system, when the miller's No. 1 pool quota is filled, all subsequent output of sugar is sold at the No. 2 pool price. The miller's No. 1 pool gross revenue cannot increase once the quota is filled. A change in the commercial sugar content of cane, however, will affect the miller's No. 1 pool *net* revenue. This occurs due to three important changes which occur with an increase in the sugar content of cane. First, fewer tonnes of cane are required to fill the miller's No. 1 pool sugar quota; second, the excess cane is used to produce excess (No. 2 pool) sugar; third, under the cane payment formula, cane prices increase.

Under the formula, the price of cane increases with sugar content by a percentage which is greater than the associated percentage reduction in the quantity of cane required to fill the No. 1 pool sugar quota. When sugar content increases, therefore, the miller pays a higher total cost for cane used to produce No. 1 pool sugar, and so the miller's No. 1 pool net revenue shrinks.

From the additional sales of No. 2 pool

N Effects of changes of sugar content of cane on the revenues of growers and their miller for an average Queensland mill, 1984-85



sugar the miller's No. 2 pool net revenue increases. However, this increase will compensate the reduction in No. 1 pool net revenue only if the No. 2 pool price exceeds a certain critical fraction of the No. 1 pool price (see below). In six of the past ten years this condition has not been fulfilled, so the miller's net revenue would have fallen in response to any increase in the sugar content of the cane.

Taking into consideration that the miller incurs other additional costs when sugar content increases, particularly sugar handling costs, the financial disincentive is more severe than figure N indicates. Faced with such disincentives, millers may avoid practices which could increase the overall net revenue of the industry, such as milling at weekends, to shorten the length of the season and hence raise average sugar content. As a result, profitable opportunities for the industry as a whole will be missed.

Mathematical representation

Mathematically, a potential for net reduction in millers' revenue in response to increases in cane sugar content can be shown to exist if the rate of change of the growers' revenue with sugar content is greater than that of the millers' gross revenue. In this section, it is proved that overpayment for cane by the miller — that is, payment that is excessive in relation to returns — will occur over a specific range of sugar content if the No. 1 pool price exceeds the No. 2 pool price by a specific factor.

Parameters

Q^c = total cane crushed (tonnes) in a single mill area

Q^s_q = mill's No. 1 pool sugar quota (tonnes)

CCS = commercial cane sugar

COW = coefficient of work (efficiency of sugar extraction)

P^s_1 = No. 1 pool sugar price ($/t)

P^s_2 = No. 2 pool sugar price ($/t).

Variables

Each of the following variables can be expressed in terms of the above parameters:

Q^c_1 = quantity of cane receiving No. 1 pool cane price

Q^c_2 = quantity of cane receiving No. 2 pool cane price

Q^s_1 = mill's quota sales, receiving No. 1 pool sugar price

Q^s_2 = mill's overquota sales, receiving No. 2 pool sugar price

P^c_1 = No. 1 pool cane price

P^c_2 = No. 2 pool cane price

GR = growers' revenue for single mill area

SR = mill's gross sugar revenue.

Definitions

The following definitions are taken as given:

(A1) $$Q^c_1 = \min \left(Q^c, \frac{Q^s_q}{\frac{CCS}{100}\,\frac{COW}{100}} \right)$$

that is, the quantity of cane receiving the No. 1 pool cane price is equal to whichever is the smaller of total cane crushed or the amount of cane needed to produce the mill's No. 1 pool sugar quota.

(A2) $$Q^c_2 = Q^c - Q^c_1$$

(A3) $$Q^s_i = Q^c_i \frac{CCS}{100}\,\frac{COW}{100} \quad \text{for } i = 1,2$$

(A4) $$P^c_i = P^s_i\, 0.009[CCS - 4] + 0.328 \quad \text{for } i = 1,2$$

Equation (A4) is the industry-wide cane payment formula (see Industries Assistance Commission 1983).

(A5) $$GR = P^c_1\, Q^c_1 + P^c_2\, Q^c_2$$

(A6) $$SR = P^s_1\, Q^s_1 + P^s_2\, Q^s_2$$

Assuming that $COW = 100$, and given that COW is independent of CCS, it can be shown that GR and SR have the following functional forms in terms of CCS and the other parameters.

Case A

In this case, the quantity of cane crushed and its CCS are not sufficient to meet the mill's No. 1 pool sugar quota; that is:

(A7) $$Q^c \frac{CCS}{100} < Q^s_q$$

When (A7) applies, it can be shown that:

(A8) $GR = 0.009\ P_1^s\ Q^c\ CCS - [0.036\ P_1^s - 0.328]Q^c$

(A9) $SR = 0.01\ P_1^s\ Q^c\ CCS$

When (A7) holds there is no production of No. 2 pool sugar and therefore no potential for overpayment as defined above. However, No. 2 pool sugar has been produced in all years, at least since 1969, and therefore case A is of no practical consequence.

Case B

In this case, the quantity of cane crushed and its *CCS* are sufficient to exceed the mill's No. 1 pool quota, that is:

(A10) $Q^c \frac{CCS}{100} \geq Q_q^s$

When (A10) applies, it can be shown that:

(A11) $GR = 0.009\ P_2^s\ Q^c\ CCS - 3.6[P_1^s - P_2^s]Q_q^s \frac{1}{CCS} + 0.9[P_1^s - P_2^s]Q_q^s - [0.036\ P_2^s - 0.328]Q^c$

(A12) $SR = [P_1^s - P_2^s]Q_q^s + 0.01\ P_2^s\ Q^c\ CCS$

Note that the first term in (A11) varies linearly with *CCS*, while the second term varies *inversely* with *CCS*. Note also that (A12) is a linear function of *CCS*.

By differentiating (A11) and (A12) with respect to *CCS*, the rate of change of *GR* and *SR* are obtained:

(A13) $\frac{\partial GR}{\partial CCS} = 0.009\ P_2^s\ Q^c + 3.6[P_1^s - P_2^s]Q_q^s \frac{1}{CCS^2}$

(A14) $\frac{\partial SR}{\partial CCS} = 0.01\ P_2^s\ Q^c$

The first term of (A13), $[0.009P_2^sQ^c]$, is 90 per cent of the right-hand side of (A14). When $P_1^s > P_2^s$, the second term of (A13) is positive and decreases toward zero as *CCS* increases. Consequently, when $P_1^s > P_2^s$ the rate of increase of *GR* with *CCS always* exceeds 90 per cent of the rate of increase of *SR*, and the *maximum* rate of increase of *GR* occurs when *CCS* has the smallest value allowable for case B. This occurs when

$$CCS = 100 \frac{Q_q^s}{Q^c}$$

and the maximum rate of increase of *GR* with *CCS* is:

$$0.009\ P_2^s\ Q^c + 0.00036[P_1^s - P_2^s] \frac{(Q^c)^2}{Q_q^s}$$

If P_1^s is sufficiently greater than P_2^s, the rate of increase in *GR* will exceed the rate of increase in *SR* and there will be a potential for overpayment. This condition can be shown to require that:

(A15) $\frac{P_1^s}{P_2^s} > [1 + 2.778 \frac{Q_q^s}{Q^c}]$

When condition (A15) is satisfied, as *CCS* increases over the range

(A16) $CCS \geq 100 \frac{Q_q^s}{Q^c}$

$$CCS < 60\sqrt{(\frac{P_1^s}{P_2^s} - 1)\frac{Q_q^s}{Q^c}}$$

the rate of increase of growers' revenue will exceed the rate of increase of miller's gross revenue. Consequently, the miller's net revenue actually decreases as *CCS* increases over the range given by (A16).

In 1984-85, the values of the parameters for the representative mill were:

$Q^c = 797\ 006$ t

$Q_q^s = 106\ 055$ t

$P_1^s = \$235$/t

$P_2^s = \$100$/t

Condition (A15) was satisfied, since:

$\frac{235}{100} = 2.35$ *is* greater than

$[1 + 2.778 \frac{106\ 055}{797\ 006}] = 1.37$

The range of *CCS* values given by (A16) is:

$$CCS \geq 100 \frac{106\ 055}{797\ 006}$$

$$CCS < 60\sqrt{[\frac{235}{100} - 1]\frac{106\ 055}{797\ 006}}$$

that is, $13.31 \leq CCS < 25.4$.

This is the situation shown in figure N. The average *CCS* for Queensland mills was 13.62 in 1984-85, which lies within the range given by (A16), and therefore the potential for overpayment existed.

Appendix B

Long run elasticity of demand for Australian raw sugar

A method for estimating export demand elasticities in a less than perfect market is given by Cronin (1979). To apply this method it is necessary to have estimates of: the own-price elasticity of demand and supply in major consuming and producing regions; the elasticity of consumer and producer prices to the export price (that is, transmission elasticities); the distribution of consumption and production between major regions; and the level of exports from the country in question (Australia).

In a single perfectly homogeneous and free world market for sugar, all transmission elasticities would be equal to unity. But the world sugar market is not a free market; consumer and producer prices in most countries are highly insulated from the world market, especially in the short term. Estimates of transmission elasticities are not available for sugar. Supply and demand elasticities to the world price are, however, available. They are the product of a country's own-price elasticity and that country's transmission elasticity and are good approximations of the elasticities required in Cronin's method.

Two sets of elasticities to the world price are available, de Vries (1980) and Brook and Nowicki (1979). The larger the supply and demand elasticities, the greater will be the elasticity of demand for Australian raw sugar exports. The objective in presenting this appendix is to show that, even with low long run supply and demand elasticities of major sugar consuming and producing regions, the export elasticity of demand for Australian exports is extremely high. It is for this reason that the elasticities of de Vries, which are generally lower than those of Brook and Nowicki, are used here.

Following Cronin's method, the distribution of world sugar consumption and production and the supply and demand elasticities to the world price are given in table 8; and, taking Australian exports to be 2.5 Mt, the export demand elasticity facing Australia can be calculated from equation (B1):

$$\text{(B1)}\ EAEX = \Sigma_i de_i C_i / X_A - \Sigma_j se_j S_j / X_A = -28.3$$

where

$EAEX$ = the long run elasticity of demand for Australian raw sugar

de_i = the world price elasticity of demand in country i

se_j = the world price elasticity of supply in country j

C_i = quantity demanded in country i

S_j = quantity supplied in country j

X_A = quantity exported by Australia.

The long run demand for Australian raw sugar is estimated to be highly elastic, and could be assumed to be infinitely elastic. This elasticity estimate compares well with a range of sugar export demand elasticities reported by Freebairn (1978). Freebairn based his calculation on an independently estimated set of demand elasticities, and derived the range 19.5 to 48.5. Freebairn, however, also pointed out that under an 'effective' International Sugar Agreement, demand for export sugar would become price inelastic, due to the control of consumption and production. However, in the long term it is unlikely that an International Sugar Agreement could be effective in this sense.

Clearly the estimate presented here is not precise. However, it is also clear that the calculation is dominated by the very small share of total world consumption produced by Australia; it is not sensitive to even large reductions in the elasticities used. If these elasticities (particularly the supply elasticities) are considered to be too large, they would nevertheless need to be grossly overestimated to change the conclusion that the long run demand for Australian raw sugar is highly if not infinitely elastic.

8 Pattern of consumption, production and elasticities

			Categories within regions			
Region	**Parameters**[a]	**Unit**	**Developed, importing**	**Developing, importing**	**Developed, exporting**	**Developing, exporting**
Europe	C	Mt	15.5	2.4	13.6	2.0
	P	Mt	8.8	1.9	18.5	2.4
	LRSE		0.119[b]	0.645[c]	0.629[d]	0.178[e]
	DE		–0.042[f]	–0.042[f]	–0.044[d]	0.036[e]
North America	C	Mt	9.3			
	P	Mt	5.3			
	LRSE		0.225[g]			
	DE		–0.056[g]			
Central America	C	Mt			3.8	1.9
	P	Mt			2.6	10.6
	LRSE			0.269[h]	0.123[i]	
	DE		–0.021[j]	–0.05[i]		
South America	C	Mt	1.0	9.4		
	P	Mt	0.6	13.8		
	LRSE		0.314[k]	1.555[l]		
	DE		–0.039[k]	–0.039[l]		
Asia	C	Mt	2.8	12.5		10.2
	P	Mt	1.0	6.7		15.6
	LRSE		0.035[i]	0.744[m]		1.116[n]
	DE		–0.086[p]	–0.117[q]		–0.125[r]
Africa	C	Mt		5.4	1.3	
	P	Mt		2.0	2.3	
	LRSE		0.512[s]	0.666[t]		
	DE		–0.021[i]	–0.021[i]		

a C, consumption; P, production; LRSE, world price long run supply elasticity; DE, world price demand elasticity. ***b*** Weighted average of other Western Europe, Eastern Europe and the USSR. ***c*** Simple average of other Western Europe and Eastern Europe. ***d*** European Community. ***e*** Eastern Europe. ***f*** Simple average of other Western Europe and Eastern Europe. ***g*** United States. ***h*** Mexico. ***i*** Cuba. ***j*** Not available; lowest region elasticity used. ***k*** Other South America. ***l*** Weighted average of Argentina, Brazil and other South America. ***m*** Weighted average of centrally planned Asia, other Asia, Indonesia. ***n*** Weighted average of Taiwan, India, the Philippines, Thailand. ***p*** Japan. ***q*** Centrally planned Asia. ***r*** Other Asia. ***s*** Africa. ***t*** South Africa.
Source: de Vries (1980).

Appendix C
Mathematical formulation of the problem

Subscripts

i = growing areas ($i = 1,..., I$)
j = tramway sidings ($j = 1,..., J$)
(j' and j'' are also tramway sidings)
m = mills ($m = 1,..., M$)
t = terminal ($t = 1$)
s = ships ($s = 1$).

Variables

X_{ij} = amount of sugar cane in tonnes of raw sugar equivalent (RSE) transported from growing area i to siding j

X_{im} = amount of sugar cane in RSE transported by truck from area i to mill m

$X_{jj'}$ = amount of sugar cane in RSE transported along the tramway link j to j' (note: j' may be a mill, m)

X^1_m = total amount of sugar cane in RSE processed in mill m at standard time

X^2_m = total amount of sugar cane in RSE processed in mill m at overtime

X_{mt} = amount of raw sugar transported from mill m to terminal t

$Y_{jj'}$ = 1 if the tramway link j to j' is activated; 0 otherwise

Y_m = 1 if mill m is activated; 0 otherwise.

Parameters

C_{ij} = unit transport cost of a tonne of sugar cane in RSE from supply area i region to siding j

C_{im} = unit transport cost of a tonne of sugar cane in RSE from supply area i to mill m by truck

$C_{jj'}$ = unit cost of a tonne of sugar cane in RSE along the tramway link j to j'

C^1_m = unit cost of standard time at mill m

C^2_m = unit cost of overtime at mill m

C_{mt} = unit transport cost of a tonne of raw sugar from mill m to terminal t

$F_{jj'}$ = fixed costs associated with activating tramway link j to j'

F_{ts} = fixed cost associated with receiving, storage and loading from terminal on to ships

F_m = fixed cost associated with activating mill m

S_i = the amount of sugar cane in RSE that is grown in supply area i

D = final demand for raw sugar (note: $D = \Sigma_i S_i$)

$U_{jj'}$ = the capacity of tramway link j to j'

U^1_m = effective capacity of mill m at standard time

U^2_m = the effective capacity of mill m at overtime.

Equations

A mathematical model consistent with the assumptions and notation described above is defined so as to mimimise the aggregate industry costs of transporting and processing sugar cane and transporting raw sugar. Formally, we have the objective function:

minimise

$$\text{(C1)} \quad TC = \Sigma_i \Sigma_i C_{ij} X_{ij} + \Sigma_i \Sigma_m C_{im} X_{im} + \Sigma_j \Sigma_{j'} (F_{jj'} Y_{jj'} + C_{jj'} X_{jj'}) + \Sigma_m (F_m Y_m + C^1_m X^1_m + C^2_m X^2_m) + \Sigma_m X_{mt} X_{mt} + F_{ts}$$

subject to:

$$\text{(C2)} \quad X_{jj'} \leq U_{jj'} Y_{jj'} \text{ for each tramway link } j \text{ to } j'$$

$$\text{(C3)} \quad X^1_m \leq U^1_m Y_m \text{ for each mill } m$$

$$\text{(C4)} \quad X^2_m \leq U^2_m Y_m \text{ for each mill } m.$$

In equation (C1) if $Y_{jj'} = 0$, siding j is not activated and the fixed cost is zero, and condition (C2) requires that if $Y_{jj'} = 0$ then $X_{jj'} = 0$, so there will also be zero variable cost. On the other hand, when $Y_{jj'} = 1$ in equation (C1), condition (C2) ensures that $X_{jj'}$ must be less than or equal to the upper capacity of that siding. Similar reasonings apply to conditions (C3) and (C4).

(C5) $\Sigma_j X_{ij} + \Sigma_m X_{im} = S_i$ for each i.

Condition (C5) ensures that the total sugar cane in RSE loaded on to various transportation modes from area i is equal to the maximum production possible in that area.

(C6) $\Sigma_{j'} X_{jj'} = \Sigma_i X_{ij} + \Sigma_{j''} X_{j''j}$ for each siding j.

Condition (C6) is a conservation constraint, which ensures that the amount of sugar cane moved out of siding j along tramway links j to j' is exactly equal to the amount supplied to siding j by various supply regions i, *plus* the amount moved into siding j from preceding sidings j'' along tramway links j'' to j.

(C7) $X_m^1 + X_m^2 = \Sigma_i X_{im} + \Sigma_j X_{jm}$.

Condition (C7) requires that the amount of cane processed by mill m is exactly equal to the total amount of sugar cane received.

(C8) $X_{mt} = (X_m^1 + X_m^2)$ for each m.

Condition (C8) requires that the amount of raw sugar transferred to the terminal from mill m is equal to the amount processed in mill m.

(C9) $\Sigma_m X_{mt} = D$.

Condition (C9) requires that the total amount of raw sugar transferred to the terminal from all mills is equal to the final demand, D.

The nine constraints represent and describe the many possible marketing flows of the study region. Additional and modified constraints could be used to increase or decrease the number of feasible marketing options. For instance, regulatory constraints such as mill production peaks could be represented in this way.

The actual size of the problem defined in (C1) to (C9) will depend on the number of growing areas, the number of transport routes for cane and raw sugar, the number of mills and the form of various constraints.

Appendix D

Inputs to the model

Combinations of quantities, costs and constraints

A computer program was written so that the model could be compiled from a simple list of features associated with each production point, each link and the final demand point. On initial supply and final demand points, the input required by the compiler program was the production and demand point code name and the quantity available or required; on links, the source and destination code names, the capacities and the costs.

Many combinations of fixed costs, variable costs and upper, lower and fixed capacity constraints need to be considered in the specification of each link of the model. In this appendix the combinations of costs and constraints that can be specified for the model are illustrated by reference to figure O.

Figure Oa represents the simplest case, where there are no fixed costs, and total costs increase proportionally with throughput up to an upper capacity, U_1.

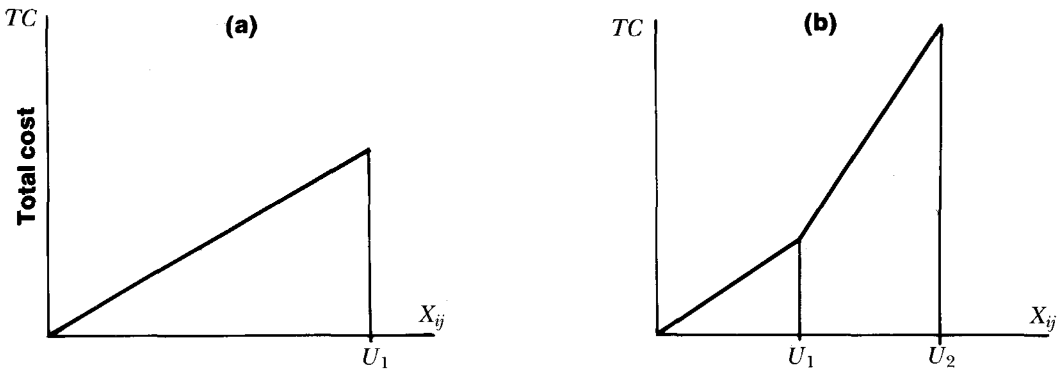
In figure Oa, overtime is an option. There is no fixed cost, but beyond the standard time capacity, U_1, total cost increases at a faster rate as throughput is increased and overtime paid, up to U_2.

Figure Oc represents the situation in which, beyond some critical point such as U_1, total costs increase at a slower rate as throughput is expanded up to U_2. (For example, in the transport of raw sugar from mill to terminal, a cartage contractor may be willing to provide a discount above some critical volume.)

Figures Od,e and f are similar, respectively, to Oa,b and c except that a fixed cost, F_{ij}, is also incurred in activating and operating the link.

In figure Og a lower constraint, U_3, is included, to specify that at least some minimum volume must pass through the link. Such a constraint could be applied with any of the cost structures represented in figures Oa to f. When U_3 is equal to U_2 (or U_1), as shown in figure Oh, a fixed capacity constraint applies: some specific volume must pass through the link.

O Cost curves of the model



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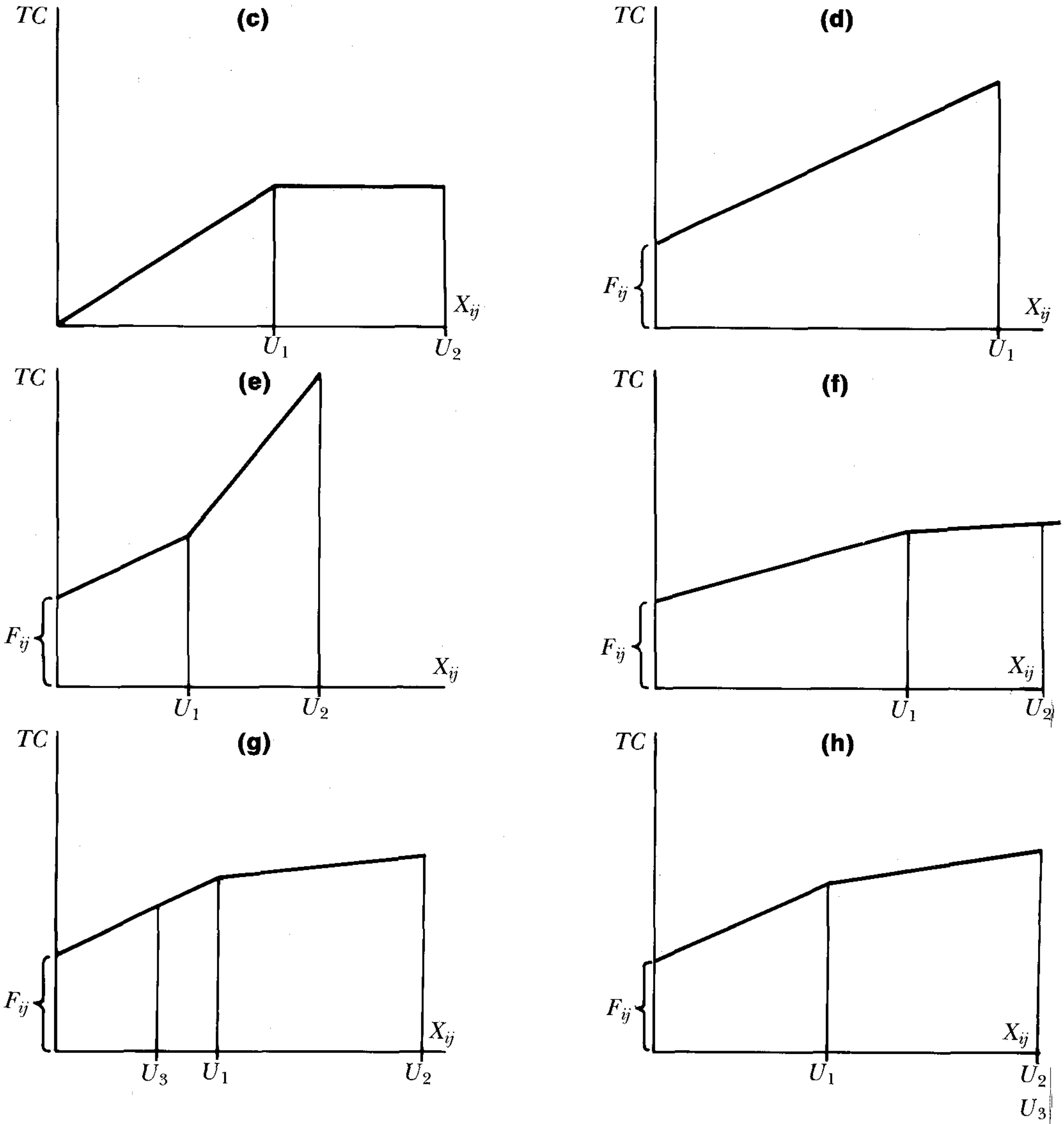


BAE chart

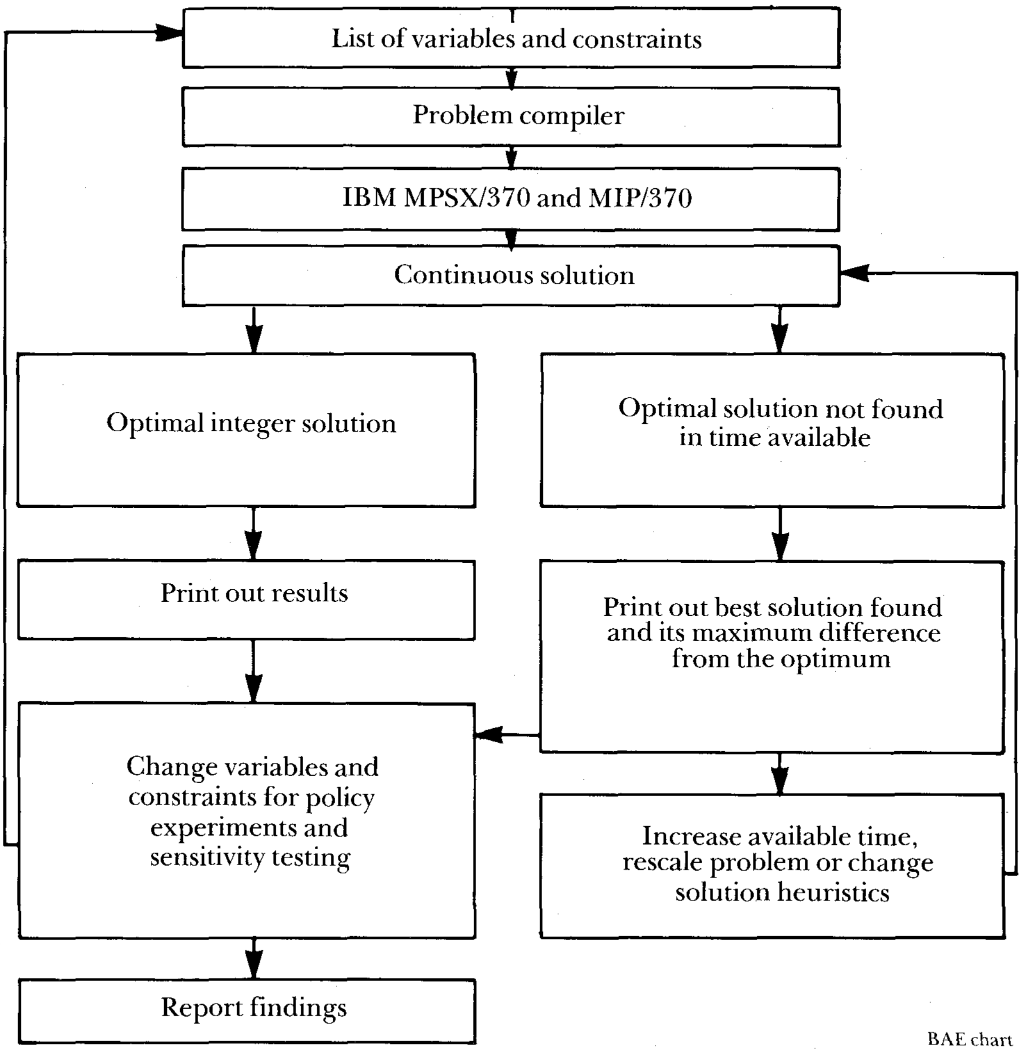
Appendix E

Features of the mixed integer formulation

The mixed integer model was run on the Bureau's computer using IBM's MPSX/370 (mathematical programming package) with IBM's MIP/370 (a feature of MPSX/370 which is necessary for solving integer problems).

The operational features of the model are presented in figure P. To operate the model, a user must supply an initial list of variables, constraints and cost parameters, as outlined in appendix D. the solution procedure is then co-ordinated by a

P Operational procedure



BAE chart

control program, which terminates when an optimal solution is found or, if this is not found, giving information on the difficulties in the way of a solution.

The solution technique involves a branch-and-bound algorithm and a linear programming algorithm (IBM 1979). The branch-and-bound algorithm, used to take account of the integer variables of the problem, is based on heuristic rules, the efficiency of which depends on the nature of the specific problem and on how the problem is scaled. If solution difficulties are encountered, therefore, the user can either rescale the problem, use an alternative heuristic rule, or increase the available computational time. In each case the control program must be changed. In many cases an optimum will not be found, but the solution technique is such that in these cases the best possible non-integer solution (one that ignores the integer variables) can be found. As the integer solution will always be of higher total cost than the non-integer solution if the two solutions are 'close', a decision should be made by weighing up the costs and benefits of using more computer time to obtain a better integer solution.

If an optimal solution is still not found, the only remaining option is to reformulate a simplified version of the model. If an optimal solution is found, the user may wish to test the sensitivity of the solution to changes in assumptions, variables or constraints, or to conduct further policy simulations by testing the effects of changes in specific policy constraints. In each case the user must make appropriate changes to the input listing, rerun the model and compare the new solution with the old.

Appendix F
Data

Regional demarcations

In the network problem depicted in figure C, space is treated as a relatively small set of discrete nodes. In reality, space is a continuum, and specification of discrete points and areas necessarily requires disaggregation and partitioning.

All potential cane growing land in the Mackay region was partitioned into areas representing groups of farms which could be regarded as homogeneous in terms of transport costs to all other locations of the model. On this basis, areas were defined by mutually exclusive sets of farms each serviced by a particular branchline of a mill's tramway network or by geographical factors such as roads or hills (where currently there is no tramway).

The boundaries to the 54 production areas of the region are drawn on the map, figure D. Area 19 is an example of the use of the first criterion to identify production areas — a set of farms supplying a common tramway. Area 14 is an example of the use of the second criterion; it has no tramway at present and is defined by geographic factors.

In cases, such as areas 47 to 50, where borders between adjoining areas were not clearly defined by geographic factors, boundaries were based primarily on statistical convenience. Areas such as 21, 22 and 31 are areas where cane is not currently grown but where there is clearly potential for sugar production. These areas were included so that the effects of an expansion or reallocation in supply could be fully analysed.

The locations of the six mills, their respective tramway networks and the bulk terminal are also shown on the map. As the model was designed for analysis of short term changes, it was assumed that the locations of the mills and terminal were fixed. In general the location of tramways was also assumed to be fixed. However, as there exist intuitively appealing opportunities to extend the tramway system, allowance was made for links between areas such as 8 and 19.

Regional supplies

For any run of the model, supplies from all areas are assumed fixed. The quantities specified for each area were estimated from information used by the Queensland Department of Primary Industries to construct maps showing land use and land suitability in the Mackay region (Holz and Shields 1985*a,b,c*). The information included areas of land, by five different 'suitability' classifications (which take into account nine limitations applicable to cane production, such as moisture availability, topography and susceptibility to flooding); average yields of cane per hectare for each classification; areas of land within assigned mill areas; and areas of land suitable for cane production but at present not available to the industry due to the assignment system.

The information provided made it possible to estimate both the present supplies allowable and the supplies that could result if any given proportion of the currently unused suitable land were used for cane production. Supplies under the current arrangements and estimated production for full use of suitable lands are shown in table 9. The additional potential supply amounts to around 30 per cent of current production.

All supplies of (raw sugar equivalent) cane were assumed to be of uniform quality. This diverges from reality, as the sugar content of cane can vary by area and, more importantly, will vary in a predictable fashion over the harvesting season. These variations are not taken into account in the current version of the model.

Demand for raw sugar at bulk terminal

It was stated in appendix B that export demand could be assumed to be perfectly

9 Sugar cane production estimated in raw sugar equivalents

Area	Estimated actual assigned	Estimated further potential	Total
	t	t	t
1	22 787	1 414	24 201
2	13 984	911	14 895
3	13 412	837	14 249
4	7 145	920	8 065
	57 328	4 082	61 410
5	23 664	8 211	31 875
6	11 954	2 500	14 454
7	14 619	5 500	20 119
8	18 039	2 491	20 530
9	20 118	27 040	47 158
10	7 909	4 550	12 459
11	12 570	2 812	15 382
12	4 876	333	5 209
13	2 348	6 836	9 184
14	4 114	348	4 462
	120 211	60 621	180 832
15	11 314	2 223	13 537
16	13 597	4 388	17 985
17	4 212	2 680	6 892
18	18 220	3 654	21 874
19	8 011	3 301	11 312
10	20 738	2 594	23 332
21	–	1 813	1 813
22	–	4 661	4 661
	76 092	25 314	101 406
23	17 083	351	17 434
24	8 559	1 408	9 967
25	28 283	6 692	34 975
26	5 866	654	6 520
27	7 484	7 990	15 474
28	14 085	6 136	20 221
29	11 386	12 730	24 116
30	32 302	7 010	39 312
31	–	3 000	3 000
	125 048	45 971	171 019
32	10 483	4 547	15 030
33	13 783	910	14 693
34	13 984	822	14 806
35	13 425	1 688	15 113
36	4 749	604	5 353
37	3 257	206	3 463
38	2 399	157	2 556
39	5 550	6 327	11 877
40	11 400	250	11 650
41	3 494	3 989	7 483
42	5 776	3 500	9 276

(Continued on next page)

9 *(continued)*

43	23 754	2 250	26·004
44	8 745	14 259	23 004
45	3 506	4 540	8 046
	124 305	44 049	168 354
46	23 052	255	23 307
47	15 559	2 639	18 198
48	25 764	2 732	28 496
49	11 458	1 178	12 636
50	16 212	872	17 084
51	17 832	1 983	19 815
52	6 000	2 000	8 000
53	7 000	1 400	8 400
54	10 000	1 500	11 500
	132 877	14 559	147 436
	635 861	194 596	830 457

Source: Estimated from Holz and Shields (1985*a*,*b*,*c*).

elastic. This assumption was included in the model by specifying total raw sugar demand as the sum of regional supplies of (raw sugar equivalent) cane.

For simplicity, it was also assumed that raw sugar was the only final product. In fact a number of by-products, such as molasses and electric power, are also produced. In discussions of cost savings arising from economies of scale in the milling operation, omission of the demand for by-products is likely to lead to an underestimation of total savings, as it is likely that scale economies could also affect the production costs of by-products.

Transport, milling and bulk terminal capacities

Using the model to analyse short term structural problems involves appropriate specification of constraints. Current mill production limits are presented in table 10. These represent policy, rather than physical, constraints, and the actual limitations on mill capacity would be quite different were some of the existing regulations to be replaced.

The set of constraints placed on each transport link in the model represents the existing aggregate of the supplies from the growing areas required to use that route. In turn, the aggregate of flows along transport links supplying a specified mill is constrained by that mill's peak. Assumed capacity limitations on links can be changed to simulate such changes as weekend milling or to reflect the physical limitation that would be applicable if restrictions on the supply of cane to mills were removed. However, physical limitations on the tramway system are likely to arise only if congestion occurs. Information obtained from the industry by the Bureau suggests that congestion is unlikely to be a problem even with substantial increases in the use of tramways.

The capacity available at bulk terminals will depend on the size of the storage sheds at Mackay and the manner in which export sales are managed or scheduled throughout the year. At present the storage capacity of the sheds is about 0.65 Mt of raw sugar, and annual receivals amount to about 1.0 Mt (Sugar Board 1982).

10 Permitted mill sugar production

Mill number	Current limit
	t
1	57 328
2	120 211
3	76 092
4	125 048
5	124 305
6	132 877

Source: Estimated from Holz and Shields (1985*a*,*b*,*c*).

Under conditions of highly elastic export demand, it is conceivable that additional receivals could be handled at the terminal if the rate of exports were increased during the six-month harvesting and receival period. It would seem reasonable to assume that the bulk terminal could physically handle an additional 30 per cent of receivals without unduly restricting the management and scheduling of export sales.

In the longer term, any desirable adjustment could be made to the capacities of transport routes, mills or the bulk terminal. In a modelling sense, these long term opportunities can be represented by placing a set of arbitrarily large constraints on facilities.

Transport, processing and handling costs

The model could be run using cost data relating to either the short or long term. The cost data presented in this paper pertain to the short term. In the main, the data were provided by management personnel of three mills, of sizes fairly representative of the median for the industry. Management personnel at each mill were interviewed to obtain a detailed breakdown of annual operating costs into their various fixed and variable components for the financial year 1982-83. These data were averaged to determine a set of costs fairly representative of the industry. These costs were subsequently adjusted after consultation with management personnel at the surveyed mills during follow-up interviews, and after consultation with other industry officials familiar with mill cost data on an industry wide scale. The adjusted costs used in the model are presented in table 11.

Transport costs

Three types of transport costs were included in the model: the cost of transporting cane by road, from paddocks to tramway sidings or directly to mills; the cost of transporting cane from sidings to mills along tramways; and the cost of transporting raw sugar from mills to the bulk terminal by either road or tramways.

Costs incurred along links involving road haulage of cane are of the form indicated in figure Oa. Two different cost functions were calculated for cane transported by road.

First, a cost schedule was determined from industry data on the costs of harvesting and the haul-out of cane from paddocks. This was used to calculate the haul-out cost, by distance, from the paddock to a tramway siding or to a truck pick-up point. This schedule is presented graphically in figure Q. The irregular nature of the schedule is due to the indivisibility of resources engaged in cane haul-out. There are only three points in

11 Adjusted fixed and variable costs of three surveyed mills

Item	Milling		Tramways and rolling stock	
	Fixed	Variable	Fixed	Variable
	$'000	$'000	$'000	$'000
Administration (including salaries, long-service leave, superannuation and levies)	1 764	300		
Interest and insurance	649			
Operations, repairs and maintenance (including labour and materials)	2 177	1 839	540	554
Provision for asset replacement	750		250	
Total	5 340	2 139	790	554

Source: BAE data.

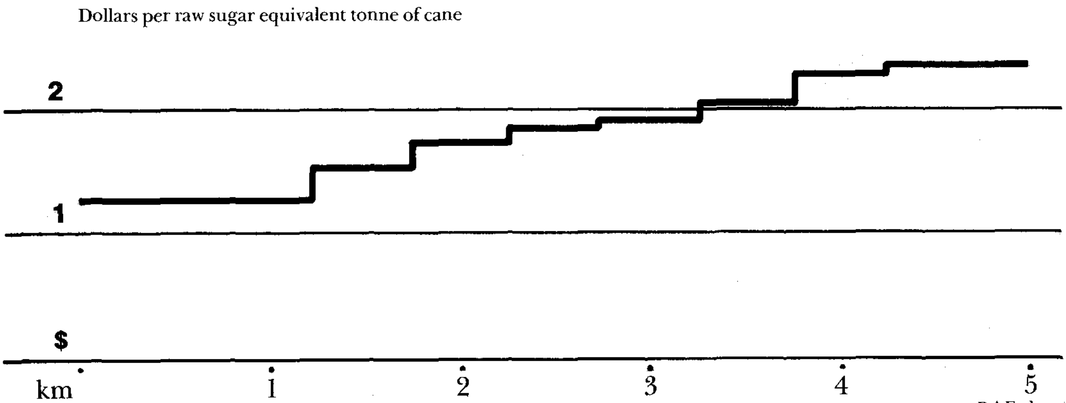
the distance range 0–5 km where the least cost combinations of one harvester and two, three or four haul-outs (vehicles for hauling out cane) are fully employed. At all other distances, either the haul-outs or the harvester will spend time idle, and the rate of cost increase with distance will differ depending on which incurs idle time. At haul-out distances in excess of 4 km it was assumed that a two-stage transport operation would be required, cane being trans-shipped 4 km from haul-outs to trucks.

Second, a trucking cost function was calculated, using data collected from a number of mill sources, in terms of a fixed depot loading and unloading charge per trip plus a cost variable based on kilometres travelled per trip. This function is represented graphically in figure R.

To determine the costs for any link, average distances from all growing areas to relevant destinations were estimated from a detailed map of the Mackay region. These distances, in kilometres, were transformed to transport costs by the functions represented in figures Q and R.

Costs of transporting raw sugar were estimated from mill data, and are of the form indicated in figure Oa. Although some mills use road transport and others use rail, a single distance-related cost

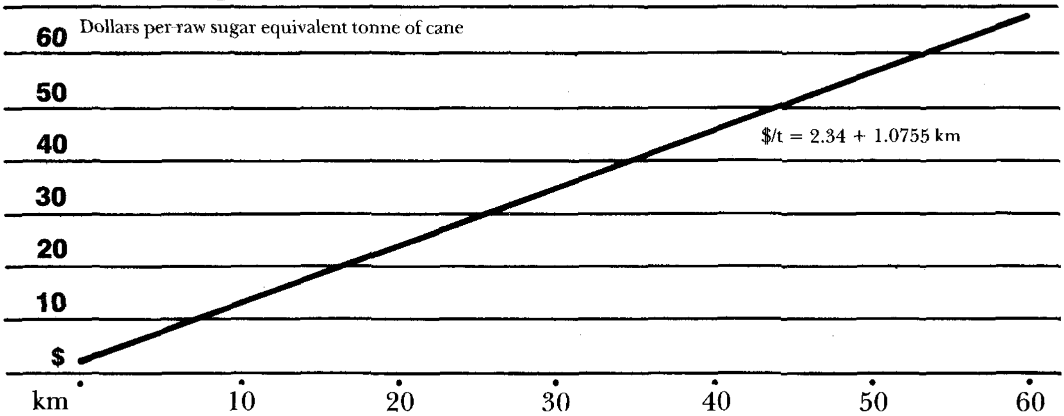
Q Minimum haul-out cost by distance



Source: Industry data

BAE chart

R Road transport cost by distance



Source: Mills

BAE chart

function, represented graphically in figure S, was estimated for raw sugar transport from mills to the bulk terminal. The difference in cost per kilometre between the two modes of transport was quite small.

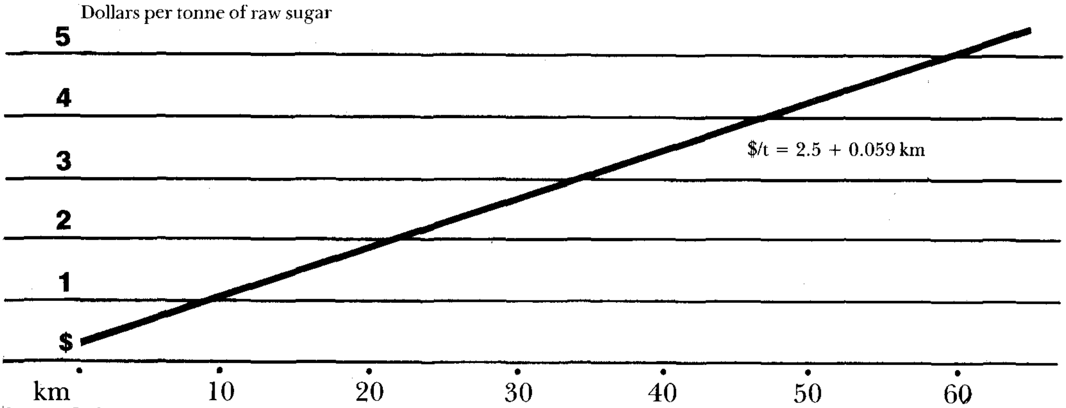
Tramway haulage of cane involves fixed and variable operating costs of the form indicated in figure Od. Around 65 per cent of tramway operating (short run) costs are estimated to be fixed. The volume of cane passing along a tramway will have a bearing on the extent of repairs and maintenance required on that line and on the associated rolling stock. However, a large proportion of repairs and maintenance will be a function of time or will be associated with random events such as accidents and unpredictable structural weaknesses. Maintenance on a regular basis is necessary to ensure timely delivery of cane to mills and to minimise the risk of accidents such as derailments which can cause costly closures of mills. Generally, mills employ mill workers to repair and maintain tracks in the off season. The associated labour costs are therefore fixed for each season. Essentially the same arguments apply to asset replacement. Expenditure on these items was judged to be considerably less than the depreciation allowance on them; it was calculated as the level of asset replacement expenditure (or operating cost) which is unavoidable over a period of about three years, although the expenditures reported are annual estimates of this expenditure.

To estimate the fixed cost component of tramway cost, an average fixed operating cost of $5881/km of tramway was determined from data supplied by mills (see table 11). Lengths of tramways were then measured from a map, and costs calculated accordingly. It should be noted that no attempt was made to distinguish between the fixed costs of branch lines and of common lines. Where the linking of tramways of adjacent mills was considered in model runs it was necessary to estimate a fixed cost of laying new track. This was placed at around $150 000/km and was amortised over 40 years at an interest rate of 15 per cent.

The tramway variable cost component was apportioned partly by distance and partly by volume. It was not possible to determine from mill data how variable costs should be apportioned by distance and volume but, rather than ignore this dependence, 70 per cent of variable costs were assumed to vary by distance, accounting for such inputs as fuel and wear and tear on rolling stock. The remainder was assumed to take account of such costs as those involved in shunting.

To determine the 70 per cent of variable costs deemed to vary by distance, a cost per (raw sugar equivalent) tonne-kilometre ($0.24) was first calculated from mill data. The average distance travelled on

S Road and rail sugar transport costs



Source: Industry data

BAE chart

tramways in all areas of the model was then estimated, from a detailed map, to be 4 km. Hence, an average variable cost of $1.00/t was included in the tramway cost function of each area line. In the model, cane produced close to the mill and passing over only one area line to reach the mill incurs this charge once; cane produced in areas more remote from the mill and passing over several area lines incurs this charge several times. In this way the cost is effectively variable by distance.

To account for the 30 per cent of variable costs deemed to be unrelated to distance, a special cost of $1.47/t was levied on area lines passing cane directly to the mill. In this way, cane passing from one tramway to another in an adjacent region en route to the mill incurs this cost only once, namely on the final segment of the journey.

It should be noted that weekend overtime charges are not included in the variable cost component because labour costs are not a large proportion of tramway costs. It should also be noted that the fixed and variable costs of rolling stock are included in the tramway cost functions.

Milling costs

Milling, like tramway haulage, involves fixed and variable costs. In this case, however, because labour is a significant component of the variable costs, overtime charges must be allowed for if weekend milling is to be considered. This was achieved by including milling costs in the model in the form indicated in figure Oe.

As with tramway operating (short run) costs, a large proportion of costs is estimated to be fixed, and for many of the same sorts of reasons. Clearly, administration costs are largely fixed, as is the case with insurance and interest charges. As to repairs and maintenance, the factory is shut down each week to check equipment, and it is logical to replace components while the machinery is inoperative rather than wait for them to wear down completely and cause an untimely and costly shutdown of the mill. Labour costs too are largely fixed, up to 80 per cent of workers being employed on an annual basis. As for tramways, the unavoidable expense of asset replacement is fixed. Materials such as power and chemicals on the other hand are largely variable.

Of the six mills in the study region, the estimated costs of four were based on the average of data collected from mills. These four mills are of a size similar to the surveyed mills; the two remaining mills are much smaller. Though the total operating costs of the small plants are expected to be less than those of the larger plants, sufficient data to determine the relationship between fixed and variable operating costs and plant size were not available.

From data in the annual reports of the two small plants, it was calculated that in 1981 and 1982 the unit operating costs of the two mills were respectively, 15 per cent and 17 per cent greater than the unit operating cost obtained for the surveyed mills. Since there was no information on the difference in relative importance of fixed and variable cost components between large and small mills, it was assumed that both cost components of small mills were, at current throughput rates, 15 per cent greater than those of large mills. Accordingly, the fixed cost was calculated as the product of 115 per cent of the unit fixed cost of the surveyed mills and the average volume throughput of the two small mills for 1981, 1982 and 1983. Unit variable costs were simply assumed to be 115 per cent of those of the surveyed mills, except that overtime costs were assumed to be equal for the two sizes of plant.

The weekend overtime cost estimates included in both the small and large mill cost functions were based on the assumption that four 33-member crews would be operated on a roster basis to maintain a continuous 160-hour week crushing period. Mills at present generally operate, and pay overtime rates on, one Saturday shift, and one shift is allowed for maintenance each week. It was assumed (with a standard time rate of $9.50 an hour) that these arrangements would be maintained; that time and a half overtime rates would be paid for two additional eight-hour shifts on Saturdays; and that double time would be paid on three shifts on Sundays. It was further assumed that continuous crushing would not lead to additional fixed costs. The fixed costs, standard variable costs and overtime variable costs for the two plant sizes are given in table 12.

Bulk terminal costs

The operation of receiving, storing and outloading to bulk vessels is a highly automated, capital intensive process. Industry officials familiar with operations at terminals have confirmed that variable operating costs are not a significant component of total costs: over a certain range of throughput, operating costs are predominantly of a fixed nature. In the case of Mackay, a significant increase in throughput would be required before it would be necessary to build additional storage capacity.

12 Fixed and variable costs of milling

Item	Variable		Fixed
	Standard time	Overtime	
	$/t	$/t	$'000
Large mills	17.10	24.35	5 340
Small mills	19.70	26.95	3 291

Source: BAE data.

In the model, only a fixed cost was included, estimated by apportioning the total cost of operating all Queensland sugar bulk terminals reported by the Sugar Board (1984). The result was approximately $8m; this cost excludes other expenses such as administration, pool management, export marketing, chartering and quantity and quality assurance.

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R 86/216 Cat. No. 86 145 72