Economic Issues in Farm-to-Port Grain Storage, Handling and Transport

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In this paper, the literature on the economics of grain distribution systems is reviewed. The emphasis of this review is on farm to port issues and largely excludes port and shipping issues. In the first part of the paper, the discussion centres on the historical institutional environment in Australia, which was heavily regulated. The second part of the paper highlights some of the issues relating to the pricing of central grain distribution services that continue to exist even in the more competitive environment which has emerged in the 1990’s. The scope for future agricultural economics research in this area is discussed.

1. Introduction

Prior to the Royal Commission into Grain Storage, Handling and Transport (1988a, 1988b), there had been very little research on the costs of grain distribution in Australia. However, in the late 1980’s a large volume of research output emerged from Royal Commission work and from other independent studies (Kerin; Blyth, Noble and Mayers; Brindal and Dumas; Piggott, Coelli and Fleming (1988a, 1988b); MacAulay, Batterham and Fisher; Brennan (1992)). This work on Australian grain distribution systems is reviewed in this article. While most of this past work was conducted in the context of a now superseded institutional environment, this review is important for two reasons. First, the analytical techniques examined here will continue to be used in the future. Second, a review of the structure of costs in the industry highlight some of the fundamental pricing problems that could persist in a "competitive" environment. Market failure problems mean that there continues to be a role for agricultural economics research in this area.

In the first part of this paper, the literature on costs of grain handling and distribution is reviewed. Hinterland distribution and storage issues are the focus of this discussion, and port and shipping issues are not addressed. In the second part of the paper, some of the pricing problems that exist in the grain distribution industry are discussed. These include the pricing problems of natural monopolies, various externality problems, capacity utilization and peak load pricing problems. Areas for future research are highlighted.

2. Cost Issues

2.1 The Grain Distribution Process

The movement of grain from farms to market involves a transformation over time and space. There are many options for transporting and storing the grain, and some of the long term choices involve the investment in transportation network (roads or rail track), the optimal location of storage facilities and the choice of storage technology. In the shorter term, the costs of grain distribution will depend on the grain paths chosen within a given infrastructure. Decisions must be made about transport modes and transport routes. Part of the process involves the use of storage, and choices must be made between alternative storage locations. Choices made by individual decision makers will not necessarily minimise grain distribution costs because of the interdependencies in the system.

The recognition of inter-dependencies between transport and handling costs has meant that most studies of the central grain distribution system have focused on total systems analysis. In the context of Australian studies, systems approaches have been necessary in order to examine the implications of certain regulations on the choice of grain paths and on the costs of grain distribution. Even in the less regulated grain distribution systems of North America, systems research has been justified on the basis that co-operative

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1 Many changes have taken place which mean that the industry is far more competitive. Some of these changes include the removal of sole receival rights from the State bulk handling authorities, removal of restrictions on road transport, introduction of competition for transport and handling services between states.
decision making is needed to ensure that the industry adjusted optimally to technological developments (Ladd and Lifferth).

Costs must be viewed in a system wide context because of the substitutability between different components of the system. For example, the optimal location of storage facilities requires a trade off between the costs of increasing farm to silo distance and the benefits of having fewer larger scale storage structures. In the shorter term, reduced handling costs might also be achieved by concentrating receivals at fewer sites, avoiding fixed opening costs and allowing economies of larger scale train operations. However, this can only be achieved by increasing farm to silo transport costs.

To date, most work in Australia has focused on short term questions, treating the location of storage capacity as a constant, and considering the optimal flow of grain through the system. A crucial part of the total systems analysis is the estimation of underlying costs. The savings from centralizing deliveries, which is an important current issue, is sensitive to the shape of operating cost curves at country receival points, and the existence of economies of throughput. Consequently, much attention has also been focused on estimating operating costs. This work is reviewed in the next section.

### 2.2 Grain Handling Costs at Country Receival Points

There are a number of conceptual problems associated with estimating grain handling cost functions at country receival points. Some of these issues apply generally to the statistical estimation of cost curves and have been discussed elsewhere (French, Piggott, Coelli and Fleming 1988a). Other issues relate to the nature of the grain handling problem and the importance of different technologies in determining grain handling costs (Brennan 1994a).

Statistical estimation and interpretation of cost functions relies on the assumption that firms are operating efficiently (French). The lack of competition in the historical environment, and the service based nature of grain handling agencies, implies that this assumption may not be relevant for the analysis of Australian grain handling costs. Piggott et al. point out that positive estimates derived by statistical studies may overestimate minimum costs for this reason.

Availability of data is another problem encountered when estimating cost curves. Prior to the Royal Commission, access to data on grain handling costs required voluntary co-operation from the bulk handling authorities. This may have been a major factor why this area had received little research attention prior to 1988. Even the Royal Commission with its extraordinary investigatory powers found that the adequacy of the data for statistical estimation of costs depended on the detail to which accounting records were kept. These problems have been also encountered by a number of researchers (Blyth; Noble and Mayers; Piggott et al.).

The most important independent variable in the estimation of operating cost functions is the throughput of grain. Definition of throughput is a problem that has been identified by a number of authors (French; Piggott et al. 1988a). Most studies use an annual throughput figure, but variation in costs may occur with the same annual throughput figure because of variation in the length of the season or rate of output per day. This is a problem that is encountered with both cross sectional and time series data because different seasonal conditions between years or between sites will vary the length of the season or the throughput per day.

Most studies have found evidence of fixed operating costs (Kerin; Piggott et al.; Blyth et al.), of which a major component is the cost of employing a skeleton labour force (Kerin). Most have also included a capacity variable, to allow comparison between cross section of sites of different sizes. Piggott et al. (1988a) found that for a given level of throughput, average costs were higher for larger sites. In other words, average costs were negatively related to turnover, where turnover is throughput divided by storage capacity.

All studies provide evidence of economies of throughput or turnover. Blyth et al. and Kerin found evidence of continuously declining average operating costs. In contrast, Piggott et al. (1988a) estimated a quadratic function because it was hypothesised that operating costs would eventually rise as a result of diminishing returns. However, they found that average costs continued to decline up until the point where throughput was twice the size of storage capacity. This result implied that most of the sites studied were operating in the downward sloping section of their operating cost curve.
Piggott et al. (1988a) recognised that the optimal turnover levels predicted from their results could not be attained because of constraints on the system. The short annual harvest period limits the turnover that can be achieved because it limits the availability of transport capacity which is used to increase turnover in the peak period. However, Brennan (1994a) argued that the emphasis in past studies on optimal turnover was inappropriate, and that important technologies affecting costs had been omitted or wrongly specified. She argued that an increase in turnover of permanent storage capacity could be achieved either by transporting grain out of the site in the peak period (which would reduce costs and provide economies of throughput), or by using high cost bunker storage technology. While Piggott et al. (1988a) included bunker storage capacity as a dummy variable which shifted average operating costs upward, it is clear that the mix of bunker storage and "rail out" will affect the shape of the curve rather than simply its position. Moreover, scarce transport capacity in the peak period means that operating costs at different sites are inter-dependent. Achievement of economies of throughput at one site precludes its achievement at another site. Inaccurate specification of cost functions implies that the grain handling cost functions derived in previous studies represent an average of a range of factors which do not adequately describe the relationship between technologies and handling costs.

Moreover, previous specifications of cost preclude the identification of an important avenue for cost reduction. This is the allocation of scarce transport capacity between sites in the peak period. Brennan (1994a) showed that there are large differences in the intensity of transport between sites and large savings in system costs could be achieved by allocating scarce transport to sites which are least intensive users of this capacity in the peak period. Costs could also be reduced by extending the receival period, thus increasing the available transport capacity in the peak period.

Construction Costs

There have been three studies which have focused on estimating construction costs in Australia which have indicated that average construction costs are a declining function of capacity due to high fixed construction costs (Freebairn; Kerin; Quiggin and Fisher. There was no evidence of eventually diminishing returns to scale in construction, over the range of capacities examined by Quiggin and Fisher.

Investment Issues

Brennan and Lindner discuss the importance of combining different technologies in order to minimise the cost of satisfying a fluctuating demand for storage, which results from fluctuating annual harvest levels. They showed that the choice of technologies involved a trade off between high capital costs and low operating costs, and depended on the expected use of capacity, which affected expected operating costs. They found that at most country sites, where the annual peak load problem limited turnover in the peak period, the use of vertical storage capacity was inefficient because the large capital costs never justified the lower operating costs. They showed that the optimal combination of technology at these sites included the use of horizontal storage to satisfy most demand, with bunker storage being used to satisfy the extra production that occurs in years of high production. They did not analyse the efficiency of vertical storage at sites that have higher turnover levels, such as at the ports and subterminals, where the operating cost advantages of vertical storage may be worthwhile.

Segregation

The cost pooling service orientated nature of bulk handling has meant that prices do not reflect the cost of providing services, and the cost of segregating grain for marketing purposes are not transparent. Statistical studies have shown that segregation affects operating costs (Brindal and Dumas; Piggott et al.). More recently, Hinchy estimated grain handling costs in New South Wales and found that adding another segregation would increase costs by about 5 per cent. Segregation also increases capacity requirements (Kerin; Cooperative Bulk Handling Ltd) which raises effective capital costs. Examination of segregation issues is difficult because there are many joint costs in providing handling services and separation of the marginal costs of alternative segregations may be difficult to obtain from accounting data.

2.3 Transport Costs

The long farm to market distances in Australian grain producing areas means that transport costs are a significant component of the total costs of grain distribution. In the past, the use of road transport was restricted by regulations, which meant that rail companies had little competition (Royal Commission into Grain Storage, Handling and Transport 1988a). The optimal mix of transport modes is an issue that has
been addressed in most analyses of grain distribution systems. While the most important issues in grain transport relate to pricing problems, which are discussed in the later part of this paper, a description of the nature of costs at this point will facilitate the discussion on system analysis in the next section. Consequently, some evidence on the nature of costs in the transport industry is presented below.

Rail transport has high fixed costs associated with maintaining rail lines (Blyth et al.) and relatively low operating costs, compared to road. There are significant economies of traffic density associated with the operation of trains. These include the effect of sharing of the high fixed costs of rail maintenance, as well as improved operating efficiency of larger scale operations (Harris). The costs of operating trains depend on the train turnaround time which is affected by loading times and travelling speeds, and per tonne costs of transport are affected by train size. Generally, large main line trains travelling at fast speeds with single point loading have economies over slower branch line trains whose size is limited by siding capacity (Brennan).

In contrast, road transport facilities are highly mobile and have low sunk costs. One problem associated with the use of road transport is the external cost of road damage caused by heavy vehicles. The presence of this externality problem implies that there may be a socially inefficient over-use of road transport in a deregulated system. However, there are other important pricing issues that affect road-rail competition which are discussed later.

Queuing Problems

Another externality problem faced in the road transport sector is the problem of truck queues that arise when demand for receival services is high during the peak period.

Queues arise because of variation in the arrival and departure rate of a servicing facility. Fluctuations in arrival or service rates mean that there are likely to be transient formations of truck queues even if the average service rate exceeds the arrival rate. Conventional queuing theory provides simple mathematical formulae to predict average waiting times (Gross and Harris). However, the analysis of truck queues at grain receival points is a more complex one for a number of reasons. First, truck arrival rates depend on silo opening hours, the harvesting pattern of farmers, the amount of on-farm storage available and the spatial distribution of farms around the silo (Burrow and Macmillan). Generally, arrival patterns vary over the day so the assumption of constant arrival patterns is not valid. Secondly, because of the finite number of trucks delivering to the silo, arrival patterns are affected by truck queues (Bouland). Also, the receival rate of trucks can vary according to the number of trucks waiting in the queue because staff tend to work harder when there are trucks waiting (Price).

Because of these problems, researchers typically have used simulation methods to examine truck queues (Bouland; Price). The results of these studies indicate that waiting times are exponentially related to truck arrivals. However, the determination of queue costs by detailed simulation of operating variables does not provide a convenient method of representing costs in a mathematical programming model which is normally used to assess the benefits of centralisation.

An alternative approach was taken by Kerin, who sought a simple relationship between the volume of grain receivals and queuing costs. He applied a regression equation to measure the relationship between truck waiting times, truck arrivals and receival rates. The exponential form of the model implies that increases in arrival rates at high levels are likely to have a greater effect on the waiting time than increases at low levels because of the congestion effect it creates on all the other trucks arriving in that time period. The exponential relationship between queuing and arrival rates and the negative exponential one between queuing and departure rates concur with conventional queuing theory (Gross and Harris), as well as empirical evidence on truck queues (Bouland). Kerin also estimated an equation which described total queuing costs as an exponential function of the total volume of grain produced in the season and the number of road receival hoppers at the site. Kerin’s results have been applied in numerous studies of grain handling costs (Kerin; Brennan (1992); and Quiggin).

The complex nature of truck queues means that aggregate models like Kerin’s have limited policy application. Policies designed to reduce queues, such as time of day and time of season pricing, silo opening hours, staffing policies, and receival technology need to be analysed with the operations research techniques used by Bouland and Price.

There are other examples of queuing problems in the grain distribution system that could be addressed by
operations research methods. For example, the appropriate provision of handling facilities at the port also requires consideration of the scheduling of ship arrivals, and the scheduling of transport services delivering grain from the hinterland. Wright, Meyer and Walker present an analysis of these sorts of transport bottlenecks in grain distribution systems in Brazil.

2.4 Total Systems Analysis

Most analyses of grain handling costs have used system models which jointly consider the costs of farm to silo transport, silo to port transport and handling and storage costs. A systems approach is necessary because of the many inter-dependencies in the system.

Most research on Australian grain distribution systems has been focused on short term issues. In general, these studies have indicated that longer farm to silo distances, with increased concentration of deliveries at fewer sites, will reduce costs. The degree of centralisation recommended by these studies varies widely, and this may be due to model design and the adequacy of data, rather than to fundamental differences in the systems studied.

For example, Kerin examined the grain distribution system of the Eyre Peninsula in South Australia. His study paid particular attention to the congestion costs associated with farm to silo delivery in the peak period and the sunk costs of the existing system. He found that these factors meant that little rationalisation of the system was warranted. However, the lack of suitable data meant that Kerin did not incorporate any of the benefits of lower rail costs due to reduced branch line infrastructure and the increased use of unit trains from larger sites.

Brindal and Dumas examined the issue of rail line abandonment in Western Australia and found that a number of low density branch lines should be abandoned, as it was cheaper to cart the grain to the port or directly to a receival point on the main line. However, the authors pointed out that the results should be treated conservatively, as the analysis ignored the peak load cost associated with increasing emphasis on road transport in the harvest period. In addition to queueing problems, Brindal and Dumas pointed out that greater farm to silo distances will increase truck turnaround time for farm to silo deliveries and will result in a greater demand for temporary on-farm storage, thus increasing on-farm costs.

MacAulay et al. used a spatial equilibrium model to examine the benefits of deregulation for a particular region in northern New South Wales. The spatial equilibrium approach accounted for the possible supply response that may result following deregulation if the costs of grain handling and transport are reduced. The main changes resulting from removing transport restrictions and disaggregated pricing of receival points were a closure of two (out of five) receival points, and an increase in the amount of grain delivered to the sub-terminal by farmers. It is not possible to extrapolate the results of this work system-wide because of the way the annual peak load problem was dealt with in the model. MacAulay et al. made the assumption that the capacity to rail grain from the sub-terminal would be unlimited. This was justified on the basis that the area examined in the model was only a small part of the state system. The model chose to double the amount of grain being railed from the sub-terminal in the harvest period. The high turnover level resulting from this "rail out" program resulted in very low costs due to economies of throughput. However, from a state wide perspective, the achievement of such turnover levels may not be possible because of limitation on the amount of rail capacity available in the harvest period.

Another reason why the benefits of centralisation may have been overestimated in this model lies in the treatment of queue costs. MacAulay et al. assumed a constant queue cost for all grain delivered in the receival period. Yet, as discussed previously, the empirical evidence on queue costs indicates that there are some diminishing returns associated with increasing the volume received at central sites.

Blyth et al. examined the effects of institutional constraints on the Eastern States grain distribution system. A major issue in the Eastern States network, in the regulated environment, was the restriction of interstate grain movements. The deregulated model simulated the removal of these boundaries and allowed farmers to choose grain paths that minimised the cost of handling, transport and shipping. Capacity constraints on rail in the peak period were accounted for by specifying a limit on the tonne-kilometres that could be transported in the peak period. Blyth et al. found that there would be an increased use of road compared to rail through a reduction in branch line use. However, they used an average charge for branch line maintenance costs, based on current tonnages on these lines. The model indicated that costs could be reduced by reducing tonnages on these lines. In fact,
the savings achieved by avoiding the use of branch lines can only be realised if all deliveries along the branch line cease and the branch line is closed.

Blyth et al. found that a greater use would be made of sub-terminals in a deregulated system and savings of about $5/t were estimated in the short term. However, queuing constraints were treated in a similar fashion to McAulay et al., so the diseconomies associated with delivering to busy sites was not captured and benefits of centralising grain deliveries may have been overestimated. Blyth et al. also modelled the long term scenario by removing existing capacity constraints. It was shown that in the long term (removing capacity constraints) there would be a consolidation of receiveal points and savings would be $2-$4/t higher than in the short term.

Brennan (1992) examined grain distribution costs for a region in Western Australia, focusing on the annual peak load problem. In contrast to earlier work, handling cost and grain receiveal points were endogenously determined, according to the type of technology available at the site, including the use of rail out in the peak period. The total amount of grain transported in the peak period depended on the rail capacity available, and queuing costs associated with road transport in this period. In the aftermath of the Royal Commission, substantial data were available, and very detailed estimates of road and rail costs were used. Several important implications for rail transport were found. First, substantial economies were available by long haul rail transport along the standard gauge main line. The model indicated a large shift in the task towards sites on these lines, with the short haul to the main line being conducted by road transport, with significant branch line closure. Concentration of deliveries at sites that were efficient users of rail in the peak period meant that large savings in the costs of operating grain handling facilities were achieved. A mixed integer programming approach recommend closure of 15 per cent of sites. However, the benefits of centralisation were limited by the cost of queuing. Brennan also investigated a deferred delivery scheme which extended the peak period, thus reducing congestion costs in the transport sector. The costs of deferred delivery were the costs of temporary storage on farm. It was found that in a normal year, the deferred delivery scheme did not substantially affect costs, and this was attributed to the large over capacity of low cost storage in the central system. However, in years of peak production, high marginal storage costs and high congestion costs meant that storage costs were reduced by 8 per cent and queuing costs were reduced by 38 per cent with a deferred delivery scheme.

There were a number of studies of grain distribution systems in North America in the 1970s which focused on the benefits of constructing new receiveal points or sub-terminals, as well as addressing rail line abandonment issues (Ladd and Lifferth; Tyrchneiwicz and Tosterud; Martin, Devine and Kulrestha; Hilger, McCarl and Uhrig). They found that there were benefits with rationalising the system, and these benefits included the abandonment of branch lines, and the increased centralisation of services which reduced handling costs and allowed efficiency savings in the operation of rail transport. These studies were conducted in the context of a competitive grain elevator system, and were justified on the grounds that individual decision makers were unable to take account the effect of their decisions on vertically linked markets.

3. Pricing Issues

Most studies have focused on least cost grain paths while failing to account for the second best pricing issues that exist in the industry. Faced with incorrect price signals, farmers never make grain delivery decisions that are based on the resource cost of services, so the "first best" solutions predicted by most modelling work are unattainable.

Market failure problems are important issues facing the newly deregulated grain handling environment. Some of these are discussed below.

3.1 Spatial Monopoly Pricing by Handling/Storage Sector

Most work on grain handling and transport has focused on determining socially optimal or cost minimizing policies without considering the effect of alternative arrangements on market structure. However, Martin et al. argue that the result of fewer, more centralised storage facilities might be an increase in spatial monopoly power. Consequently, the benefits of centralisation might not be passed on to the farmer.

Quiggin and Fisher noted that there may be potential for spatial monopolies in the grain storage industry due to economies of size in the construction of permanent storage. They pointed out that an effective limit to the extent of monopoly exploitation will be the use
of bunker storage which has low capital costs and, therefore, low exit costs. This observation is based on contestability theory (Baumol) which states that, provided a market is contestable (entry and exit is free), a monopoly will produce a socially desirable outcome because the firm will be restrained from gaining monopoly profits by the threat of entry.

Quiggin and Fisher also argued that the cost of transporting grain from the farm to the receival point provided an effective limit to the natural monopoly power that might otherwise be achieved at a receival point due to economies of size. They noted the potential for price discrimination that might arise between competing receival points in a deregulated system, as receival points attempt to increase their market area by charging lower prices to more distant farmers. Quiggin argued that price discrimination (which could be administered by vertical integration of storage and delivery services) could result in grain being delivered to sites other than the least cost one. In contrast, Hobbs showed that spatial price discrimination can be superior to mill pricing (charging at constant price at the receival point). This result implies that regulation restricting price discrimination in a "deregulated" grain handling industry is not necessarily the best solution. Clearly, an examination of spatial pricing policies in the grain handling industry is an important area for future research.

3.2 Imperfect Competition in Transport

Systems analysis of grain distribution costs has indicated that if farmers were aware of the true costs of grain paths, different grain paths would be chosen (Blyth et al.; Brindal and Dumas; Brennan). In particular, grain paths based on cost minimisation generally involve an increase in the use of road transport. For regions close to the port, there is an increase in direct transport to the port, and for outlying regions, longer farm to silo hauls which enable high cost branch lines to be avoided are chosen by these models. However, these models have failed to take into account the second best pricing practices adopted by the grain freight industry.

Second best pricing problems arise because of the nature of costs in the railroad industry, in particular, the high fixed costs associated with the establishment and maintenance of rail track. Since there are large sunk costs associated with rail transport, an appropriate criteria for analysing rail prices is Faulhaber's cross-subsidy criteria for regulated monopolies (Faulhaber). He argued that provided prices for joint services were above incremental costs and below stand alone costs, there was no cross subsidy. This test is applied wherever there are services which involve a joint cost, and has been applied to the transport industry. In a recent study of branch line viability, the Western Australia Department of Transport argued that all branch lines in Western Australia were viable because prices covered operating costs and made a contribution to track and overheads. However, Brennan (1994b) argues that track maintenance costs should not be considered as a joint cost that must be shared across all users. If they were correctly included as an "incremental "cost, the cross-subsidies evident in the current pricing system would be more apparent. She presents a model of intermodal competition and optimal investment in rail track, and argues that socially optimal rail networks will always operate at a profit if road rate pricing is used. In contrast, public monopolies that operate subject to a break even constraint will over invest in rail track. The monopoly power afforded to the rail industry where it has economies of traffic density mean that it can cross-subsidise operations where road transport is the more competitive alternative. Thus, deregulation will not achieve efficiency gains if the current public rail monopoly continues to operate subject only to break even constraints.

Quiggin and Fisher examined the contestability of the rail industry and argued that, while the provision of rail freight services as a whole was not contestable because of high sunk costs, the operation of rolling stock may have competitive characteristics. Competition between different state rail authorities, or between private owners of a rail fleet and the state rail authority could provide competition which could encourage cost minimisation. However, Brennan (1994b) argued that the extent to which alternative rail operators can compete with the state rail authority will depend largely on the policy used to price rail network services. If the incumbent rail companies retain ownership of the network, they will retain all price setting power, because of the price they set for rail network services. The limit on the price that can be charged for rail network services is the road rate less the cost of operating trains. Because of the high sunk costs of the rail network, the rival firms could not contest the rail network, and must pay the charge that the incumbent sets. It is possible that the incumbent will erode efficiency gains by raising the price of network services, or could even price rival firms out of the market.
Because of the second best pricing problems in the grain freight industry, which arise largely because of the high fixed costs of track maintenance, deregulation may not be effective in promoting cost savings. It appears that further measures need to be taken to ensure that competition is effective in the transport industry. This is an area that requires more research and policy analysis.

3.3 Cost Pooling

Quiggin, Fisher and Petersen discuss the pooling arrangements historically used by grain handling authorities. They suggest that efficiency costs associated with cost pooling are inversely related to distributional consequences. For example, efficiency costs are small when pooling occurs between sites that are not in direct competition (because grain paths are not affected). However, in these situations there are large distributional consequences and they suggest that this is why pooling across states was removed.

They also argue that removal of pooling between sites will not necessarily encourage long run efficiency improvements. This is because if charges are set equal to operating costs, and growers have control over investment decisions, those growers experiencing high marginal costs will vote to increase investment in cost reducing storage technology, thus raising capital costs.

The problem of pricing for receival points services is a significant one as the industry moves towards a more rationalised system. Demand for receival point services depends not only on the price of services, but also on the costs of transport routes associated with particular locations. Increased choice of transport modes and changes in freight rates may result in shortages in storage capacity along certain routes in the short term. Appropriate pricing policies will ensure that efficient use is made of existing infrastructure.

That is, from the short term perspective, marginal cost pricing will be better than pricing according to average operating costs. To see this, consider two receival points. Receival point A has a large rail out program in the peak period, but more grain is received than can be railed out or stored in low cost facilities, so bunker storage has to be used at the margin. This site will have low average operating costs but high marginal costs. Consider another site which has low receivals and excess low cost storage capacity, so that average operating costs are high but marginal costs are low.

Pricing according to average operating costs will induce more deliveries to Site A where the marginal cost of storage is high, and less to Site B where the marginal cost of storage is low, and is inefficient in the short term.

Prices that reflected marginal costs would ensure that more efficient use was made of existing facilities in the short term, and would guide more appropriate investment decisions. Sustained demand for storage at sites with high marginal operating costs would justify additional investment in low cost storage capacity at these sites in the longer term.

3.4 Externalities

There are a number of external effects in the grain distribution system which are not accounted for in current prices. One is the cost of road vehicle damage. While taxes and license fees help to raise the cost of road transport towards the true social cost, not all the costs of road damage are recovered. In the absence of other distortions, this would result in the overuse of road transport. However, as discussed above, monopoly power in the rail industry limits the competitiveness of road transport, and there is empirical evidence to suggest that the distortions created by monopoly pricing of rail transport are much larger than the externalities associated with road damage (Brennan 1994a).

Another area where external effects exist is in the handling-transport and storage-transport interfaces. For example, grain handling costs can be reduced by using "rail out" in the peak period, and this implies that there is a shadow price on scarce rail capacity. In circumstances where there are a number of independent grain handling companies, scarce capacity will not be allocated efficiently unless some sort of peak load pricing system is used. A pricing strategy for rail wagons that is based on peak load pricing has been used in the USA (Wilson). In this system, rail car availability is a right that is auctioned in a manner resembling a forward contract. Users may ensure priority of supply provided they are prepared to pay the price. Raising according to willingness to pay ensures an efficient allocation of rail cars between sites in periods of shortage.

Further improvements in the pricing of rail services would involve charging for rail demurrage. This would ensure that those sites with slow outloading rates would make appropriate investment decisions.
concerning outloading facilities. Further, the cost of different loading strategies (e.g. segregation and two point loading compared to homogenous single point loads) would be signalled to decision makers.

Another transport/handling interface is the receipt of grain into the system in the peak period. Congestion results in truck queues at silos, and this causes efficiency losses as trucks are idle. Peak load pricing methods which even out this congestion problem have been suggested by a number of researchers (Bouland; Quiggin).

Another important externality is the problem of grain insect control. The presence of grain insects can spoil an entire stock of stored grain, yet the introduction of insects into the system is difficult to detect. The problem will be exacerbated by storing the grain on farm for long periods, as less control is possible over grain insect control methods. One aspect of the problem is the threat of pesticide resistance, which can be exacerbated by inappropriate grain hygiene. These problems are internalised by having a single operator responsible for storing grain. The grain insect control problem has been addressed widely in the past (Love, Twyford-Jones and Woolcock); Johnston; Johnston and Roberts), and more recently by the Royal Commission (RCGH 1988b).

The Royal Commission recommended that in a deregulated system, the grain insect problems associated with on-farm storage might be avoided by increasing farm extension efforts and encouraging growers to improve farm hygiene practices (RCGH 1988b). They also suggested that an on-farm certification scheme and chemical residue testing could be used to overcome the externality problems associated with farm insect control. This approach could also be used to certify private grain storers. The problem of monitoring and control of the grain insect control problem adds to the cost of a more competitive storage environment. However, provided the costs of control are signalled to decision makers, appropriate choices concerning investment in private storage can be made.

The externality problems associated with various aspects of the grain distribution industry imply that agricultural economists may have an important role to play in identifying ways of reducing the costs of grain distribution. In particular, analysis of pricing strategies which attempt to reflect the social costs of decisions will promote more efficient choices in the grain distribution system.

4. Conclusion

This review has focused mainly on the hinterland aspects of the grain distribution system, concerning the infrastructure used and grain paths taken to get the grain from the farm to the port. Areas where the costs of the central grain distribution system might be reduced include the increased centralisation of receivals, with closure of receival points and branch lines. The extent to which economies of throughput can be achieved will be limited by transport constraints in the peak period, including the cost of queuing as truck arrivals at a site increase, and the scarcity of transport capacity that limit the ability to increase turnover in the peak period. The possibility of peak load pricing schemes which reduce these transport constraints could be investigated.

In the intermediate term, one of the main problems facing the industry is the transition to an improved system. Dramatic changes in prices to reflect resource costs may guide grain along least cost paths, but it will also result in capacity shortages. Better use could be made of existing facilities if price rationing were used. If receival point ownership is privatised, one of the problems that would have to be addressed is the externality associated with the use of transport in the peak period. Appropriate pricing of rail rolling stock, include demurrage charges would encourage an improved handling/transport interface.

An important issue facing the industry is the achievement of efficiency gains in the transport sector. Economies of density in rail transport provide monopoly power which enables cross subsidisation and results in efficiency losses. Appropriate institutional arrangements which restrict unfair pricing practices need to be addressed.

Agricultural economists may have an important role to play in identifying ways of reducing the costs of grain distribution. For example, the techniques of systems analysis can be used to address interdependent choices relating to transport and storage. With collaboration from the interested parties, substantial benefits could be achieved from developing system models in terms of identification of system bottlenecks and investment planning. Moreover, economists may have an important role to play in the design of appropriate pricing strategies to guide grain along least cost grain paths. Pricing issues are very important in the transition to an improved grain distribution system. Economists also have role in the ongoing
debate concerning market structure issues in the deregulated grain handling environment.

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