POOLING

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Abstract

Pooling of costs and revenues is commonly practised by public utilities, and by other firms exercising a degree of market power. In this paper, a variety of explanations of pooling are considered. A new explanation based on the concept of common property, is advanced. The costs of pooling are assessed, and some alternatives to pooling are considered.

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Introduction

The practice of pooling is both widespread and poorly understood. Cost pooling occurs in a wide range of contexts. While it is surprisingly difficult to provide a precise definition, cost pooling may be said to involve the provision of a range of different services at a common price calculated to cover average costs. Revenue pooling arises frequently in rural industries characterised by marketing boards with powers of compulsory acquisition. Once again, definitional issues are fairly complex.

A number of different interpretations of pooling are possible. Writers including Thomson and Walsh (1981) have analysed pooling arrangements as a purely redistributive device adopted by governments. A second group of explanations are based on the assumption that the organisation has operational independence and seeks to maximise its own objective function. In the case of private firms, the objective is profit-maximisation and the analysis treats pooling as a variant of price discrimination. A closely related approach, based on Niskanen's (1968) model of bureaucracy, may be appled to public utilities with objectives such as output maximisation. A third explanation is based on the transactions costs associated with charging different prices to different consumers. Finally, recent developments in the theory of sustainable monopoly raise the possibility of an efficiency-based justification for pooling. In this paper, all of these approaches are discussed, and it is argued that none of them provide an adequate account of pooling.

A new analysis will be advanced, in which consumers rather than owners, management or governments exercise effective control, or at least veto powers, over the firms pricing and production policy. This analysis is referred to as a 'common property' model following the work of Quiggin (1983, 1988a). It is argued that pooling may be understood as a device for securing unanimous agreement to the adoption of cost-minimising production techniques.

A secondary but still important, aspect of the paper is an assessment of the costs, in terms of the efficiency criterion, associated with pooling. It is argued that in a number of important cases, the costs associated with pooling between geographically disparate consumers may be quite small, particularly in relation to the transfers involved. The case of grain handling is used as an example.

Cost and revenue pooling

Cost pooling is typically defined as a practice whereby low-cost consumers subsidise high-cost consumers through the payment of a uniform price. This definition focuses attention on the distributional aspects of pooling, but in other respects it is not very useful as a basis for analysis. It is more fruitful to consider pooling as a pricing policy for multi-product firms. On this interpretation the products supplied to high-cost and low-cost consumers must be differentiated in some fashion. Otherwise, there would be no difference in the cost of service.

The most common form of pooling arises with products differentiated by place of delivery, as in the case where public utilities subsidise rural consumers at the expense of urban ones. Such 'geographical' pooling is used as the basis of pricing for a number of public utilities, and is of particular relevance to the rural sector since many utilities pool costs between urban and rural users or among geographically disparate rural users. Important examples of the former practice are Telecom and electricity authorities, while the latter is exemplified by the pricing policies of public authorities associated with the processing of rural commodities. An example which will be examined in the present paper is the handling and transport of grain.

Pooling of this kind is not confined to public utilities, however. Consider, for example, the case of supermarkets which offer free delivery. The cost of delivery varies among consumers, broadly speaking according to the distance between the supermarket and their homes. Moreover, some customers will not choose to avail themselves of the services. Nevertheless, all consumers bear the cost of delivery in the form of higher prices. Thus, the provision of free delivery is a form of pooling. Among other things, this implies that they must possess some degree of local market power, since, otherwise, consumers who placed a low value on free delivery services would shop elsewhere.

A more subtle case of pooling arises when each consumer is supplied with a slightly different good or service. In this case, there are commonly economies associated with high-volume consumers. These economies usually result from fixed costs associated with taking on additional consumer (that is producing the differentiated product associated with that consumer). The larger the volume of consumption by a given consumer, the lower the level of average costs. Cost pooling arises when this reduction of average costs is not reflected in corresponding volume discounts.

Telephone services are a notable example. There are a range of fixed costs associated with connecting new subscribers and maintaining their service. If charges are based purely on the number of calls made, then subscribers who make few calls will, in effect, be subsidised by those who make large numbers of calls.

Finally, pooling may occur when costs vary according to the time at which the good or service is supplied. Many public utilities are subject to peak-load problems and these may not be reflected in charges. On the other hand, costs may be high at times when volumes are low. For example, late night bus services frequently involve a much higher cost per passenger than do peak hour services.

Two main forms of revenue pooling may be distinguished. First, there is the case where revenue from a high-priced (normally controlled by means of a quota system or a monopoly marketing boards) market is pooled with revenue from a low priced market. Second, there is the case where producers are paid a return which does not take account of quality characteristics which affect the ultimate market value of their output.

The first case will not be treated in detail here. In this case, pooling is typically a subsidiary element of a policy in which the crucial feature is the existence of the high-price market. Important cases are the domestic market in the case of home consumption price schemes and the fluid milk market in the dairy industry. The effect of pooling in a policy of this kind is to dissipate the monopoly rent extracted from the high-price market, by generating production in excess of the amount where marginal costs equal the price obtainable in the low-price market. The standard (second-best) policy option is the imposition of production controls aimed at restricting production to that prevailing in the discriminating monopoly solution. Unlike the other cases discussed here, the commodity is normally of uniform quality and producers differ primarily in their legal rights of access to the high-priced market. Some aspects of this type of pooling may, however provide useful insights into the forces behind the emergence of more general cost and revenue pooling.

The second case is conceptually fairly similar to cost pooling and indeed, it is not always possible to distinguish the two. For example, consider the situation where the same net return is paid to graingrowers regardless of the handling costs they incur. This may be viewed either as cost pooling (treating grain handling as a service provided to growers before their grain is ultimately sold) or as revenue pooling (treating grain as a commodity differentiated by time and place of delivery as well as by quality characteristics). Explanations of pooling will display a similar duality. For example, an explanation of cost pooling in terms of monopoly will correspond naturally to an explanation of revenue pooling based on monopsony.

This duality will be exploited in the present paper. Rather than presenting parallel analyses of cost and revenue pooling, the choice of focus will be dictated by the simplicity of the resulting analysis. Questions focusing on the organisation of the firm or public authority practising pooling will be treated primarily in terms of cost pooling. This permits the employment, in a natural way, of a range of conditions on cost functions and the analysis of their implications for market structure. There have been a number of important developments in this area, particularly associated with the work of Baumol, Panzar and Willig (1982). By contrast, questions relating to the implications of pooling for farm-level production decisions will be treated in terms of revenue pooling.

Cost Conditions and Market Structure

In this section some conditions on costs for multi-output firms will be defined. In all cases, analogous definitions can be made for the net revenue obtained by a marketing authority dealing with a range of products.

Define the feasible production set by the condition

(1) $$F(x_1,x_2, \ldots x_n,y_1,y_2 \ldots y_m) = 0$$

where $F:\Re^{n+m} \rightarrow \Re$ is a production function;
$y = (y_1,y_2 \ldots y_m)$ is a vector of outputs; and
$x = (x_1,x_2, \ldots x_n)$ is a vector of inputs.

Given a production function, F, and a vector of input prices $c = (c_1, c_2 \ldots c_n)$, the cost function $C: \Re^m \times \Re^n \rightarrow \Re$ is defined as

(2) $$C(y;c) = \{\min \sum_{i=1}^{n} c_i x_i : F(y;x) = 0\}$$

That is, the cost function is the minimum cost of producing a given output y at the input price vector c. For the remainder of this paper, input prices are assumed fixed, so that we deal with a function $C:\Re^m \rightarrow \Re$ and can simply refer to C(y) for any output vector y.

The cost function is said to be symmetric if, for any permutation of the y_i, the total cost C is constant. In particular

(3) $$C(y_1,y_2 \ldots y_i, \ldots y_j, \ldots y_n) = C(y_1,y_2 \ldots y_j, \ldots y_i, \ldots y_n) \text{ for all } i,j.$$

A symmetric function is said to be additive if its value depends only on $\sum_{i=1}^{n} y_i$. In this case, the different outputs are perfect substitutes in production, though they will not, in general, be perfect substitutes in consumption. An example would occur if a good was produced at a single central location and then shipped to a set of n points equidistant from that location. This defines a set of n goods differentiated in space by the point of delivery, but the total cost of production depends only on the total amount produced. It is an obvious generalisation of this case to consider the situation where the delivery points are not equidistant from the point of production. In this case, the cost function takes the form

(4) $$C(y) = C_1 \left(\sum_{i=1}^{n} y_i \right) + \sum_{i=1}^{n} k_i y_i$$

where C_1 represents the cost function for the central location and k_i is the cost of transporting one unit of the good to point i. This cost function also applies to the case of an organisation producing a good or services at a number of points, with central overheads dependent on the level of total costs and production at each point subject to constant returns to scale with different average cost levels. An analogous definition would apply to the net revenue obtained by an organisation marketing a range of commodities with constant unit premiums reflecting quality differences.

Pooling is frequently associated with monopoly, and one of the most important questions here is the idea of natural monopoly, based on the existence of size economies. Before discussing natural monopoly, it is necessary to give a rigorous form to the notion idea of size economies, using the concept of subadditivity, developed by Baumol, Panzar and Willig (1982).Let $y^1, y^2, \ldots y^n$ be possible output vectors. The cost function is said to be subadditive if for all $y^1, y^2, \ldots y^n$

$$C\left(\sum_{i=1}^{k} y^i\right) < \left(\sum_{i=1}^{k} C(y^i)\right) \qquad (5)$$

Baumol , Panzar and Willig (1982) define an industry as a natural monopoly where the cost function is globally subadditive. A natural monopoly is an industry in which the first-best social optimum involves a single producer, setting price equal to marginal cost. Two major difficulties are likely to prevent this desirable outcome from occurring.

The first is the fact that the existence of natural monopoly implies that marginal costs must be less than average costs. Thus, marginal cost pricing implies that the firm must make a loss. In the presence of a costless source of revenue (such as a lump-sum tax), the socially optimal course would be the provision of a suitable subsidy from general revenue to ensure that the firm set prices equal to marginal cost.. However, such costless revenue sources are not normally available.

The second problem arises from one of the most surprising results associated with the recent 'uprising in the theory of industrial organization' (Baumol 1982). This concerns the case of non-sustainable natural monopoly. In this case, monopoly is cheapest method of supplying all markets, but there is no sustainable price vector which covers average costs. That is, at any price vector which permits a single firm to meet all the demand for the relevant commodities and still cover average costs, it will be profitable for an entrant to produce an amount meeting only part of the demand. In the multi-product case, it is possible that production costs are lowest when all products are produced by a single firm, but that an entrant can profitably 'cream off' the market for a single product. Examples of non-sustainable natural monopoly are given by Sharkey (1982).

These problems complicate the definition and analysis of pooling, since it is difficult to establish a base against which pooled prices can be compared.

Definition of Pooling

No simple and completely satisfactory definition of cost (or revenue) pooling is possible. The general notion is that goods with different production costs are sold at the same unit price. There are two immediate possibilities for making this definition more exact. The first is that pooling involves uniform prices with different marginal costs of supply. This is an inadequate definition because it is both too broad and too narrow. It is too narrow because it excludes the important case where marginal costs are equal but returns on some products are too low to cover costs of production.This might apply, for example, in the case of telephone service. On the other hand, it may be regarded as too broad because of the implicit assumption that marginal cost pricing is the appropriate benchmark for efficiency. If scale economies prevail, marginal cost prices will not cover costs and will not necessarily be efficient in the absence of a costless source of revenue such as a lump-sum tax.

A second alternative is to define pooling as involving uniform prices with different average costs of supply. However, average costs are generally not an appropriate benchmark for pricing. In general, the most efficient prices which achieve a given degree of cost recovery are the Ramsey prices derived from Ramsey's (1927) theory of optimal taxation. Using the standard criterion of minimising the loss of consumer surplus, it may be shown (Sharkey 1982, p.51) that, assuming demands for the different products are independent, the optimal set of prices, subject to the requirement that revenue should cover average costs, is given by

(6) $$\frac{p_i - \partial C/\partial y_i}{p_i} = -\frac{k}{\eta_i} \quad i = 1,2..n$$

where, p_i is the price of output i, η_i is the elasticity of demand for output i, and k is a proportionality constant which determines the proportion of total costs which are recovered. Ramsey pricing depends on marginal costs and elasticity of demand. Because of the introduction of conditions of demand as well as cost it seems inappropriate to use divergences from Ramsey pricing as a criterion for cost pooling.

For the purposes of this paper, the broadest possible definition of pooling, subject to the restriction that only cost conditions should be considered, will be adopted. Cost pooling will be defined to occur whenever

(i) the same unit price is charged for goods 1..n

(ii) the firm's cost function is not symmetric in goods 1..n

Similarly, revenue pooling will be defined to occur when the revenue function is not symmetric in the different goods but all producers receive the same unit return.

Particular attention will be paid to the case where the cost function is of the form (4) and prices are set so as to achieve cost recovery. The unit price in this case will be

(7) $$P = C_1\left(\sum_{i=1}^{n} y_i\right) / \left(\sum_{i=1}^{n} y_i\right) + \bar{k}$$

where

(8) $$\bar{k} = \sum_{i=1}^{n} k_i y_i \; / \; (\sum_{i=1}^{n} y_i)$$

Using this formulation, it is possible to derive simple estimates of the divergence between pooled prices and prices based on average or marginal costs, and hence of the efficiency costs of pooling.

In some cases, partial cost-pooling may be said to occur. However, this is very difficult to define. In the case where the cost function is of the form (4) however an obvious form of partial pooling arises when

(9) $$P_i = C_1 (\sum_{i=1}^{n} y_i) / (\sum_{i=1}^{n} y_i) + \lambda \bar{k} + (1-\lambda)k_i$$

Resource allocation effects of pooling

In this section, the resource allocation effects of pooling of net returns will be considered. As noted above, this type of pooling may be arise either because of pooling of revenue from final markets or because of pooling of handling costs. The model presented here refers to cost and revenue pooling in the handling of grain, but could clearly be applied to analogous cases of pooling in other industries.

It is necessary to characterise grain not merely by quality, but also by time and place of delivery. Suppose that there are R grades of wheat, j=1..R, S delivery points k = 1...S , T delivery times t = 1..T and N farmers i = 1..N. Then the output of farmer i may be represented as a vector $\mathbf{y}$. Let $\mathbf{p}$ denote the vector of unit returns (net of handling costs) payable to farmers. Given a production function $F_i(\mathbf{y}, \mathbf{x})$, where $\mathbf{x}$ represents the least cost vector of on-farm inputs the farmers problem may be written

(10) $$\text{Max } \mathbf{p}.\bullet \mathbf{y}.- \mathbf{c}\bullet\mathbf{x} - \lambda \; F_i(\mathbf{y}, \mathbf{x}) = 0$$

yielding the necessary conditions

(11) $$p_{jkt}y_{ijkt} - \lambda \; \partial F_i / \partial y_{ijkt} = 0$$

$$c - \lambda \; \partial F_i / \partial x = 0$$

In order to estimate the effects of pooling using this general model, it is necessary to obtain a large number of cross-elasticities of supply. A more tractable model may be obtained using the following special assumption on the cost function

(12) $$w \; x_i = g_i(y_i) + \delta_{ij} \; y_{ij} + \delta_{ik} y_{ik} + \delta_{it} y_{it}$$

where

$$y_i = \sum_{j=1}^{R} \sum_{k=1}^{S} \sum_{t=1}^{T} y_{ijkt} \text{ (total output of grain)}$$

$$y_{ij} = \sum_{k=1}^{S} \sum_{t=1}^{T} y_{ijkt} \text{ (total output of grain of grade j)}$$

$$y_{ik} = \sum_{j=1}^{R} \sum_{t=1}^{T} y_{ijkt} \text{ (total output of grain at point k)}$$

$$y_{it} = \sum_{j=1}^{R} \sum_{k=1}^{S} y_{ijkt} \text{ (total output of grain at time t)}$$

The crucial assumption here is that there is no interaction between the different elements of grain type- grade, delivery point and delivery time. This implies that each farmer will select a single grain type that which maximises the net premium

(13) $$\pi = p_{ijk} - \delta_{ij} - \delta_{ik} - \delta_{it}$$

and the farmers output is determined by the condition

(14) $$\pi = \partial g_i / \partial y_i$$

This model may be extended in a straighforward fashion to cover the case when grain quality is uncertain, depending on interaction between farmer decisions and random climatic variables. In this case, the output quantity y_{jkt} may be interpreted as the output from a particular productive process j, j = 1 ...R, receiving a random price $p_{ijk}(\theta)$ where θ is a random variable representing climate. Assuming risk-neutrality[1], condition (7) will follow with p_{ijk} replaced by $E[p_{ijk}]$.

Now consider the implications of introducing, or removing pooling. Suppose that a particular price p_{ijk} falls as a result. The resulting reduction in supply of grain of type (i,j,k) will have two components. First, all farmers producing this type of grain will reduce their output to a level where condition (8) is once again fulfilled. (In some cases, this will be the only effect. This would apply, in particular, to cost pooling between grain handling services in widely separated regions. This is the case examined by Spriggs, Geldard, Gerardi and Treadwell 1987).

Given the assumptions presented above, this response will be exactly equal to that associated with a uniform fall in the price of all types of grain. Assuming that the appropriate aggregation conditions hold, it can, therefore, be determined by reference to the aggregate elasticity of wheat supply. In some cases a more accurate indication may be obtained. For example, if pooling depends on place of delivery, then regional supply elasticities will be relevant. In this situation, the elasticity of demand for the relevant service will depend solely on the elasticity of supply of wheat.

[1] This assumption is stronger than is required. It is sufficient to assume that the marginal risk associated with each of the possible production activities is the same.

The efficiency loss associated with this aspect of pooling.may be examined using the welfare triangle method developed by Harberger (1954). Regarding pooling as a tax on one type of grain counterbalanced by a subsidy on another. Assuming competitively determined supply and demand functions, it is possible to draw the standard cross diagram to determine the competitive market price and then consider the welfare costs, measured in terms of consumer and producer surplus, of, say, a tax on consumers. This welfare loss may be estimated by

$$L = 1/2\, t^2 \varepsilon \tag{15}$$

where

L is the welfare loss, expressed as a proportion of total revenue PQ;
t is the tax rate, expressed as a proportion of the price; and
ε is the elasticity of demand (normalised to be positive).

The crucial requirement is the estimation of the elasticity of demand for handling and marketing services. Let p_g be the price per tonne of grain at the farm-gate, net of inspection services, let c_i be the handling charge and let the quantity of grain supplied in a given region be Q. Then the elasticity of demand for inspection services is the same as the elasticity of Q with respect to c_i which is given by

$$\varepsilon_h = -\left(\frac{\partial Q}{\partial c_i}\right)\left(\frac{c_i}{Q}\right) = -\left(\frac{\partial Q}{\partial p_m}\right)\left(\frac{p_m}{Q}\right)\left(\frac{c_i}{p_m}\right) \tag{16}$$

so that

$$\varepsilon_h = (c/p_g)\, \varepsilon_g \tag{17}$$

where ε_h is the elasticity of demand for the service, ε_g is the elasticity of supply of wheat, c is the charge for the service and p_g is the price of wheat at the farm gate. If the cost of providing one service is $c(1+\theta)$ and the cost of another is $c(1-\theta)$, then the model of pooling as a combined tax-subsidy may be applied. The same analysis could be applied to a large class of services with a 10 per cent coefficient of variation in costs. Combining (15) and (17), the estimated net welfare loss, expressed as a percentage of the cost of the service, is

$$L = \varepsilon_g\, \theta^2\, (c/p_g) \tag{18}$$

Vincent, Powell and Dixon (1982, p.223) estimate of the elasticity of supply of wheat at 0.8. Suppose that $c/p_g = 0.1$ and $\theta = 0.2$ (this implies that one service is 50 per cent more expensive than the other). Then the total net loss is 0.32 per cent of the total cost of the service, or 0.032 per cent of the total value of the wheat crop. At a wheat price of \$100 per tonne this is equivalent to a loss of \$0.03 per tonne.

This is a small figure (about $480 000 for a crop of 15 million tonnes). The question then arises as to why the first move away from cost pooling taken by the Australian wheat industry was to remove pooling between states. Although the efficiency consequences of this step may not be large, the distributional effects are substantial. If the 10 per cent distortion referred to above applied to the average costs of two states, with an output of 5 million tonnes each, then the low-cost state would be losing $1.50 per tonne, or $7.5 m per annum, as a result of pooling.

Thus, it is necessary to examine the entire distribution of gains and losses rather than simply the net efficiency effects. This analysis may be assisted using an approach developed in Quiggin (1988b). A measure of costliness is proposed, based on the ratio of the net social benefit to the gross benefits. Suppose there is a set Z of possible decisions, including a 'status quo' decision z_0. If a given decision z yields gains of δ_i to individual i relative to z_0, then the net benefits are given by $N(z) = \Sigma_i \delta_i(z)$ and the gross benefits by $G(z) = \Sigma_i \max(\delta_i(z), 0)$. The ratio N/G is 1 for a Pareto improvement and 0 for a zero-sum redistribution. For decisions which yield positive net gains overall, but involve losses for some people, N/G will lie between 0 and 1. The measure is not very useful when N is negative, but this can always be avoided by an appropriate choice of z_0.

In the example given here, the ratio N/G is approximately 0.06, so that the effect of the shift is far closer to a pure redistribution than to a Pareto improvement. It seems reasonable to conclude that the maintenance or removal of pooling in cases of this kind reflects ethical attitudes and the distribution of political power rather than judgements concerning economic efficiency..

In addition to effects dependent on own-price supply elasticity, a reduction in price will have efficiency effects because some farmers will switch out of the production of type (i,j,k) into some other type. A converse analysis applies to a price increase. Thus when pooling between two or more types is introduced (or removed) the supply response will involve both a shift of aggregate supply from farmers who produce the types which fall in price to those who produce the types which increase in price and a shift of some farmers from the first category to the second.

This second effect is likely to be much more significant. This is a reflection of the more general point that a distortion affecting the relative prices of commodities which are close substitutes in production or consumption is likely to be much more costly than one affecting goods with little cross-substitution (Dixon 1978). Conversely, a tax, subsidy or tariff with a uniform incidence across a range of close substitutes is likely to yield significant transfer effects with a relatively low deadweight cost (Quiggin 1980).

The extent of the second type of supply response will depend on the variation between farmers in the values of the relevant δ's. The value of δ is likely to be fairly high for differences in place of delivery since the point of production for farmers is fixed and costs of transport from farm to receival point are high in relation to processing costs. Nevertheless, within a suitable radius farmers may have a choice of receival points with varying marginal costs and there will be an efficiency loss associated with pooling. An arithmetic illustration of the loss may be given as follows.

Suppose two receival points are 50 km apart and farms are uniformly distributed along the interval between them. Suppose further that each site is subject to constant marginal costs and that these are $1 higher at site A than at site B an assume that the marginal cost of transport is $0.125 per tonne km. Thus the most cost-effective solution is for farmers less than 17 km from site A to deliver to that site and all others to deliver to site B. Under pooling, all those less than 25 km from site A will deliver to that site. The average social loss associated with deliveries to the 'wrong' site is $0.50 per tonne. Since these represent 8/50 =16 per cent of total deliveries, the average social loss across all deliveries is $0.08 per tonne. Broadly speaking this loss will increase with the square of the divergence in costs. However, the assumption of constant marginal costs is crucial. If marginal costs are rising at both sites, then the social cost of pooling will be considerably lower.

The value of δ is likely to be comparatively small for changes in grain quality. Farmers have a fair amount of choice in the cutlivar produced. In addition, there are a number of quality factors such as grain moisture content which may be directly influenced by farm management decisions. Indeed, the present system of payment contains perverse incentives to increase moisture content to the maximum allowable level. The introduction of additional segregations is likely to lead to a significant supply response as farmers switch from grades which fall in price relative to available alternatives.

Time of delivery may be altered either by cropping and harvesting decisions or by on-farm storage. Variations in delivery time may yield cost savings by reducing queuing times at grain receival points. This issue is examined in detail in Quiggin and Fisher (1987).

For the purpose of analysing distributional effects, farmers may be divided into three groups. First, there are those who continue to produce the categories which fall in price. These suffer a loss of $\approx \Delta p_{ijkt}(y_i - 1/2 \partial y_i/\partial p_{ijkt})$. Those who initially produced types which rose in price will make a corresponding gain. The outcome for those who shift between the two categories will lie somewhere between the two. Under plausible conditions, the gains/losses for this group will be uniformly distributed about the median gain.

Thus, the variance of gains (losses) will be greatest in the situation where very few farmers alter the type of grain which they produce. This is also the situation in which the efficiency costs of pooling (and, hence the gains from its removal) are likely to be smallest. Thus the ratio N/G will fall rapidly as the situation is approached where efficiency effects rely purely on changes in output with no change in the type of grain produced by a given farmer.

It is necessary to consider in detail which types of pooling are likely to fall into this category. In particular, it is necessary to consider pooling which is not directly related to the characteristics of grain delivered by farmers eg pooling across markets or across sale times. Begin with case where this is entirely unrelated to characteristics. Removal of pooling may be regarded simply as a source of additional noise. However, if farmers can exert political pressure to affect routing of grain etc there may be some potential for rent-seeking.

In most cases, the correlation between the characteristics of delivered grain and the point and time of final sale will be greater than zero. Nevertheless, if this correlation is small and especially if it is mainly based on characteristics, such as point of delivery, which have a low response elasticity then the efficiency gains from eliminating pooling may be trivially small.

Explanations of Pooling

A range of explanations may be offered for the existence of pooling arrangements. Each of these explanations involves different assumptions about the relevant cost conditions and about the institutional framework in which pooling takes place. Hence, they imply different analyses of the effects of pooling and the range of alternative policies.

To explain pooling, it is necessary, not only to point to the reasons why individuals or firms might want to practice pooling but also to describe the market conditions which permit pooling to take place. In general, some degree of market power is necessary to permit cost pooling. This may take one of two forms. First the cost function for the relevant goods may meet the conditions required for the existence of a sustainable natural monopoly. If size economies outweigh the extra charge imposed on lower cost goods, it is possible that there may be a sustainable uniform price vector . The alternative form of market power is the existence of legal or contractual barriers to entry, such as occur frequently in public utilities, including telecommunications and postal services. In some industries both size economies and barriers to entry may be observed.

Given these complexities, it is unlikely that a single explanation will account for all observed cases of pooling, or even that any particular case will fit neatly into any of the categories presented below. Even granting this it does not seem that the explanations which have been advanced fit the Australian case very well. For this reason, an alternative explanation, based on the concept of common property will be considered.

Redistribution

The simplest explanation of pooling is that based on redistribution. On this interpretation, cost pooling is purely a means of redistributing income from low-cost customers to high-cost customer. This may or may not involve lower efficiency costs than effecting similar redistribution through the tax system, either by taxpayer funded subsidies of the high cost product or by direct income transfers. Thomson and Walsh (1981) compare the costs of cross-subsidy and taxpayer funded subsidy. Akerlof (1978) discusses the issues involved in targeting the group which should receive income transfers.

If this explanation is accepted, there is no need to assume that industry has any of the technical characteristics of natural monopoly. The existence of high-cost and low-cost customers and the desire for redistribution are sufficient to generate a demand for restrictions on competitive entry.

The major problem with this explanation is the need to give an account of the political process which generates the demand for redistribution and the appeal of this particular form of redistribution. For example, subsidies to rural telephone users may be explained either as a form of tariff compensation or by reference to the electoral weighting in favour of rural seats which prevailed until recently. However, this explanation is less satisfactory when pooling among groups of rural producers, as applies in the case of meat inspection or grain handling, is considered. Users of high-cost facilities are not, in any obvious way, either more deserving or more politically influential than users of low-cost facilities.

Discriminating monopoly

An alternative explanation is based on the standard analysis of a discriminating single-product monopolist. The firm can maximise profits by pricing each unit at the marginal willingness to pay of the consumer concerned. Perfect discrimination arises when each unit is priced in this way. A less complete form of discrimination is obtained when the total market can be divided into a number of separate sub-markets, each of which is charged the corresponding monopoly profit-maximising price. Sieper (1982) analyses home-price consumption schemes on this basis.

Overt price discrimination is frequently impossible, but it can be introduced in a number of ways, one of the most important of which is 'bundling'. Bundling in general has been analysed by Schmalensee (1982). A particularly interesting case may be set out as follows. The firm differentiates its product by customer, supplying each customer with a composite good consisting of a unit the original combined with a variable quantity of some second good, such as transport services. The higher the elasticicity of demand of the consumer concerned, the more of the second good they are given. Thus, for example a supermarket may offer free delivery on the assumption that consumers who live further away are more likely to shop elsewhere. This may be represented using the cost function presented in equation (4).

In this model, no consumer is charged less than marginal cost. For this reason, a model of this kind is particularly consistent with an assumption that the industry satisfies the conditions of natural monopoly. The main additional requirement is the existence of groups of consumers who differ in the elasticity of their demand, and of a good which can be supplied in inverse proportion to the elasticity of demand.

A simple estimate of the potential transfer associated with this type of discrimination may be obtained using the example of uniformly spaced farms presented in the previous section. Suppose that the two silos are 100 km apart as before and that there are no cost differences between them. Given a bundled service, the optimal price for both firms is equal to the marginal cost plus the cost of transport for 50 km. Further, each site will find it profitable not to accept deliveries from outside a 50 km radius. This procedure involves potential efficiency losses if the provision of free delivery induces firms to deliver to a receival point other than the least-cost one. There is also some potential for cartelisation through a formal or informal demarcation of territories. This has occurred in the past in both regulated environments (for example, sugar) and unregulated markets (for example, newspaper delivery areas).

This kind of analysis can be extended from profit maximising firms to the output-maximising bureaucracy model of Niskanen (1968). Unlike the standard budget-funded bureaucracy, the firm is required to sell its output and is subject to a break-even constraint. Assuming that the firm can capture some or all of the consumer surplus associated with infra-marginal customers, it can supply other consumers at prices below average costs, thereby expanding total output. As in the profit maximising case, a bundling procedure is used to discriminate against consumers with a highly elastic demand.

Neither variant of the discriminating monopoly explanation seems particularly appealing in relation to cost pooling for rural services, because there is no obvious reason why the beneficiaries of pooling should have a more elastic demand than those who are discriminated against.

Transactions costs

Transactions costs represent something of a residual category in economics, so that almost any phenomena can be explained by invoking their existence. Although the concept of transactions costs is subject to almost indefinite extension, it is frequently useful to consider specific examples. In the present case, it is apparent that pooling may occur in some cases because the cost to the producer of the good or service concerned is less than the administrative cost of distinguishing high and low cost customers and charging accordingly.

A simple example is given by the case of shops and restaurants which must pay penalty rates to their staff on weekends. This means that is cheaper to serve customers during the week than on weekends, a fact that is frequently reflected in the prices charged by restaurants, but hardly ever in those charged by grocery stores or supermarkets. This is presumably, at least in part, a reflection of the fact that changing the prices in a grocery store is a more difficult than adding a surcharge to a restaurant bill, though it is not immediately clear what prevents shopkeepers from posting a notice advising that an additional charge will be levied at weekends. A second aspect of the transactions costs associated with price differentiation applies when firms advertise their price lists. Any form of differentiation is likely to create costs here.

Provided transactions costs are confined to the restrictive definition used here, it does not seem likely that they will play a major role in the explanation of economically significant cost pooling arrangements. The major argument for prices against other systems of allocation is the relative ease with which prices can be adjusted, and this implies that the costs which will be borne in preference to a price adjustment must be relatively small.

Non-sustainable natural monopoly

The notion of non-sustainable natural monopoly provides a possible explanation of, and indeed justification for, pooling. Suppose that an industry is subject to conditions of non-sustainable natural monopoly and that marginal costs are equal for all consumers. Then the optimal form of organization is one in which a single firm supplies the entire market at a uniform price and competitive entry is prohibited. In this situation, there always appears to be cross-subsidisation in that some market can be supplied more cheaply by an outside entrant.

A case of particular relevance to the question of pooling may be constructed as follows. Suppose that the goods in question can be produced at a central location under a cost function displaying increasing returns to scale, and that there is a set of n equidistant delivery points. Thus, the cost function is symmetric, and takes the form (4) with all k_i equal. Suppose further that there is an alternative technology depending on a specific resource, and, therefore, subject to decreasing returns to scale at the industry level. This technology could produce an amount sufficient to serve the needs of any single delivery point at a cost below the average industry cost, but above the marginal cost. The cost function for the two technologies is illustrated in Figure 2.

In this situation, the total demand can be served at least cost by the centralised technology, and given similar demand elasticities at each point, the optimal price structure is a uniform charge at each point. Assuming that the firm is required to cover costs, this charge will be equal to industry average cost. However, this natural monopoly solution is not sustainable in the absence of restrictions on entry, since the alternative technology would be profitable at this price. Hence, cost minimisation requires a pooling solution with restrictions on entry.

The case of non-sustainable natural monopoly is interesting because it provides an efficiency argument in favour of pooling, and also because it appears that many of the advocates of pooling have something like this case in mind. However, it must be noted that only a limited degree of pooling can be explained in this way. In particular, this cannot explain any case in which consumers are charged prices below marginal cost.

Common property analysis

An alternative approach, which has not been considered previously, involves a 'common property' analysis. The common property framework is presented in Quiggin (1983) and has been applied to a range of problems including dryland and irrigation-related salinity. The approach represents a fusion of the asset-utilisation approach to externality problems (Mohring and Boyd 1971) with the recent re-appraisal of historical and existing common property systems in agriculture (Dahlman 1980). A particularly important feature of this re-appraisal is the recognition that common property is in fact property with its own rights of use and exclusion, and that the usage, frequently encountered in economic literature, by which 'common property' is equivalent to 'no property', is a contradiction in terms.

The central idea is that problems commonly classed as 'externalities' should be modelled in terms of the actions of joint owners of an asset. The issues of size economies and natural monopoly may be fitted into this framework, since the existence of size economies implies that consumers generate (positive and reciprocal) externalities as their numbers increase.

Such an externality can, of course, be internalised by a single private owner, that is, a monopolist. But, unless transactions costs are absent, the owner's profit-maximising pricing structure will not be such as to maximise the value of the asset to users. (In the present case, this is just the standard result concerning monopoly pricing). Hence, there are potential efficiency gains to users if a decision procedure yielding a closer approach to the maximum can be found.

One possible approach is based on common ownership by the group of users. This may be expressed in formal terms, as is the case with the common property component of a system of strata titles in property. Alternatively, the concept of common property can be used as the basis for analysis of problems where groups of people have some effective control over an asset, but this control has not been crystallised into the form of property rights. The requirements for this analytic approach are

(i) specification of the asset

(i) specification of the group of common owners

(ii) specification of a decision procedure for management of the asset

In the common property analysis of pooling, it is assumed that the industry has technical characteristics of natural monopoly. If the industry were made up of a number of firms, they would generate positive and reciprocal externalities and individual optimisation would not yield a global optimum. Hence, for the purposes of the analysis, the industry as a whole may be regarded as an asset.

The next assumption is that consumers have more or less effective ownership rights over the firm which provides the service. Consumers' rights may be expressed in a formal co-operative structure, but similar control may be exercised over a publicly owned organisation. If such an organisation is self-financing, the main external pressure is likely to come from consumers of its services. Similar considerations may apply in the case of a regulated private utility, subject to a profit constraint. This assumption is particularly appropriate in the case of the rural sector since many relevant services are provided either by co-operatives or by statutory authorities with substantial farmer representation on the board.

It is useful to compare this model with the control by employees or managers implicit in the Niskanen model discussed previously. In any large organisation, and particularly one with diffuse ownership, a principal-agent problem will arise. The Niskanen model may be regarded as one in which the interests of the principal have been completely eliminated. This is an extreme case. In general, there is no logical difficulty in combining a common property analysis of the kind employed here with the recognition that managers and employees of the relevant enterprise may have considerable scope to pursue their own interests. From the point of view of the owners (individual or collective) the principal-agent problem is simply a constraint on the manner in which their asset may be managed.

Collective ownership by consumers will alter the firm's objective function. In particular it will not maximise profits or returns to employees as in the models considered previously. Its actions will depend on the decision procedure through which consumers (with divergent interests) determine policy. A particularly important case is that of a 'conservative' decision rule where unanimous or near-unanimous agreement is required for policy changes, with disagreement resulting in maintenance of the *status quo*.

If costs are pooled through a uniform pricing rule, this decision procedure implies that the firm will be technically efficient since there will be unanimous agreement for the adoption of the cost-minimising production technique. However, the vector of goods supplied will not satisfy allocative efficiency conditions.

Consider, for example, the case of a telecommunications authority deciding where to make a set of lumpy investments, such as the installation of a fibre-optic cable, which would greatly increase the capacity for calls between the points where it was installed. Under a Ramsey pricing rule, than the decision to install the cable between particular points would benefit farmers subscribers at those points, since the marginal cost of making a call would decline. Conversely, since the decline in average costs would probably be smaller than the decline in marginal costs, the system overhead charge paid by all other subscribers would increase.

This would offend common-sense notions of equity since those who had to put up with worse service in terms of the availability of lines would have to pay extra to finance improvements in service for others. Hence, such a decision would be likely to be vetoed by the losers. In practice, this might result in a policy of spreading investment funds around on an 'equitable' but technically inefficient basis.

By contrast, under pooling, charges are determined by average costs. Obviously subscribers would still prefer that investments be directed so as to improve their own service. However, when faced with the choice of approving or rejecting an investment which would lower average costs for the system as a whole, they would gain by approval. Moreover, for decisions which did not affect their own service, everyone would favour the investment being directed wherever it would secure the greatest possible reduction in system costs.

Alternatives to Pooling

The alternatives to pooling will depend to a significant extent on the reason for the existence of pooling. Thus, each of the explanations of pooling presented above implies a different set of alternatives. In this section, attention will be confined to the cases of redistributive pooling and pooling as a common property arrangement.

There are two major alternatives to redistributive pooling. The first is the adoption of competitive pricing without alternative distributional measures. As noted above, on the redistribution analysis, there is no particular reason to suppose that cost-conditions are such as to make the concept of competitive pricing problematic. Simply removing the entry restrictions which permit cross-subsidisation should be sufficient to achieve this outcome.

Although the resulting equilibrium is not Pareto comparable with that prevailing under pooling, it is preferable if 'efficiency' is adopted as the normative criterion for comparing different outcomes. However, since any redistributive policy will involve some efficiency costs, this conclusion is not remarkably helpful. A second approach to the assessment of this type of policy change involves a trade-off between some notion of 'equity' and the efficiency costs or benefits associated with a given policy change.

The second alternative to redistributive pooling is the adoption of competitive pricing in conjunction with a' 'native distributional measures. In the ideal case, where a lump-sum method of redistribution exists this will provide a Pareto-improvement. The redistribution method need not be perfectly lump-sum to yield this possibility. What is required is that the same group of beneficiaries should be targeted and that the efficiency losses per dollar transferred should be lower than under cross-subsidisation.

If the common property analysis of pooling is accepted in a given instance, the industry concerned is a natural monopoly. Thus, the set of alternatives are essentially those which have been employed for dealing with natural monopoly in the past. These are private monopoly, regulated monopoly and public ownership. . Since the common property analysis implies some form of public ownership, this last case should be differentiated. Direct forms of public ownership, in which the objectives of the firm are determined by interaction between representatives of affected parties (consumers, workers, taxpayers etc.) may be analysed using the common property approach described above. The major alternative is rational-bureaucratic forms of public ownership, where managers are expected to follow some rule such as 'maximise subject welfare subject to the constraint that revenues cover costs'.

The private monopoly case is treated fairly exhaustively in standard microeconomic texts. Normally, a private monopoly will involve both substantial transfers from consumers to the monopolist and efficiency losses associated with the setting of prices in excess of both marginal and average costs. Two important exceptions have been analysed. The first is the case of the perfectly discriminating monopolist, where the transfer amounts to the whole consumer surplus associated with the product, but there is no efficiency loss. This solution will, in most cases, be unacceptable on equity grounds. Attempts to resolve equity objections through redistributive taxation will involve the re-introduction of efficiency costs

The second major exception is the case of contestable monopoly analysed by Baumol, Panzar and Willig (1982). They show that provided entry to the industry is free and exit is costless, there is no sustainable price vector yielding super-normal profits, since such profits would attract competitive entry. Unfortunately the conditions for contestability are very stringent. In addition, Perry (1983) shows that by setting multiple prices a monopolist subject to competitive entry can always earn super-normal profits. The standard requirements to impose price discrimination do not apply in this case. In particular, the monopolist does not need to restrict resale, as does a normal discriminating monopolist.

The case of regulated monopoly has also been analysed extensively, although the theory is not as unified as in the case of profit-maximising monopoly. Averch and Johnson (1962) and others have argued that rate-of-return regulation is likely to distort the input mix, while a number of writers have suggested that forms of cost padding are likely to emerge in this situation.

A bureaucratic-rational approach could yield gains in efficiency by over-riding the veto power of losers, since the vector of services supplied could then be brought into line with allocative efficiency conditions. However, it should be noted that these efficiency costs may be small if demand is inelastic. Criticisms similar to those applied to the regulated monopoly case have been applied to the bureaucratic-rational model, drawing on relatively recent developments in principal-agent theory to refine the much older view that independent bureaucracies are likely to be captured either by their own employees or by the groups whose activities they are intended to regulate.

Concluding Comments

The phenomenon of cost pooling is closely associated with violations of the convexity assumptions (constant or decreasing returns to scale) on which standard micro-economic theory is based. In assessing the costs of pooling, the reasons why it takes place and the viability of potential alternatives, the theory of competitive markets provides useful insights, but its standard prescriptions, such as marginal cost pricing must be treated with care. The treatment of pooling as a simple cross-subsidy may be appropriate in some cases but should not be employed uncritically.

Recent developments in economic theory, including the work of Baumol and others on natural monopoly and related issues and the development of more general notions of property rights, such as those employed here offer the potential of a much richer understanding of cost pooling, as well as more general issues of pricing in non-competitive markets.

In dealing with problems of this kind, policy-makers must steer a course between the Scylla of dogmatic misapplication of textbook micro theory and the Charybdis of second-best agnosticism. This is only possible if a careful consideration of the theoretical possibilities, such as those outlined in this paper, is combined with detailed empirical analysis of the problem at hand.

References

Australian Government (1986), *White Paper on Rural Policy*, AGPS, Canberra.

Akerlof, G. (1978), 'The economics of "tagging" as applied to the optimal income tax, welfare programs and manpower planning', *American Economic Review* 68(1), 8-19.

Averch, H. and Johnson, L.L. (1962), 'Behavior of the firm under regulatory constraint', *American Economic Review* 52(5), 1052-69.

Baumol, W. (1982), 'Contestable markets: An uprising in the theory of industry structure', *American Economic Review* 72(1),1-15.

Baumol, W., Bailey, E. , and Willig, R. (1977), 'Weak invisible hand theorems on the sustainability of multiproduct natural monopoly', *American Economic Review* 67(3), 350-65.

Baumol, W., Panzar, J., and Willig, R. (1982), *Contestable Markets and the Theory of Industry Structure*, Harcourt Brace Jovanovich, New York.

Coase, R. (1937), 'The nature of the firm', *Economica* 4,368-405.

Dahlman, C., (1980), *The Open Field System and Beyond*, Cambridge University Press, Cambridge.

Dixon, P. (1978), 'Economies of scale, commodity disaggregation and the cost of protection', *Australian Economic Papers* 17(31),.

Fisher, B.S. (1981), 'The impact of changing marketing margins on farm prices', *American Journal of Agricultural Economics* 63(2),261-3.

Harberger, A.C. (1954), 'Monopoly and resource allocation', *American Economic Review Proceedings* 44(2).

Mohring,H. and Boyd,J. (1971),'Analysing "externalities":"direct interaction" vs "asset utilisation" frameworks', *Economica* 38(5), 347-61.

Niskanen, W.A. (1968), 'The peculiar economics of bureaucracy', *American Economic Review Proceedings* 58(2),293-305.

Perry, M. (1983), 'Sustainable positive profit multiple-price strategies in contestable markets', *Journal of Economic Theory* 32, 246-265.

Quiggin, J. (1980), 'A note on economies of scale, commodity disaggregation and the cost of protection', *Australian Economic Papers* 19(35),375-9.

Quiggin, J. (1983), The common property approach, Unpublished M.Ec. thesis, A.N.U.

Quiggin, J. (1988a), 'Common property, private property and regulation : the case of dryland salinity', *Australian Journal of Agricultural Economics*, forthcoming.

Quiggin, J. (1988b), 'Scattering in common property systems', *Journal of Economic Behavior and Organisation* , forthcoming.

Quiggin, J. snd Fisher, B.S. (1987), An assessment of the effects of peak-load pricing at country receival points, unpublished paper, Department of Agricultural Economics, University of Sydney.

Ramsey, F. (1927), 'A contribution to the theory of taxation', *Economic Journal* 37(1),47-61.

Schmalensee, R. (1982), 'Commodity bundling by single product monopolies', *Journal of Law and Economics* 25(1),67-72.

Sharkey, W.W. (1982), *The Theory of Natural Monopoly*, Cambridge University Press, Cambridge.

Sieper, E. (1981), *Rationalising Rustic Regulation*, Centre for Independent Studies, Sydney.

Thomson, N. and Walsh, C. (1981), 'Cross-subsidisation of rural areas via utility pricing policies', *Australian Journal of Agricultural Economics* 25(3), 221-32.

Vincent, D., Powell , A.A., and Dixon , P. (1982), Changes in supply of agricultural products, in Williams, D.B. (ed), *Agriculture in the Australian Economy* (2nd ed), Sydney University Press, Sydney.