

# **Pricing of Interconnected Transport Services: A Case of Complementary Monopoly**

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## **ABSTRACT**

*This paper is concerned with pricing behaviour in, and the most efficient form of organization for, interconnected transportation markets. Such markets are a prominent example of a class of monopolistic markets - denoted complementary monopoly - in which several services or products are subject to a demand for their joint use and, in addition, an independent demand for their separate individual use. A basic question addressed in the paper is whether single or separate ownership of production is the most efficient form of industrial organization for such markets. It is demonstrated that the 'dead-weight' welfare loss due to monopoly is typically lower when the supply of all linked transport services is controlled by a single monopolist. In short, the merger of several individual complementary transport companies is socially desirable. In addition, where the firms are subject to overall break-even price regulation, such regulation will be more efficient if the services are supplied by a single firm as opposed to several individual firms. Finally, the feasibility of third degree price discrimination between the joint and independent markets, under single and separate ownership is examined. It transpires that with complementary products, individual market price elasticities below unity do not preclude solvent supply for individual markets due to the presence of the joint market.*

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## **INTRODUCTION**

A basic characteristic of most transport facilities is their 'lumpy' or indivisible nature. As a consequence the supply of many transport services (being non-storable) is subject

to irregular decreasing unit cost conditions. Thus, specific transport markets can involve substantial monopoly elements.<sup>1</sup> A second characteristic of most transport facilities is the fact that they are normally interconnected and form a transport network that can serve a large number of different point to point demands for transport services. Thus, separate transport facilities are often linked and thereby supply complementary services to serve a joint demand. Although these two basic characteristics of transport facilities have received considerable attention as separate topics, an examination of their interaction is lacking. Accordingly, it is the purpose of this paper to examine, by way of a rudimentary theoretical model, the organization of production and associated pricing behaviour of interconnected transport services.

While the present analysis was motivated by the case of interconnected transport facilities and the model that follows is couched in these terms, the analysis is either directly applicable, or can be extended to, other similar market situations in which products that are complements in consumption (or for that matter, production) are each produced by a firm with a significant degree of monopoly power.<sup>2,3</sup> This class of market

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1. Of course, the extent to, and manner with which monopolistic operation proceeds depends, inter alia, on the form, if any, of public intervention, which may vary from, for example, public ownership of the right of way to price regulation.
  2. For example, light fixtures and light bulbs, automobiles and tyres, chemicals and primary metals.
  3. A question that immediately arises concerns the viability of complementary monopoly. If their products are complementary would not the monopolists always have an overwhelming incentive (antitrust constraints aside) to merge? This question is examined specifically below. However, it is important to recognize at the outset that often the products of the monopolists have a dual character. In addition to a market for the joint product, formed by combining each monopolist's product, there also typically exists separate and independent markets for the product of each monopolist. Under these circumstances, the inevitability of a merger between the monopolists is less clear.

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situations, of which interconnected transport facilities is a prominent example, may be conveniently denoted as complementary monopoly.<sup>1</sup>

The analysis below is composed of three sections. We begin by specifying a concrete example of the general class of problems under study. For convenience the rudimentary example of two interconnected transportation services is employed. Next, the case of a joint market only is examined, that is, a situation in which the only relevant transport market is for through traffic, served by utilizing the services of each monopolist. The focus in this section is on the incentive for, and social desirability of, merger between the monopolists. In the following section, the market context is enlarged to accommodate the presence of independent transport markets for each monopolist's service. The main issue examined here is the nature of the third-degree price discrimination that emerges under separate, as compared with merged, monopoly. A summary and appraisal of the findings is provided in the concluding section.

### A MODEL OF TWO INTERCONNECTED TRANSPORT SERVICES

Consider the situation which is illustrated in Figure 1: A, B and C represent three major centres which are nodes of a linear passenger transport network consisting of two links AB and BC which join nodes A and C via an intermediate node B. Total demand for travel on the links AB and BC is composed of three components. Two components arise from the desire for travel on each link alone, that is, between A and B or B and C. Each of these travel demands is independent (at least in the short-run) of the price of travel on both links,

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1. A general analysis allowing for non-zero cross price elasticities between the (complementary) products is given in Gannon (1975).

that is, between A and C. This travel demand clearly depends upon the price of travel on each link. Furthermore, suppose that there are alternate means for travel between any of the three centers and that the characteristics of these alternate, substitute means (typically other modes) are embedded in the demand parameters for travel on the network.<sup>1</sup>

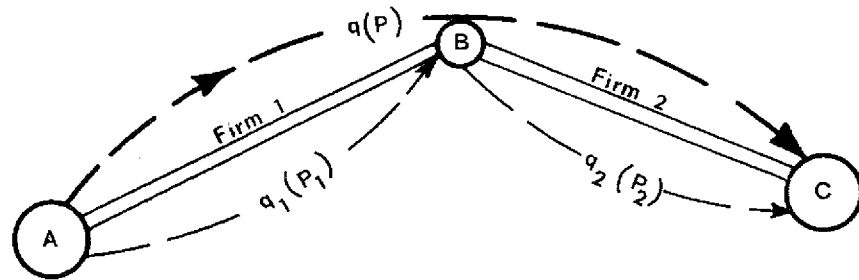


FIGURE 1

# RUDIMENTARY NETWORK WITH TWO INTERCONNECTED TRANSPORT SERVICES

Thus, typically, three separate markets are served when two transport facilities are interconnected: a market for transport services provided by the first facility, a market for transport services provided by the second facility and a market for transport services provided by the joint use of both facilities. Clearly, since riders in this last market consume the services of each facility in fixed proportion (one to one), we have a situation of joint consumption. Moreover, it is typical, especially when such circumstances prevail in a commuting context, for the group of riders who use both facilities to be separated, in an economic

1. For example, suppose that travel between A and B is by a commuter railroad and travel between B and C is by subway. Alternatively, bus or automobile is also available for either trip.

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sense, from the other two groups of riders who use only one facility. An effective device for separating these markets is the use of "transfers". Since transfers are invariably conditional upon the prior use of one transport facility, the purchase of a cheaper<sup>1</sup> ride on the connecting facility is 'tied' to the purchase of a ride on the first facility.<sup>2</sup> Moreover, since the group of commuters who use both facilities are treated differently (in terms of fare charged) from the group of commuters who use only one of the facilities, third-degree price discrimination<sup>3</sup> is practised by the transportation company or companies who offer transfers. Under these conditions, complementary monopoly fosters an application of tying arrangements and third-degree price discrimination. Although this form of market structure is quite overt, it is apparently neither widely nor explicitly recognized. A secondary purpose of this paper is to demonstrate and elaborate upon this rather important market condition.

1. In general, the combined (or through) fare associated with the use of transfers cannot exceed the sum of the fares for the use of each facility separately - unless, of course, there is some advantage from prior purchase, as might arise if queuing existed for the second facility and the tying arrangement conferred preferential service on riders of the first facility, or substantial transaction costs were associated with each ticket purchase. We ignore these possibilities.
2. In this case the tying arrangement typically provides the tied service at a price lower than the untied price, contrary to the usual form of tying contract. For a general discussion and analysis of tying arrangements, see Bowman (1960).
3. The concept of third-degree price discrimination has its origin in the work of Dupuit and Pigou. It simply refers to the common practice of setting a different price for the same product or service in two (economically separable) markets with dissimilar price elasticities. Unlike first degree (or perfect) and second degree price discrimination, the price in each market is constant and does not depend on the quantity purchased. For a classical analysis of price discrimination see Robinson (1969), Ch. 15. For a discussion of its application in the pricing of public utilities see Bonbright (1961), Ch. 19, and (more specifically to transport services) Turvey (1975).

Now suppose that the average daily (or peak-hour) demand for travel between A and B, B and C and A and C is  $q_1(p_1)$ ,  $q_2(p_2)$  and  $q(P)$  (person-round-trips per day) respectively, where  $p_1$ ,  $p_2$  and  $P$  are the corresponding fares (dollars per person-round-trip).<sup>1</sup> Moreover, if  $Q_1$  and  $Q_2$  denote the total demand for travel on links AB and BC respectively, then

$$Q_i(p_i, P) = q_i(p_i) + q(P) \quad (i=1,2) \quad (1)$$

and

$$P \leq \sum_{i=1}^2 p_i \quad (2)$$

Finally, the variable (operating and maintenance) production costs for transportation services on links AB and BC are given by  $C_i(Q_i) = C_i(q_i + q)$ , for  $i=1,2$ .

#### JOINT MARKET ONLY: PURE COMPLEMENTARY MONOPOLY

Suppose that a separate, independent and exclusive market for each monopolist's transport service does not exist; demand for travel exists only between A and C. In short,  $q_i(p_i) = 0$ , for  $i=1,2$ .

Assume initially that the transport services on links AB and BC are supplied by two monopolists denoted firm 1 and 2, respectively. Then the corresponding profit functions for these firms are given by:

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1. A minor complication that arises when dealing with transport services is the need to differentiate demand by direction of travel. For the sake of convenience (as well as to preserve the generality of the analysis for other product markets) it is assumed that travel on the network consists only of round trips originating at either A or B. In keeping with the commuter travel example suggested above, nodes C, B and A would correspond to the central business district, an inner transit terminal and a suburban rail station, respectively.

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$$\pi_i(p_i) = p_i q - C_i(q) \quad (i=1,2) \quad (3)$$

where  $p_i$  ( $i = 1,2$ ) are the prices charged by firms 1 and 2, respectively and

$$P = \sum_{i=1}^2 p_i \quad (4)$$

Consequently

$$\frac{\partial \pi_i}{\partial p_i} = q(P) + (p_i - \frac{\partial C_i}{\partial q}) \frac{dq}{dP} V_i \quad (5)$$

where

$$V_i \equiv \frac{dP}{dp_i} = 1 + \frac{\partial \hat{p}_k}{\partial p_i} \quad (i, k=1, 2 \text{ and } i \neq k) \quad (6)$$

represents the total marginal change in the joint market price  $P$ , which firm  $i$  associates with any marginal unit adjustment in its own price  $p_i$ , and  $\frac{\partial \hat{p}_k}{\partial p_i}$  is the underlying price conjectural

variation that firm  $i$  attributes to firm  $k$ .<sup>1</sup> From equation (5) the optimal<sup>2</sup> (profit-maximizing) for each firm, denoted  $p_i^*$  ( $i=1,2$ ), is given by

$$p_i^* = \frac{P}{V_i \epsilon(P)} + c_i(q) \quad (i=1,2) \quad (7)$$

where  $\epsilon(P)$  is the price elasticity of the joint market demand

1. The second-order condition is

$$\frac{\partial^2 \pi_i}{\partial p_i^2} = \{2 + (p_i - \frac{\partial C_i}{\partial q}) \frac{\partial V_i}{\partial p_i}\} \frac{dq}{dP} - V_i^2$$

$$\{(dq/dP)^2 \frac{\partial^2 C_i}{\partial q^2} + d^2 q/dP^2 \cdot (p_i - \frac{\partial C_i}{\partial q})\} < 0.$$

2. Dynamic adjustment considerations associated with the achievement of this equilibrium are beyond the scope of this present paper. However, note that the equilibrium is statically stable provided  $\epsilon V_i > 1$ , ( $i=1,2$ ).

and  $c_i(q)$ , ( $i=1,2$ ) is the marginal production cost of firm  $i$ .

Equations (7) represent a pair of simultaneous (in general, non-linear) equations in  $p_1^*$  and  $p_2^*$ . If we let  $p_1^e$  and  $p_2^e$  denote their simultaneous solution (assuming it exists and is unique) then these prices represent the equilibrium fare levels of the monopolists. In order to simplify the analysis, we assume that the marginal production cost of each firm is constant. It then follows that

$$p_1^e = \frac{(\epsilon - w_2) c_1 + w_1 c_2}{(\epsilon - w)} \quad (8)$$

$$p_2^e = \frac{w_2 c_1 + (\epsilon - w_1) c_2}{(\epsilon - w)} \quad (9)$$

where  $w_i \equiv V_i^{-1}$  and  $w \equiv \sum_{i=1}^2 w_i$ .

Hence the equilibrium level of the joint market price  $P^e$ , say, is given (implicitly) by

$$P^e = \sum_{i=1}^2 p_i^e = \frac{c}{1 - w/\epsilon} \quad (10)$$

where

$$c = \sum_{i=1}^2 c_i.$$

Thus, the (equilibrium) maximum profit level of each monopolist, denoted  $\pi_i^e$ , ( $i=1,2$ ) is given by

$$\pi_i^e = (p_i^e - c_i) q^e \quad (i=1,2) \quad (11)$$

where  $q^e = q(P^e)$ . Moreover, the aggregate maximum profits earned by the monopolists, denoted  $\pi^e$  are given by

$$\pi^e = \sum_{i=1}^2 \pi_i^e = (P^e - c) q^e \quad (12)$$

We may now investigate the extent to which the total profits yielded under separate ownership and independent operation of each facility fall short of total profits achievable by coordinated



operation or merged common ownership of the facilities. Consider the total (joint) profit function,  $\pi_M$ , which is given by

$$\pi(P_M) = \sum_{i=1}^2 \pi_i = (P_M - c)q \quad (13)$$

The optimal merged monopoly price,  $P_M^*$ , is given by

$$P_M^* = \frac{c}{1 - 1/\epsilon(P_M^*)} \quad (14)$$

thus the maximum joint profit level,  $\pi_M^*$ , is given by

$$\pi_M^* = (P_M^* - c)q_M^* \quad (15)$$

It is now quite easy to appraise the relative magnitude of  $\pi_M^*$  and  $\pi^e$ . The approach hinges on comparing the pure monopoly price ( $P_M^*$ ) and the combined price ( $P^e$ ) under (pure) complementary monopoly. Suppose we rewrite equations (10) and (14) as

$$c/P^e = 1 - w/\epsilon(P^e) \quad (10a)$$

and

$$c/P_M^* = 1 - 1/\epsilon(P_M^*) \quad (14a)$$

Since  $P^e$  and  $P_M^*$  are defined only implicitly by these equations, their relative magnitudes are most conveniently identified graphically. The graphs of  $c/P$ ,  $1 - 1/\epsilon(P)$  and  $1 - w/\epsilon(P)$  are illustrated in Figure 2. Assuming, quite plausibly, that price elasticity does not decrease with price<sup>1</sup>, that is,  $\epsilon'(P) > 0$ , the functions of the form  $1 - K/\epsilon(P)$ , for any non-negative number  $K$ , are non-decreasing functions of  $P$ .<sup>2</sup> It follows that

1. For an arbitrary demand function  $q=q(p)$  that is twice continuously differentiable,  $\epsilon'(p) = \epsilon(\epsilon+1)/p-pq''/q$  so  $\epsilon'(p) > 0$  if  $q(p)$  is concave or  $-pq''/q' > \epsilon+1$ . However, for every bounded demand function, price elasticity uniformly approaches zero as price approaches zero (i.e.  $\epsilon(p) \rightarrow 0$  as  $p \rightarrow \beta$ , where  $\beta$  is the finite upper bound for  $p$ ).
2. The broken horizontal lines in Figure 2 indicate the graphs of  $1-1/\epsilon$  and  $1-(w_1+w_2)/\epsilon$  for the (hypothetical) case of constant elasticity of demand.

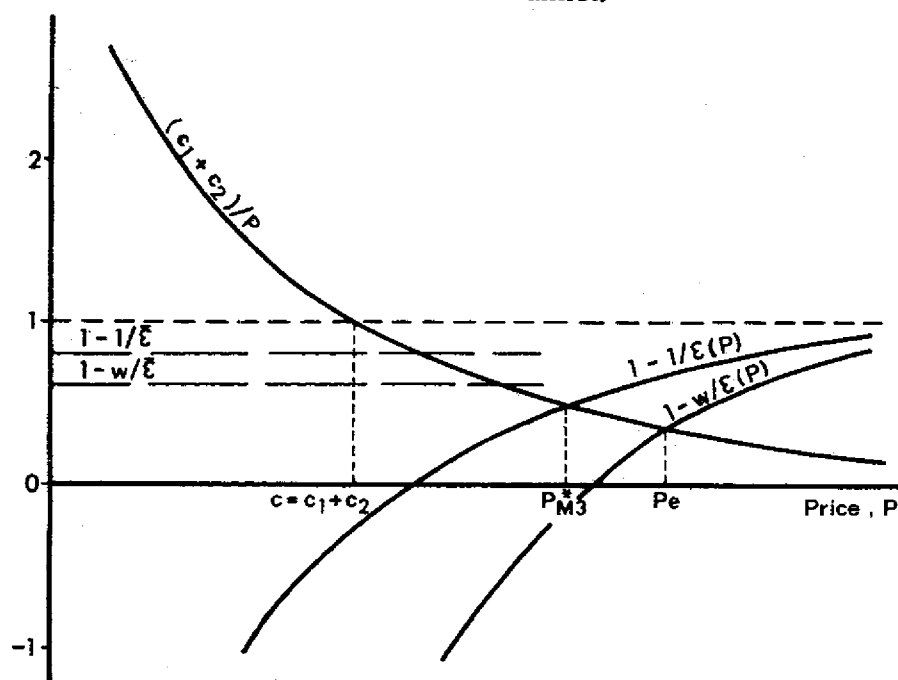


FIGURE 2

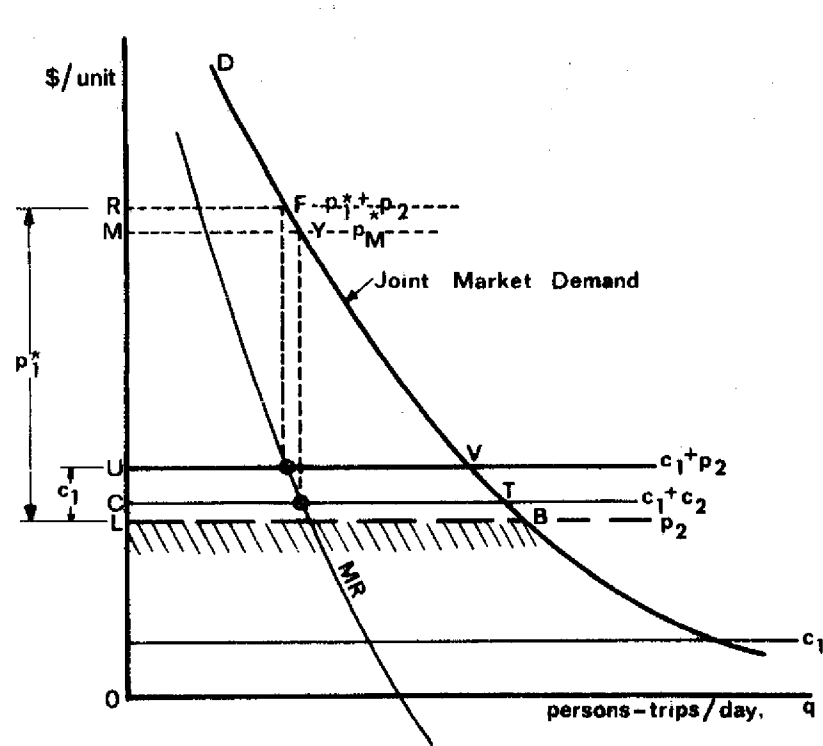
$$P_M^* \left\{ \begin{matrix} \leq \\ \geq \end{matrix} \right\} P^E \Leftrightarrow w \left\{ \begin{matrix} \geq \\ \leq \end{matrix} \right\} 1 \quad (16)$$

or substituting for  $w$  in terms of the underlying price conjectural variations of the firms

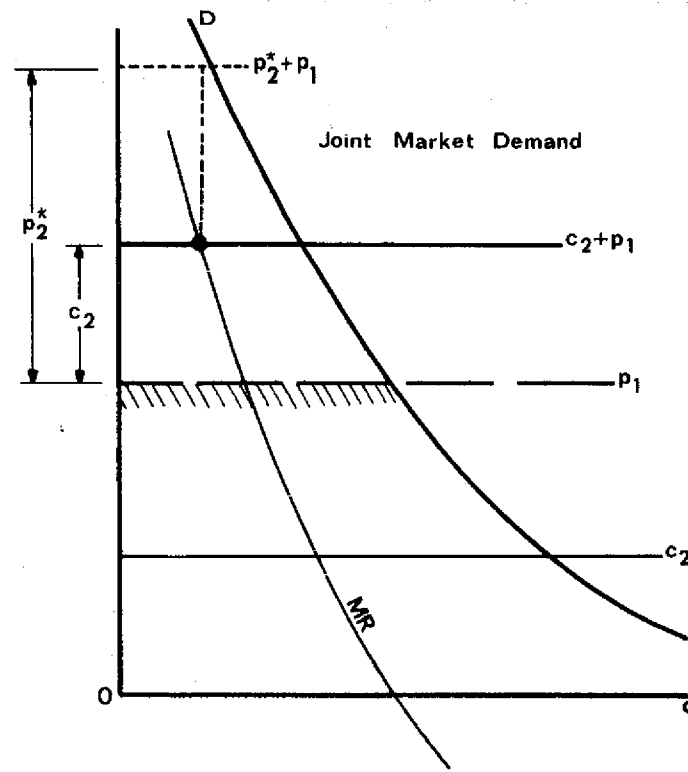
$$P_M^* \left\{ \begin{matrix} \leq \\ \geq \end{matrix} \right\} P^E \Leftrightarrow \left( \frac{\partial \hat{p}_1}{\partial p_2} \right) \cdot \left( \frac{\partial \hat{p}_2}{\partial p_1} \right) \left\{ \begin{matrix} \leq \\ \geq \end{matrix} \right\} 1 \quad (17)$$

Hence, the optimal single monopoly price will exceed (fall short of) the jointly determined bi-monopoly price whenever the composition (product) of the firms' price conjectural variations is below (above) unity. In other words, if each firm anticipates that the other will always react by "less than matching" any price adjustment (that is  $\frac{\partial \hat{p}_i}{\partial p_k} < 1$ ), ( $i \neq k$ ,  $k=1,2$ ), then a single monopoly will set a lower  $\frac{\partial p}{\partial p_k}$  price than a joint (or bi-) monopoly. Clearly, since the monopolists are operating in a region where demand is relative elastic ( $\epsilon > 1$ ), and marginal production costs are constant, it follows immediately that a decrease in (total) price increases (total) profit. Thus, strictly greater profits can indeed be obtained if the pricing

of the two firms' services is co-ordinated - either by collusion or by common management and ownership of the facilities. On reflection, this finding is not at all surprising. Under separate ownership, each firm estimates a curtailed demand schedule based upon a price level that reflects the other firm's price (which is above that firm's marginal cost) representing a lower bound on the total market price. This fosters an under-estimation of the (joint) optimum level. This aspect of the price setting behaviour of each firm is indicated in Figure 3, which is based upon the assumption of zero price conjectural variations. Thus, firm 1 estimates the curtailed joint market demand as DB, given firm 2 has set a price of  $p_2$ . Hence, for a constant marginal cost level of  $c_1$ , firm 1 sets marginal cost equal to its estimated marginal revenue at G with a price  $p_1^*$  for its own services, to yield a total joint market price of OR or  $p_2 + p_1^*$ . A similar argument applies for firm 2. Since each firm sets a price above its own marginal cost level, each firm, in effect, acts as if the total joint service marginal cost is higher than it actually is. For example, in Figure 3, firm 1 acts as if the total marginal cost is at a level of OU and not OC, thereby yielding a market price for the joint service of OR. A single monopolist would set total marginal cost to marginal revenue at H with a total price level of OM (or  $p_M^*$ ) which would in general be lower than OR. However, in addition, each firm computes its own marginal revenue schedule on the basis that the other firm adjusts its price. In equating its own marginal cost to a conditional marginal revenue schedule, each firm may over or under estimate the optimum output level. The smaller the expected price response the higher the expected marginal revenue schedule and hence the greater the tendency to set a higher price and underestimate the (joint) optimum output level. In short, each firm's profit-maximising calculus and pricing decisions are based on its own marginal costs, without regard to the other firm's marginal costs, but instead with attention to the other firm's price level and a conjectural price reaction. However, since the joint profits of the two firms depend upon their combined price relative to their combined



FIRM 1 - LINK 1



FIRM 2 - LINK 2

FIGURE 3  
PRICING BEHAVIOUR UNDER JOINT MARKET DEMAND  
(PURE COMPLEMENTARY MONOPOLY)

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marginal costs, a profit-gain incentive for a merger will typically exist between two separate complementary monopolists.

Furthermore, observe that if the pure monopoly price  $P_M^*$  is strictly less (greater) than the combined price  $P^e$  corresponding to separate operation, there is strictly more (less) "dead-weight" welfare loss associated with separate ownership and operation of the facilities than there is with joint or single ownership. In short, a gain (or loss) in welfare would result from a merger between two complementary monopolists.

These basic findings are illustrated in Figure 4 for the case where  $P_M^* < P^e$ . The areas WET and XYT represent the "dead-weight" welfare losses associated with separate and single (or joint) ownership, respectively. The output level  $q_S^*$  represents the Pareto optimum output. The shaded area WNEYX represents the reduction in welfare loss, or welfare gain, that can be effected by a merger of the two separate monopolists. The gain in joint profits obtained by such a merger is given by area WNYX - area MSEN.

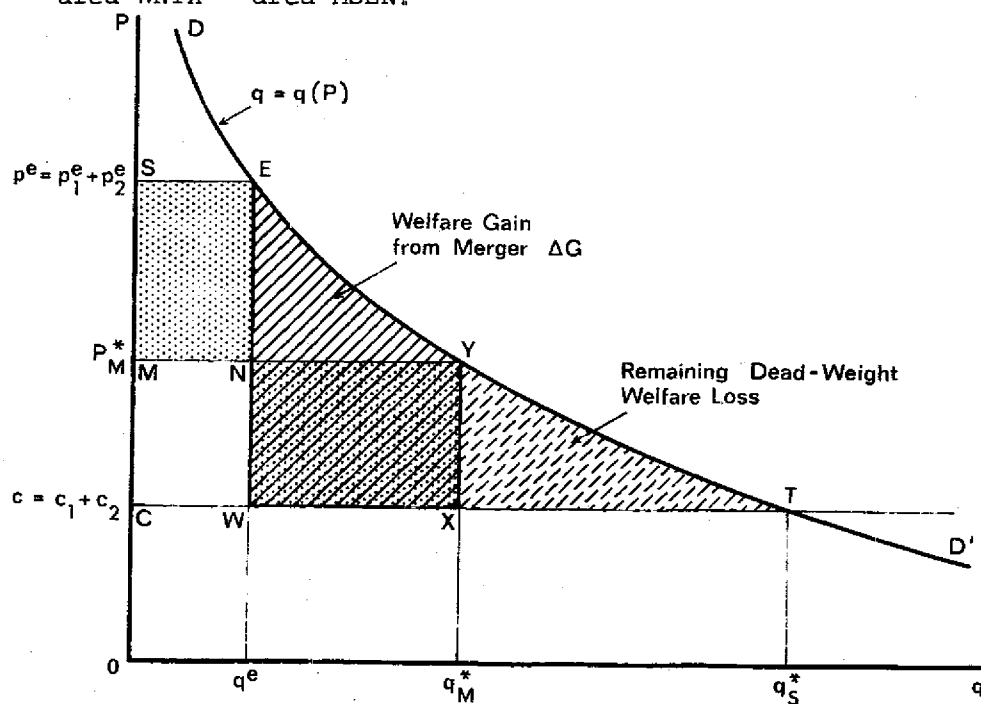


FIGURE 4

If the demand  $q(P)$  is approximated, at least over the relevant range, by a linear function  $q = \alpha(\beta - P)$ , then estimates of these welfare and profit gains can be made quite readily. For linear demand:

$$p^e = (w\beta + c)/(1+w) \text{ and}$$

$$\pi^e = \alpha w(\beta - c)^2/(1+w)^2$$

and

$$p_M^* = \frac{1}{2}(\beta + c)$$

$$\pi_M^* = \frac{1}{4}\alpha(\beta - c)^2$$

Thus, the profit gain from merger,  $\Delta\pi \equiv \pi_M^* - \pi^e$ , is  $\frac{1}{4}\alpha(\beta - c)^2 [(1-w)/(1+w)]^2$  and hence the incentive for merger will be the greater: (i) the lower the marginal production costs of providing each service, (ii) the larger the (joint) market (as indicated by the parameter  $\alpha$ ), (iii) the lower the price elasticity of demand ( $=P/\beta - P$ ) as indicated by the parameter  $\beta$ , and (iv) the lower the price conjectural variation (as indicated by the parameters  $w_1$  and  $w_2$ ).

The welfare gain from merger,  $\Delta G$ , is given by

$$\Delta G = \frac{1}{2}(q_M^* - q^e)(p_M^* + p^e - 2c)$$

or

$$\Delta G = \alpha(w - 1)(3w + 1)(\beta - c)^2/8(1 + w)^2 \quad (18)$$

It follows that  $\Delta\pi = (2(w - 1)/(3w + 1))\Delta G$ , hence (for  $w > 1$ ) the stronger the incentive for merger the greater the potential gain in welfare that can be achieved. Thus, in complementary monopoly the private objective of the monopolists to secure higher profits through merger and the social objective of reducing welfare losses are in harmony.

It must be emphasized immediately that the policy implications of this result need to be carefully drawn. In brief, although separate ownership in complementary monopoly is less socially desirable than single ownership (that is, pure

monopoly) both forms of market organization are socially undesirable.<sup>1</sup> From a social standpoint a welfare loss (area yTX in Figure 4) still remains under single ownership and appropriate efforts should be considered to reduce this loss further, and assuming implementation costs warrant, to eliminate it altogether. In fact, it is a simple matter to compute the fraction of total dead-weight welfare loss, L (as given by area WET in Figure 4), that is eliminated by a merger arrangement. Clearly,  $L = \frac{1}{2}(P^e - c)(q(c) - q^e) = \alpha w^2(\beta - c)^2/2(1 + w)^2$ . Hence, using equation (18)

$$\Delta G/L = \frac{1}{4}(w - 1)(3w + 1)/w^2 = 3/4 - 1/2w - 1/4w^2$$

Thus, independent of the level of marginal production costs or the values of the demand parameters, merger of the two (complementary) monopolists, will typically reduce the dead-weight monopoly loss by (as most) 7/16 or 44 percent (when  $w = 2$ ).

Finally, suppose that a complementary monopoly is brought under public price regulation and required to set rates that yield normal profits. In this case, what is the socially more desirable form of organization: single ownership (and/or control) or separate ownership?<sup>2</sup> Under separate ownership, each firm must set its price equal to its own average total costs. Thus,

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1. The point was made, in a different context, by Comanor (1967) in reply to Spengler's (1950) demonstration that vertical integration, that is, a single monopoly, would eliminate the cumulative distortions of two or more vertically linked and separately monopolized production stages.
  2. Coordinated control could be achieved without single ownership, for example, if the facilities were operated by two public authorities (bureaucratic problems aside).

$$p_1^o = c_1 + \frac{f_1}{q(p_1^o + p_2^o)} \quad (19)$$

$$\text{and } p_2^o = c_2 + \frac{f_2}{q(p_1^o + p_2^o)} \quad (20)$$

Where  $p_1^o$  and  $p_2^o$  are the regulated price levels and  $f_1$  and  $f_2$  are the (equivalent daily) fixed costs of firms 1 and 2, respectively. On the other hand, if the facilities are operated by a single regulated firm, the total price that will then be set,  $p_M^o$  is

$$p_M^o = (c_1 + c_2) + \frac{(f_1 + f_2)}{q(p_M^o)} \quad (21)$$

But observe that if  $p_1^{oe}$  and  $p_2^{oe}$  are the regulated rate levels that simultaneously satisfy equations (19) and (20), then their sum will also satisfy equation (21). That is  $p_1^{oe} + p_2^{oe} = p_M^{o.1}$ . Hence regulation of pure complementary monopoly yields the same price/output level whether there is single or separate ownership. In this case the social desirability or undesirability of merger must be determined on other grounds and, ceteris paribus, regulation not surprisingly need not be concerned with the pattern of ownership or control.

#### JOINT AND SEPARATE MARKETS: MIXED COMPLEMENTARY MONOPOLY

In this section it is assumed that each transportation facility is separately owned (and/or operated) and that there is, in addition to the demand for joint use of the facilities (that is, travel demand from A to C), an exclusive demand for the services of each facility (that is, travel demand from A to B and from B to C, independent of travel demand from A to C). Under these conditions, each firm has two independent

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1. Typically, two values of each price satisfy equations (19), (20) and (21). In each case only the lower value is relevant for regulation purposes.



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markets. If each firm is able to enforce separation of its own two markets<sup>1</sup> then it is possible to determine the conditions under which third degree price discrimination between these markets may be adopted and the form it will take.

With both an exclusive and a joint market present, firm  $i$ 's profit function becomes

$$\pi_i(r_i, p_i) = r_i q_i(r_i) + p_i q(P) - c_i(q_i + q) \quad (i=1,2) \quad (22)$$

where  $r_i$  is the price charged by firm  $i$  in its exclusive separate market. For constant marginal costs, the optimal (profit-maximizing) prices<sup>2</sup> in each sub-market,  $r_i^*$  and  $p_i^*$ , are such that

$$r_i^*(1 - 1/\epsilon_i) = p_i^e(1 - P/p_i^e \epsilon) = c_i \quad (23)$$

1. In the case of two interconnected transport facilities, separation is normally enforced by physical means. Transfers are usually not storable and can only be purchased either inside the ticket barriers of each transport company or simultaneously with the purchase of a regular fare on the first facility. Note that transfers from one facility to another require the sanction of the firm accepting the transfer and reimbursement to that firm or all or a negotiated amount of the fare on its facility. Hence by issuing transfers a firm is able, if it wishes, to "subsidize" one of its (sub-) markets, and thus price discriminate via the use of a tying arrangement between them. Since both firms may wish to adopt such a policy, the use of transfers is potentially in their mutual interest, however the combined price they each wish to set for such transfers may differ (see below). Either a compromise net subsidy level will be set or cash refunds (or some other more sophisticated financial-pricing arrangements) will be required.
2. In order to focus on the question of price discrimination and keep the analysis from getting too cumbersome, price conjectural variations are now set equal to zero, i.e. Cournot behaviour is assumed; each firm simply takes the other firm's price as fixed. Hence  $w = 2$  and  $P^e = c/(1-2/\epsilon)$ .

where the equilibrium values  $p_i^e$  ( $i=1,2$ ) are given by equations (8) and (9) above.<sup>1</sup> Note that for marginal revenue to be positive and monotonically decreasing in each sub-market (and hence to ensure that each firm will actually be in equilibrium in serving both its sub-markets) is is necessary (but not sufficient) that<sup>2</sup>

$$\epsilon > 2 \text{ but } \epsilon_1 > 1 \quad (i=1,2) \quad (24)$$

On the other hand, if  $\epsilon < 2$ , then the joint market will not be priced separately and each firm will charge a single price for its service to all customers. In this case, firm  $i$ 's profit function is

$$\pi_i(p_i) = (p_i - c_i) \{q_i(p_i) + q(P\{p_i\})\} \quad (i=1,2)$$

and its optimal price,  $p_i^*$ , is now given by

$$p_i^* (1 - E_i) = c_i \quad (i=1,2) \quad (25)$$

where  $E_i$ , ( $i=1,2$ ), are the price elasticities of the aggregate market for the services of firm  $i$ . In this case, a minor extension of the well known formula for the total elasticity arising from two different elasticity markets yields:

$$E_i = m_i \epsilon_i + \theta_i (1 - m_i) \epsilon \quad (i=1,2) \quad (26)$$

- 
1. In general,  $\epsilon_1$ ,  $\epsilon_2$  and  $\epsilon$  will be functions of  $r_1$ ,  $r_2$  and  $p_1$  and  $p_2$ , respectively. Throughout this section, unless otherwise stated, it is assumed that all market demands are of constant elasticity. (However see next footnote)
  2. If  $\epsilon > 2$  and  $\epsilon_i < 1$ , ( $i=1,2$ ), then theoretically both firms will set an arbitrarily high price and sell an infinitesimal quantity. This unrealistic outcome stems from the untenable assumption that price elasticity remains below unity even at extreme levels of price. Consequently, situations in which market demand is relatively inelastic over very wide ranges of price are dismissed.

where  $m_i = q_i / (q_i + q)$  are the (quantity) shares that each firm's exclusive market is of its total market and  $\theta_i = p_i / P$  is the share of joint market price ( $P$ ) received by firm  $i$ . Observe that a submarket may be served, even though (in the relevant range) its individual price elasticity is below unity, provided that the price elasticity of the firm's other submarket is sufficiently above unity. Thus, notably if  $2 > \epsilon > 1 > \epsilon_i$ , it is possible that a complementary monopolist would not (separately) serve the relatively elastic joint market, but lump his relative inelastic, exclusive market with the joint market and serve the aggregate.

Now assuming each firm serves both its submarkets, the (equilibrium) price differential,  $s_i^e$  say, between firm  $i$ 's two submarkets is

$$s_i^e = r_i^* - p_i^e = \frac{c_i}{(1 - 1/\epsilon_i)} - \frac{(\epsilon - 1)c_i + c_k}{(\epsilon - 2)} \quad (i, k=1, 2; i \neq k)$$

or

$$s_i^e = \frac{(\epsilon - \epsilon_i - 1)c_i - (\epsilon_i - 1)c_k}{(\epsilon_i - 1)(\epsilon - 2)} \quad (i, k=1, 2; i \neq k) \quad (27)$$

But price discrimination by each firm is only possible if these differentials are positive and

$$s_i^e \geq 0 \Leftrightarrow \epsilon \geq 1 + \epsilon_i + (\epsilon_i - 1)c_k/c_i > 2 \quad (i, k=1, 2; i \neq k) \quad (28)$$

That is, the price elasticity of the firms' joint market must be "sufficiently high" relative to the price elasticity of each firm's exclusive market. Moreover, the minimum level of price elasticity in this joint market that will enable each firm to implement price discrimination is inversely proportional to the firm's marginal costs but directly proportional to the other firm's marginal costs. A consequence of this influence of relative marginal costs is that the greater the divergence between the firms' marginal costs (and hence between  $c_k/c_i$ ), the lower the

likelihood for feasibility of price discrimination by the firm with the lower marginal costs.<sup>1</sup>

The existence conditions for  $s_i^e$ , ( $i=1,2$ ), are illustrated in Figure 5. For example, if  $c_2/c_1 = 2.0$  and  $\epsilon_1 = 1.5$ , then only if  $\epsilon > 3.5$  will  $s_1^e > 0$  and hence  $p_1^e < r_1^*$ . However, for the same ratio of  $c_2/c_1 = 2.0$  and  $\epsilon_2 = 1.5$ ,  $s_2^e > 0$  provided  $\epsilon > 3$ . Thus, if the price elasticity of the joint market,  $\epsilon$ , is 2.75 then  $s_1^e = 0$  but  $s_2^e > 0$ . The combinations of  $\epsilon_1$  (or  $\epsilon_2$ ) and  $\epsilon$  that allow only one of the firms to practice price discrimination are indicated for  $c_2/c_1$  (or  $c_1/c_2$ ) = 2.0, by the dotted area in Figure 5.

There is no reason, a priori, why the joint market (that is, travel demand of the group of consumers who use both services) should be more (or less) price elastic than the demand by consumers who use only one of the services.<sup>2</sup> Hence, quite logically, the question of the existence of third degree price discrimination in this context, and whether it will be unilateral (that is, utilized by only one of the firms) or bilateral

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1. Note that if  $c_i = c_k$ ,  $s_i^e > 0 \leftrightarrow \epsilon \geq 2\epsilon_i$  ( $i,k=1,2; i \neq k$ ).
  2. However, it may be possible to make accurate judgements about these relative price elasticities for a specific transportation system. For example, if the service offered by firm 2 is a downtown subway and the service offered by firm 1 is a high-speed commuter railroad from suburban areas, then typically the average income of riders on the subway is considerably less than that of riders on the commuter railroad, and because of the limited substitution possibilities of the subway riders it is most likely that  $\epsilon_1, \epsilon > \epsilon_2$ . Also typically,  $c_1 < c_2$ . In this case there is a higher probability that the subway operator will offer a reduced fare ( $s_2^e > 0$ ) to the suburban (higher income) commuters than the railroad! However the relative magnitudes of  $\epsilon_1$  and  $\epsilon$ , and hence the existence of price discrimination by the commuter railroad requires more detailed additional information regarding characteristics of the ridership of the railroad.

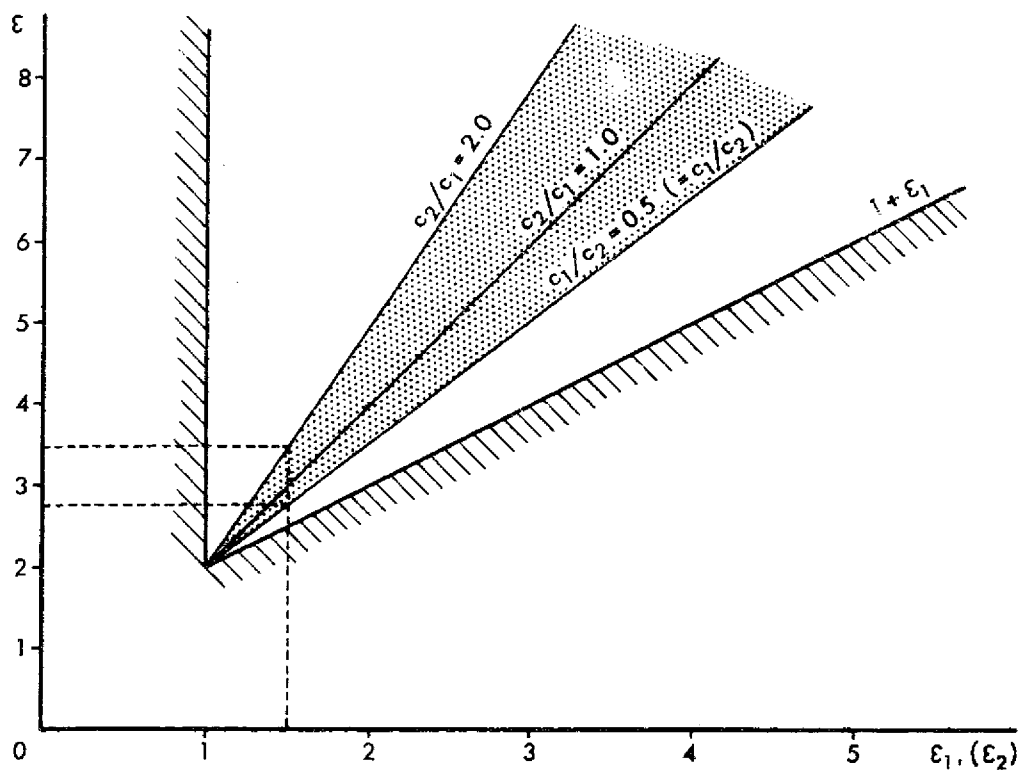


FIGURE 5  
FEASIBLE REGIONS FOR  
EXISTENCE OF SUBMARKET PRICE DISCRIMINATION

Case	Relative elasticities	Relative marginal costs	$c_1 > c_2$	$c_1 = c_2$	$c_1 < c_2$
I	$\epsilon_1, \epsilon_2 > \frac{1}{2} > 1$		$s_1^e = s_2^e = 0$	$s_1^e = s_2^e = 0$	$s_2^e = s_1^e = 0$
II	$\epsilon_1 > \frac{1}{2}\epsilon > \epsilon_2 > 1$		$s_1^e \geq s_2^e$	$s_2^e > s_1^e = 0$	
III	$\frac{1}{2}\epsilon > \epsilon_1 > \epsilon_2 > 1$		$s_1^e \leq s_2^e$	$s_1^e < s_2^e$	$s_1^e < s_2^e$
IV	$\frac{1}{2}\epsilon > \epsilon_2 = \epsilon_1 > 1$		$s_1^e > s_2^e$	$s_1^e = s_2^e$	$s_1^e < s_2^e$
V	$\frac{1}{2}\epsilon > \epsilon_2 > \epsilon_1 > 1$		$s_1^e > s_2^e$	$s_1^e > s_2^e$	$s_1^e \geq s_2^e$
VI	$\epsilon_2 > \frac{1}{2}\epsilon > \epsilon_1 > 1$		$s_1^e > s_2^e = 0$		$s_1^e \leq s_2^e$
VII	$\epsilon_2 > \epsilon_1 > \frac{1}{2}\epsilon$		$s_1^e = s_2^e = 0$		

TABLE 1  
RELATIVE MAGNITUDE OF  
DEGREE OF SUBMARKET PRICE DISCRIMINATION

(that is, by both firms), is an empirical one.<sup>1</sup>

Consider next the magnitude of the price differential that a firm would introduce. From equation (27)

$$\frac{\partial s_i^e}{\partial c_i} > 0, \quad \frac{\partial s_i^e}{\partial c_k} < 0, \quad \frac{\partial s_i^e}{\partial \epsilon_i} < 0 \quad \text{and} \quad \frac{\partial s_i^e}{\partial \epsilon} > 0 \quad (i, k=1, 2; i \neq k)$$

Hence the price differential offered by each firm will be greater (i) the higher its own marginal costs, but the lower the other firm's marginal costs, and (ii) the lower the price elasticity of its own exclusive market, but the higher the price elasticity of the joint market. Moreover, since

$$\frac{p_i^e}{r_i^*} = \frac{1 - 1/\epsilon_i}{1 - 2/\epsilon} \left\{ (1 - 1/\epsilon) + (1/\epsilon)(c_k/c_i) \right\} \quad (i, k=1, 2; i \neq k) \quad (29)$$

it follows that similar results hold for the price differential as a proportion of the firm's optimal exclusive market price (that is,  $s_i^e/p_i^*$ ).

In terms of the relationships between the optimal price in each sub-market and sub-market price elasticities, these results are analogous to those that obtain for a single discriminating monopolist. However, the influence of marginal cost on the ratio of optimal sub-market prices is novel in the context of third degree price discrimination.

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1. Note that an implication of both the unilateral and bilateral forms of price discrimination (but especially the former) is their need for appropriate market separation and pricing arrangements. The problems this presents for a unilateral price discriminating firm may be less troublesome with storable products since, unlike transport services, they may, if necessary, be combined by the firm itself.

Now consider the relative magnitude of the price differentials offered by the firms. Applying equation (29).

$$\frac{s_i^e/p_i^*}{s_k^e/p_k^*} = \frac{(1/\varepsilon_i - 1/\varepsilon)}{(1/\varepsilon_k - 1/\varepsilon)} \cdot \left( \frac{1 + 1/\varepsilon(c_k/c_i - 1)}{1 + 1/\varepsilon(c_i/c_k - 1)} \right) \quad (i, k=1, 2; i \neq k)$$

Hence the relatively larger price differential, as a proportion of its exclusive market price, is offered by the firm with the relatively smaller exclusive market price elasticity, if the firms experience equal marginal costs and/or the firm with the relatively lower marginal costs, if the firms experience equal exclusive market price elasticities (and vice versa). Otherwise, the relative size of the (percent) price differentials depends strictly on the values involved. Moreover, the relative size of the price differentials themselves is less evident. From equations (30) and (31)

$$s_1^e - s_2^e = \frac{(\varepsilon_2 - 1)(\varepsilon - 2\varepsilon_1)c_1 - (\varepsilon_1 - 1)(\varepsilon - 2\varepsilon_2)c_2}{(\varepsilon_1 - 1)(\varepsilon_2 - 1)(\varepsilon - 2)}$$

Hence

$$s_1^e \begin{cases} > \\ < \end{cases} s_2^e \text{ iff } (\varepsilon_2 - 1)(\frac{1}{2}\varepsilon - \varepsilon_1)c_1 \begin{cases} > \\ < \end{cases} (\varepsilon_1 - 1)(\frac{1}{2}\varepsilon - \varepsilon_2)c_2 \quad (30)$$

In order to specify the nature of inequality (30) consider the following possibilities:

- Case I :  $\frac{1}{2}\varepsilon > \varepsilon_1 = \varepsilon_2 > 1$  and  $c_1 \neq c_2 \rightarrow s_1^e > s_2^e$  iff  $c_1 > c_2$   
 II :  $\frac{1}{2}\varepsilon > \varepsilon_1, \varepsilon_2 > 1$  and  $c_1 = c_2 \rightarrow s_1^e > s_2^e$  iff  $\varepsilon_1 < \varepsilon_2$   
 III :  $\frac{1}{2}\varepsilon > \varepsilon_2 > \varepsilon_1 > 1$  and  $c_1 > c_2 \rightarrow s_1^e > s_2^e$   
 IV :  $\frac{1}{2}\varepsilon > \varepsilon_1 > \varepsilon_2 > 1$  and  $c_1 < c_2 \rightarrow s_1^e < s_2^e$   
 V :  $\varepsilon_1 > \frac{1}{2}\varepsilon > \varepsilon_2 > 1$  and  $c_1 \leq c_2 \rightarrow s_2^e < s_1^e = 0$   
 V :  $\varepsilon_2 > \frac{1}{2}\varepsilon > \varepsilon_1 > 1$  and  $c_1 \geq c_2 \rightarrow s_1^e > s_2^e = 0$   
 VI :  $\varepsilon_1, \varepsilon_2 > \frac{1}{2}\varepsilon$  and (a)  $c_1 > c_2 \rightarrow s_2^e = 0$   
 (b)  $c_1 = c_2 \rightarrow s_1^e = s_2^e = 0$

$$\text{or (c) } c_1 < c_2 \rightarrow s_1^e = 0$$

$$\text{VII : } \varepsilon_1, \varepsilon_2 < 1 \text{ and/or } \varepsilon < 2 \rightarrow \text{price discrimination irrelevant.}^1$$

These seven specific cases, together with the remaining possibilities, are summarised in Table 1 above. Observe that in general the relatively higher (equilibrium) price differential is associated with the firm that experiences relatively higher marginal production costs but relatively lower price elasticity of demand for its own exclusive market.<sup>2</sup>

Finally, it is possible to contrast the above form of price discrimination with the "perfect" third-degree price discrimination that can be employed by a single monopolist. The optimal prices in each market,  $p_{M1}^*$ ,  $p_{M2}^*$  and  $p_M^*$ , for a single monopolist are

$$p_{Mi}^* (1 - 1/\varepsilon_i) = c_i \quad (i=1,2)$$

$$p_M^* (1 - 1/\varepsilon) = c$$

and hence

$$p_M^* = \sum_{i=1}^2 \left( \frac{1 - 1/\varepsilon_i}{1 - 1/\varepsilon} \right) p_{Mi}^*$$

provided  $p_M^* < \sum_{i=1}^2 p_{Mi}^*$ ; otherwise  $p_M^* = \sum_{i=1}^2 p_{Mi}^*$ . Hence the price differential  $s_M^*$  under single monopoly is

$$s_M^* = \sum_{i=1}^2 p_{Mi}^* - p_M^*$$

1. Cases VI and VII pertain to the (price discrimination and supply) existence conditions (25) and (28) established above.
2. Note that the price differentials will be equal only under three special conditions: (i)  $c_1 = c_2$  and  $\frac{1}{2}\varepsilon > \varepsilon_2 = \varepsilon_1$ , or (ii)  $c_2, \frac{1}{2}\varepsilon > \varepsilon_2, \varepsilon > 1$  and  $(\frac{1}{2}\varepsilon - 1)\varepsilon_1 c_1 / (\varepsilon_1 - 1) = (\frac{1}{2}\varepsilon - 1)\varepsilon_2 c_2 / (\varepsilon_2 - 1)$ , or (iii)  $c_1 < c_2, \frac{1}{2}\varepsilon > \varepsilon_1 > \varepsilon_2 > 1$  and  $(\frac{1}{2}\varepsilon - \varepsilon_1) c_1 / (\varepsilon_1 - 1) = (\frac{1}{2}\varepsilon - \varepsilon_2) c_2 / (\varepsilon_2 - 1)$ .



$$= c_1(1 - 1/\varepsilon_1) + c_2(1 - 1/\varepsilon_2) - (c_1 + c_2)/(1 - 1/\varepsilon)$$

or

$$s_M^* = \frac{(\varepsilon - \varepsilon_1)(\varepsilon_2 - 1)c_1 + (\varepsilon - \varepsilon_2)(\varepsilon_1 - 1)c_2}{(\varepsilon_1 - 1)(\varepsilon_2 - 1)(\varepsilon - 1)} \quad (31)$$

It follows that a single monopolist will only be able to engage in price discrimination if  $s_M^* > 0$ , that is, if

$$\varepsilon > (1/(1+A) \varepsilon_1 + A/(1+A) \varepsilon_2) = \underline{\varepsilon}, \text{ say} \quad (32)$$

where

$$A = \left( \frac{\varepsilon_1 - 1}{\varepsilon_2 - 1} \right) \cdot \frac{c_2}{c_1}$$

Since  $\min(\varepsilon_1, \varepsilon_2) < \underline{\varepsilon} < \max(\varepsilon_1, \varepsilon_2)$ , a sufficient condition for viable price discrimination is  $\varepsilon > \varepsilon_1, \varepsilon_2$ , while a sufficient condition to render price discrimination infeasible is  $\varepsilon_1, \varepsilon_2 > \varepsilon$ . Hence, to ensure a lower (total) price in the joint market it is not essential that the joint market have a price elasticity higher than both exclusive markets (as normally required in discriminatory pure monopoly). In the present context as long as the joint market elasticity exceeds the price elasticity in one of the exclusive markets, a lower joint market price, and hence complementary monopoly price discrimination, is possible.

Again, note that if price discrimination between the markets is not possible, then the (single) monopolist will base his prices  $P_{Mi}$  ( $i=1,2$ ) on total demands  $Q_i$  ( $i=1,2$ ) in his two markets such that

$$P_{Mi} (1 - 1/E_i) = c_i \quad (i=1,2)$$

where  $E_1 = (q_1/q_1 + q)\varepsilon_1 + (q/q_1 + q)\varepsilon$  and  $E_2 = (q_2/q_2 + q)\varepsilon_2 + (q/q_2 + q)\varepsilon$ , provided that  $\varepsilon_1, \varepsilon_2 > 1$  and  $\varepsilon_1, \varepsilon_2 > \varepsilon > (q/q_1 + q)\varepsilon_1 (q/q_2 + q)\varepsilon_2$ .

Assuming a single monopolist does discriminate, how does his price differential  $s_M^*$ , compare with the combined price differential  $s_1^e + s_2^e = s^e$ , for two monopolists? It was established earlier that a single monopolist will charge a lower price in the joint market than two separate monopolists whenever less than price-matching reactions are expected. In this case, since the single monopolist will set the same optimal price in each exclusive market as the single monopolists, it follows that the single monopolist will offer a larger price differential than will the two separate monopolists.<sup>1</sup> Naturally, with a single monopoly operation, total profits are again higher and welfare losses again lower than under the separate monopoly arrangement. Furthermore, since a positive price differential reduces the gap between price and marginal cost in the joint market, the adoption of price discrimination as is generally the case reduces the dead-weight welfare loss induced by either the separate or the single monopoly form of market organization.

An interesting consequence of introducing separate markets and price discrimination into the comparison of single versus separate monopoly operation relates to the question of public policy. On the one hand, the standard prescription for (Pareto) efficiency requires that the price to each consumer should reflect the marginal (social) cost of providing service to that consumer. Thus, in terms of the present example, the practice of charging different groups of commuters different fares for exactly the same service is inefficient. On the other hand, where average total costs are falling, marginal cost pricing will not yield sufficient total revenues to cover

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1. The magnitude of the gap between the price differentials, namely  $s_M^* - s^e$ , may be shown, from equations (27) and (31), to be  $c/(\epsilon - 1)(\epsilon - 2)$ . Clearly, this gap increases with  $c_1$  and  $c_2$  and decreases with  $\epsilon$  (since  $\epsilon > 1$ ).

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total costs. Under these circumstances either a government subsidy can be provided<sup>1</sup> or public regulation can keep prices at average total cost. It was demonstrated above that if the firms serve only their joint market then the same optimal combined price level can be achieved by public regulation whether there is single or separate ownership. Clearly, this is not the case if separate markets are present and price discrimination is possible. Since the separate monopolist can charge a lower (combined) price and earn greater profits in the joint market than the separate monopolists, there must exist some vector of prices that yields zero excess profits to the single monopolist and is strictly less than any corresponding vector of prices that yields zero excess profits to (at least one) separate monopolists. Thus, single ownership is more desirable than separate ownership for public regulation purposes, when there exists exclusive markets in addition to the joint market and price discrimination between the joint and exclusive markets is viable.

### SUMMARY AND CONCLUSIONS

Interconnected transport services are a prominent example of an intriguing class of market structure - denoted complementary monopoly - that has not been previously examined.<sup>2</sup> Unlike pure monopoly, monopolists who sell complementary products are not isolated from each other, yet unlike oligopolists who sell substitute products their interests are in (partial) harmony. Pure complementary monopoly prevails

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1. The source of the subsidy should be determined in the light of the objectives of public policy. For example, under a benefit related taxation scheme, a property tax might be levied on land in the proximity of the transit facilities. For a discussion of the financial aspects of urban transit see, among others Vickrey (1963).
  2. A more general analysis is given in Gannon (1975).

when the monopolists serve only their joint market. Such joint markets are associated with goods and services that are always complements to each other, which for the present case of interconnected transport services involved "through traffic" only, separate ownership and independent control in pure complementary monopoly is less efficient than common or single ownership whenever the firms expect less than "matching" price change reactions from each other. Thus, *ceteris paribus*, merger between two separate complementary monopolists should be given consideration. However, if public intervention is extended to break-even price regulation then single ownership has no (welfare) advantage over (or indeed economic distinction from) separate ownership.

The presence of an exclusive market for each monopolist's product, in addition to their joint market - a pervasive form of market organization in transport systems - modifies the structure of pure complementary monopoly in several important ways. Fundamentally, each monopolist may be able to introduce third-degree price discrimination between his exclusive market and his participation in the joint market. The properties of such price discrimination differ substantially from price discrimination in pure monopoly. Most notably, the feasibility and extent of third degree price discrimination in complementary monopoly depends not simply on the relative price elasticities of each monopolist's sub-market but also on the relative marginal costs of the monopolists. Where a substantial divergence exists between the monopolists' marginal (short-run) costs (as is often the case in transportation systems where a new capital intensive facility interconnects with an older labor intensive facility), there is a high probability that price discrimination will only be sought by the monopolist who experiences the higher marginal costs. This raises the whole question and strategy (not addressed here) of policies designed to change relative marginal costs (such as technological improvements) and policies directed toward influencing sub-market price elasticities (such as those aimed at service

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quality, comfort, ease of transfer and automobile parking).

Quite plausibly, there is also a higher profit incentive and a welfare gain justification for merger and single ownership even when exclusive markets exist. However, although single versus separate ownership is not a regulatory consideration in pure complementary monopoly, this is not so when exclusive markets are present. If average cost pricing is imposed on (mixed) complementary monopoly by public regulation, then the single ownership form of market organization allows a socially more desirable set of prices to be established than would be feasible with separate ownership.

Finally, while it is true that complementary monopolists are not in direct conflict, neither are they typically in perfect harmony. Whether or not exclusive markets are available to the monopolists, each monopolist bases his pricing policy for the joint market on his own marginal costs and his expectations of what price level and price reaction his companion monopolist will adopt. With regard to the price level set by his companion, each monopolist uses these prices to estimate a "nett" (to him) demand schedule for the joint market. In as much as these prices always exceed the marginal cost of the monopolist with whom each is associated, the full marginal cost of serving the joint market is overestimated by both monopolists. This fosters the supply of a lower level of service (or quantity of product) relative to that level of service that will yield maximum (joint) profits. This myopic self interest is successfully eliminated by common or single ownership. With regard to the problem of having to assign a rate of price response to his companion monopolist's service, each monopolist has a wide range of choice. Since the monopolists sell complementary products, it is plausible for each to assume

that the other will not "over" react to any price change he makes himself.<sup>1</sup> However, since the monopolists typically seek a different combined price for their joint market, it is possible that they might employ more sophisticated pricing strategies in their joint market. If either firm (or both) tries to "outguess" the other firm's reactions to its pricing policies then the price equilibrium outcome is not at all obvious. The situation is, in structure, essentially a two-person, non-zero sum game, the equilibrium outcome of which (assuming one exists) depends on the bargaining abilities of the two firms, among many other factors. Should price instability arise, it is highly likely that a tacit or overt agreement will eventually be reached by the monopolists and either a negotiated combined price level

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1. An interesting consequence of this for Cournot behaviour is that if the complementary monopoly market extended to include a total of  $n$  firms, then the equilibrium combined price for their joint market becomes  $n \sum_{i=1}^n c_i / (1 - n/\epsilon)$  where  $c_i$  is the marginal cost of the  $i$ th firm and  $\epsilon$  is the price elasticity of their joint market. Note that firms will regard this price level as viable only if  $\epsilon > n$ . This is hardly an assumption that would be maintained indefinitely in the light of the fact that the joint market is viable to a single monopolist if  $\epsilon > 1$  (fixed costs aside) and moreover it assumes constant price elasticities. Thus separate ownership and complementary monopoly is only likely to persist when the number of complementary monopolists is small and/or there are substantial diseconomies of single ownership.

Of course, it was assumed that the cost of providing the services is the same under separate or common ownership. Thus, for example, there are no economies of reorganization. The analysis could quite easily be extended to incorporate such cost changes. In this regard the discussions of Koo (1970) and Shepherd (1972) suggest the kinds of modifications that warrant consideration. Notwithstanding, the problem of allocative vs. X-Efficiency, would be subsumed, not resolved.

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established or full co-ordination introduced by common administration of the joint market (or full horizontal integration by merger). Indeed, the desire to maintain price stability and achieve greater profits are strong pressures for merger. However, they are clearly not the only forces shaping market organization here, as both joint and separate forms of complementary monopoly are observed in practice.

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