THE TRANSPORTATION CENTER

PROFITS, PRICE DISCRIMINATION, AND ENTRY: THE MOTOR CARRIER INDUSTRY IN DIFFERING REGULATORY ENVIRONMENTS*

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The purpose of this paper is to present an analysis of freight transport under various regulatory frameworks. Our particular emphasis is on trucking, although much of the formal analysis is in an explicitly multi-modal framework. The focus of our investigation is on the phenomena of profits, price discrimination (including cross-subsidization) and entry.

In the first section of the paper we consider the nature of optimal regulation in transportation. Our model is based on work by Ronald Braeutigam [4], who extended earlier arguments due to Boiteux [3] and Baumol and Bradford [2] to a framework applicable to transportation. The second section briefly considers the relationships between such optimal regulation and the current pattern under the Interstate Commerce Commission, then turns to consideration of the likely effects on profits, pricing patterns, and entry of continued ICC regulation and of deregulation of motor freight transport.

I. OPTIMAL REGULATION

In this section we present and analyze a formal model of regulation in the spirit of the traditional theory of regulation. We posit that the regulatory agency seeks to regulate the industry in the public interest in the sense of maximizing profits plus consumer surplus. The agency is an omniscient planner, with full knowledge of demand and cost conditions, and has the power to fix quantities or control entry and exit as well as to set prices. However, we assume that it is not able (or chooses not) to use multipart tariffs, and in parts of the analysis we will assume that certain subsectors are beyond the scope of regulation.

This analysis, even if treated as normative rather than positive economics, is clearly unrealistic. A less naive analysis, which would recognize the presence of uncertainty, the lack of complete control of even the regulated parts of the industry (and thus the possibility of regulation-induced behavior), and the costs of regulation itself, is highly desirable. Still, we believe that the present model does offer some insights into questions of regulation of the transportation industry and public policy towards it.

Our work is based on a recent important contribution by Braeutigam [4] in which he extended the Boiteux-Baumol-Bradford analyses of socially optimal management of a multi-product firm or industry with increasing returns to scale to treat the situation of demands that are interdependent across industries. Since Braeutigam's work is both basic to our analysis and very recent, we will sketch some of his results here.

Braeutigam's model follows the tradition of welfare economics in taking the viewpoint of a regulator interested in maximizing social welfare as measured by consumer surplus plus profits. He considers a situation in which there

are n goods being shipped by m modes. Service differentials are assumed between modes and play a crucial role in the analysis, since they permit one to assume that the demand price in mode i for shipment of commodity j is given by the indirect demand function $p^{ij} = p^{ij}(x_{1j}, \ldots, x_{mj})$, where x_{hj} is the amount of j being shipped on mode h. Note that the demand for transport of one good is assumed not to depend on the prices and quantities of other goods being shipped. We will further assume that no income effects exist and that the integrability condition

$$\frac{\partial p^{ij}}{\partial x_{hj}} = \frac{\partial p^{hj}}{\partial x_{ij}}$$

holds for all h, i, and j.

Mode 1 is distinguished by having a cost function $C(x_1) = C(x_{11}, \ldots, x_{1n})$ displaying decreasing average costs. The desired interpretation is that mode 1 is the railroads. The other modes are marked by constant average costs, with total costs of the form $\sum_j s^{ij}x_{ij}$. Here the examples would be trucking and perhaps barges.

The objective is to maximize net surplus, i.e., consumer plus producer surplus. Assuming no income effects, this can be written as

$$G = \sum_j \int_0^{x_{1j}} p^{1j}(w, o, \ldots, o)dw + \sum_j \int_0^{x_{2j}} p^{2j}(x_{1j}, w, o, \ldots, o)dw +$$
$$\ldots + \sum_j \int_0^{x_{mj}} p^{mj}(x_{1j}, x_{2j}, \ldots, x_{(m-1)j}, w)dw$$
$$- C(x_{11}, \ldots, x_{1n}) - \sum_{i\neq 1} \sum_j s^{ij}x_{ij} .$$

It is a classical result that maximization of G leads to prices equal to marginal costs for each mode and each good actually shipped on that mode.

However, this rule would lead to the railroads' suffering deficits, since by assumption, marginal cost is less than average cost in this declining cost industry. This deficit is real, and whether public or private ownership prevails, it would have to be covered in some fashion. The ideal way is by idealized lump sum taxes, which, being independent of any economic choices, would not distort optimality. Such taxes do not appear to exist outside of economics textbooks however, and use of revenues raised via other distortionary taxes is undesirable on efficiency grounds. One might also question such taxes on equity grounds as well, since they would involve the general public subsidizing the purchasers of rail services.

This leads to consideration of maximization subject to the constraint that the railroads should at least break even, generating sufficient revenues to cover all costs, including the opportunity cost on the firms' capital. In the absence of the other modes, or if the regulator ignores the interactions between the modes, solving this problem yields the following conditions on the prices charged by the railroad:

$$\left(\frac{p^{1j} - \partial C/\partial x_{1j}}{p^{1j}}\right)\frac{1}{n_{11}^{j}} = \left(\frac{p^{1h} - \partial C/\partial x_{1h}}{p^{1h}}\right)\frac{1}{n_{11}^{h}} \quad \text{, all } j \text{ , } h \text{ ,}$$

$$\sum p^{1j} x_{1j} - C(x_1) = 0 \text{ ,}$$

where n_{11}^{j} denotes the own-quantity elasticity of the demand price for railroad shipments of commodity j. (In this simple case, n_{11}^{j} is the inverse of the usual own-price elasticity). In words, the percentage markup of price over marginal cost for any commodity is proportional to its elasticity of demand, with that factor of proportionality being equal across commodities and chosen so that the railroad earns no excess profits.

However, if other, competing modes come into existence, then Braeutigam's work shows that optimality requires bringing these competing modes under regulation. The corresponding conditions now require that there exists r such that for all commodities j,

$$r = \left(\frac{p^{1j} - \partial C/\partial x_{1j}}{p^{1j}} \right) \frac{1}{n^j_{11}} ,$$

$$r = \left(\frac{p^{ij} - s^{ij}}{p^{ij}} \right) \Big/ \left(n^j_{1j} - \frac{p^{ij} - s^{ij}}{p^{ij}} \right) , \text{ all } i \geq 2$$

and

$$\sum p^{1j} x_{1j} - C(x_1) = 0 ,$$

where n^j_{1i} is the elasticity of demand price in mode 1 for good j with respect to shipments in mode i of this commodity, i.e., $n^j_{1i} = \frac{x_{ij}}{p^{1j}} \frac{\partial p^{1j}}{\partial x_{ij}}$.

Again, a factor of proportionality and certain elasticities, along with the zero profit condition, characterize the optimal markups.

From these conditions, we observe that social welfare (and not just the interests of the industry) require that price discrimination be practiced in all modes, that the constant cost modes earn supernormal profits and that entry be controlled into these modes. Price discrimination arises in the first mode from the desirability of departing as little as possible from the first-best optimal quantities (i.e., those quantities where price equals marginal cost). That it carries over into the other modes is a general feature of such second-best solutions: if price exceeds marginal cost in one mode, it should in other, competing modes as well. In any case, if we view different commodities as representing the shipments of different classes

of customers who vary perhaps as to the size of shipments, location, frequency of shipment or whatever other factors might lead to differing elasticities, then third degree price discrimination is desirable on efficiency grounds. The profits in trucking and other regulated modes will occur in the shipment of any commodity where $\partial p^{ij}/\partial x_{ij} < 0$. If, for example, we are considering only two modes, rail and trucking, then this will obtain if the two modes offer substitute services and the own price effects are larger than the cross effects. This is perhaps the "normal" case. Finally, given that prices are set to exceed average costs in the constant cost modes, the regulator must erect barriers to entry in these modes to insure optimality.

Note further that if, as Friedlaender has suggested, we define cross-subsidization as existing whenever markups of price over marginal cost (not average cost, however that might be defined) differ from the values that they would take under deregulation, then second-best optimal regulation probably involves cross-subsidization as well. The qualification "probably" is required since it is not completely obvious what industrial structure would emerge under deregulation. If one assumes trucking would be competitive (so price equals marginal cost) then certainly cross-subsidization is involved. At the other extreme, if trucking is completely cartelized, the profit maximizing condition is

$$\frac{p^{ij} - s^{ij}}{p^{ij}} \qquad \frac{1}{\eta^{j}_{ii}} = 1,$$

and again cross-subsidization is involved in optimal regulation unless $\eta^{j}_{ii} = \lambda\eta^{j}_{il}$, where λ is the Lagrangian multiplier associated with the

breakeven constraint. If, however, some oligopolistic solution would occur, it is not clear what the resulting markup would be and thus whether cross-subsidization is optimal.

What is striking about these results is that, at least qualitatively, they correspond precisely to the policies now being followed by the ICC! Price discrimination and cross-subsidization apparently prevail, the regulated highway common carriers do earn supernormal profits, and, via the certificates of public convenience and necessity, the ICC attempts to control entry into the industry.

However, before one gets too enthusiastic about the wisdom and foresight of the ICC and of Congress in bringing the motor carriers under regulation decades before Braeutigam's work, a few cautionary notes are in order.

First, while the relationships determining the optimal markups involve only local information about demands and costs, the informational and computational requirements of optimal regulation are still formidable. One finds it hard to believe that the regulators consciously try to approximate this pattern of optimal discrimination, and there appear to be no forces (such as competitive pressures) which would lead to this approximation. Indeed, the basic constraint of the railroads' breaking even is not being met! Second, the analysis takes as given the decreasing cost situation in the railroads. While currently such decreasing costs do exist, as has been argued most recently by Keeler [7], these are a result of excess capacity. In an optimally adjusted rail system (which might be on the order of one-quarter the size of the current system) marginal and average costs would

tend to coincide. The whole problem of second-best regulation considered here would then disappear: optimality would call for marginal cost pricing across the board, which one might expect to be realized in an unregulated but competitive environment. Taking the excess capacity and thus the structure of railroad costs as given means that either one is taking a relatively short-run view or else that implicitly one has introduced criteria other than efficiency into the decision. Finally, it should be noted that the ICC does not, in fact, completely control entry into the constant cost modes. The most obvious example of unregulated highway transport is the carriers of agricultural exempt commodities. However, to the extent that the service characteristics of the railroads preclude their supplying these markets, it is in fact optimal that these commodities be exempt. (Since $x_{ij}\partial p^{1j}/\partial x_{ij} = 0$ for such a commodity, optimally p^{ij} equals s^{ij}, which is the competitive, free entry outcome). A similar argument holds with regard to shipments within a single urban area: here railroads cannot compete, so there is no efficiency rationale for regulating intra-urban trucking. But more significantly, the ICC does not regulate the number of trucks used by those carriers it does regulate, only the number of such firms, and it does not regulate private haulage. Moreover, in the current political environment one must assume that, even if full deregulation of entry and exit does not occur, at least the purview of ICC regulation of these questions will not be expanded.

It thus becomes of interest to consider a variant of Braeutigam's second-best problem in which there are three modes: railroads (mode 1), which show decreasing average costs over the relevant range of shipments, the regulated motor carriers (mode 2) and unregulated private haulage (mode 3). For certain

commodities (where, as before, a commodity may be distinguished not only by its physical characteristics but also by its original location, its destination, the size and frequency of shipments and the characteristics of the shipper) regulated trucking and private haulage may be very close to perfect substitutes. However, we will continue to use a system of demand prices which are assumed differentiable to describe the demand for the various modes. One could not obtain such a system in the case of perfect substitutes, but perhaps our assumption in such cases may be partially justified in terms of an ad hoc recognition of the costs of shifting between modes. We are thus implicitly taking a rather short-run viewpoint. Further, we will assume that firms in private haulage transfer transportation services within the firm at transfer prices equal to marginal costs, so that quantities in these markets are such that $p^{3j} = s^{3j}$. We do not, however, assume $s^{3j} = s^{2j}$.

The Lagrangian for the problem of selecting a social optimum subject to constraints insuring non-negative profits for the railroads and price equaling marginal cost in private haulage is

$$\max_{p^1,p^2,p^3} [G + \lambda(\textstyle\sum_j p^{1j}(x_{1j}, x_{2j}, x_{3j}) - C(x_{11}, \ldots, x_{1n})) + \textstyle\sum_j \beta_j (p^{3j}(x_{1j}, x_{2j}, x_{3j}) - s^{3j})] .$$

Among the first-order conditions are

$$\frac{\partial L}{x_{1j}} = p^{1j} - \frac{\partial C}{\partial x_{1j}} + \lambda(x_{1j} \frac{\partial p^{1j}}{\partial x_{1j}} + p^{1j} - \frac{\partial C}{\partial x_{1j}}) + \beta_j(\frac{\partial p^{3j}}{\partial x_{1j}}) \leq 0$$

$$\frac{\partial L}{\partial x_{2j}} = p^{2j} - s^{2j} + \lambda(x_{1j} \frac{\partial p^{1j}}{\partial x_{2j}}) + \beta_j (\frac{\partial p^{3j}}{\partial x_{2j}}) \leq 0$$

$$\frac{\partial L}{\partial x_{3j}} = p^{3j} - s^{3j} + \lambda(x_{1j}\frac{\partial p^{1j}}{\partial x_{3j}}) + \beta_j(\frac{\partial p^{3j}}{\partial x_{3j}}) \leq 0$$

$$\frac{\partial L}{\partial \beta_j} = p^{3j} - s^{3j} = 0$$

$$x_{ij}\frac{\partial L}{\partial x_{ij}} = 0 , \quad x_{ij} \geq 0 , \quad i = 1, 2, 3; \; j=1, \ldots, n .$$

Using the last two equations we can solve for $\beta_j = -\lambda(x_{1j}\frac{\partial p^{1j}}{\partial x_{3j}})/\frac{\partial p^{3j}}{\partial x_{3j}}$ on the assumption that $x_{3j} > 0$.

Then, repeatedly using the Hotelling integrability conditions, $\partial p^{ij}/\partial x_{hj} = \partial p^{hj}/\partial x_{ij}$, we can obtain the following expressions characterizing the optimum:

$$\left(\frac{p^{1j} - \partial c/\partial x_{ij}}{p^{1j}}\right)\left(\frac{\eta^j_{33}}{\eta^j_{11}\eta^j_{33} - \eta^j_{31}\eta^j_{13}}\right) = \frac{-\lambda}{1+\lambda} , \quad j=1, \ldots, n;$$

$$\frac{\dfrac{p^{2j} - s^{2j}}{p^{2j}}}{\left(\dfrac{\eta^j_{33}\eta^j_{21} - \eta^j_{31}\eta^j_{23}}{\eta^j_{33}}\right) - \left(\dfrac{p^{2j} - s^{2j}}{p^{2j}}\right)} = \frac{-\lambda}{1+\lambda} , \quad j=1, \ldots, n;$$

$$p^{3j} - s^{3j} = 0 , \quad j=1, \ldots, n;$$

$$\sum_j p^{1j} x_{1j} - C(x_1) = 0 .$$

Again, these conditions characterize the optimum, which involves price discrimination and cross-subsidization between commodities in amounts depending on various elasticities. Note, however, the escalation in the informational requirements over the situation in which all modes were controlled: checking the

optimality of the regulated prices still involves only local information, but now the ICC needs to know $5n$ partial derivatives, a number which is most certainly in the hundreds of trillions, as well as marginal costs, current prices and quantities!

It is worth noting that $p^{2j} - s^{2j}$ can be shown to be positive in this case if modes 1 and 2 are substitutes for one another in transporting good j (i.e., $\partial x_{1j}/\partial p^{2j} = \partial x_{2j}/\partial p^{1j} > 0$) . To see this, write

$$p^{2j} - s^{2j} = \left(\frac{-\lambda x}{\partial p^{3j}/\partial x_{3j}}\right)\left(\frac{\partial p^{1j}}{\partial x_{2j}}\frac{\partial p^{3j}}{\partial x_{1j}} - \frac{\partial p^{3j}}{\partial x_{2j}}\frac{\partial p^{1j}}{\partial x_{3j}}\right) \quad .$$

The first term in parentheses is positive, since $\lambda > 0$ and $\partial p^{3j}/\partial x_{3j}$ is negative by the negative definiteness of the Antonelli matrix, A. The second term in parentheses is just $|A|$ times $\partial x_{2j}/\partial p^{j}$, where $|A| < 0$ and $\partial x_{2j}/\partial p^{1j} < 0$, and so it too is positive. Thus, regulated trucking again makes supernormal profits in the optimal solution to this problem.

A further interesting question involves consideration of the nature of the outcome of optimal regulation if, as is sometimes suggested by the trucking industry, there are decreasing rather than constant costs in trucking. To get a first feel for this question, let us initially ignore the service differentials between trucking and rail transport and also ignore the existence of non-regulated trucking. In that case, the demand price p^{j} of commodity j depends only on the total quantity shipped, $x_{1j} + x_{2j}$.

The regulator now must be concerned that both modes break even. In this case, it is desirable to have the trucking industry organized monopolistically so as to capture the cost savings from the returns to scale. The regulator's optimization problem then becomes

$$\text{maximize} \quad \sum_j \int_0^{x_{1j}+x_{2j}} p^j(w)dw - C^1(x_1) - C^2(x_2)$$

subject to

$$\sum_j p^j(x_{1j}+x_{2j})x_{1j} - C^1(x_{11}, \ldots, x_{1n}) \geq 0$$

$$\sum_j p^j(x_{1j}+x_{2j})x_{2j} - C^2(x_{2j}, \ldots, x_{2n}) \geq 0 .$$

The first order conditions for this problem (assuming $x_{1j}>0$, $x_{2j}>0$) are

$$p^j - \frac{\partial C^1}{\partial x_{1j}} + \lambda\left(x_{1j}\frac{\partial p^j}{\partial x_{1j}} + p^j - \frac{\partial C^1}{\partial x_{1j}}\right) + \beta\left(x_{2j}\frac{\partial p^j}{\partial x_{1j}}\right) = 0 ,$$

$$p^j - \frac{\partial C^2}{\partial x_{2j}} + \lambda\left(x_{1j}\frac{\partial p^j}{\partial x_{2j}}\right) + \beta\left(x_{2j}\frac{\partial p^j}{\partial x_{2j}} + p^j - \frac{\partial C^2}{\partial x_{2j}}\right) = 0 .$$

As usual, one could derive conditions describing the optimal markups in terms of the relevant elasticities, assuming that both modes are used to haul a commodity. However, it is interesting to consider the possibility of trucking earning positive economic profits as it does at the optimal solutions to the various problems posed under the constant cost assumption. If, in fact, positive profits are earned, then the constraint on profits in trucking is not binding and thus $\beta=0$. In this case, and assuming that both modes carry commodity j , we have

$$\frac{p_j - \partial C^2/\partial x_j}{p_j - \partial C^1/\partial x_j} = 1 + \lambda > 1 .$$

This condition cannot hold if the marginal cost in trucking exceeds that in the railroads for hauling commodity j. We thus conclude that if the trucking industry is to earn positive profits in this situation, it will carry only those commodities for which it is the lowest marginal cost producer. Of course, the same is true of the railroads. But note that by the nature of the problem both modes cannot optimally earn positive economic profits: if both did, there would be lost consumer surplus exceeding the profit level. The only situation that possibly might call for both the high marginal cost producer as well as the low cost one to be involved in shipping a particular commodity is if the high marginal cost producer is earning zero profits (i.e., no return to capital above a competitive one). Further, if trucking is uniformly the high marginal cost mode and all costs are avoidable, it will pass completely out of existence.

If the two modes are imperfect but close substitutes for one another in carrying some commodity, then the preceding results would continue to hold to the extent that the service differentials do not cancel out the cost differentials. At the other extreme, if trucking offers such superior service on some commodity that the railroads cannot compete in hauling it (i.e. $x_{1j}\partial p^{1j}/\partial x_{2j} = 0$), then freight rates for this commodity must equal the marginal costs of carrying it by truck unless the industry is earning zero profit. Thus, if trucking is earning profits under optimal regulation, has increasing returns and enjoys the service differentials sometimes claimed for it, then it ought to be pricing those products in which it has market dominance at prices below average costs.

It is worth noting here that within the context of optimal regulation, the creation of transportation companies providing service in both modes is

quite desirable. The basic reason is, of course, that the breakeven constraint is now on the whole company's multi-modal operations, rather than just on the individual modal operations, and this gives the regulator more degrees of freedom in setting optimal prices. It is a simple matter to revise the earlier analysis to introduce transportation companies, obtaining expressions for the optimal markups. In the case corresponding to Braeutigam's basic result noted above, where all sectors are served by the transportation company and no competitors exist, the optimal markups on product j in mode i are given by

$$\left(\frac{p^{ij}-\partial C^i/\partial x_{ij}}{p^{ij}}\right)\left(\frac{1}{\sum_h \eta^j_{ih}}\right) = \frac{-\lambda}{1+\lambda} \quad ,$$

where as before, η^j_{ih} is the elasticity of the demand price for shipment of j in mode i with respect to shipments in mode h. If in addition to the transportation company there are regulated motor carriers who show constant costs, the form of the conditions on the transportation company's markups are unchanged, while the markups for the trucking companies are given by

$$\frac{(p^{3j}-s^{3j})/p^{3j}}{(\eta^j_{31}+\eta^j_{32}) - \left(\frac{p^{3j}-s^{3j}}{p^{3j}}\right)} = \frac{-\lambda}{1+\lambda}$$

where the indices 1 and 2 refer to the operations of the transportation company and the index 3 refers to regulated trucking. If this latter sector is deregulated and behaves competitively, then the conditions become considerably more complex:

$$\left(\frac{p^{1j}-\partial C^1/\partial x_{1j}}{p^{1j}}\right)\left(\frac{\eta^j_{33}}{\eta^j_{33}(\eta^j_{11}+\eta^j_{12}) - \eta^j_{13}(\eta^j_{32}+\eta^j_{31})}\right) = \frac{-\lambda}{1+\lambda} \quad ,$$

$$\left(\frac{p^{2j}-s^{2j}}{p^{2j}}\right)\left(\frac{\eta^{j}_{33}}{\eta^{j}_{33}(\eta^{j}_{21}+\eta^{j}_{22}) - \eta^{j}_{23}(\eta_{31}+\eta^{j}_{32})}\right) = \frac{-\lambda}{1+\lambda}$$

and

$$p^{3j} = s^{3j} .$$

In any case the earlier pattern of price discrimination and cross-subsidization with markups depending on certain elasticities prevails and regulated trucking still earns positive profits (if it exists at all).

The existence of positive profits for the regulated motor carriers, as is called for under optimal regulation (except, perhaps, if there are increasing returns to scale in trucking at optimal output levels), has important long-run implications. One would expect that, at least for frequent high-volume shippers, the costs of private haulage would be very close to those realized by the regulated trucking firms. Further, the quality of service that such a shipper could obtain by private haulage also ought to approximate and perhaps to surpass that available from the common carriers. Thus, in the medium-to-long-run private haulage is, again for the big, frequent shippers especially, a close to perfect substitute for shipping via the regulated carriers. This in turn means that any significant gap between prices and costs in regulated trucking will, given time to adjust, induce a movement by these shippers away from the common carriers towards private haulage. This may well be undesirable from a social point of view, both because private haulage may be more costly in real resource terms than use of the common carriers and because erosion of demand for the common carriers limits the range of policy open to the regulator in pursuing his assumed goals of achieving efficiency. In any case, it is certainly not in the interest of the common carriers, whose profits are being eroded.

The dynamic theory of the firm offers some insight into the questions raised by leakage into private haulage. In particular, consider a firm or group of firms faced with the possibility of entry of new competitors, which would erode the demand for the existing firms in a manner completely analagous to the growth of private haulage, and suppose the rate or probability of entry is a function of the markup taken by the existing firms. One alternative is to ignore the potential competition and maximize current profits. The cost of this is greatly reduced profits in the future. The other extreme policy is to push prices low enough to completely prevent entry. This clearly involves sacrifices of current profits. However, it is now fairly well established that, as one might expect, such extreme solutions are typically not optimal. Rather, the firm should adopt a strategy of pricing between the two extremes, trading off current against future profits by sacrificing the former in order to slow entry and thereby improve the latter.

One would expect that a dynamic analysis of optimal regulation would lead to a similar policy in the presence of potential entry of private haulage. Starting, for the sake of simplicity, with an initial situation without private haulage, the two extreme policies are to set short-run surplus maximizing markups, which imply rather rapid erosion of demand, or to set the prices in regulated trucking at sufficiently low levels to prevent the emergence of private haulage. This latter policy carries a cost in terms of reduced static efficiency, since essentially it corresponds to giving up the policy tool of optimally setting trucking markups so as to reduce the social cost of meeting the railroad's break even constraint. (The optimal prices in this context have been obtained by Braeutigam.) It seems intuitive that the

optimal policy will involve a tradeoff of present versus future consumer and producer surplus, implying a policy of slowing but not preventing the growth of private haulage. It is significant that if the intuition is correct, the demand for the services of the regulated modes will be eroded over time, or, if demand in aggregate is growing, the regulated sector will get only part of the growth. An important question is then whether the optimal policy calls for uniform or differential rates of demand shifting and, if the latter is the case, whether the leakage is greatest for the cream (the big, frequent shippers) or the milk (relatively smaller, more infrequent or irregular shippers). We hope to investigate this issue, as well as the general question of the validity of the intuition that optimality involves slowing entry, in the context of an explicit dynamic optimization model in future work.

II. CURRENT REGULATION AND DEREGULATION

The analysis in the previous section suggests the patterns that would mark an optimally regulated transportation sector. While there are qualitative parallels between these patterns and the current pattern under ICC regulation - entry controls, excess profits in trucking, widespread price discrimination and cross-subsidization - one must doubt that current regulation in any serious, quantitative way approximates optimal regulation. Apart from the already-noted fact of railroad losses, there are several reasons for this doubt. In the first place, the ICC does not have, and for the most part, does not particularly seek to obtain the information relevant for optimal regulation, and, given the complexity of the various rules, one would hardly expect them to be met by accident. Second, even if the ICC did attempt to gather the

required data, the informational, computational and administrative costs and difficulties of determing and adopting optimal prices would be overwhelming. Moreover, the ICC could presumably obtain much of this information only from the regulated firms themselves, and there would be incentives for the firms to supply distorted information. Indeed, rather than attempting to compute and institute optimal rates, the ICC tends to operate by ruling on the acceptability of tariffs proposed by the carriers. Given the exemptions of the transportation industry from anti-trust and given the existence of the rate bureaus, one would expect these proposed prices to approximate a non-cooperative solution for a duopoly with product differentiation. The ability of competitors to enter into the hearings to argue against rate reductions (i.e., to prevent price cutting that would break cartel price discipline) and the willingness of the ICC to disallow such reductions if they would cause any diversion of traffic or injury to profits (i.e., if they would have any of the effect prices are supposed to have), suggest that the rates actually approved will also look like these imperfectly competitive, profit maximizing prices. This suggestion is further supported by the use of the operating ratio as a test of reasonableness of rates. The class I carriers have had a ratio of annual revenue to capital of about 5, which with a .93 operating ratio implies a 35% allowed rate of return. Further, the form of entry control being exercised cannot be optimal, since it exacerbates the backhaul problem and thus increases costs, while the current pattern of price discrimination, at least to the extent that it involves relatively lower markups (not prices) for small and infrequent shippers and for shippers in low-volume areas, also seems out of line with optimality.

Many of these factors which suggest the non-optimality of current regulation also suggest the impossibility or, at least, economic undesirability of "optimal" rate setting if the costs of running the regulatory process are recognized. The question that then arises is whether imperfect regulation is preferrable to partial or complete deregulation. This involves comparative statics analysis of a form that economic theory does not presently seem capable of providing, primarily because we lack an adequate theory of informational costs and computational costs. Thus, in this section we will not attempt such an analysis. Rather, we will offer some impressionistic scenarios as to the likely paths of development of the industry under various regulatory schema and try to offer some suggestions as to the implications for the industry, its customers and the regulators.

In the course of this discussion, we will focus on two aspects of the industry's structure, conduct and performance. The first of these relates to returns to scale, the size distribution of firms and the relationship of size and profitability. The second concerns the pricing policy of the industry, including patterns of price discrimination, and the impact of pricing and profits on the growth of private haulage. We will briefly examine the current situation with regard to these aspects, then attempt some prediction of the future under continued regulation and under deregulation. Since the current situation with regard to these issues is well-documented, our treatment will be very brief and far from complete.

The trucking industry is a remarkably diverse one. The general public tends to think of it in terms of its two extremes, the independent owner-operators of popular song and myth and the largest common carrier freight

companies, whose rigs are such a familiar feature on American highways. This perception ignores most of the carriers under ICC regulation, of which there were 16,472 in 1975, ranging in size from relatively tiny outfits with perhaps a hundred thousand dollars in physical assets to relative giants, publicly held corporations with thousands of trucks and networks of private warehouses. Moreover, it also ignores those firms operating outside the ICC's jurisdiction, i.e., those specializing in agriculturally exempt commodities and in intra-state or intra-urban operations, and the large volume of private and contract haulage. Indeed, the part of the industry under ICC common carrier regulation accounts for only a relatively small fraction of total truck shipments. In addition to the diversity in size, there is a specialization even among regulated carriers as to the products they carry. Obvious examples here are the inter-city movers of household goods, the firms specializing in fluids and those specializing in individual shipments of less-than-carload size. With this specialization goes specialization at least of the trailers and some concommitant limitations on substitutability: it is rather expensive to carry wheat on a trailer built for transporting automobiles. However, this specialization of equipment ought not to be of great significance over a period of more than a few years, since it is easily possible to buy and sell used equipment.

In an unregulated industry the persistance of such a wide diversity in firm sizes would be survivor-test evidence of the absence of significant economies or diseconomies of scale. Regulation, however, removes much of the validity or "usefulness" of such a test by dulling or altering the nature and effects of market forces. Thus, for example, while statistical studies

tend to show that banking is not a constant cost industry, under regulation a diversity of sizes of firms exists that presumably could not continue under free entry and exit. In trucking there has apparently been no conclusive evidence published of the existence or absence of significant economies of scale. However, rather crude regression results based on American Trucking Association data [5] do show that the rate of return in regulated trucking is a strictly increasing function of capital and sales volume. This evidence, which is summarized in the Appendix, is supplemented by more recent casual observation of the industry extremes. It seems clear that, in economic opportunity cost terms,most independent owner-operators suffer losses at the best of times, while in hard times these losses are magnified into accounting losses. Thus, for example, after the rise in fuel prices and reduction in speed limits beginning in 1973, one fifth of the independents left the industry over the course of three years. At the other extreme, the eleven largest motor common carriers in 1976 averaged a 22% return on common equity, the second highest among U.S. industries in a Business Week study [11]. This rate was more than 50% higher than the all-industry composite, and would have been significantly higher yet but for Spector Industries' dismal performance.

This pattern of profitability has three possible sources. These are not mutually exclusive, but do have quite different implications. On the one hand, it could arise from true economies of scale. Spychalski [10] for one has suggested that while most economists tend to think of trucking as the example par excellence of a constant cost industry, since the basic unit of capacity is a "driver's license, a used truck and a rented office," this

perception is really most applicable to the carriers specializing in hauling full truckloads from shipper to consignee. For those specialized in less than carload shipments, he suggests that other, less perfectly divisible and more illiquid forms of capital (including especially terminals, break-bulk facilities and information systems) represent a significant share of total non-current assets. These conceivably could represent a source of economies of scale, although one would not expect them to be so large as to account for the differential rates of profit. The second possible source is pecuniary economies and, in particular, the lower cost of borrowed capital and other financial inputs enjoyed by larger firms. These are real cost advantages to the firm, although their social significance is not so clear. Finally, the greater profitability may come from demand factors. Many of these are created or compounded by regulation. Consider a shipper who wants to ship from point A to point B, where a third point, C, lies between A and B. It is clearly to his advantage to send his shipment with a carrier with operating rights from A through to B, rather than with one having rights only as far as C. In the former case there is a better probability of speedy, safe delivery, and if anything goes wrong, one knows whom to blame, while with the second policy the goods must be transferred to another carrier, with a corresponding loss of time, increased likelihood of loss or damage, and dilution of responsibility. Moreover, if one also wants to ship to C and the first carrier also has rights from A to C, it is reasonable to deal with him for these shipments too, since using a single supplier typically results in lower transactions costs and these cannot be offset by other carriers via rate reductions in the context of regulation. This advantage on the demand

side enjoyed by firms with more extensive operating rights is compounded by its effects on costs: since shippers at any location have the same incentives as the one at A, the firm with extensive rights has a better chance of finding a load for at least part of the return trip, thus reducing his incidence of empty backhauls.

This all means that, at least partially as a result of regulation, larger firms with more extensive operating rights will be more profitable. It also suggests that there is a strong incentive for firms to acquire new operating rights and that the large firms will be in the best position to do so.

The second aspect of the industry under regulation that we wish to consider relates to the adoption and continued use of railroad-style value-of-service pricing. The analysis in the previous section does indicate that marginal cost pricing in regulated trucking is <u>not</u> optimal so long as the railroads have excess capacity. It does not, however, automatically suggest that current patterns, with higher markups for high-valued or dense products supplemented by regulator-induced favoritism of certain shippers on a geographic basis, is at all desirable. The relationship between optimal markups and own price elasticities, as given by the various formulae in the previous section, is a very complex one, especially when it is recognized that the quantity elasticities of demand price are not simply the reciprocals of the usual price elasticities of quantities demanded. Thus, there is no obvious reason why markups that vary inversely with price elasticities (i.e., value of service pricing) should even represent the right directions of discrimination.

One major consequence of price discrimination is common both to current and optimal patterns of price discrimination, namely the loss of business to unregulated carriage. Figures given by Friedlaender [6, p. 204] indicate that at least through the mid-sixties about 60 to 65 percent of all truck transportation was in the unregulated sphere, while trucking's share of total transport rose from 10% in 1940 to 23% in 1965. The growth in the unregulated sector paralleled that of regulated trucking, so that through 1967 the immediate pre-war distribution of traffic between regulated and unregulated motor freight was maintained. However, since 1967, the percentage of unregulated traffic has fallen dramatically from the 1967 level of 64% to 56% in 1974, although unregulated ton miles did increase [1]. This may be indicative of limit pricing by the regulated motor carriers. The big losers in all this have been, of course, the railroads.

Friedlaender also gives an excellent discussion, based on the work of Oi and Hurter, of the nature of the shippers who have gone to private or contract haulage [6, p. 111-120]. This discussion indicates that, as one might expect, the incidence of private haulage increases with firm size except for the very largest firms, who apparently extract price concessions from the common carriers, and that it is highest among firms with large numbers of short hauls, with many shipment points and with high-valued commodities. Moreover, firms tend to use private haulage to handle a base level of regular shipping and rely on common carriers to handle any shipments above this.

The granting of (limited) freedom to the railroads in rate-making is a basic fact which must be assumed in considering the future of trucking. However, the existing service differentials in terms of speed, certainty and safety of delivery presumably limit the cross-elasticities of demand between

rail and trucking, so that any rate reductions by the railroads might well be expected to have limited impact and, consequently, perhaps never materialize. If, however, this measure of deregulation is extended by allowing rationalization of the rail system through merger and abandonment, the situation may change markedly. In particular, freed from operating unremunerative branch lines and able to realize the full economies of traffic density on a system of mainlines from which the current, costly excess capacity has been eliminated, the railroads may be able to close many of these service differentials. In particular, a revitalized, rationalized rail system would be in a position to repair roadbeds so as to allow greater speed in shipments and reduced dangers of damage. It could also afford to invest in modern, computerized information systems that would allow roads to keep better track of individual cars and shipments, thus reducing the uncertainty of delivery and the incidence of loss. The possibilities in this direction are well-illustrated by the experience of the Southern Railway and some of the other profitable lines like the Union Pacific and Missouri Pacific. Freed from the current cycle of failing service - falling demand - falling profits - inability to maintain service, the rail system might well be able to meet the competition from trucking. In the 1930's, the railroads sought to beat the trucks by forcing them, through regulation, to play the railroads' game. They have lost badly this way, but it is entirely possible that they might do much better if they play the truckers'game of speedy, certain service.

If regulation of the present form continues, one should expect that the trucking industry will be marked by a continued pattern of differential profit rates and that this will continue to spur the relative growth of the largest

firms and demise of the smaller ones unless the ICC actively seeks to prevent this. To the extent that the greater profitability of the larger firms is not solely regulation-induced via the restrictions on operating rights, one would expect that this pattern would also continue under deregulation. Indeed, given that the industry is marked by substantial excess capacity (estimated by Friedlaender to be on the order of 50%), freedom of rate-making, entry and exit ought to be accompanied by a marked reduction in capacity. This is very unlikely to be uniformly distributed; rather, one would expect the larger, better capitalized, more professionally managed firms to come out of this shaking-out in a relatively even stronger position. Thus, the deregulated industry would likely show some significant concentration too, especially on submarkets.

However, the profits of these large firms cannot be expected to continue at current rates under deregulation. Current prices and profits reflect the combined effects of cartel pricing through the rate bureaus, the feeble competitive position of a sick railroad industry, and the actions of the ICC in controlling defections from the cartel agreements and the entry of new competitors in order to protect the regulated common carriers from one another and the forces of the market. The removal of the ICC's protection would immediately exert downward pressure on prices and presumably on profits. This pressure would be intensified if the rate bureaus were to become illegal, but it would still exist even if they survived. In an industry with such relative ease of entry, price cutting would be impossibly difficult to contain.

The existence of the current levels of excess capacity does suggest that the industry's nightmares of a re-occurence of 1930's-style destructive

competition might well emerge in the wake of deregulation. The important point, however, is that this process of elimination of excess capacity is desirable from society's point of view. Once the shake-out has been completed, a process which on the basis of the time required to achieve contraction of the fringe of owner operators after 1973 one might expect to take three to five years, there is no reason to believe that the industry ought to be particularly subject to price wars. On the one hand, the cyclical dependence of demand on business conditions would encourage price wars, but this ought to be balanced by the ease of entry and exit and by the limited to non-existent economies of scale. The result should be relatively stable prices supporting competitive profit rates.

The extent to which these predictions, which are hardly novel, might be invalidated by increased concentration might be questioned. However, the basic technological data of free entry and limited economies of scale place rather tight upper limits on any appearance of oligopolistic profits.

This downward pressure on prices might be further accentuated by cost reductions made possible and even necessary by deregulation. If, as Thomas Moore has argued, the major beneficiaries of regulation now are the Teamsters (and, one might suggest, the manufacturers of trucks), deregulation would exert downward pressure on wages and truck prices and thus on costs.

Thus, deregulation presumably would bring increased concentration in the industry, but prices and profit levels that are reduced and held in check by the threat of entry as well as by competition among firms already in the industry. The pattern under continued regulation would presumably also involve increasing concentration. However, the continuation of high

prices and profits would be dependent on the ability of the railroads to improve their competitive positions. The pressure from the railroads would particularly be intensified by the inevitable increases in fuel prices over the next few decades. Since railroads not only achieve many times the fuel efficiency of trucks, but also are in a better position to reconvert to more plentiful fuels, they hold a clear long run advantage in an era of dwindling petroleum supplies.

As to the pattern of price discrimination, there is no obvious reason to suppose that it will change if current regulation continued and the railroads continue to decline. However, if the railroads do improve service markedly, they will exert the greatest pressure on long haul markets. This means that increasingly trucking will find its primary demand in short-haul markets, replacing rail branch-line service and serving as feeders to the railheads, while the long haul markets will be eroded. This pattern might be expected whether or not regulation continues in trucking.

Presumably ICC regulation would allow existing truckers to earn profits to the extent possible under new demand conditions, especially if the truckers were its only remaining constituency. This might then point to even higher prices to small, irregular or isolated shippers. This is not obviously consistent with some measure of social welfare, but it is consistent with past experience of the ICC's permitting geographical and (illegal) personal discrimination (see Friedlaender [6, p. 63]) and with modern positive theories of the nature of regulation (see, e.g. Noll [9]). The temper on this tendency under regulation would be the threat of further erosion into private haulage which, as noted, has been greatest in the short haul business

that would be of increasing importance for the motor carriers, as well as pressure on the Commission from shippers.

Certainly an unregulated motor carrier industry would be in a position to attempt price discrimination, especially in those markets where rail competition was not a factor. The limitation on this would be the usual one: the possibility of entry. This suggests that it is the smallest shippers, who are in the worst position either to employ private haulage or to attract new entrants by the promise of their business, would face the greatest markups. But even here there would be checks on the extent of discrimination in the form of the growth of freight forwarders, brokers and cooperatives.

It thus seems that price discrimination is a likely outcome under either regulation or deregulation. Moreover, since many of the forces that would check discrimination are significantly stronger under deregulation, it is not clear that there would be worse discrimination in the deregulated industry than under ICC regulation. In fact, to the extent that the ICC has held down markups to certain shippers and practised policies of cross-subsidization, one would expect that there would be higher prices for these formerly-favored shippers, but reduced price discrimination.

APPENDIX

This appendix reports the results of some elementary statistical testing which examined the widely held belief in the American Trucking Industry: that the relative profitability of a motor carrier is related to its size.

Data was drawn from the Financial Analysis of the Motor Carrier Industry [5], an annual study published by the American Trucking Associations, Inc. Arbitrarily, data for the years 1966 through 1975 was used to characterize the "average firm" in each of four privately owned and the large publicly held carriers of general freight:

Carrier Group A	Annual Revenues less than $1 million
Carrier Group B	Annual Revenues $1 million to $5 millions
Carrier Group C	Annual Revenues $5 millions to $10 millions
Carrier Group D	Annual Revenues over $10 millions.
Carrier Group E	Publicity held motor carriers

Certainly these five classes represent only a part of the trucking industry [although the sample accounts for gross revenues exceeding $16 billions in 1975] but restricting our attention to them allows us to deal with a consistent and homogeneous data source even though we cannot make statistical inferences about non-regulated carriers or private haulage.

We hypothesize that the profits of a regulated trucking firm are a stricktly positive function of its size. Hence our statistical model is

$$P_{it} = C + \beta X_{it} + e_{it} \qquad (1)$$

where P_{it} is the profit of the ith firm in period t, X_{it} is a variable representing the size of the firm, β denotes the (positive) expected relation between profits and size and e_{it} is an independent stochastic term which we assume is distributed $N(0, \sigma^2)$.

The variables chosen to test (1) were Net Operating Income (freight revenues less operating expenses and depreciation) as a measure of profitability and Carrier Operating Property (Net of Depreciation) as a measure of size and capital. NOI is biased downward by excluding the very large book item depreciation which represents real income to the firm while COP (net) is understated since operating rights are not included and may have substantial value. This measure of capital, however, approximates the reported book values of the firms. Each variable was adjusted by the GNP implicit price deflator reported annually by the United States Department of Commerce.

It was not possible to estimate equation (1) directly since the model failed to satisfy the homoscedasticity requirement on the e_{it}. If the variances, σi^2, are proportional to λX_i the following equation can be estimated in generalized least squares form:

$$\frac{P_i}{X_i} = \frac{\alpha}{X_i} + \beta \qquad (2)$$

where the dependent variable now represents the fractional profit on capital employed. Making the necessary assumption we obtained for equation (2)

$$\frac{P_i}{X_i} = \underset{(3.33)}{\frac{-9.00}{X_i}} + \underset{(.011)}{.224}$$

with the standard errors of the coefficients in brackets. It is clear that profits as a function of investment increase asymptotically up to the 22 percent

range since the first term on the right hand side increases to zero as the firm's capital increases. This estimate of β lies in the range reported by industry specialists.

Correcting for heteroscedasticity reduced the Durbin-Watson statistic to 1.31, the lower boundary of the inconclusive test region at the one percent level. Although the estimated autocorrelation coefficient is small ($\hat{\rho} = .347$), using ordinary least squares in the presence of autocorrelation could yield unbiased estimates of the coefficients but the variances of the estimates would be understated. To check the severity of this imprecision in this model we estimated a revised form of equation (2), using an estimate of the autocorrelation coefficient, ρ,

$$\frac{P_{it}}{X_{it}} - \rho\frac{P_{i,t-1}}{X_{i,t-1}} = \alpha^* \left[\frac{1}{X_{it}} - \frac{\rho}{X_{i,t-1}}\right] + \beta^* (1 - \rho)$$

which yielded estimates

$$\frac{P_{it}}{X_{it}} - \hat{\rho}\frac{P_{i,t-1}}{X_{i,t-1}} = \underset{(.747)}{-1.83} \left[\frac{1}{X_{it}} - \frac{\hat{\rho}}{X_{i,t-1}}\right] + \underset{(.003)}{.026}(1 - \hat{\rho})$$

with the standard errors in brackets. This equation is more difficult to interpret since P_{it}/X_{it} depends up $P_{i,t-1}/X_{i,t-1}$ and the unknown parameter, ρ. Nevertheless, it is still true that an increasing level of investment increases net return since the first term on the right hand side increases as X_{it} increases, and the remaining terms are positive for $P_{i,t-1}>0$ and $\rho>0$.

Finally, since the variances of the estimators in (2) can be shown to be overstated because of the use of aggregated data (see 8, pp. 284-285), we use (2) with reasonable confidence to predict the direction and magnitude of the relation of capital investment to profits for the regulated motor carriers of general freight.

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