PRIVATELY-PROVIDED URBAN TRANSPORT SERVICES

Entry Deterrence and Welfare

By Philip A. Viton*

1. INTRODUCTION

In a recent paper (Viton, 1980) the present author presented a simulation model of an urban transport market, designed to determine when a profit-maximising carrier could successfully enter the market. The results of that model showed that entry is possible under a wide variety of circumstances. In addition, the numerical results served to confirm what is observed in several urban transport markets in the United States: entry, when it takes place, does so in such a way as to provide high-quality service at a fare as much as three times the fare of conventional services.¹

That paper, however, did not consider two important aspects of the problem. First, though one does observe instances of entry by private carriers, it must be admitted that, despite the encouraging tenor of the simulation results, these instances are not numerous. Two explanations immediately come to mind. The first is that the legal and regulatory environment of urban transport allows private carrier entry only in limited circumstances. In New York City, for instance, entry is permitted only upon the granting of a franchise by the Board of Estimate, and the uncertainty and length of the procedure may well dampen a private carrier’s enthusiasm. Whether the opportunities for private carrier entry are restricted by statute or by regulation would be an interesting question for legal scholars, but it is not pursued here.

The second explanation is much the more interesting, and reflects a special feature of the previous model. Because that model imposed as a market structure oligopolistic competition between the private carrier and individual automobile users, it did not take account of an important structural property of the urban transport environment. In most large cities there already exists an urban transit system, and this, moreover, is generally run as a public service and is not constrained to cover all costs from the fare-box. The possibility immediately arises: might not the effect of this existing service be to deter a private carrier from entering? If so, this would reconcile the optimistic conclusions of the previous paper with the reality of infrequent entry by private carriers. In addition, it would also imply that relaxing purely procedural regulatory barriers would have little effect.

The second aspect not previously considered is the welfare effects of private carrier entry. This is particularly important where a loss-incurred “public utility” carrier

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¹ See Morlok and Viton (1980) for a recent extensive survey.
already provides service. It is sometimes alleged that the effect of allowing private-carrier entry would be to "skim the cream" from the public carrier, to the detriment of the general community. The cream-skimming argument appears, at least in this form, to have little merit: it is hard to see what, in the context of the typical single service-class/single fare-structure "public utility" mode, constitutes the "cream". But the welfare effects are not so simple. By attracting riders from the public system (whether "cream" or not), a private carrier may yet cause hardship. In addition, there is a substantial distributational issue: if the best way of entering a market as a private carrier is to offer high quality at a high fare, then wealthier consumers may benefit at the expense of poorer commuters.

This paper presents some evidence on both these questions. The model of Viton (1980) is briefly reviewed in the next section, and then extended to model interaction between two carriers, one of whom is a profit-maximising private potential entrant, while the other provides "public utility" service. Section 3 discusses a class of welfare comparisons that can be made; and simulation results and discussions appear in Section 4. Section 5 presents conclusions.

2. THE MODEL

The model used here is substantially similar to that used in Viton (1980). All travel takes place between a circular residential area of radius r miles, and a one-mile-square central business district (or main shopping centre) located L miles from the centre of the residential area. Origins in the residential area and destinations in the CBD are uniformly distributed over the radii and the CBD area, respectively. Finally, the two areas are connected by a limited-access arterial highway; and speeds on all roads are assumed to be invariant to traffic usage.²

The relevant population is Q peak-period commuters from residence to CBD. The preferences of travellers are described by a conditional logit model of mode choice, the estimated coefficients of which are shown in Table 1. The model is estimated from a 1973 sample of San Francisco Bay Area commuters by Train (1976); the paper by Viton (1980) compares this model with a more detailed formulation, and concludes that the simple model is adequate for present purposes.³ The demographics of the population are shown in Table 2, which also shows three distributions of the population over income categories. Of the three distributions, distribution I approximates the actual distribution of Bay Area consumers, while distribution II describes a substantially poorer, and distribution III a rather richer, commuting population.

From the demand model, the characteristics influencing demand for transit modes, for given values of the demographic variables and automobile travel and cost characteristics, are: the transit fare, access time to the transit system, waiting time for transit vehicles, and in-vehicle time. The assumptions of the model mean that in-vehicle time is not subject to choice by a transit system. It has been shown elsewhere that access and waiting time can be captured by two variables under the

² See, for a diagram of the market, Viton (1980), p. 301. The assumption of speeds invariant to traffic is justified in Section 2.1 of that paper.

³ Viton (1980), Section 1 and Appendix.
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TABLE 1

Mode Choice Model*

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Coefficient</th>
<th>T-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost divided by post-tax wage (c + c/min)†</td>
<td>-0.0372</td>
<td>6.84</td>
</tr>
<tr>
<td>In-vehicle time (min)†</td>
<td>-0.0322</td>
<td>4.45</td>
</tr>
<tr>
<td>Other time (min)†</td>
<td>-0.0338</td>
<td>6.58</td>
</tr>
<tr>
<td>Auto alternative dummy‡</td>
<td>-0.322</td>
<td>1.41</td>
</tr>
</tbody>
</table>

* Train (1976), model 21. Mode 1 = auto, Mode 2 = bus.
† Round-trip units.
‡ Variable is one for auto alternative, zero otherwise.

TABLE 2

Income Distribution

<table>
<thead>
<tr>
<th>Group</th>
<th>Post-Tax Wage in $/min*</th>
<th>Approximate Post-tax Annual income†</th>
<th>Approximate Pre-Tax Annual income†</th>
<th>Distribution d∗</th>
<th>I§</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$0.032</td>
<td>$4,000</td>
<td>$5,000</td>
<td>0.15</td>
<td>0.25</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.047</td>
<td>6,000</td>
<td>7,000</td>
<td>0.20</td>
<td>0.35</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.068</td>
<td>8,500</td>
<td>10,000</td>
<td>0.25</td>
<td>0.20</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.095</td>
<td>12,000</td>
<td>14,500</td>
<td>0.30</td>
<td>0.10</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.205</td>
<td>25,500</td>
<td>34,000</td>
<td>0.10</td>
<td>0.10</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Average post-tax wage</td>
<td>$0.080</td>
<td>$0.062</td>
<td>$0.112</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average post-tax annual income†</td>
<td>$9,984</td>
<td>$7,738</td>
<td>$13,978/year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* See Cluff (1978).
† Assumes 40-hr week, 52-week year.
§ Approximate actual Bay Area distribution.

direct control of the transit system: the number $R$ of equally-spaced routes covering the residential area, and the vehicle headway $ψ$.4

In this context, the problem facing a private entrant to the market is simple. It is assumed that the private entrant is motivated by profit maximisation; he must therefore select the fare, number of routes and headway to achieve this aim. Formally, if $P_i^v$ is the probability that a member of demographic group $i$ selects the private entrant, if $d_1, d_2, ..., d_n$ is the distribution of the population over demographic groups and $C(ψ_e, R_j)$ is the round-trip cost of providing a trip in this market at headway $ψ_e$ and accessibility $R_j$, then the problem of the entrant is to

4 Specifically, if arrivals at bus stops follow a Poisson distribution, average wait time is $R ψ/2$, where $ψ$ is headway as measured on the linehaul segment. Access time, which is assumed to be by walking at 3 mph, is $πr/6R$. See Viton (1980).
Max: \[ \Pi^e = Q \sum P_i d_i - C^e(\psi_e, R_e)/\psi_e \]  

where \( f_e \) is the fare. Note that the optimisation in equation (1) is deceptively simple, since the functions \( P_i \) are complicated non-linear functions of the characteristics of all modes available to consumers. In the spirit of modelling a high-quality-of-service entrant, we also require that service be provided in such a way that the seating capacity of the vehicles is not exceeded. If \( V_e \) is the seating capacity, the problem of the entrant is to maximise (1) subject to

\[ Q \psi_e \sum P_i d_i \leq V_e. \]  

Thus far we merely follow the previous paper. Our interest here, however, is in entry deterrence and welfare when the entrant must compete not only with the private automobile, but also with a possibly subsidised “public utility” transit system, now to be described. Two features appear to characterise the politico-economic environment of many large transit systems. First, little or no attempt is made to exploit market power by charging what the traffic will bear: it is often part of the “public service” connotation of such systems that the fares be set at some politically acceptable (low) level. Second, the public utility generally lacks the option of cost-cutting by providing service at so low a level that consumers will simply choose not to travel at all. This means, of course, that public utility transit systems cannot be profit maximisers: constraints on service mean that losses must often be incurred, and subsidies paid.\(^5\)

We shall assume that the public utility carrier acts in such a way as to minimise any losses associated with the provision of some exogenously given level of service quality. It is not suggested that this theoretical motivation captures the actual behaviour of public service transit agencies, but rather that it represents an interesting standard from which comparisons can be made. Specifically, it is assumed that the problem facing the public service transit carrier is to minimise losses subject to three constraints. The first is that the fare must not exceed some maximum, \( f_s \). The second is a user-perceived service constraint: we require that the access-plus-wait-time facing an average user of this mode must not exceed some time \( n_s \). Finally, we also impose a loading constraint on the carrier: that vehicles do not contain more than \( V_s \) travellers. Note that \( V_s \) may exceed \( V_e \), so public service vehicles may be more crowded. Formally, we recall that, under the assumptions of the model, if the public service carrier provides \( R_s \) routes and headway \( \psi_s \), then average wait is \( \psi_s R_s/2 \) and average walk time is \( \pi R_s/6 \). The problem facing the public service carrier is

\[ \text{Min:} \quad -\Pi^s = Q \sum P_i d_i - C^s(\psi_s, R_s)/\psi_s \]  

subject to

\[ f_s \leq f_s \]  
\[ \psi_s R_s/2 + \pi R_s \leq n_s \]  
\[ Q \psi_s \sum P_i d_i \leq V_s \]  

\(^5\) A profit-maximiser would, of course, elect to provide no service rather than incur losses.
Table 3
Operating Costs

<table>
<thead>
<tr>
<th>I. Bus</th>
<th>$12.77/hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs varying with bus hours*</td>
<td></td>
</tr>
<tr>
<td>Costs varying with vehicle miles†</td>
<td>$0.2557/mile</td>
</tr>
<tr>
<td>II. Automobile-Compact Car</td>
<td></td>
</tr>
<tr>
<td>Operating cost‡</td>
<td>$0.0513/mile</td>
</tr>
<tr>
<td>Freeway operating cost§</td>
<td>$0.0467/mile</td>
</tr>
<tr>
<td>Arterial operating cost§</td>
<td>$0.0640/mile</td>
</tr>
<tr>
<td>Parking cost∥</td>
<td>$1.35</td>
</tr>
<tr>
<td>Auto occupancy¶</td>
<td>$1.07</td>
</tr>
</tbody>
</table>

‡ From Keeler, Small, Viton et al (1975). Includes only gasoline, oil and maintenance costs. Taxes added: gasoline $11/gal; oil $0.06/gal. These cost concepts are compatible with the costs used in estimating the demand models. See Reid (1977), p. 42. All costs inflated by 1.0559.
∥ Ibid, p. 98. Inflation factor, 1.0559. Cost is one-way per auto occupant.

where $P_i$ is the probability that a member of demographic group $i$ selects the public service carrier, $C^+$ is the round-trip cost of providing service, and (4), (5) and (6) are the fare, service and loading constraints, respectively.

The model here presented is of a duopolistic transit market. The optimising choices of each carrier will depend on the choices of the other, and on the model parameters. Thus, we must specify the way in which the carriers interact. We adopt the conventional Cournot-Nash (zero conjectural variation) framework. Each duopolist acts on the assumption that the other’s choice of service characteristics will not change, and sets its level of service to optimise its objective function subject to the applicable constraints. The other carrier proceeds in its turn to optimise, taking the service characteristics of the first as given; this procedure continues until an equilibrium obtains. Entry by the private carrier will be said to be deterred if non-negative profits cannot be attained as its best response to the service offered by the public service carrier.

Two additional matters remain to be treated. First, costs. It is assumed that both the private and the public carrier operate bus transit systems only, and incur route expenses linear in mileage-related and time-related unit costs. Further, the levels of these costs are the same for both carriers. It is possible that the entrant (private) carrier would have substantially lower costs because of differing unionisation and seniority rules; but this possibility is not explored here. The costs assumed are shown in Table 3, together with the costs of making trips by car.

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⁶ In the numerical results, an equilibrium was said to obtain if the mode-choice probabilities were stationary within 1%.
Finally, following the previous paper, we suppose that a part of the perceived disadvantage of the public service carrier is that it makes more circuitous trips: and we model this by assuming that for $XL = 2$ miles, when auto users and riders of the private bus mode travel at limited-access arterial speeds of 50 mph, the riders of the public service carrier travel at the slower residential/city streets speed of 14 mph. Since according to the demand model it is travel time that matters, this indirect characterisation of circuity is quite adequate. On residential and city streets, both transit carriers travel at 14 mph (reflecting transit stopping patterns), while auto speeds are a faster 25 mph.  

3. WELFARE COMPARISONS

We shall be interested, in the sequel, in two questions: (1) when a private carrier can successfully enter a transit market, and when a public service carrier, by providing money-losing service, can deter entry; and (2) what welfare conclusions may be drawn when entry has occurred. The answer to the first question will emerge from the numerical results of the next section, but for the second some additional discussion is needed.

In a world in which groups of different income characteristics were not treated differently in questions of public policy, welfare comparisons would present no problem. The appropriate welfare comparisons would be based on the theoretical measures of compensating or equivalent variations; and Willig (1976) shows that the conventional calculation of consumer surplus is generally a good approximation to these measures. The focus of the present inquiry, however, is explicitly on situations in which different groups respond differently to transit options, and in which these differing responses may be of direct policy concern. Here, too, there is a sound theoretical answer: to weight each group's consumer surplus by "welfare weights" reflecting the politically determined importance of the various groups. But these weights are unknown.  

We shall therefore content ourselves with examining three welfare measures which do not require inter-group comparisons. First, suppose that a private carrier enters and that (1) the fare and service constraints of the public service carrier are satisfied as equalities both before and after entry, and (2) the losses of this carrier do not increase. In this case it is immediately clear that there is an unambiguous welfare gain. For consumers still have the option of using the public carrier with no worsening of perceived service. If they choose not to do so, they must receive a utility gain. And  

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1 We summarise distances and travel times for the three modes. Denote (as in Viton (1980)) linehaul speed by $S$; residential speeds are $ASPD$ for autos, $SPD$ for both bus systems. Then travel time for auto users is $(r + XL/2 + 0.5)/ASPD + L/S +$ car-pooling delay, assumed to be 2.5 minutes. On the "subsidised" bus mode average travel time is $(0.5r + XL + 0.5)/SPD + (L + XL/2)/S$. For the private entrant, average travel time is $(0.5(r + XL + 1))/SPD + L/S$. For both transit modes round-trip vehicle times are twice average travel time + $r/SPD$.  

2 Cluff (1980) reports the results of assuming different "welfare weights" on the optimal design of an urban transit system, along the lines of Viton (1977).
since public carrier losses do not increase, and the entrant makes non-negative profits, there must be an increase in producers' surplus as well.

The second case to be examined results in what I shall call a "potentially beneficial" welfare change, as distinguished from the last case where the gain was unambiguous. Suppose again that entry takes place, that condition (1) above is satisfied, but that losses on the subsidised system increase. This may occur, for instance, because the private entrant attracts a sufficient number of riders from the public carrier to make it more costly to maintain the required service level. Suppose, specifically, that losses on the public carrier increase by $\Delta L$, and that in duopolistic equilibrium the entrant makes profits $\Pi > \Delta L$. Then there is the potential for an unambiguous welfare gain, since a profits tax (which of course has no effect on efficiency) could redistribute the gains in such a way as to leave the entrant with positive profits—and, if these are economic profits, positive profits will sustain entry—and reimburse the public carrier for its increased losses. Consumer welfare increases unambiguously for the same reason as before.

Finally, as we shall see, when travel volumes are high enough, even a public service carrier can provide its basic service level at a profit. If a private carrier enters, that profit will of course decrease. I shall say that the welfare effects of entry are again "potentially beneficial" under these circumstances if total profits increase, for again a suitable tax system could restore the pre-entry profits of one carrier while leaving the entrant with positive net revenue. Consumer benefits, of course, cannot fall.

4. RESULTS

Tables 4 and 5 show, for two values of linehaul lengths and nine assumed travel volumes per peak hour, the basic conclusions on welfare and entry-deterrence for each of the three income distributions of Table 2.\(^9\) For each distribution, the three columns show: first, a qualitative indication of whether entry by a single franchised carrier will occur when the only alternative in the market is the private car; second, a qualitative indication of whether entry would still occur if a possibly subsidised public carrier providing service at a maximum fare of $0.50 and a user-perceived wait-plus-access time of at most 30 minutes already existed in the market; and third, an indication (where relevant) of the welfare conclusion to be drawn from private-carrier entry resulting in a two-transit-carrier market.

Our first question was whether the public service (i.e., possibly subsidised) carrier could deter entry. An indication on this is obtained by comparing the first two columns of each income-distributional case. If for any travel volume a plus sign appears in the first column and a minus in the second, the existence of the public service carrier has deterred entry by a profit-maximising potential entrant.

On examination of the two tables, it appears that the range of deterrence can be substantial. For example, when the linehaul distance is 12 miles and the income

\(^9\) The radius of the residential sector is in both linehaul causes $r = 2$ miles. This differs from Viton (1980) in the case $L = 12$. 

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### Table 4

**Entry and Welfare—Case I**

<table>
<thead>
<tr>
<th>Peak Hourly Commuters</th>
<th>Income Distribution I</th>
<th>Income Distribution II</th>
<th>Income Distribution III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single Carriers</td>
<td>Two Carriers</td>
<td>Welfare Conclusion</td>
</tr>
<tr>
<td>5,000</td>
<td>+</td>
<td>+</td>
<td>P</td>
</tr>
<tr>
<td>4,000</td>
<td>+</td>
<td>+</td>
<td>P</td>
</tr>
<tr>
<td>3,000</td>
<td>+</td>
<td>+</td>
<td>P</td>
</tr>
<tr>
<td>2,000</td>
<td>+</td>
<td>+</td>
<td>P</td>
</tr>
<tr>
<td>1,500</td>
<td>+</td>
<td>+</td>
<td>NA</td>
</tr>
<tr>
<td>1,000</td>
<td>+</td>
<td>-</td>
<td>NA</td>
</tr>
<tr>
<td>800</td>
<td>-</td>
<td>-</td>
<td>NA</td>
</tr>
<tr>
<td>600</td>
<td>-</td>
<td>-</td>
<td>NA</td>
</tr>
<tr>
<td>400</td>
<td>-</td>
<td>-</td>
<td>NA</td>
</tr>
</tbody>
</table>

* Linehaul length L = 8 miles.

* Entries are: + if a profit-maximising carrier enters a previously autos-only market; — otherwise.

* Entries are: + if a profit-maximising carrier enters a market in which autos are available and a “subsidised” carrier provides service at a maximum fare of $0.50 and wait + walk time ≤ 30 minutes; — otherwise.

* Entries are: U if the two-carrier market is an unambiguous welfare gain; P if the gain is potentially beneficial; — if ambiguous; and NA if not applicable.

* Profitable service is feasible for the “subsidised” carrier providing the basic service of note “c” at the only carrier in the market.

* Profitable service is feasible for the “subsidised” carrier providing the basic service of note “c” even in competition with the private entrant.

The distribution of consumers is skewed to the lower tail (distribution II), a subsidised carrier can deter entry when peak travel volumes lie between 600 and 1,500 per hour. It is difficult to translate this into an estimate of overall residential densities (except under some stringent assumptions, for example that all destinations of all residents lie in the CBD), but it is likely that this range covers a substantial proportion of observed travel patterns. In other words, one explanation for the lack of observed profitable entry to transit markets lies very probably in the nature of the competition.

As might be expected, the range within which deterrence is possible is much narrower in the case of the richer income distribution III. This is because, faced with the subsidised carrier’s non-price level of service, wealthy consumers prefer to use their cars, even at much greater cost.

The tables also indicate that even low-fare service can cover its costs when travel volumes are high enough. As the tables show, that profitability depends critically on the competition. Entry by a private carrier limits the possibilities quite stringently, and they would also, of course, be limited in application by the relatively high volumes necessary.

The second question of interest was the welfare implications of entry; and this is answered by the third column of each section of the tables. Recall that we have limited

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10 Deterrence is even more pronounced if the public service carrier provides better service than that modelled here. For instance, provision of service at perceived wait and walk time of 15 minutes (rather than the 30 minute service discussed in the text) effectively bars any entry by a private carrier.
the scope of the question to those equilibria in which a private profit-maximising carrier enters a market already served by a public service carrier.

The results are highly encouraging. First, in no case is the welfare gain unambiguous: in other words, entry does indeed impose economic hardship on the public service carrier in the form of either increased losses or lost profits. But, in every case shown in the tables, there is a simple Pareto-improving remedy to this. A neutral profits tax will restore the pre-entry position of the public service carrier and still leave positive profits, and hence an entry incentive, to the private carrier.\textsuperscript{11}

However, the results are not wholly to the good. In each case there exists a small range not shown in the tables (generally where travel volumes are within 200 per hour of the minimum necessary to sustain entry) where the profits of the entrant do not suffice to compensate the subsidised carrier for increased losses. In these cases our simplified criteria of welfare changes will not allow a conclusion to be drawn. Whether entry in these cases is to be accounted a welfare gain depends on the gains in consumer surplus shown by the members of the various groups, and on any "welfare weights" assigned to those gains.

But the range of these ambiguities is extremely small. We may conclude that in a wide variety of situations competition to the public service bus system, if accompanied by a suitable tax mechanism, can lead to a net welfare gain.

\textsuperscript{11}As in Viton (1980), the profits here are economic profits, since they are net of an assumed 6\% return on capital investment.
5. CONCLUSIONS

We began this inquiry to answer two questions left untreated in previous research. First, can it be that the rarity of observed entry by private carriers into urban transit markets is due to a deterrent effect of the service offered by an existing public service carrier? Our simulation model strongly suggests that the answer to this is “yes”. It appears that in many situations a possibly subsidised carrier’s service has precisely this effect. Thus it would seem that merely relaxing administrative barriers will not generally serve to induce entry.

The second question involved the welfare implications of entry when it did occur. Under the specific circumstances adumbrated here—that the public service carrier did not worsen the level of user-perceived amenities—our conclusion was encouraging. Even though the public service carrier did suffer economic hardship following entry, a neutral profits tax could, in a substantial number of cases, alleviate that hardship and allow consumers to receive an unambiguous welfare gain.

I close with a caveat. Without a more detailed specification of the dependence of aggregate consumer benefits on the welfare of individual groups of consumers, it is impossible to answer what for many is the most relevant question: should the private carrier replace entirely the public service mode? The results presented here should emphatically not be taken as having any bearing on that issue.

REFERENCES