A Comment on "Subsidization of Urban Public Transport and the Mohring Effect"

by

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April 22, 2009

Abstract

Van Reeven (2008) argues that the Mohring effect is not relevant to the determination of transit subsidies because a profit-maximizing monopolist would supply frequencies that are the same as, or greater than, those that are socially optimal. We find that his results depend on the reduction or elimination of the effect of fares on demand, causing optimal prices to be indeterminate within broad ranges. Consequently, his model is an unsatisfactory tool for discussing subsidies in general, and the optimal combination of fare and frequency in particular.

1.0 Introduction

In a classic 1972 paper, Herbert Mohring argued that transit subsidies could be justified because of the scale economies conferred on riders. Subsidies increase ridership, the ridership increase engenders higher service frequencies, and the higher frequencies reduce the average waiting times at stops. A recent paper by Peran van Reeven (2008) attempts to refute this line of argument by advancing a proposition that a profit-maximizing monopolist will choose to provide a frequency of service that, depending on the particular parameters within a tightly defined model, is the same as or greater than the frequency that maximizes social welfare. From this, van Reeven concludes that "economies of scale do not constitute a justification for general subsidisation of urban public transport" (abstract).[1] But do his results really undermine the case for public transport subsidies arising from the "Mohring effect"?

A major limitation of van Reeven's model is that price has no effect on welfare within a range of conditions, because within certain ranges transit demand is perfectly price inelastic, making it impossible to discuss optimal pricing. Mohring's original paper had a similar assumption, but this was a harmless assumption made for convenience because he considered only cases where welfare optimization implies marginal-cost pricing. Furthermore, the extensive theoretical and empirical literature that is derived from Mohring's work has not been so restrictive.

2.0 A Model with Price Sensitivity

2.1 Consumers who do not know the timetable

In Section 3.1 of van Reeven's paper, consumers who arrive randomly at a transit stop without knowledge of a timetable all have the same reservation price — call it p^r — which depends on

[1] In the paper's concluding section, van Reeven more properly qualifies this statement: "… do not *necessarily* constitute a justification for subsidising urban public transport" (page 357, emphasis added).

frequency; the demand curve therefore consists of two vertical line segments joined by a horizontal section at price p^r.

The easiest way to introduce demand elasticity within van Reeven's framework is to allow for a continuous variation in reservation prices. This is the approach taken by Frankena (1983) and Jansson (1993) in their reworking of the Mohring model. Using van Reeven's terminology, and his assumption that service frequency is provided at a fixed unit cost (c), the monopolist profit (π) will be given by:

(1) $$\pi = pD[G(p,f)] - cf$$

where p is the fare, f is service frequency (departures per hour) and $D(\cdot)$ is the demand function. Demand depends on the generalized price of travel, $G(\cdot)$, which is a function of fare and average waiting time, the latter depending inversely on frequency so that $\partial G/\partial f<0$. Profit maximization produces the following first order conditions:

(2) $$\frac{\partial \pi}{\partial p} = p\frac{\partial D[G(p,f)]}{\partial P} + D[G(p,f)] = 0$$

and

(3) $$\frac{\partial \pi}{\partial f} = p\frac{\partial D[G(p,f)]}{\partial f} - c = 0$$

Social welfare (W) is defined as the combination of area under the demand curve and above the equilibrium level of generalized price plus the profit/loss of the operator:

(4) $$W = \int_{G(p,f)}^{\infty} D[x]\partial x + pD[G(p,f)] - cf$$

Welfare maximization produces the first order conditions;

(5) $$\frac{\partial W}{\partial p} = -D[G(p,f)]\frac{\partial G(p,f)}{\partial p} + D[G(p,f)] + p\frac{\partial D[G(p,f)]}{\partial p} = 0$$

and

(6) $$\frac{\partial W}{\partial f} = -D[G(p,f)]\frac{\partial G(p,f)}{\partial f} + p\frac{\partial D[G(p,f)]}{\partial f} - c = 0$$

In setting fares, equation (2) indicates that the profit-maximizing monopolist (assuming that it decides to produce) will set a positive price consistent with marginal revenue equaling zero, whereas equation (5) simplifies to indicate that the socially-optimal fare is zero. Not surprisingly, we can conclude that the monopolist will charge a higher than optimal fare.

In setting frequency, equation (3) indicates that the profit-maximizing monopolist will equate the (constant) marginal cost of providing additional frequency to the marginal revenue from that frequency. However, from equation (6), welfare will be maximized when the same marginal cost is equated to the same marginal revenue *augmented by* the Mohring benefits of reduced waiting times, $-D\partial G/\partial f$ (which are positive because $\partial G(\cdot)/\partial f<0$). Therefore, *for a given fare,* the profit-maximizing monopolist will provide a lower frequency than is socially optimal. Furthermore, the monopolist charges too high a fare, leading one to suspect that its frequency is even further from the first-best optimal one, although this need not always be true.[2]

Therefore, determination of whether a profit-maximizing monopolist produces a larger or smaller frequency than is socially optimal will depend on the parameters and functional forms governing how marginal revenues and marginal Mohring benefits depend on frequency. While we cannot be sure which situation will produce a higher frequency, we can reject van Reeven's conclusion from proposition 1 that "*any* subsidy has an adverse effect" (page 355, emphasis added). Properly structured subsidies to a profit-maximizing monopolist will enable fares to be reduced toward their socially optimal level (zero in this formulation), and possibly lead to higher

[2] Because the social welfare-maximizing fare is zero, equation (6) simplifies to tell us that this first-best optimal frequency occurs when the marginal cost of additional frequency equals the marginal Mohring benefits.

frequencies, if that is desirable. Frankena (1983) provides a very extensive discussion of fare and frequency choice in these circumstances.

We note in passing that van Reeven's model removes much of the richness of Mohring's model. Additional riders may impose negative as well as positive externalities on other riders, as buses may have to stop more often to pick up and drop off passengers, and have longer dwell times at existing stops. Moreover, the slower average vehicle speeds have cost implications for the bus company as more vehicles are required to provide a set number of departures per hour.

2.2 Consumers who know the timetable

The general model just formulated also describes the case when passengers know the timetable, and plan their arrival time at transit stops. At a more detailed level, models of this case are considerably more complex than those used to describe random arrivals at stops. Panzar (1979), for airlines, and Jansson (1993), for transit, provide extensive analyses. Transit models in which consumers decide whether or not to travel depending on the difference between their desired departure time and the known schedule are found to be analogous to the standard industrial organization model of quality choice (with frequency as the measure of quality).

It is a standard result in this literature that a profit-maximizing monopolist may produce a higher or lower level of quality than is socially optimal (Spence, 1975; Sheshinski, 1976). This is because the profit-maximizing monopolist sets quality based on the preferences of the marginal consumer, while the social-welfare maximizing firm bases it on the preferences of the average consumer. Because the profit-maximizing monopolist also raises price and restricts the number of passengers, we cannot be sure of the relative magnitude of the preferences of the monopolist's marginal consumer and the average consumer who would purchase in a social-welfare maximizing world. Frankena (1983) discusses the Spence/Sheshinski result in a transit context.

Van Reeven's consumers who follow a timetable do have some elasticity (within a certain range of parameters), because they do not all have the same preferred schedule. Nevertheless, the model lacks the usual features that create a downward sloping demand curve, namely either price-responsiveness in the amount of travel by each individual or heterogeneity in individuals' reservation prices for making a fixed number of transit trips. This is why van

Reeven obtains a non-ambiguous result comparing monopoly with optimal frequency, leading him to advocate a tax on frequency; and it is why once again the optimal fare is undefined, thus obscuring the result following from (5) in our formulation.

2.3 Summary

By oversimplifying the demand structure, van Reeven's model is rendered incapable of saying much about optimal prices. This makes it an unsatisfactory tool for discussing subsidies or the optimal combination of fare and frequency.

3.0 Empirical Evidence

Because it is theoretically indeterminate whether a profit-maximizing monopolist will produce too much or too little frequency, the issue of the role of the Mohring effect in determining optimal subsidies becomes an empirical one. The empirical literature has not directly addressed the issue raised by van Reeven (monopolist's profit-maximizing choice versus social optimality), but rather has analyzed whether providing additional subsidies to encourage operators to lower their *existing* fare and/or expand their *existing* frequencies is socially desirable (Dodgson, 1987; Glaister, 1987, 2001; Savage and Schupp, 1997; Small and Gómez-Ibáñez, 1999; Savage, 2008; Parry and Small, 2009). Some of these analyses have found situations where subsidies to expand frequencies are socially worthwhile, and the majority of the benefits accrue from the Mohring effect.

Another interesting finding from the empirical work is that, for a given budget constraint, transit agencies typically have a suboptimal mix of fare and frequency. Too high a frequency is produced at too high a fare. Thus, even in an optimum constrained by a fixed subsidy budget (perhaps zero), the scale economies inherent in the Mohring effect are likely to substantially influence the desired operating configuration.

4.0 Other Issues

Several authors have noted the institutional problem that subsidies are often used to cover an increase in unit costs rather than to improve services by lowering fares and/or increasing frequencies. There is a debate as to whether the rapid increase in subsidies in the 1970s was the cause of, or a consequence of, rising unit costs (Pickrell, 1985). We agree with van Reeven that this is an important practical consideration in considering transit subsidies, especially the structure they should take.

An even more interesting question, mentioned in passing by van Reeven, is that there are many goods produced under increasing returns to scale. Indeed, one can argue that this is typical of large segments of an economy, as recognized in models like that of Dixit and Stiglitz (1977). Why not subsidize all of these products? To examine this question carefully would require a general-equilibrium model with a tax system that creates distortions by causing one or more prices (*e.g.* of labor) to differ between suppliers and demanders. While it is difficult to make generalizations, several authors have examined transport within such a model and found that optimal prices still include a Mohring effect term, pretty much in the form described by the simple model here, but modified by other terms that capture the degree of existing tax distortions (perhaps summarized in a marginal cost of public funds) and the degree of substitutability between public transport and labor supply.[3]

5.0 Concluding Comments

Even excluding the problems caused by the suppression of the role of price, van Reeven overstates his case within his own model. Under many, perhaps most, parameters his model produces the result that a private monopolist produces unsatisfactory results. For example, in his Proposition 2 there is a range of reservation prices covering a factor of 1.41 for which the monopolist fails to produce at all, even though an optimal operator would do so. This range consists of the entire range of demand conditions between that where optimal service is zero to that for which the monopolist's service frequency is so high that the transit service meets

[3] See, for example, Parry and Bento (2001), van Dender (2003).

everyone's reservation price. In van Reeven's Proposition 1, the monopolist offers the optimal frequency but charges the highest price compatible with achieving non-zero demand. Surely then it is an exaggeration to say that "the results in this paper actually favour private operation" (page 358).

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