ELSEVIER Journal of Public Economics 59 (1996) 1–15

JOURNAL OF PUBLIC ECONOMICS

Competition and regulation in the taxi industry

Robert D. Cairns[a], Catherine Liston-Heyes[b]

[a]*Department of Economics, McGill University, Montreal, Quebec H3A 2T7, Canada*
[b]*School of Management, Royal Holloway College, University of London, London, UK*

Received March 1993; final version received September 1994

Abstract

A simple model of the taxi industry suggests that deregulation of fares and entry may not be optimal. The conditions of competition do not hold in the industry, even approximately. A model of search, where drivers and riders search for each other, is presented for the cruising-taxi market. This indicates that equilibrium of a deregulated industry does not exist. Price regulation is essential, and entry regulation may be useful. In addition, viewing the medallion as a bond for appropriate performance provides another possible rationale for regulation.

Keywords: Regulation; Bonding; Transportation; Taxis

JEL classification: 022; 612; 613; 615

1. Introduction

The taxi market in large cities has been one of the prototypical examples used by economists of the inefficiency of governmental regulation and of the power of the market to regulate an industry so as to maximize social welfare. In the more specialized literature of transportation economics, however, a long-standing debate has raged over whether the industry ought or needs to be regulated by civic authority.[1] In some US cities in the 1980s

[1] Tullock (1975), Coffman (1977) and Williams (1980) have argued in favour of deregulation. Deregulation of entry while retaining regulated fares, if sometimes not actually advocated, has at least been implicit in the work of Douglas (1972), Beesley (1973, 1979), De Vany (1975), Abe and Brush (1976) and Manski and Wright (1976). Shrieber (1975, 1977, 1981), Schroeter (1983), Gallick and Sisk (1987) and Teal and Berglund (1987) have argued for fare and entry regulation.

SSDI 0047-2727(94)01495-7

there was some experimentation with deregulation of the taxi industry,[2] but eventually those cities backed away from the policy of deregulation, usually after severe problems in the industry.

In the present paper, we reformulate the notions of those earlier writers who have argued that regulation is in the public interest. First we present models of monopoly and the second best. Then we consider an unregulated market. We find that the industry does not satisfy the conditions of competition. Indeed, existence of an equilibrium depends on regulation of fares. Regulating entry as well can bring society closer to the second best, but achievement of the second best also requires regulation of use of licensed taxis. In addition, requiring a medallion or licence to operate a taxi may be viewed as a substitute for posting a bond. It generates a surplus in the relationship between the regulator and the taxi owner, ensuring good conduct by the driver and quality service.

2. A simple model

As the continuing discussion in the literature suggests, the taxi industry exhibits some interesting analytical problems. First, it is subject to an interrelatedness of demand and supply: one individual's ride will, at the margin, increase the waiting time of all other potential riders, a negative externality. Second, there is a difference between the cost of a trip, which is the output of the industry, and the cost of operation of a taxi, which is incurred as a cost per hour the taxi is in service. Apart from the opportunity cost of being unavailable while one's taxi is in service, the incremental cost of a trip is essentially nil.

In any given hour, the number of trips demanded (assumed for simplicity to be of constant duration and distance and hence of constant fare) is a fraction of the fare p and the waiting time for a ride w. Thus, $Q = f(p, w)$, where w in turn depends on the number of available taxis and hence the level of demand, and where the partial derivatives of f with respect to p and w, f_1 and f_2, are both negative. Suppose that there are N taxis in the industry, each working h hours per day, $0 < h < 24$, and that demand is distributed uniformly through the day. Then, in any given hour there are (on average) $Nh/24$ taxis in service, each of which has $q = Q/(Nh/24) = 24Q/Nh$ rides per hour. We assume that a trip is of duration t (a fraction of an hour). On average, then, $Nh/24 - tQ$ taxis are available (in service but not occupied) at any given time. Waiting time is negatively related to the

[2] See Frankena and Pautler (1984) and Teal and Berglund (1987). Only a half-dozen US cities deregulated both fares and entry, and deregulation did not occur in any city in which street hails of taxis predominated.

number of taxis available; i.e. $w = w(Nh - 24tQ)$ and $w' < 0$. Demand is an implicit function of itself: $Q = f(p, w(Nh - 24tQ))$. Thus, for a fixed fare p there may be more than one set of equilibrium values of Q, N and h. Also,

$$\partial Q/\partial p = f_1 + f_2 w'(-24t\, \mathrm{d}Q/\mathrm{d}p) = f_1/(1 + 24tw'f_2) < 0\,;$$
$$\partial Q/\partial N = f_2 w'h/(1 + 24tw'f_2) > 0\,;$$
$$\partial Q/\partial h = f_2 w'N/(1 + 24tw'f_2) > 0\,.$$

As mentioned above, cost depends on the number of hours per day that a taxi is in service: $c = c(h)$. For the usual reasons given in micro textbooks we assume that $c(h)/h$ is u-shaped, with minimum value m at $h = h^*$. Costs of keeping a vehicle in service will surely rise rapidly as h approaches 24, if only because of the need to maintain the vehicle. But in terms of the number of rides q that a given taxi provides in any given hour that it is in service, cost is fixed. Average cost per ride, then, is hyperbolic up to a maximum possible number of rides per hour of $1/t$.[3] At $1/t$, the average cost curve becomes vertical.[4]

Hourly profit is, then, $p[Q/(Nh)]h - c(h)/24 = pQ/N - c(h)/24$. In the model, t is a parameter; Q is endogenous; p, N and h are either endogenous or subject to regulation.

3. Monopoly, the social optimum and the second best

As usual in microeconomic problems, a monopolist will maximize profits per unit time. Fleet profits per hour are

$$\pi = pf(p, w(Nh - 24tQ)) - Nc(h)/24\,,$$

and the monopolist maximizes with respect to choices of p, h and N:

$$0 = \partial\pi/\partial N = p\, \partial Q/\partial N - c(h)/24 = pf_2 w'h/(1 + 24tf_2 w') - c(h)/24\,;$$
$$0 = \partial\pi/\partial h = pf_2 w'N/(1 + 24tf_2 w') - Nc'(h)/24\,.$$

Therefore, $c(h)/h = c'h$, so that the monopolist's taxis operate at minimum average cost per hour m. Also, $24f_2 w' = m/(p - mt)$.

Maximizing with respect to p yields

$$0 = \partial\pi/\partial p = f + f_1 p/(1 + 24tf_2 w')\,.$$

[3] Fractional rides on average are conceptually possible because of the irregular nature of arrivals of customers and taxis.

[4] This is a different result from that obtained by others. For example, De Vany (1975, p. 87ff.) assumes smooth average cost curves as a function of output.

Substituting for $24f_2w'$ yields an implicit function for p:

$$p = mt - f/f_1 \,. \tag{1}$$

Rewritten as $(p - mt)/p = -f/pf_1$, Eq. (1) is the usual monopoly price mark-up formula. Marginal cost is $mt = tc'(h^*)$, the cost of increasing capacity to provide a trip of duration t at either margin, intensive (increasing h) or extensive (increasing N).

Social welfare per hour is defined to be the sum of consumers' and producers' surpluses. But the consumers' surplus must be carefully specified because of the fact that waiting time enters the demand curve. We emphasize that the consumers' surplus is obtained by integrating under a (hypothetical) demand curve in which the service level (waiting time) is held fixed while p varies, rather than under the market demand curve.[5] If $\bar{p}(w)$ is the choke price at the level of waiting time w, then social welfare when waiting time is fixed at w is

$$W = \int_p^{\bar{p}(w)} f(x, w)\,\mathrm{d}x + pf(p, w) - Nc(h)/24 \,.$$

The social optimum is obtained by maximizing W with respect to p, h and N. Assuming that W is concave in the relevant ranges of p, h and N, and recalling that $w = w(Nh - 24tf(p, w))$, we can use simple calculus:

$$0 = \partial W/\partial p = f(\bar{p}(w), w)\bar{p}'(w)\,\partial w/\partial p - f(p, w) + \partial w/\partial p \int_p^{\bar{p}(w)} f_2(x, w)\,\mathrm{d}x$$
$$+ f(p, w) + pf_1(p, w) + pf_2(p, w)\,\partial w/\partial p \,.$$

Let $\alpha = 24tw'$ and $I = \int_p^{\bar{p}(w)} f_2(x, w)\,\mathrm{d}x$. Since $f(\bar{p}(w), w) = 0$ and $\partial w/\partial p = w'(-24t)(f_1 + f_2\,\partial w/\partial p) = -\alpha f_1/(1 + \alpha f_2)$, this simplifies to $p = 24tw'I$. Also,

$$0 = \partial W/\partial N = (\partial w/\partial N)(I + pf_2) - c(h)/24 \,.$$
$$0 = \partial W/\partial h = (\partial w/\partial h)(I + pf_2) - Nc'(h)/24 \,.$$

Using $\partial w/\partial N = w'h/(1 + \alpha f_2)$ and $\partial w/\partial h = w'N/(1 + \alpha f_2)$, these three expressions can be simplified to show that $h = h^*$ and that $p = mt$. At the social optimum, taxis are used to their optimal intensity. Price is set equal to

[5] The market demand relates quantity demanded and price, conditional at any point on the waiting time inherent in that combination of quantity and price. An intra-marginal consumer's surplus must be calculated with respect to the waiting time inherent in the market price and quantity. A similar analysis is done by Anderson and Bonsor (1974).

the marginal cost of adding capacity (by increasing N or h). Since $q < 1/t$ (taxis are not always occupied), $pq < m$: at the optimum, profit is negative.

Running a private industry requires restricting N so that profits are non-negative. In that case, the second best is derived by forming the Lagrangean, $\mathfrak{L} = W + \lambda\pi$, and setting its derivatives with respect to p, h and N to zero. We find that profits are zero; that taxis are used at their optimal intensity; and that

$$p = mt - [f/f_1][24w'I - m]/[24w'(ff_2/f_1 + I)] . \tag{2}$$

In order to provide non-negative profits, price must exceed mt. But the second-best price is not necessarily less than the monopoly price.[6] If waiting is very costly to intra-marginal consumers, it may be socially superior to increase the number of taxis and to reduce quantity demanded by holding price above the monopoly level. Still, second-best pricing yields zero profit; optimal regulation would produce a medallion value of zero.

4. Free entry into an atomistic market

Modelling this industry as competitive would imply large numbers of firms facing large numbers of customers at a given instant at a given place. These conditions do not hold even approximately in the taxi industry. For example, in the cruising-taxi market, it is usual for a single customer to hail a single taxi as it goes by.[7] In this situation, where search may be costly to the consumer, customers who are risk averse may prefer a somewhat higher fixed fare to a fare established through bargaining with operators accustomed to 'sizing up' customers, with a high variance across conditions.[8] However, if there are few customers and large numbers of taxis, as may occur at a taxi stand, for example, then the customers have an advantage. Because the only cost incurred for giving a ride is the opportunity cost of being in service when another customer may come, Bertrand competition will drive the price to a low level. The taxi driver may prefer a fixed fare to facing a disadvantageous bargain in this situation, too. This may be the reason for the violence and bickering that broke out in some US cities when

[6] See the appendix for an outline of the derivation of these results.

[7] Because of the assumed nature of the industry, by and large there is no way a customary, mutually acceptable price can be established through repeated dealings between an individual who rides frequently and the same driver. Thus, we abstract from such phenomena as a customer's reserving a taxi each day at the same time.

[8] Gallick and Sisk (1987) give a heuristic account of the importance of costs of search in the taxi market.

fares were deregulated.[9] Modelling these intuitive notions is the purpose of this section.

Consider first low-demand periods such as late at night. One reason for regulation of the industry may be the social necessity of having service at these times. Customers and taxis will meet fairly rarely. In an unregulated market, questions of private information about the valuation placed on a trip loom important.[10] It is reasonable to suppose that, once the parties begin to negotiate a fare, there is a high cost to each to search for an alternative partner with whom to negotiate. Let us make, then, the extreme assumption that there is no opportunity to search for an alternative partner. In such a bargaining situation, Myerson and Satterthwaite (1983) have shown that there does not exist an equilibrium which is individually rational, incentive-compatible and efficient. This finding suggests that it may well be socially useful to institute some regulation in the market in periods of low demand.

During higher-demand periods there may be an opportunity to bargain with more than one counterpart if one incurs the cost of search. The existence of alternatives will affect the bargain concluded. We argue by contradiction that an equilibrium will not exist when search is possible.

Suppose that an equilibrium is established in the market in which arrivals of passengers at any time (i.e. demand) are distributed according to some probability distribution, and that taxi arrivals (supply) are distributed according to some other probability distribution. By the assumption of free entry, expected profits of a taxi driver will be nil. Suppose also, as seems reasonable at least for the cruising-taxi market, that the convention is that the driver quotes the fare. If there is an equilibrium at a fixed fare p and expected search cost is $c > 0$, then only potential passengers with valuations $v \geqslant p + c$ will enter the market seeking trips.[11] By a well known argument,[12] a driver, knowing that the passenger's valuation exceeds p, will quote a higher fare, breaking the equilibrium. Thus, there is no single-price equilibrium. By the same token, if there is a dispersion of fares in

[9] See Zerbe (1983) and Frankena and Pautler (1984). It is of some interest to note that Teal and Berglund (1987) observed that most of the new suppliers in deregulated markets went into the taxi-stand market, where customers' waiting time was already effectively nil. For telephone-dispatched taxis, the rate of 'no-shows' or refusals to serve a customer increased in almost all cities they studied.

[10] The valuation of a consumer, of course, takes into account any substitutes that exist for taxi service, such as bus, walking, etc.

[11] Here, it is not necessary to assume that consumers have different valuations of a trip. The important observation is that, whatever the distribution of v, only those willing to incur at least the sum of the equilibrium fare and the waiting cost will enter. If there is a distribution of waiting costs with greatest lower bound $\gamma > 0$, then a customer's being in the market reveals that $v \geqslant p + \gamma$.

[12] See, for example, Salop and Stiglitz (1982) and Stiglitz (1989).

equilibrium, the firm with the lowest price will lose no customer by charging a slightly higher price, given that the customer is in the market. The distribution of fares will collapse; there is no equilibrium.[13]

At this point it is worthwhile to digress briefly to discuss the implications of some other market institutions. In many cities, drivers group themselves into firms or cooperatives. It is important to recognize, however, that the fairly small number of cooperatives or firms observed in most cities is also not compatible with perfect competition. Cooperatives and firms would have reputations and other incentives to serve in a different way from competitors. The cooperative could fix the price, and an oligopolistic equilibrium could emerge.

Cooperatives are often established in order to operate telephone-dispatch systems. The cooperative's dispatcher acts like a broker, quoting a fare over the telephone. This brokerage function could operate for many taxi stands as well. A broker can capture surplus from the type of transaction involved in the taxi market (Myerson and Satterthwaite, 1983, p. 278ff.). In a market where there are important common facilities (such as telephone dispatching systems), some have advocated that the public sector own and operate those facilities (e.g. Baumol et al., 1982); but, if the civic government owned the dispatching facilities, the resulting civic control of the fare-setting process would be tantamount to regulation. Also, there would still be the possibility that the agency running it would be captured by the industry and would act as an effective means of promoting its interests in the civic government.

If the cooperatives were private, there would remain a problem of there being more than one equilibrium. As noted above in Section 2, the solution displays all the problems of multiplicity of equilibria found in the literature in job search.[14] There is no guarantee that the equilibrium chosen by the cooperative would be close to the second best, even if it did allow free entry into the cooperative and zero profits. Regulation may, then, be desirable.

5. Effects of regulation

We have seen in Section 3 that the second-best solution to the problem with a large number of individual taxi operators allows each no profit, with each taxi being used at optimal intensity (minimum hourly cost). But,

[13] If the passenger quotes the fare (as may be the case at a taxi stand where there are several drivers), the fare will be driven toward the short-run opportunity cost of a trip. Again, there will be no equilibrium.

[14] Orr (1969), Douglas (1972), Abe and Brush (1976) and Manski and Wright (1976) have also observed that there may be more than one equilibrium. Manski and Wright provide a numerical example. The reason for this is that, as N increases, w falls and consumers may be willing to pay a higher price.

depending on the demand function $f(p, w)$, there may be more than one pair (p, N) which satisfies these conditions. The expression for price allows the analyst to determine the second-best solution. Suppose that the second best is at (p^*, N^*). How can (p^*, N^*) be achieved?

An obvious solution is to regulate price, as many authors have suggested. The civic authority is in a position to estimate the optimal pair, (p, N), given demand. That means the authority knows the long-run reservation price p of the industry when there are N taxis in it. Price regulation would amount to setting a take-it-or-leave-it price at the then-known reservation value of the drivers. One might be inclined to view this as optimal, by analogy to a well known result (Tirole, 1988, p. 24).

Therefore, the position of those who advocate only price regulation is understandable: it is sufficient to regulate p. Certainly, with a regulated price an equilibrium will be established, a major step from the unregulated situation. Let us check the implications of regulating price only, at some level P.

In this case each taxi has $24Q/(Nh)$ trips per hour and daily profits of $24Pf(P, w)/N - c(h)$. In a Nash equilibrium an individual taxi-owner maximizes this expression with respect to h. Therefore,

$$(24Pf_2/N)(\partial w/\partial h) - c'(h) = 24Pf_2w'/(1 + 24tf_2w') - c'(h) = 0\,,$$

or,

$$P = tc'(h) + c'(h)/(24f_2w')\,. \tag{3}$$

Also, in a free-entry equilibrium, profits are nil, so that $24Pf = Nc(h)$. Eq. (3) is quite different from Eq. (2) for p in the second-best solution. Indeed, even if $h = h^*$, so that $c'(h) = m$, N will not be N^*. In general $h \neq h^*$ and $N \neq N^*$. Therefore, although an equilibrium can be attained by regulating price, price regulation is not enough to attain the second best. For further discussion see the appendix.

If only price is regulated, the civic authority must choose p while anticipating the response summarized by Eq. (3). That is to say, the regulator must take into account how the firms (non-optimally) take into account the congestion externality in equilibrium. The Lagrangean involves two constraints and one control, p:

$$\begin{aligned}\mathfrak{L} = \int_p^{\bar{p}(w)} f(x, w)\,\mathrm{d}x &+ \lambda[pf(p, w) - Nc(h)/24] \\ &+ \mu(24f_2w'p - 24f_2w'tc' - c')\,.\end{aligned}$$

Taking $\partial\mathfrak{L}/\partial p = 0$ we obtain expressions that involve, among other things, f_{12}, f_{22} and w'', each of which may be positive or negative.

Once p is regulated, an equilibrium can emerge. The market will in that case be like an open-access resource (e.g. a fishery); too much entry may ensue. Limiting N as well as p may help to improve welfare. If the regulator optimizes with respect to N, the constraint $\pi \geqslant 0$ may not (usually will not) be binding; a positive medallion value may arise.[15] Therefore, positive medallion values are not necessarily evidence of non-optimal regulation. Achieving the second best would require regulating h as well as p and N. But h may be difficult to monitor.[16]

In reality, too, rides are of varying duration and distance. The opportunity cost of taking one passenger is that the operator gives up the chance to transport another passenger (at the regulated fare, given the number of taxis operating). This is the reason for both the fixed component and the waiting-time compensation in the fare structure. The fact that rides are of different length means that regulation requires a meter as a method of determining the fare for any ride. This meter must be tamper-proof, and thus practicality dictates a single fare structure throughout the day, despite the peak-load problems.

6. Medallions as bonding devices

Our model can explain why prices and entry are regulated, as means of promoting the existence and efficiency of a market, and also why medallions have a positive market value. Here, we consider a second possible justification for a positive medallion value. Given the efficiency rationale, the medallion also constitutes a bond of the owner to the authority, which hopes to prevent 'shirking' in the delivery of services.

In a decentralized taxi market overseen by a civic government, monitoring of quality of service, including safety and comfort of passengers, proper maintenance of the vehicle, taking the most direct route, and holding to the regulated fare (or indeed to the fare agreed upon if bargaining is permitted) when the passenger is captive, can be potentially difficult.[17] This is a

[15] Suppose that the real interest rate is 5%, a taxi is in service an average of 15 or 16 hours per day and the medallion value V is \$50 000 or \$60 000. Then the rent per hour in service, $rV/365h^*$, is about half a dollar, a small fraction of the fixed component of the fare for a single ride.

[16] What, then, if p and h are regulated? Free entry will still result in profits of zero. If the regulated values of p and h are the second-best values then (unless there are two or more values of N satisfying all of these conditions), if $\partial\pi/\partial N < 0$ at (p^*, N^*, h^*) the second best can be attained, but not if $\partial\pi/\partial N > 0$. Of course, h is difficult to regulate.

[17] This can be true even if all the taxis of a city are organized into firms or cooperatives exercising only loose control over individual drivers. Looseness of control would seem inherent to the industry.

particularly acute problem in large cities, where many rides are taken by people from out of town. Anecdotes abound of 'shirking' in individual cases, but are far from describing the norm of daily operation.

If free entry were permitted into the industry, the owner would receive only his opportunity cost of labour and capital, as discussed above, and would have an incentive to shirk to the extent possible. If he were receiving more than these opportunity costs, then suspension of the right to drive as a penalty for shirking would entail an economic loss.

In the taxi industry there do not appear to be natural sources of surplus in the relationship between the owner and the civic government, such as those listed by Carmichael (1990, p. 279) as obviating the need for payment of efficiency wages in labour markets. For example there is little special, job-specific training (many drivers are recent immigrants hired by owners for periods when the latter are not working); there do not appear to be high costs of mobility into or out of the industry, etc. There is at least one major exception to this last observation: in London, taxi-cabs and drivers are specialized to the industry. Gallick and Sisk (1987, p. 125) observe that regulation, such as of the turning radius of the vehicle, makes the vehicle industry-specific. Also, prospective drivers must take an intensive course, involving considerable time, in order to qualify. In London, the medallion system is not used.

Carmichael doubts the relevance of models of efficiency wages to the labour market.[18] One of the most serious critiques he levels, however, is the possibility that other mechanisms, such as bonding, could perform the function of efficiency wages, without the accompanying Pareto inefficiency. Many observers of labour markets have noted that bonding is rarely observed. Such a mechanism does appear to exist in the taxi market, if the medallion is viewed as a substitute for a bond.

The economic literature on the taxi industry does occasionally discuss this rationale for a high positive medallion value. Frankena and Pautler (1984, p. 63–5) dismiss the reason, arguing that one would have to weigh the bonding aspects of the scheme against the benefits of greater competition in the industry that would result if medallions were eliminated; that bonding-type arguments were not originally used to motivate restrictions on entry; and that some cities do not appear to use revocation of licences as an enforcement device. Kitch et al. (1971, p. 292) argue that sanctions are usually light, amounting to a warning for the first offence and a several-day suspension for subsequent offences, and that only a small proportion of drivers are actually suspended. They report over 1600 suspensions in a 6 month period in Chicago in 1967. Suspensions for several days would

[18] For good discussions of efficiency-wage models, their problems and empirical evidence from two points of view see Carmichael (1990) and Lang and Kahn (1990).

constitute a threat of a more substantial economic penalty, such as revocation of the medallion. If the device is effective, one should not expect to observe frequent suspensions.[19]

In spite of their observations that medallion systems can control shirking and that a bond could be subject to opportunism by the regulator, Gallick and Sisk (1987, p. 127) conclude that a direct bonding arrangement might be superior to the medallion system. They express the intuition that a bond does not give rise to deadweight loss by remarking that, by investing the bond, one could earn a return that would not require a rise in the fare. One reason why the medallion system may be superior to a bond is that it obviates the criticism of Bull (1987), who argues that, for workers with finite lives, a reputation mechanism would be necessary in addition to a bond, in order to prevent opportunism by an employer. Moreover, the regulator has nothing to gain from unjust suspensions; indeed, he loses in terms of a reduction in the number of available taxis and consequent complaints about inconvenience to the public.

In this sense, the transitional gains trap (Tullock, 1975) could be viewed as a reputation mechanism: a civic government would not allow expected efficiency rents to fall, because such a fall would reduce incentives to provide good service. Allowing a fall could lead to a very substantial increase in the discount factor applied to anticipated future rents. However, as a city grows, monitoring of a dispersed industry may become more difficult. Increased difficulty of monitoring is a possible explanation for the fact that medallion values tend both to be positively related to the size of the city and to ratchet upwards periodically.

7. Conclusion

Price regulation is necessary to produce equilibrium in a simple model of the taxi industry, but if only price regulation is attempted the second best cannot be attained because of an externality among passengers. The second best can be achieved only if at least fares and intensity of use of taxi-cabs are regulated, but intensity of service may be difficult to monitor. The authority can improve upon price regulation by regulating the number of taxis as well. In this case, positive medallion values may be observed. In addition, if medallions are viewed as a type of bond of the owner of the taxi to the civic government or regulatory authority for the assurance of good service, positive medallion values may be justified. The type of regulation adopted can be viewed as having two rationales.

[19] An alternative device would be to fine offenders, but fines would not allow for the establishment of an equilibrium as discussed above.

Our results should not be interpreted as implying that any particular system of regulation in any particular city is socially efficient. Clearly, as we have mentioned in passing, a regulatory authority can be captured by the industry it regulates. This paper should be interpreted as implying that there are good reasons for regulation of this industry, and that a positive value for a taxi medallion is not necessarily evidence that regulation is inefficient. Neither is it evidence that the regulation was instituted because of rent seeking by the industry. Judging the effectiveness of regulation is an empirical matter.

Acknowledgements

We thank Helmuth Cremer, Russell Cooper, Georges Dionne, Gérard Gaudet, Chris Green, Joseph Greenberg, Seamus Hogan and Pierre Lasserre for helpful comments. Research on this paper was supported by the FCAR and by the SSHRCC.

Appendix

Results for the second best

We use the partial derivatives of w given in Section 2. Maximizing $\mathfrak{L}$ with respect to h and N yields $c(h)/h = c'(h)$. Eliminating λ from the equations obtained by maximizing with respect to p and N yields $(\partial W/\partial p)(\partial \pi/\partial N) = (\partial W/\partial N)(\partial \pi/\partial p)$. But,

$$(1+\alpha f_2)^2(\partial W/\partial p)(\partial \pi/\partial N) = f_1(p-\alpha I)h(pf_2 w' - m(1+\alpha f_2)/24)\,;$$

$$\begin{aligned}(1+\alpha f_2)^2(\partial W/\partial N)(\partial \pi/\partial p) = h[&w'(I+pf_2)\\ &- m(1+\alpha f_2)/24][f(1+\alpha f_2)+f_1 p]\,.\end{aligned}$$

Equating the two expressions on the RHS gives Eq. (2).

An example will show that monopoly and second-best prices, p_{m} and p^*, cannot be ordered. Suppose the elasticity of demand, $f_1 p/f = \varepsilon$ is constant. Then

$$\begin{aligned}&\varepsilon[(p_{\mathrm{m}} - mt)/p_{\mathrm{m}} - (p^* - mt)/p^*]\\ &\quad = -[m + 24w'ff_2/f_1]/[24w'(I + ff_2/f_1)]\,.\end{aligned}$$

The difference in price-cost margins (where the RHS is evaluated at second-best values), and hence in price, can be of either sign.

The second best and regulation

We have implicitly assumed that over the relevant range, π is concave in p, h and N. Therefore, π is quasi-concave, in h and N when p is fixed. Thus, the set of points for which $\pi \geqslant 0$ when p is fixed is convex. If p is regulated to be p^*, the set of points in (N, h)-space for which $\pi \geqslant 0$ is convex, and (N^*, h^*) is in its boundary.

Suppose regulation sets $p = p^*$ and $N = N^*$, i.e. to the second-best values, but leaves h free. Then

$$\begin{aligned}\partial\pi(p^*, N^*, h)/\partial h &= \partial/\partial h[p^*f(p^*, w) - N^*c(h)/24] \\ &= p^*f_2(p^*, w)\,\partial w/\partial h - N^*c'(h)/24 \\ &= N^*[p^*f_2w'/(1 + 24tf_2w') - c'(h)/24]\,.\end{aligned}$$

This may be compared with Eq. (3); p^* replaces P. The RHS is zero in equilibrium. At the second best $(h = h^*)$,

$$\partial\pi(p^*, N^*, h^*)/\partial h = N^*[p^*f_2w'/(1 + 24tf_2w') - m/24]\,.$$

Suppose this is zero, so that h^* is the equilibrium intensity of use of taxi-cabs. Then $24p^*f_2w'/(1 + 24tf_2w') = m$, or $p^* - mt = m/(24f_2w')$. Equating this expression for $p^* - mt$ to that in Eq. (2) yields

$$p^* - mt = -f/f_1\,.$$

All of Eqs. (1), (2) and (3) give the same result; i.e. industry profits are maximized at the second best, where $\pi = 0$. The set $\pi \geqslant 0$ degenerates to a single point. Otherwise (if $\partial\pi(p^*, N^*, h^*)/\partial h \neq 0$), firms will not choose h^* when regulation sets $(p, N) = (p^*, N^*)$.

Suppose, however, regulation sets $p = p^*$ and $h = h^*$ but leaves N free. Then

$$\begin{aligned}\partial\pi(p^*, N^*, h^*)/\partial N &= \partial/\partial N[p^*f(p^*, w) - Nc(h^*)/24] \\ &= p^*f_2(p^*, w)\,\partial w/\partial N - c(h^*)/24 \\ &= h^*[p^*f_2w'/(1 + 24tf_2w') - m/24]\,.\end{aligned}$$

Therefore, at the second best $(N = N^*)$,

$$\begin{aligned}(1 + 24tw'f_2)(24/h^*)\,\partial\pi/\partial N &= 24f_2w'(p - mt) - m \\ &= -I[m + 24w'ff_2/f_1]/[I + ff_2/f_1]\,, \quad \text{by Eq. (2)}.\end{aligned}$$

This can be positive, negative or zero. If $\partial\pi(p^*, N^*, h^*)/\partial N = 0$, we obtain $p^* - mt = m/(24f_2w')$ and the set $\pi \geqslant 0$ degenerates to a single point. If $\partial\pi(p^*, N^*, h^*)/\partial N > 0$, then entry will occur only until $\pi = 0$ and $\partial\pi(p^*, N^*, h^*)/\partial N < 0$. The second best cannot be attained by regulating only p and h in this case. If $\partial\pi(p^*, N^*, h^*)/\partial N < 0$ then free entry will lead to the equilibrium $N = N^*$, and the second best can be obtained by regulating p and h.

References

Abe, M.A. and B.C. Brush, 1976, On the regulation of price and service quality: The taxicab problem, Quarterly Review of Economics and Business, Autumn 16, 105–111.

Anderson, F.J.and N.C. Bonsor, 1974, Allocation, congestion and the valuation of recreational resources, Land Economics 50, February, 51–57.

Baumol, W.J., J.C. Panzar and R.D. Willig, 1982, Contestable markets and the theory of industry structure (Harcourt, Brace, Jovanovich, New York).

Beesley, M.E., 1973, Regulation of taxis, Economic Journal 83, 150–169.

Beesley, M.E., 1979, Competition and supply in London taxis, Journal of Transport Economics and Policy 13(1), 102–131.

Beesley, M.E. and S. Glaister, 1983, Information for regulation: The case of taxis, Economic Journal 93, 594–615.

Bull, C., 1987, The existence of self-enforcing implicit contracts, Quarterly Journal of Economics 102, February, 147–159.

Carmichael, H.L., 1990, Efficiency-wage models of unemployment: One view, Economic inquiry XXVIII 2, 269–295.

Coffman, R.B., 1977, The economic reasons for price and entry regulation of taxicabs: A comment, Journal of Transport Economics and Policy 11(3), 288–297.

De Vany, A.S., 1975, Capacity utilization under alternative regulatory constraints: An analysis of taxi markets, Journal of political economy 83(1), 83–94.

Diamond, P., 1971, A model of price adjustment, Journal of Economic Theory 3, 156–168.

Douglas, G.W., 1972, Price regulation and optimal service standards: The taxicab industry, Journal of Transport Economics and Policy 20, 116–127.

Frankena, M. and P.A. Pautler, 1984, An economic analysis of taxicab regulation, Staff Report of the Bureau of Economics of the Federal Trade Commission, Washington, May.

Gallick, E. and D. Sisk, 1987, A reconsideration of taxi regulation, Journal of Law, Economics and Organization 3(1), 117–128.

Kitch, E., M. Isaacson and D. Kasper, 1971, The regulation of taxicabs in Chicago, Journal of Law and Economics XIV, October, 285–349.

Lang, K. and S. Kahn, 1990, Efficiency-wage models of unemployment: A second view, Economic Inquiry XXVIII 2, 296–306.

Manski, C.F. and J.D. Wright, 1976, Nature of equilibrium in the market for taxi serivces, Transportation Research Record 619, 11–15.

Myerson, R.B. and M.A. Satterthwaite, 1983, Efficient mechanisms for bilateral trading, Journal of Economic Theory 29, 265–281.

Orr, D., 1969, The taxicab problem: A proposed solution, Journal of Political Economy 77(1), 141–147.

Salop, S. and J.E. Stiglitz, 1982, The theory of sales: A simple model of equilibrium price dispersion with identical agents, American Economic Review 72(5), 1121–1130.

Schroeter, J.R., 1983, A model of taxi service under fare structure and fleet size regulation, Bell Journal of Economics 14(1), 81–96.

Shrieber, C., 1975, The economic reasons for price and entry regulation of taxicabs, Journal of Transport Economics and Policy 9(3), 268–293.

Shrieber, C., 1977, The economic reasons for price and entry regulation of taxicabs: Rejoinder, Journal of Transport Economics and Policy 11(3), 198–204.

Shrieber, C., 1981, The economic reasons for price and entry regulation of taxicabs: A rejoinder, Journal of Transport Economics and Policy 15, 81–83.

Stiglitz, J.E., 1989, Imperfect information in the product market, in: R. Schmalensee and R. Willig, eds., Handbook of Industrial Organization, (North-Holland, Amsterdam), 769–847.

Teal, R.F. and M. Berglund, 1987, The impacts of taxicab deregulation in the USA, Journal of Transport Economics and Policy 21(1), 37–56.

Tirole, J., 1988, The theory of industrial organization (MIT Press, Cambridge, MA).

Tullock, G., 1975, The transitional gains trap, Bell Journal of Economics 6(2), 67–78.

Williams, D.J., 1980, The economic reasons for price and entry regulation of taxicabs: A comment, Journal of Transport Economics and Policy 14(1), 105–112.

Zerbe, R.O., 1983, Seatttle taxis: Deregulation hits a pothole, Regulation, November–December, 43–48.