An Optimal Regulatory Framework for
The Taxicab Industry

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Abstract

This paper confirms the possibility, as discussed in a number of papers on the subject, for regulation of the taxicab industry to improve welfare. While admitting the possibility that regulation may prove to be unsuccessful because of a lack of information or a lack of incentive, this paper outlines a regulatory framework that can enhance the likelihood of successful regulation. It consists of linking the different components of the taxi fare to economic costs and the joint determination of the per-trip fixed charge component with the annual licence fee of the taxi. This scheme is found to be superior to the auction of medallions which tend to lead to more politicisation in the fare determination process.

I. Introduction

The taxi industry provides an interesting case for public policy study for many reasons. First, the supply of taxicabs is often regulated. There is an argument to regulate the number of taxicabs on the road on grounds of externality because taxis are known to be an important cause of congestion and air pollution. Yet controlling the supply of taxicabs often is also in the private interest of the existing "firms" in the taxicab industry. In particular, given the system of "medallions" or permanent taxi operation permits commonly found in many jurisdications, unexpected restrictions in the supply of medallions will lead to impressive capital gains for the medallion holders. Because taxi-fares are also often regulated, speculation over the extent of periodic fare raises is yet another cause for large swings in the market price of the medallions.

In the literature analysts of the taxi industry fall into three camps: those in favour of regulation, those who are skeptical of the benefits of regulation, and those who actually oppose regulation. Shreiber(1975) favours restriction of supply to contain the external costs caused by taxis running on the road and to limit possible diversion of traffic from more economical modes of public transport. He also argued in favour of fare regulation to prevent the tendency of fares to creep upward(p.271). Douglas (1972), using a mathematical model, demonstrated the likely possibility of the equilibrium price being higher than the efficient one. While agreeing that regulation could improve welfare, Beesley and Glaister(1983) are concerned that regulators may not have the needed information to regulate correctly, and the "direct costs of operation and indirect costs of mistakes" may well nullify any benefits from regulation. Still others, such as Coffman(1977) and Frankena(1979) argue that regulators had little incentive to regulate in the public interest (Coffman, p.295; Frankena, p.75). Regulation would only generate monopoly profits for the medallion owners, and, by limiting the number of taxis and limiting competition, would raise fares and thus would even hurt the lower-income people relatively more because they "spend a larger share of their incomes on taxis than do high-income people" (Frankena. pp.74-75)[1].

While there is indeed no guarantee that regulation of taxis will improve welfare, this paper shows that a pricing structure that reflects economic costs will enhance the likehihood for regulation to improve welfare will improve welfare. Whereas in the conduct of macroeconomic policy discretion is a potential source of uncertainty and policy makers themselves may also be subject to errors of judgement, in the regulation of taxi fares and taxi numbers discretion is also a cause for much speculation and in the absence of clear guidance or policy rules regulators are likely to be subject to public pressures from various interest groups. A policy rule that specifies pricing according to economic costs will minimize regulatory errors. Unproductive rent-seeking behaviour may also be avoided.

Section II affirms the result, demonstrated in the literature, that there exists a potential for regulation in the taxi industry to improve welfare(Douglas, (1972), Beesley and Glaister(1983)). Section III discusses the crucial subject of pricing, and argues that a multi-component fare structure reflecting the various cost components of costs will improve welfare. Section IV addresses the subject of rent-seeking and regulator incentives, and argues for replacing the medallion system with a scheme of annual licensing. Finally, the concluding section will generalize the principle of multicomponent pricing in transportation pricing and discuss its relationship to land use.

II. A Simple Model

We represent the total equilibrium output of taxis per day(Q) as a function of the number of taxis on the road(T) and the average fare per trip(F). For simplicity output is

[1] This is probably true in Hong Kong, where many rich people have chauffeurs. Any expenditure by the rich people on taxi-trips is out of proportion to their income, while even the very low income people have to take occasional taxi-trips.

assumed to be equated with the number of passenger trips. It rises with productive capacity as represented by taxi number T and declines with fare level F. One peculiar aspect of the taxi industry is that the demand for taxi-trips will rise with productive capacity and fall with the fare, while the equilibrium output as measured by the number of taxi-trips accommodates to changes in demand. The social value of output Q is assumed to decline with the average waiting time per passenger trip(w) and can be represented by:

$$V(Q(F,T)) - w.Q.c_t \qquad \textbf{(1)}$$

where V is the value of output in the absence of any waiting, and c_t is the time cost per minute for each passenger. V can alternatively be written as

$$\int_{q=0}^{q=Q} MBdq \qquad \textbf{(2)}$$

where MB is the marginal benefit of output. Accordingly, $\partial V/\partial Q = MB(Q)$.

The net social value of taxi services per day is equal to:

$$Z=V(Q(F,T))-w(F,T).Q(F,T)c_t-c_o.T-C_e(T) \qquad \textbf{(3)}$$

where c_o, is the all-inclusive daily operating cost per taxi while c_o, is the total external cost caused by the taxis T. This formulation incorporates the fact that it is the taxis cruising in the streets, rather than *engaged* taxis, that cause external costs. Waiting time is assumed to depend on the ratio of passenger trips(Q) to the number of taxis on the roads, and is written simply as a declining function of the fare F and taxi number T.

We can maximize Z with respect to the fare F and taxi number T. Using this approach the government is seen to determine the number of taxis permitted, and to set the fare at the optimal level. Under this approach the permitted taxi-operators will generally earn an economic rent. If entry into the taxi industry is to be open and fair, an *annual* licence fee will have to be imposed and it will have to be at a level consistent with normal profit *and* the optimal fare for *that year*. Clearly, with demographic and economic changes, the optimal fare will change each year, leading to a different optimal licence fee from year to year. To achieve optimality Z must be maximized simultaneously with respect to the fare F and the licence fee L each year[2]. We can rewrite (3) as:

$$Z=V(Q(F,T(F,L))-w(F,T(F,L)).Q(F,T(F,L))c_t-c_oT(F,L)-c_e(T(F,L)) \qquad \mathbf{(3')}$$

Maximizing Z with respect to F and L gives:

$$\frac{\partial Z}{\partial F}=\frac{dV}{dQ}\frac{\partial Q}{\partial F}+\frac{dV}{dQ}\frac{\partial Q}{\partial T}\frac{\partial T}{\partial F}-\frac{\partial w}{\partial F}Q.c_t-\frac{\partial w}{\partial T}\frac{\partial T}{\partial F}Q.c_t-wc_t\frac{\partial Q}{\partial F}$$

$$-wc_t\frac{\partial Q}{\partial T}\frac{\partial T}{\partial F}-c_o\frac{\partial T}{\partial F}-\frac{dC_e}{dT}\frac{\partial T}{\partial F}=0 \qquad \mathbf{(4)}$$

and

$$\frac{\partial Z}{\partial L}=\frac{dV}{dQ}\frac{\partial Q}{\partial T}\frac{\partial T}{\partial L}-Qc_t\frac{\partial w}{\partial T}\frac{\partial T}{\partial L}-wc_t\frac{\partial Q}{\partial T}\frac{\partial T}{\partial L}-c_o\frac{\partial T}{\partial L}-\frac{dC_e}{dT}\frac{\partial T}{\partial L}=0 \qquad (5)$$

which can be rewritten:

[2] Actually the optimal licence fee and the optimal fare could vary from day to day, but changing these variables each day will be impossible because of information, administrative, and adjustment costs. In principle, optimality *could* be achieved under the present medallion auction mechanism if the government *knows* the right number of medallions. Normal profit for taxi-owners *could* result if the price of medallions accurately reflects economic rents well into the future. If there is no perfect foresight, medallion prices may over- or under- represent future economic rents, generating unknown pressures for fares to deviate from optimal levels.

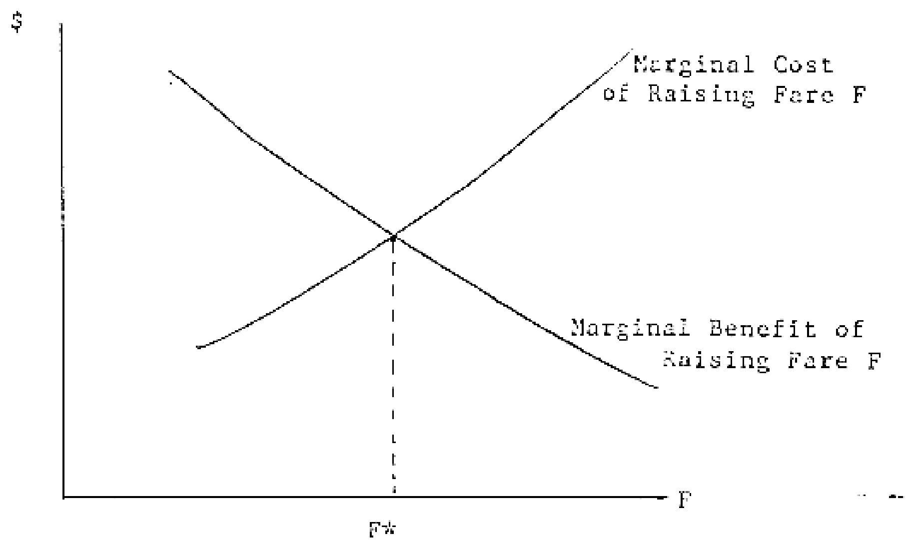
$$(\frac{dV}{dQ} - wc_t)\frac{\partial Q}{\partial T}\frac{\partial T}{\partial F} - (\frac{\partial w}{\partial F} + \frac{\partial w}{\partial T}\frac{\partial T}{\partial F})Q.c_t = (\frac{dV}{dQ}wc_t)\frac{\partial Q}{\partial F} + (c_o + \frac{dC_e}{dT})\frac{\partial T}{\partial F} \quad \textbf{(4')}$$

and

$$(\frac{dV}{dQ} - wc_t)\frac{\partial Q}{\partial T}\frac{\partial T}{\partial L} - Q.c_t\frac{\partial w}{\partial T}\frac{\partial T}{\partial L} = (c_o + \frac{dC_e}{dT})\frac{\partial T}{\partial L} \quad \textbf{(5')}$$

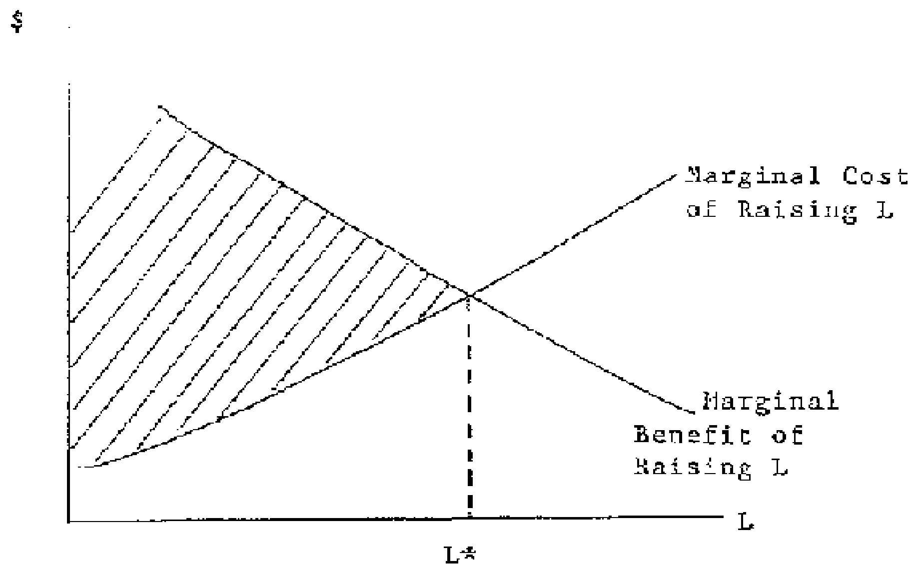
Equation (4') equates the marginal benefit of raising taxi fare(LHS) with the marginal cost of raising taxi fare(RHS) . The former consists of (1) the net value of induced output resulting from attracting entry of new taxi operators, and (2) the direct and indirect effects of raising fares on waiting. The latter consists of the net cost in terms of reduced output resulting from the higher fare, as well as the operating and external costs associated with induced entry. Equilibrium condition (4') can be pictured as follows:

Figure 1



Equation (5') equates the marginal cost of raising taxi licence fee L(LHS) with its marginal benefit (RHS). The former consists of the net value of output lost as the licence fee discourages entry and the cost in terms of longer waiting for the original passenger trips. The latter consists of lower operating and external costs associated with the discouraged entry. The equilibrium condition is pictured below:

Figure 2



Clearly, the optimal outcome has to be based on the joint determination of F and L. Free entry in the absence of a licence fee will result in a loss of welfare equal to the area of the shaded triangle in Figure 2, even if the fare is right. On the other hand, if the licence fee, actual or imputed as obtains under a quota system, deviates from L*, the second best fare will also deviate from F*.

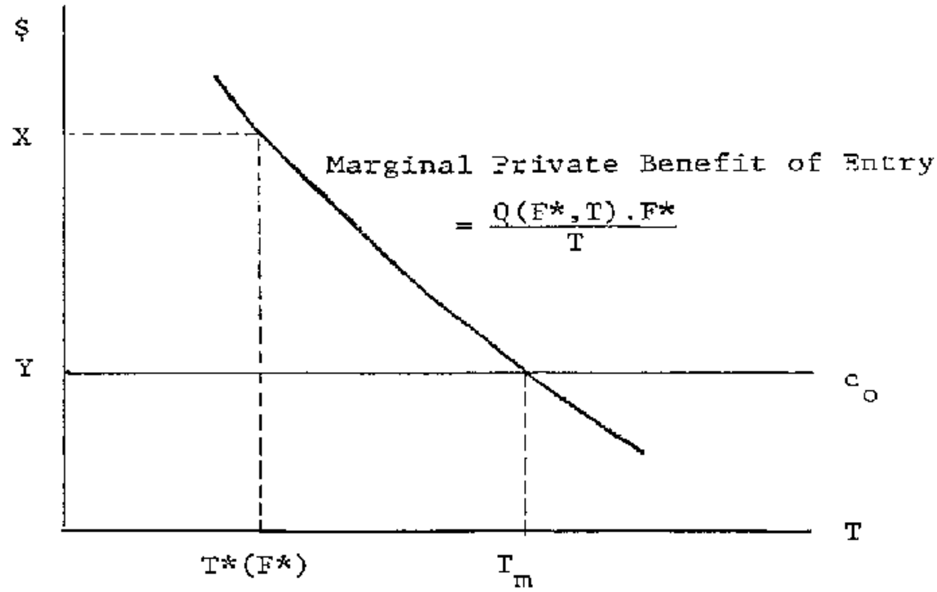
Taking another perspective, Figure 3 shows that even if the fare is at the first best level F*, unregulated entry will increase the total number of taxis as long as the average revenue per taxi exceeds the average operator's cost, i.e., as long as:

$$\frac{Q(F^*,T).F^*}{T} > c_o$$

entry will continue. The free market equilibrium with licence fee at 0 is T_m, which exceeds the optimal taxi number given the optimal fare F* as determined above[2]. It may be noted that in general the competitive equilibrium number of taxis is not unique, because different combinations of (F, T) can be consistent with normal profit (Douglas, pp.119-122). Of these equilibria, only one set (F*, T) is economically optimal.

Assuming that T* is the optimal number of taxis, then a licence fee equal to XY per day and allowing unrestricted entry will automatically achieve the desired number of taxis, given taxi fare F*. This when annualized should equal the optimal licence fee as discussed above. Moreover, with free entry and exit taxi operators will cover all opportunity costs of operating, inclusive of their normal returns.

Figure 3



[2] A corollary of this argument is that at the optimal taxi number T* the taxi fare compatible with normal profit and zero licence fees would also deviate from the optimal level.

III. Pricing

It is clear that whether regulation will indeed improve welfare depends on whether the optimum number of taxis are allowed to run and whether fares are set optimally. Without a guiding principle that helps regulators find these numbers regulators are likely to respond to pressures from the various interest groups. More importantly, without a fare-fixing formula that is deemed scientific fare determination as well as decisions over how many taxis are permitted to run readily becomes a political issue. Intelligent decisions become impossible.

To obtain the optimal pricing formula we first note that in the real world all taxi trips are not homogenous. Some trips are longer while other trips are shorter. Some trips are smooth while others may be caught in heavy congestion. In Hong Kong frequent complaints have been lodged against taxi-operators who differentiate among and select passengers. In order to minimize the complaints it is necessary to reduce the uncertainty and anxiety confronting taxi operators every day by structuring fares so as to make them better reflect costs.

In particular, the fare should comprise a time-based component, a mileage-based component, and a per-ride charge. This is because the economic cost of a typical trip can be broken down into these components. The cost of the operator's time and the economic rental cost of the taxi are time-based and has to be covered.[3] It does not matter if the taxi is running or waiting. The cost of fuel and maintenance are mainly mileage-based. In order for the mileage-based component to cover the cost of running the taxi, the per-unit-distance charge should simply equal the fuel cost and expected maintenance cost per unit distance. Finally, each time a taxi has completed a trip it has to spend time looking for new passengers. The

[3] The rental cost of the taxi should provide the taxi owner a competitive rate of return to his investment.

"non-engagement time" of a taxi generally rises with the number of separate trips it makes in a day. Thus the per-ride charge is intended to cover the average opportunity cost of the 11 non- engagement" of the taxi when it is in between engagements. It is at the same time the variable to adjust in order to achieve the optimal waiting time for passengers. When the value of passengers' time is higher the per-ride charge should also be higher.

If the taxi fares are to be structured in the way proposed, fare determination will become more objective, and can be worked out easily on the basis of hourly compensation to driver, operation and maintenance cost of taxis, opportunity cost of capital, and target average waiting time for passengers. An annual taxi licences should also be introduced to regulate the number of taxis as suggested in the last Section.

III. Rent Seeking and Licensing

Concern over the quality of the environment and traffic congestion often requires strict control over the number of taxis that are allowed to run. We have already seen how the optimal number of taxis and fares should be determined in consideration of economic costs, both private and external. Under a medallion system such as in operation in Hong Kong, however, competitive rent seeking on the part of medallion owners and would-be owners may interfere with the correct pricing of taxi fares and the number of new medallions auctioned per year. Concern for the profitability of the taxi industry and protection of public transit on the part of regulators may also dominate over concern for efficient resource allocation (Frankena, 1979, p.75).

From the point of view of medallion owners, fare increases with no entry is the best, for this will raise the rental charges for taxis, with consequent capital gains in medallion values. From the point of view of would-be-owners, medallion prices should be depressed as long as they have not yet owned a medallion, so that they could buy cheap. These would-be-operators are mainly taxi-operators currently renting cabs from owners. They also like to raise the fares, even though increases in rentals will tend to erode any incomes over the transfer earnings of the taxi operators. Finally, to the extent that the medallions fall into the hands of only a few investors these investors have some leeway of limiting the supply of medallions in the secondary market, where demand is subject to complex influences of expectations and speculator behaviour.

Table 1 Number of Registered Taxis and Average Tender Premiums

1980-1991

Year	Number of Registered Taxis	Average Tender Premium $
1980	9118	210798(Jan.) 178805(March) 210090(June) 259686(Sept.)
1981	10171	244066(Jan.) 267958(April) 182144(Sept.) 171709(Dec.)
1982	11367	178647(March) 182024 (June) 206550(Sept.) 182675(Dec.)
1983	12468	160761(March) 143865 (July) 133902(Sept.) 140222 (Dec.)
1984	13534	157183(March) 164886(July)
1985	13800	199255(Jan.) 219771(June)
1986	14000	292140(Jan.) 372042(July)
1987	14132	449530(Jan.) 596189 (July)

1988	14400	600886(Jan.) 694443(July)
1989	14600	820546(July)
1990	14750	909562(Nov.)
1991	14750	1512055(Dec.)

Source: Transport Department

In Hong Kong medallions for urban and New Territories taxis are auctioned on a "fee simple" basis. As of 1993 about 15000 urban taxis and 2600 N.T. taxis are in operation. The number of new medallions auctioned varies from year to year. The market price of these medallions fluctuates greatly, but in general has risen very rapidly over the years (Table 1). This spectacular surge in the price of the medallions, amounting to some 10-fold increase since 1984, is very much a result of intense demand fuelled by the expectation that taxi-fares may be raised rapidly and that the demand for medallions will continue to outstrip supply. The rise in the opportunity cost of time and the concern over traffic congestion in general[5] combine to make higher fares and a limit to the number of taxis economically sensible. This naturally increases the economic rents accruing to the owners of taxis. who reap these rents generally in the form of capital gains in the prices of the medallions.

As the prices of the medallions rise, there is much pressure from the more recent owners who had acquired the medallions at premium prices to raise the rentals charged to the taxi-operators. As taxi-operators need to cover their opportunity costs, these rentals can only be increased if fares are raised. It is apparent that the taxi-operators will hardly benefit from these fare increases. Indeed as the fares rise and taxi rentals rise the dream of becoming a taxi owner will become even more remote. With incomes more or less fixed at competitive levels, higher medallion prices will become increasingly unaffordable. While this is in itself not an economic problem in itself, the fact that owning a taxi is getting beyond the reach of the taxi-operators has led to much public concern, and could potentially lead to policies not economically justifiable.

If taxi fares are determined according to the framework that we have proposed, compensation to taxi-operators will no longer become a consideration in fare fixing. This would be an important departure from the current system, where taxi-operators propose a new fare structure every year for consideration by the Transport Advisory Committee. If the proposed pricing scheme is implemented, the daily economic rent from operation of the taxis will become a residual consisting of (a) the excess of expected total per-ride charges collected per day net of compensation for driver's time and operation cost during the non-engagement time plus (b) total taxi rentals net of the imputed cost of capital invested in the taxi per day. One logical policy recommendation that emerges from this analysis is to issue taxi operation licences at an annual cost reflecting this economic rent.

If annual taxi operation permits or licences are to be issued in place of medallions, one question is what to do with the existing medallions. The easy way out is to allow both taxis authorized by medallions and taxis authorized by annual permits to operate alongside each other. Medallion owners will simply collect the per-ride charges as a rent without having to pay annual fees, while permit-holders will pay the annual licence fee for the right to collect the per-ride charges. Another option is for the government to buy back the medallions from their present owners. This option will involve a cash outlay on the part of the government, but in return the government will collect any increase in economic rents arising from unexpected fare rises and other developments.

V. Conclusions

The proposed pricing framework has relevance beyond Hong Kong and the taxi industry. The principle that efficient pricing formula should be based on the structure of economic costs associated with a service has been applied to road pricing in Ho (1986), where it was shown that time-based road pricing was superior to mileage-based road pricing. In telephone service operator-assisted calls is likewise based on a connection charge and a time-related charge. In each case the time-related charge proves to be an important mitigating factor against congestion. The taxicab industry is, however, particularly interesting because it is often regulated and that under the medallion system owners have much stake in both the pricing formula and in the number of new medallions issued.

In general, taxi fare determination as well as government policy regarding the supply of new medallions has important redistributive effects, bitterly lobbied for and against by different groups. A scheme of pricing that specifically link different components of fares to costs, and a system of licensing based on annual charges will avoid these problems and will more likely lead to the efficient outcome.

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