THE ECONOMICS OF CHEATING IN THE TAXI MARKET

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(Rceived 11 March 1982, in revised form 28 April 1982)

Abstract—Drivers and fare usurers usually increase with the length of the ride and because many passengers are ignorant of which is the most direct route to their destination, taxi drivers have an incentive to cheat their customers by taking circuitous routes. In this paper we provide a theoretical analysis of such cheating. We find that a monopolist's profit per customer is increased from a competitive firm; that an increase in the number of taxicabs will increase the extent of cheating; and that in the absence of a certain form of differential pricing policy, operators will either cheat some customers or refuse to serve others.

1. INTRODUCTION

In most cities the fare for a taxicab ride is an increasing function of the length of the trip, so that a taxicab operator can increase his profits by taking a circuitous route to the passenger's destination, instead of taking the most direct one. Although no reliable data exist concerning the extent of such cheating, this phenomenon is not merely a theoretical possibility; in twelve trips between the Los Angeles airport and downtown Los Angeles, an investigating reporter for the Los Angeles Times was charged seven times. Drivers taking indirect routes added as much as $2.60 (that is, 43%) to the cost of a ride (see Los Angeles Times 1979).

This type of overcharging is, of course, present in other markets as well (such as those for the services of physicians, lawyers, plumbers, or automobile repairmen). But the taxicab market possesses some distinguishing features which make it particularly appropriate for study. First, because few passengers are likely to encounter the same driver more than once and because many passengers are visitors who will leave the city soon after obtaining service, the prospect of repeat patronage is remote; a taxicab operator who cheats his customers loses little future business by doing so. This feature distinguishes the present analysis from that given by Doherty and Karmi (1975) in their seminal paper. The latter authors see each firm as choosing a price that will maximize the value of current profits plus the anticipated present value of future profits obtained from services to a given customer. In contrast, our analysis focuses on the relationship between different price structures and a firm's incentive to serve many customers quickly and honestly, instead of spending that time defrauding a few unfortunate consumers.

Second, cheating in the taxicab market usually takes the form of providing overly long rides; it is a rare passenger who is delivered short of his destination. (Nevertheless, taxicab operators may simply refuse to serve some passengers, an issue we deal with below.) Finally, a passenger obtains no benefit whatsoever from a ride which is longer than necessary. All these stand in contrast to the medical market, for example, in which the client relationship plays an important role, and where the benefit obtained by the customer is usually an increasing function of the amount of service provided.

By considering these special features of the taxicab market, we are able to offer a reasonably simple model of a market in which cheating occurs. Our assumptions are set forth in Section 2. In Section 3 we consider the case in which all consumers are identical; this model is generalized in Section 4. In section 5 we determine the characteristics of a fare structure that makes cheating unprofitable. Concluding comments are offered in the final Section.

2. FRAMEWORK

As mentioned above, this paper determines the relation between the fare structure (which is taken to be exogenously set), and the degree of cheating in the taxicab market. In providing a ride of duration t, the operator earns a revenue of x(t) dollars. We treat x(t) as being given exogenously, but it is useful to discuss the forms it may take. Fares in the taxicab industry are usually set by a governmental agency. Most of the fares consist of a fixed charge, F, plus a variable charge (let, say, p), for each minute or mile the passenger is served. Then, the regulated fare is roughly F + pt. But the driver faces the risk that a passenger refuses to pay the fare, or that, believing he has been cheated, the passenger imposes monetary and non-monetary costs on the driver. Thus, x(t) = F + pt + some other, generally nonlinear, term.

Let c(t) be the variable cost of providing service, so that the driver's net revenue in serving a passenger for t minutes in x(t) = x(t) - c(t). Such a function is shown

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curve GG in quadrant I of Figure 1. The only assumption made about \( g(t) \) is that it be an increasing function of \( t \). If \( g(t) \) is not everywhere convex, we need consider only its convex hull. Thus, in Fig. 2, if \( g(t) \) is given by the solid curve, the curve relevant for our purposes is the one depicted with broken segments. For convenience, this latter curve is referred to as \( g(t) \).

Taxis operate in the following manner. A driver picks up a passenger and serves him for, say, \( t \) minutes, thereby earning a net revenue of \( g(t) \) dollars from that customer. The driver must search for a new passenger upon the completion of each ride. The driver does not know precisely how long he will have to wait until he finds a new customer; but he does know that the expected length of time spent searching for a new customer is \( w \) minutes. The operator earns no revenue and incurs no expenses during a period in which the taxi is unoccupied.

The taxi operator's objective is to maximize profit, that is, to maximize his total net revenue for the period under consideration, or, equivalently, to maximize average net revenue. In serving any \( N \) passengers the driver earns a profit of \( N g(t) \) dollars, and spends an average of \( N(w + t) \) minutes waiting and driving. Thus, the driver's average net revenue is \( g(t) \cdot (w + t) \), and he wishes to maximize this function given his control over \( t \). Maximization requires the marginal net revenue equal average net revenue. Thus, in Fig. 1, if \( w = w^* \), the optimal value of \( t \) is \( t^* \). Average net revenue is given by the slope of line \( w = w^* \), which equals marginal net revenue as given by the slope of curve GG at point C.

There is no reason to suppose that this value, \( t^* \), represents the minimum time required to serve a passenger. It may well be that the same distance could be covered in only \( t' \) minutes (where \( t' < t^* \)). The value of \( t - t' \) represents the extent of cheating practiced in the market. The equilibrium duration of a ride depends on \( w \), a driver's expected waiting time for a passenger. In a market in which there are many taxis, no one driver can affect the value of \( w \) observed in that market. Yet \( w \) itself is a function of the lengths of rides offered. Recall that to such value of \( t \) these corresponds a price for the

![Figure 1](image-url)
ride, \( d(t) \). Consumers' demand for taxi rides is, of course, a function of this price, of the expected duration of a ride (ceteris paribus, consumers' demand for taxi service is greater the more quickly a passenger is delivered to his destination), and of the expected length of time a consumer must wait until he is served. But a consumer's expected waiting time is, in turn, a function of the total number of consumers who desire service; the greater the number of passengers served, the longer each consumer must wait for service. Thus, consumer demand, which we denote by \( D \), can be given by the function \( D = f(D, d(t), t) \). But this means that holding constant consumer income and the prices of all other goods, \( D \) is a function of \( t \) alone, say \( D = g(t) \).

We can now turn to a discussion of drivers' waiting times. For any fixed number of taxis, each driver's waiting time is a function of the number of passengers who wish to be served and of the average length of a ride; the greater the demand for rides, the longer the duration of a typical ride, the shorter the expected length of time each driver must wait to find a new passenger. We can therefore write \( w = w(D(t), t) = g(t) \).

Thus, it is evident that a driver's expected waiting time is a function of the length of rides. Note that the form of the function \( w \) reflects the effects of two important features of the market: that the demand for rides is a function of a passenger's expected waiting time and of the amount of cheating practiced in the market.

It is impossible to determine on a priori grounds whether \( w \) is an increasing or a decreasing function of \( t \). An increase in \( t \) has two opposing effects. On the one hand, it should decrease the number of consumers who demand service, and thereby increase \( w \). On the other hand, the longer each passenger is served, the fewer the number of taxis that are occupied, and therefore the lower the value of \( w \). Because the analysis is very similar in the cases in which \( w \) is a decreasing and an increasing function of \( t \), the interests of theory and of the market both consider only the former case. Two such functions are shown as curves A and B in the fourth quadrant of Fig. 1.

With the aid of the 45° line shown in quadrant III of Fig. 1, we can put the apparatus to work, and determine the equilibrium levels of the duration of a ride, the price of a ride, and a taxi driver's waiting time.

A EQUILIBRIUM IN A SIMPLE MODEL

Two equilibria are depicted in Fig. 1, at points C and D. We examine first the former one (and ignore for the moment curve BB). When \( t = t_2 \), we read from curve AA that \( w = w_2 \). Given that \( t = t_2 \), each driver maximizes average net revenue by setting \( t = t_2 \). At this equilibrium, the net revenue obtained from each customer is \( g(t_2) \), average net revenue equals \( g(t_2) + \frac{w(t_2)}{2} \), and line \( x = w(t_2) \) is tangent to curve BB at point C.

Suppose next that the function \( w \) changes in any manner, whatever the effect of increasing a driver's expected waiting time for any given value of \( t \). In quadrant IV of Fig. 1 this is depicted by a shift in the function \( w(t) \) from curve AA to curve BB. If curve \( GG \) is concave, then such a shift necessarily leads to an increase in the equilibrium value of \( t \) in our case, given curve BB rather than AA, the new equilibrium value of \( t \) in \( t_3 \), where \( \frac{w(t_3)}{2} = w_2 \), the net revenue obtained from each customer has increased from \( g(t_2) \) to \( g(t_3) \), and a driver's average revenue has decreased from that given by the slope of line \( w = w(t_2) \) to that given by the slope of line \( w = w(t_3) \).

Two applications of this result may prove useful. Suppose that in the initial equilibrium \( t = t_2 \). If the number of passengers is increased, then we would expect that for any given value of \( t \), each driver's waiting time increases; that curve AA shifts down to curve BB. In the new equilibrium the value of \( t \) has increased from \( t_2 \) to \( t_3 \). An increase in the supply of taxis that has resulted in an increase in cheating.

As another application, suppose there is an exogenous increase in the demand for rides (which may be caused, for example, by a busy strike). This has the effect of shifting a curve such as \( AA \) upward and to the left. In the new equilibrium, the value of \( t \) will have decreased and the extent of cheating will have diminished.

These effects have been ignored in the literature (see,
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for example, Aby and Bruijn (1976), Coffman (1977), De Vany (1973), Doughts (1972; Markit and Wright (1976), Orr (1969) and Schriber (1977). Virtually all of this literature on the taxicab industry focuses on one aspect of the market: consumers' demand for service, and the utility they derive therefrom, is a function not only of the price of a ride, but also of the length of time a consumer waits for service.

The authors of these articles therefore agree that excess capacity does not necessarily reduce the level of social welfare; for the lower the utilization rate of taxis, the less time consumers have to spend waiting for service. But this view is misleading: it ignores the possibility that drivers cheat their passengers. Because a driver can serve each passenger for an unduly long time, and will wish to do so when passengers are hard to find, an increase in the number of taxis has the effect of increasing both the average length of a ride and the fare that passengers pay; the increase in capacity may have little effect on the availability of taxis.

*Analytically, the monopolist's objective is to maximize $g(w(t)+\delta t)$. A necessary condition for a maximum is that $g'(w(t)+\delta t) = g'(w(t)) + \delta t$. From this, we have $w(t)+\delta t = \pi^{\text{eq}}(t)+\delta t$, and therefore $g'(w(t)+\delta t) = g'(w(t)) + \delta t$. But at point $t$, $g(w(t))+\delta t = \pi^{\text{eq}}(t)+\delta t$, so that at point $t$, $g'(w(t)) > g'(w(t)) + \delta t$. This is, the monopolist can increase his profit by choosing a value of $\delta t$ which is greater than the equilibrium value of $\delta t$ in a competitive market (282).

So far we have analyzed the equilibrium solution in an atomistic market in which the behavior of any one driver does not affect the behavior of other drivers or consumers. We can, however, also determine the profit maximizing level of $t$ that would be chosen by a monopolist.

Suppose that a fixed number of taxis are operated by one firm; that is, management can instruct each driver on the length of time, $s$, he should serve each passenger. As before, assume that the net revenue function, $g(w(t))$, is continuously fixed, and that the firm's objective is to maximize total revenue; but once again this objective is identical to the maximization of the revenue earned each minute a taxi is in operation. The monopolist will choose that value of $t$ that maximizes $g'(w(t)+\delta t)$; but whereas an operator in a competitive market views $w$ as fixed, the monopolist recognizes that $w$ is a function of $t$.

A monopolist's optimal solution is shown by point $P$ in Fig. 1. Each passenger is served for $\mu w$ minutes, each driver waits an average of $\mu w$ minutes until he finds a new passenger; the average revenue earned per minute is given by the slope of line $w(t)M$, which we note, is less than the slope of line $w(t)$, representing average net revenue in a competitive market.

In this example, the monopolist serves each passenger for a longer period than would a driver who individually maximizes revenue. This result is generally true if the curves depicting $g(t)$ and $w(t)$ are upward sloping. Cheating may be a more serious problem in a monopolist than in a competitive market.

Fig. 1. $g(t)$ and $w(t)$ are upward sloping.
A TWO CLASSES OF CONSUMERS

The present section examined the equilibrium amount of cheating for the case in which all consumers are identical. More generally, each consumer, different consumer, wish to be transported to different locations. One passenger's destination may be a shun a ride away, where the driver may be mugged, while another passenger's wish to be driven to a suburb a distance of twenty miles.

The net revenue, $n(t)$, obtained from these two passengers may be shunted to the same side. A passenger's ticket is $t$, in which case several interesting questions arise. How long is each consumer served? Are all passengers served or does a driver find it profitable to refuse service to some consumers and instead to wait for some other passengers? What is the effect of an increase in the fare for one class of customers on the quantity of service provided to other customers?

We suppose that the population of potential passengers is equally divided between the two classes. The net revenue obtained from each type-I consumer is shown by curve H1 in Fig. 3, and the net revenue obtained from type-II consumers is shown by curve H2. A driver need not, of course, treat these two types of consumer identically; let $t_i$ be the length of time provided to type-I consumers, and let $t_2$ be the corresponding value for type-II consumers.

The first topic we address are the values of $t_i$ and $t_2$ chosen by a driver when both classes of consumers must be served. The problem is easily solved by considering it in two stages: first the optimal choice of $t_i$, and then (the average time a passenger is served), and second, the optimal choices of $t_i$ and $t_2$ subject to the constraint that $[t_1 + t_2] = T$.

Consider first the latter problem. It is clear that for any fixed $T$, the values of $t_1 + t_2$ must satisfy the condition that the added revenue of obtaining from serving a consumer for an additional unit of time to be equal for all consumers, or that $g(t_1 + t_2) = t_1 + t_2$. Given this condition, and the identity that $T = [t_1 + t_2]$, we can find the optimal values of $t_1$ and $t_2$ for any given value of $T$. We can therefore also determine the value of $t_1 + t_2$; $g(t_1 + t_2)$; and $t_1 + t_2$. This function $g(T)$, representing the admissible operator's net revenue from providing rides whose average length is $T$ minutes, is shown by curve $T_2$ in Fig. 3. For example, when $T$ equals $72$, the optimal value of $t_1$ is $42$, and the optimal value of $t_2$ is $30$. $g(T)$ is given by the length of segment $T_2$, the slope of curves $T_1$ at point $I$, $J$ at point $J$, and $SS$ at point $S$. $SS$ is the average duration of a ride is $T$ minutes, then the average revenue that can be obtained from a passenger is $g(T)$, which can be read off the curve $T_2$.

Once curve $T_2$ has been derived $T_2$ can be used in the same manner as $T_1$ was used in $T_1$. If the average duration of a ride is $T$ minutes, then the average revenue that can be obtained from a passenger is $g(T)$, which can be read off the curve $T_2$.

In the absence of space, each driver also spends some time searching for passengers. A driver's average waiting time per customer, $w$, is a function of the average values of $t_1$ and $t_2$ observed in the marketplace. But since we know the values of $t_1$ and $t_2$ for any value of $T$, we can determine the function $w(T)$, which is shown by curve $AA$ in quadrant IV of Fig. 3. Finally, as in the discussion of the simpler case, once the value of $w$ is known, the driver's optimal strategy can be found from the point of tangency between the curve $AA$ and a line originating at point $(0, 0)$.

Under the assumption that both classes of consumers are served, an equilibrium is depicted in Fig. 3 by those points with superscripts $A$. The equilibrium value of $w$ is $w^{*}$. The optimal value of $t_1$ and $t_2$ at this value of $w$ is $T_2$, and point $SS$ line $w^{*}$ is tangent to curve $T_1$, and $SS$ is the average duration of a ride in $T$ minutes, and each type-II passenger is served for $2S$ minutes. The driver's average net revenue is given by the slope of the line $w^{*}$. There is no reason to suppose, however, that a driver will wish to carry all passengers he may find. It may be worthwhile for any one driver to serve only type-II passengers. Suppose that initially all but one of the drivers serve both classes of customers, and the other driver serves only type-II passengers. As these type-II consumers constitute only half of the total number of consumers, the driver's average waiting time for a type-II consumer is $w = 2T_2$. Given this value of $w$, the driver maximizes net revenue by serving each type-II customer for $2S$ minutes; for all that value of $s$, the line $w^{*}$ is tangent to curve $H_1$. Observe that the slope of line $w^{*}$ is greater than the slope of line $w^{*}$, which means that the driver earns a larger average revenue than do drivers who serve all passengers. Moreover, passengers may prefer to be served by a driver who serves only type-II consumers. Recall that the slope of curve $H_1$ at point $S$ is $2S$, which is equal to the slope of curve $S$ at point $S$. But if $N^*$ is $w^{*}$ is stronger than line $w^{*}$, and curve $H_1$ is concave, then $SS$ must be less than $SS$. It matters in which city that is, the provision of unconceivably long rides is a problem, consumers served by a driver who transports only type-II consumers will be cheated less than are other consumers. To summarize, a driver who does not serve all...
classes of customers will earn greater profits and will change a lower fare than will drivers who serve all customers. In equilibrium, it is likely that the operators refine to serve some classes of customers.

Finally, given the restraints between curves SS of Fig. 3 and curve GG of Fig. 1, it is easy to see that all of the results obtained in Section 3 also apply to the case in which there exist more than one class of customers; in general drivers will find it profitable to cheat their customers; an increase in the number of taxicabs in service will lead to more cheating, and may therefore have little effect on decreasing customers' waiting time; cheating is likely to be an even more serious problem in a monopolistic than in a competitive market.

A CHEAT PROOF PRICES

The previous sections showed that the value of $t$ chosen by the seller is determined by the fact structure, i.e., the form of $g(t)$. In this section we determine the nature of a price structure that induces drivers to serve all customers without cheating any one of them.

The nature of the problem is best illustrated by a simple example, although the results can be applied more generally. Let the population be equally divided between two types of customers. Let the maximum amount of time required to transport each type-H and type-L customer be $t_H$ minutes and $t_L$ minutes respectively; we define cheating to occur whenever a driver serves a passenger in service for a longer period than this required minimum. Let the taxicab operator receive $p_D$ dollars for serving a customer for $t_L$ minutes, and let him receive $p_H$ dollars for serving a customer for $t_H$ minutes. Although these fares are fixed, the operator determines the length of service he provides each customer; he may, for instance, serve type-H customers for $t_H$ minutes, where $t_H > t_L$.

Our first goal is to determine prices such that the driver will not find it profitable to cheat in such a manner. If the driver does not cheat, his average revenue is

$$\frac{p_H + P_D}{2t_H + t_L}$$

If he does cheat, he serves each passenger for $t_L$ minutes at a charge of $p_H$; the driver's average revenue would be

$$\frac{2p_H}{2t_H + t_L}$$

The driver will not cheat type-H customers if

$$\frac{p_H + P_D}{2t_H + t_L} > \frac{2p_H}{2t_H + t_L}$$

or

$$P_D = \frac{2t_H + t_L}{2t_H + t_L} p_H$$

(4)

As all that matters is relative prices, we can assume that $p_H$ is fixed; it follows that the lowest value of $p_D$ for which the driver will find no gain in cheating a type-H passenger is that for which

$$p_D = \frac{2t_H + t_L}{2t_H + t_L} p_H$$

(5)

But eqn (5) implies that, in general, the price structure must have the form $g(t) = p_L + p_H = F + pt$ where $t$ is the length of a ride, $p$ is the charge per minute of service, and $F$ is a fixed charge.

This pricing structure has an additional attractive feature: it provides the driver with an incentive to serve a passenger regardless of the length of ride the passenger desires. To see this, recall that the average revenue earned by a driver who serves all customers (with no cheating) is given by eqn (1). If the driver serves only type-H customers he expects waiting time for a customer to be $2t_H$, so that his average net revenue is

$$\frac{p_H}{2t_H + t_L}$$

(6)

The driver will find it unprofitable to serve only type-H passengers if and only if

$$\frac{p_H + P_D}{2t_H + t_L} > \frac{2p_H}{2t_H + t_L}$$

(7)

Substituting $p_H = p_L + p_H$, and $p_H = p_L + p_H$ in expression (7), we obtain

$$\frac{2p_H + F + p_L + p_H}{2t_H + t_L} = p_L$$

(8)

But inequality (8) is always satisfied; given the prices specified drivers will not find it profitable to refuse service to some customers.

Notice that these prices, $F + pt$, are non-linear in the sense that

$$F + \frac{pt}{2t_L}$$

We conclude that, apart from any considerations of price discrimination, the average price per mile of a long taxicab ride should be less than that of a short ride. The price of a ride would be proportional to the total time necessary to provide service, including the expected time a driver spends to find a passenger. In other words, cheat proof prices should consist of both a fixed charge and of a variable charge that is a function of the length of service provided.

The fixed charge, $F$, should be proportional to $t_H$. If $F < pt$ then, in general, a driver would feel it profitable to
serve few customers and to cheat those customers he
does serve. If $F > pw$ the driver would find it profitable
to refuse service to some passengers who require long
rides, and would instead serve many customers each of
whom he can transport in a short period. That is, any set
of prices that differ from the ones specified above may
cause drivers to cheat or else to refuse service to some
groups of customers.

4. CONCLUSION

Regulation of the taxicab industry has traditionally
consisted of two uncoordinated parts: the setting of
fares at some remunerative level, and the use of ad-
ministrative procedures to deal with problems of service
quality. The usual response, for example, to complaints
of inadequate service in some areas of the city is the
instituting of ineffective rules requiring taxicab operators
to serve all customers; complaints of cheating by drivers
may lead to the occasional levying of fines against the
culprits.

We have argued, however, that these problems may
arise simply because of the adoption of an improper fare
structure. The use of a two-part tariff which reflects both
the cost of transporting a passenger and the cost of
finding him may prove effective in solving problems of
the quality of service.

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