# THE AUCTIONING OF URBAN HIGHWAY FRANCHISES*

**Pablo Serra****

## ABSTRACT

**Urban highways are a scarce resource. For this reason, the auction of urban highway franchises to the private sector should take into account the congestion which affects them. In this paper a form of auction is proposed which consists of fixing maximum tolls, taking social welfare into account at both peak hours and off-peak hours, and then, following the proposal of Engel, Fischer and Galetovic, by granting the franchise to the applicant that demands the least revenue for constructing and operating the highway until such revenue has been collected. The authority could temporarily raise either or both maximum tolls.**

## SINTESIS

**Las vías urbanas de alta velocidad son un recurso escaso. Por esta razón, la licitación de concesiones de tales vías al sector privado debe tomar en cuenta la congestión que las afecta. En este artículo se propone un mecanismo de licitación que consiste en la fijación de tasas máximas de peaje, tomando el bienestar social en cuenta, tanto en las horas de congestión como también en las de no congestión, para luego, siguiendo la propuesta de Engel, Fischer y Galetovic, adjudicar la concesión al postulante que demanda el retorno más bajo por construir y operar la vía hasta que el ingreso respectivo haya sido recolectado. La autoridad podría aumentar, transitoriamente, uno o ambos peajes máximos.**

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## 1. INTRODUCTION

This note proposes a means of auctioning the construction and operation of urban highways in Chile.[1] Franchises should be designed so as to maximize social welfare at the same time as being attractive for private entrepreneurs. Although to reconcile these two objectives certain practical and theoretical challenges need to be resolved, it should not be forgotten that, at the world level, Chile has been a pioneer in the application of efficient regulation systems for privatized public utilities. The auction method proposed here to a large degree fulfills the objectives indicated above, and, in particular, the analysis is extended to the principal practical problems of auctioning.

The government is franchising highway projects to take advantage of the management capacity of the private sector in the running of the highways, within an overall social welfare-maximizing objective. For the government it is difficult to administer highway projects efficiently. Charging the appropriate toll is not simple, especially due to the pressure of transport industry associations. For the same reason it is difficult to penalize users whose vehicles exceed the weight limit, something which has a big impact on a road's useful life. In addition, the maintenance of public highways is erratic, because it is strongly influenced by public finances, and governments tend to underinvest in maintenance because it is more attractive to inaugurate new projects.

Through the concessions system the private sector is financing the construction of new highway and airport projects. The first project —a 20 million dollar tunnel— was put out to tender at the end of 1992 and inaugurated in September 1995. The second project put out to tender is the so called "lumber route" at a cost of around 25 million dollars. The third franchised project is the northern access to the city of Concepción with a cost of approximately US$100 million. Recently bids for the airport at Tepual were opened, and in the coming months other airports will follow. It is expected that, in the next five years, projects with a total value of US$3 billion will be auctioned.

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[1] The auctioning of franchises has long been recognized as an alternative to the regulation of natural monopolies. The idea is, in the the words of Chadwick (1959), to "promote competition for the field when competition on the field is not possible."

In general the auctioning of inter-urban highway franchises has operated in the following way. The government specifies the technical conditions of the project and grants the concession to the bidder that offers to charge the lowest toll to users. In some cases a ceiling and floor price are imposed. If the ceiling is very low the bidders may seek a subsidy, with the concession going to the applicant that seeks the lowest subsidy. On the other hand, if the floor is very high the concession will be won by the firm which offers the biggest payment to the state.[2] An alternative form of auction is where the state fixes the toll and duration of the franchise, and this is granted to the applicant that offers the highest payment or demands the least subsidy.[3] Recently Engel, Fischer and Galetovic (1996) have proposed setting the toll and then giving the concession to the firm demanding the lowest income in present-value terms for constructing and operating the highway, until the required income is achieved. In this case the duration of the concession is endogenous. This method of auction is, as we shall see, particularly appropriate for urban highway franchises.

In Chile there is experience with inter-urban highway project concessions. However, there are at least four differences between the urban highway franchise and the inter-urban one: (i) The authorities have more possibilities of influencing the results of the urban franchise-holders, (ii) the charging of tolls in cities is technically more difficult, (iii) the construction of rapid highways generates urban problems, and (iv) unlike inter-urban highways which are always susceptible to widening to accommodate a growing vehicle stock, space for constructing urban roads is a scarce resource.

In highway concessions, traffic, and therefore the franchise-holder's income, can be strongly influenced by government decisions regarding the rest of the road network. Although this also occurs in inter-urban franchises, in the urban case the range of decisions influencing traffic on a given road is much broader. For example, traffic can be affected by the construction of access roads, complementary or substitute routes, the expansion of the subway system, or by road-user charges on congested streets. In the case of inter-urban networks the impact of eventual decisions by the authority is less.[4]

Until a few years ago one obstacle to the use of tolls on urban highways was the cost of collecting the toll. Manual charging would have meant the installation of a high number of toll booths which would have had a negative urban impact, as well as increasing journey time. Likewise this would have strongly limited the number

[2] The ceiling price is justified for social reasons. A high toll may be privately profitable but socially inefficient. For its part the floor allows the transfer of money to the state for related work previously carried out by the government, which facilitates the creation of a coherent toll infrastructure.

[3] In the auction of the El Melon tunnel in practise the government fixed the toll and granted the concession to the bidder that offered to pay most.

[4] Unless the authority, for some reason, had as an objective harming the franchise-holder. But even in this case it would be difficult for the authority to explain behaviour which reduced social welfare, and the franchise-holder could have recourse to the courts of law.

of accesses and exits on the toll road. However the experience of Hong Kong in the 1980s has shown that electronic toll-charging is technically feasible (Arnott, de Palma and Lindsey, 1993). Singapore is also implementing a system of electronic charging.

The construction of a large-capacity urban highway can cause the deterioration of an area or else may even improve it. The complexity of the real estate business makes it difficult to coordinate urban remodelling with the construction of a highway project. However there should be a commitment regarding the forms and times of remodelling so as to ensure an appropriate result. In this way the opposition of residents in the zones affected by the passage of the road will be diminished. In addition, according to expert opinion, it is not possible to provide roads for an increasing vehicle stock, because the latent demand set always uses up whatever expansion there may be in urban highway capacity. As a consequence urban highways are a scarce commodity, for which reason it is plausible to expect them to be congested at least at peak hours. Besides, it is also necessary to remember the problem of atmospheric and noise pollution associated with vehicle use, which ought to indicate a preference for public means of transport.

Considering the problem of congestion in this paper, it is proposed to fix the maximum tolls both for peak periods and off-peak periods, and then grant the franchise to the bidder requiring the least income in present-value terms for building and operating the highway, until the desired amount has been received. Maximum tolls are determined so as to maximize social welfare. The discount rate for calculating present value corresponds to the market rate relevant to this sector. This form of auctioning franchises has several advantages. As the present value of incomes to be received by the franchise-holder would be determined, the risks associated with the decisions of the authority would be less. However incentives for the franchise-holder to operate efficiently would also be maintained, because in this way it will recover the income needed in a shorter time, which in turn reduces the present value of operation and maintenance costs.

To determine optimum tolls precisely is practically impossible. Furthermore these ought to change over time. For this reason the authority should have the freedom to raise the maximum prices. The advantage of using ceiling prices is that in the event that the authority decides to raise them, the franchise-holder would not be obliged to change the tolls. In this way the possibilities of conflict between the authorities and the private operator are reduced. However it is highly probable when the authority raises the ceiling prices a franchise-holder would do something similar with the tolls.

The rest of this paper is organized in the following way. Section 2 presents a review of the literature on congestion. Section 3 compares the different forms of auctioning urban highway concessions. Section 4 analyzes the franchise business. The last section gathers together a few final observations.

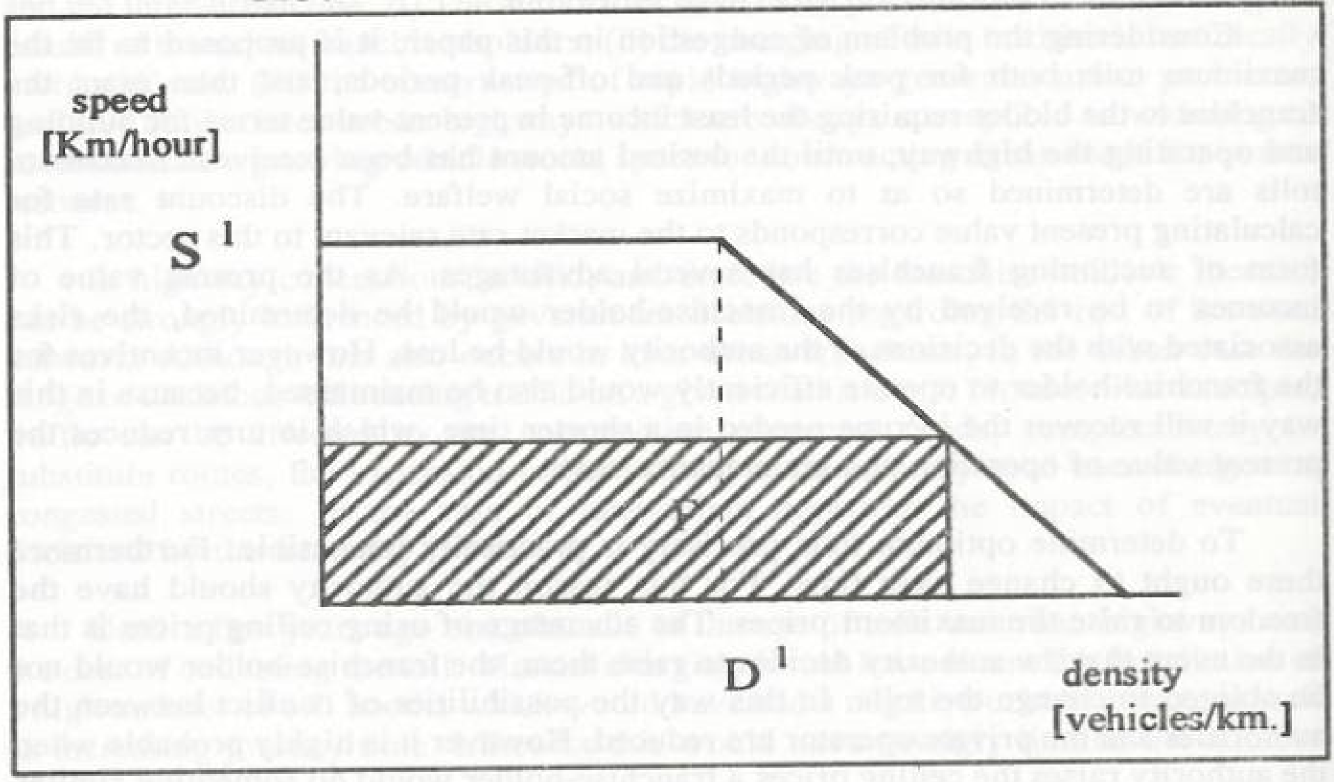
## 2. CALCULATION OF TOLLS

The concern to derive optimal tolls to meet congestion on urban highways dates back to the middle of the past century (see for example Winston, 1985, page 78). The problem however was formalized for the first time by Walters (1961). The central element of his approach is the observation that the speed of movement along a road beyond a certain threshold depends on the traffic flow along it.[5]

### 2.1. Congestion model

In this section the Walters approach is presented graphically.[6] A route is said to be congested when the entry of vehicles reduces speed. One talks of hyper-congestion when the entry of new vehicles not only increases journey time, but also reduces the total flow. In consequence when there is congestion (or hyper-congestion) speed depends on traffic density. Vehicles can move at the maximum speed which we denote by $S^1$ when traffic density is reduced, but when the threshold $D^1$ is surpassed, speed diminishes with density, as is shown in Figure 1.

FIGURE 1. SPEED AS A FUNCTION OF DENSITY

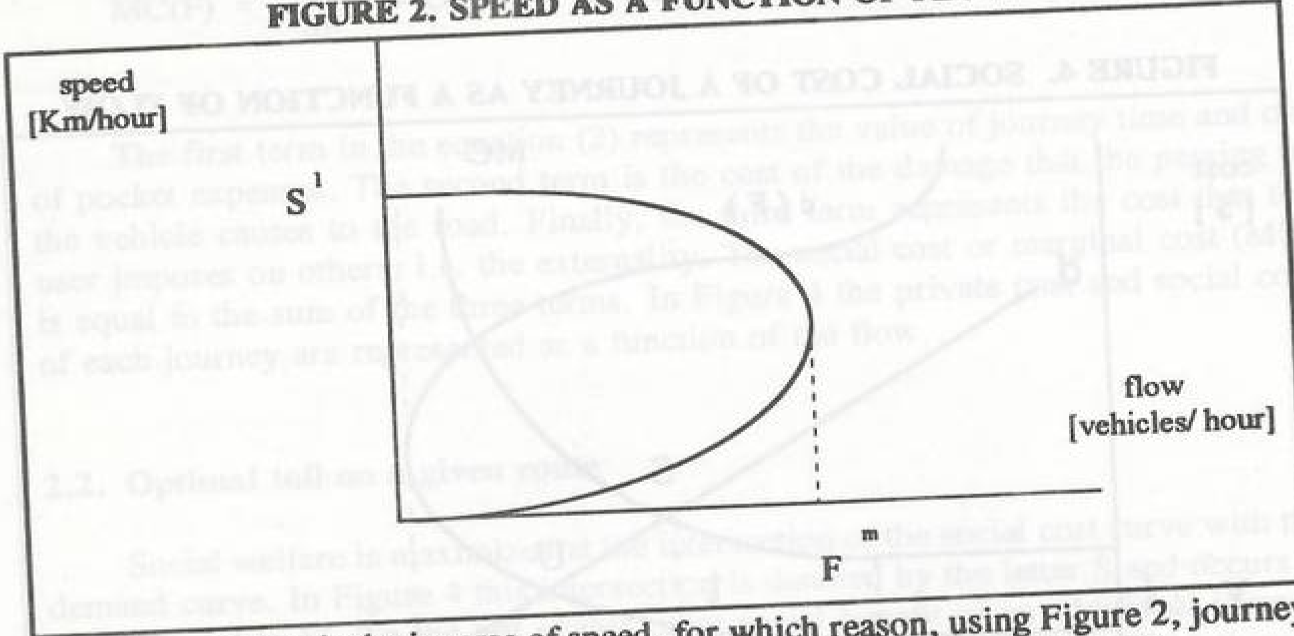



[5] This approach has been criticised by Arnott, de Palma and Lindsey (1993), who hold that the Walters interaction-congestion model is incomplete because it does not take in to account dynamic aspects. Journey time does not only depend on the number of users at that moment, but also on the number of vehicles which had previously entered the highway. For that reason they prefer the Vickery model (1969), in which congestion takes the form of a queue behind a bottleneck. On the other hand this model only considers a very special situation: a highway that is not congested except at peak hours.

[6] Expositions of the work of Walters (1961) can be found in Schiff (1991) and Hau (1992).

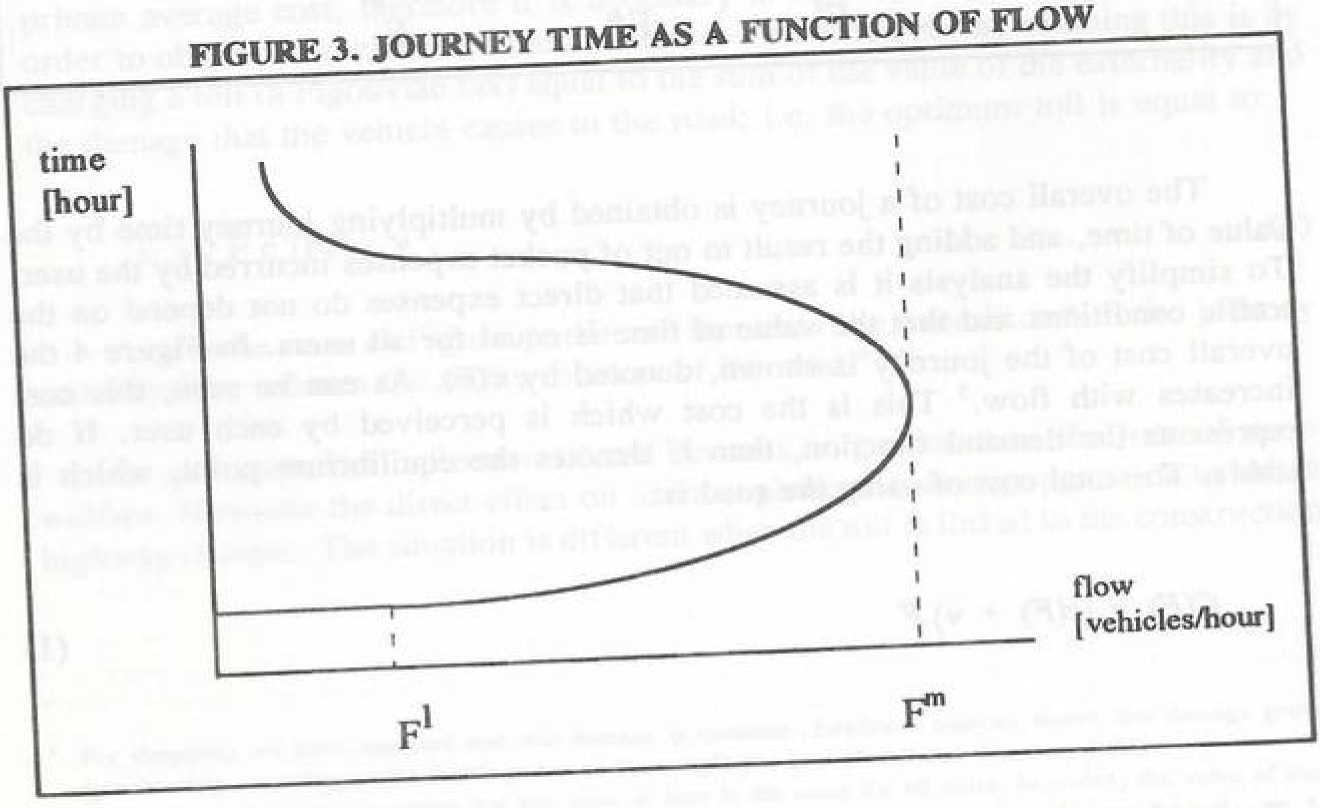
The total flow per hour which we denote by F, is obtained by multiplying the speed by density. On the basis of Figure 1 the total speed is derived as a function of the flow, which is represented in Figure 2. There is a maximum flow which it is possible to achieve on the highway, and this we denote by $F^m$.

FIGURE 2. SPEED AS A FUNCTION OF FLOW



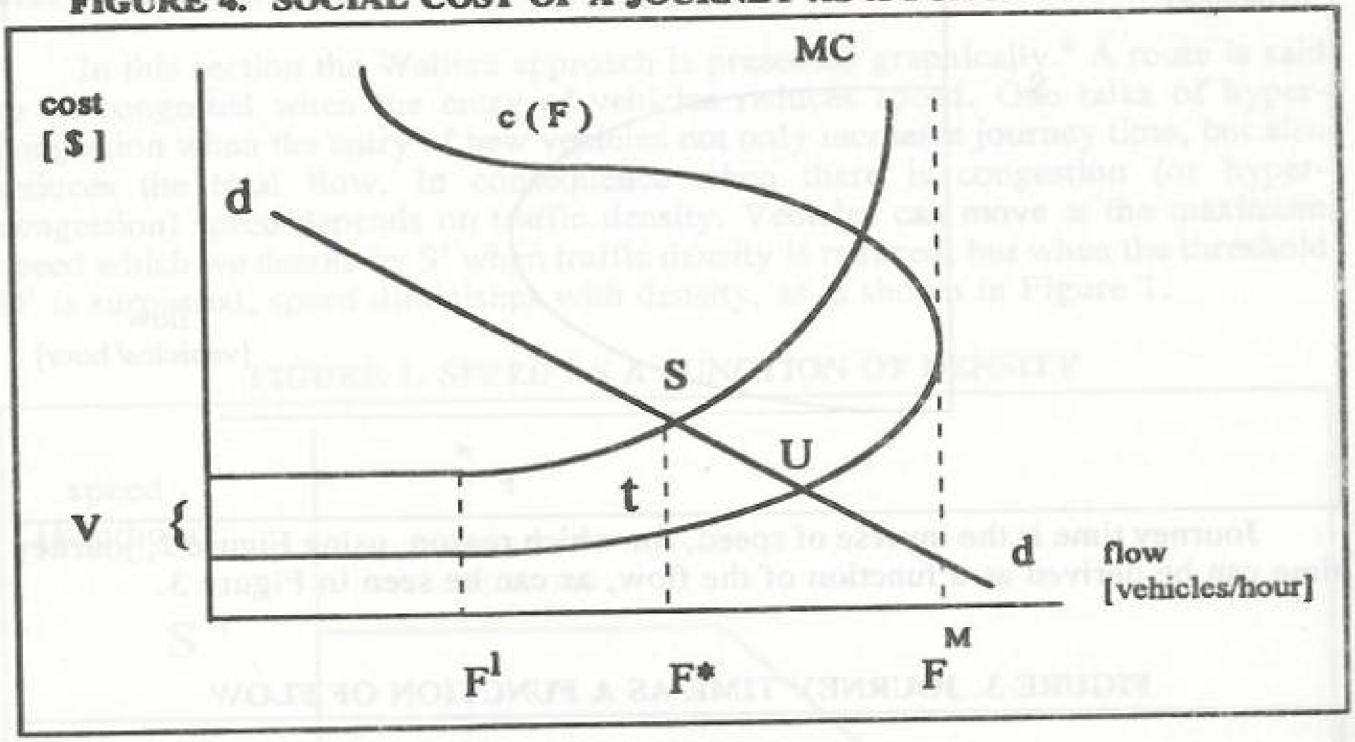

Journey time is the inverse of speed, for which reason, using Figure 2, journey time can be derived as a function of the flow, as can be seen in Figure 3.

FIGURE 3. JOURNEY TIME AS A FUNCTION OF FLOW



When the flow per hour is less than $F^1$ ($=D^1 S^1$) there is no congestion, and journey time is $1/S^1$. If the flow exceeds $F^1$, journey time increases with the flow; this is the congestion zone. When density exceeds that which allows achieving maximum flow $F^m$, any additional increase in density not only reduces speed but also total flow; this is the hyper-congestion zone.

FIGURE 4. SOCIAL COST OF A JOURNEY AS A FUNCTION OF FLOW




The overall cost of a journey is obtained by multiplying journey time by the value of time, and adding the result to out of pocket expenses incurred by the user. To simplify the analysis it is assumed that direct expenses do not depend on the traffic conditions and that the value of time is equal for all users. In Figure 4 the overall cost of the journey is shown, denoted by c(F). As can be seen, this cost increases with flow.[7] This is the cost which is perceived by each user. If dd represents the demand function, than U denotes the equilibrium point, which is stable. The total cost of using the road is:

$$C(F) = (c(F) + v)F \tag{1}$$

[7] There may be a cost arising from the increase in the accident rate with congestion.

Where $\nu$ represents the cost of the damage caused to the road by the passing of a vehicle.[8] Then the entry of the new user on the road has the following effect on total cost:

$$MC(F) = \frac{dC(F)}{dF} = c(F) + \nu + F c'(F) \tag{2}$$

The first term in the equation (2) represents the value of journey time and out of pocket expenses. The second term is the cost of the damage that the passing of the vehicle causes to the road. Finally, the third term represents the cost that the user imposes on others, i.e. the externality. The social cost or marginal cost (MC) is equal to the sum of the three terms. In Figure 4 the private cost and social cost of each journey are represented as a function of the flow.

## 2.2. Optimal toll on a given route

Social welfare is maximized at the intersection of the social cost curve with the demand curve. In Figure 4 this intersection is denoted by the letter S and occurs at a flow equal to $F^*$. To the left of this point social benefit of an additional journey is greater than its cost whereas to the right the opposite is the case. When there is free entry, equilibrium is produced at the point U where the demand curve cuts the private average cost, therefore it is necessary to restrict access to the highway in order to obtain the socially optimum solution. The efficient way of doing this is by charging a toll (a Pigouvian tax) equal to the sum of the value of the externality and the damage that the vehicle causes to the road; i.e. the optimum toll is equal to:

$$\tau = F c'(F) + \nu \tag{3}$$

As can be seen in Figure 4, the toll increases the overall cost of the journey and therefore reduces the utility to users of the road.[9]

In any case, the collection of toll revenue is greater than the loss of user-welfare. However the direct effect on users explains the strong opposition to urban highway charges. The situation is different when the toll is linked to the construction

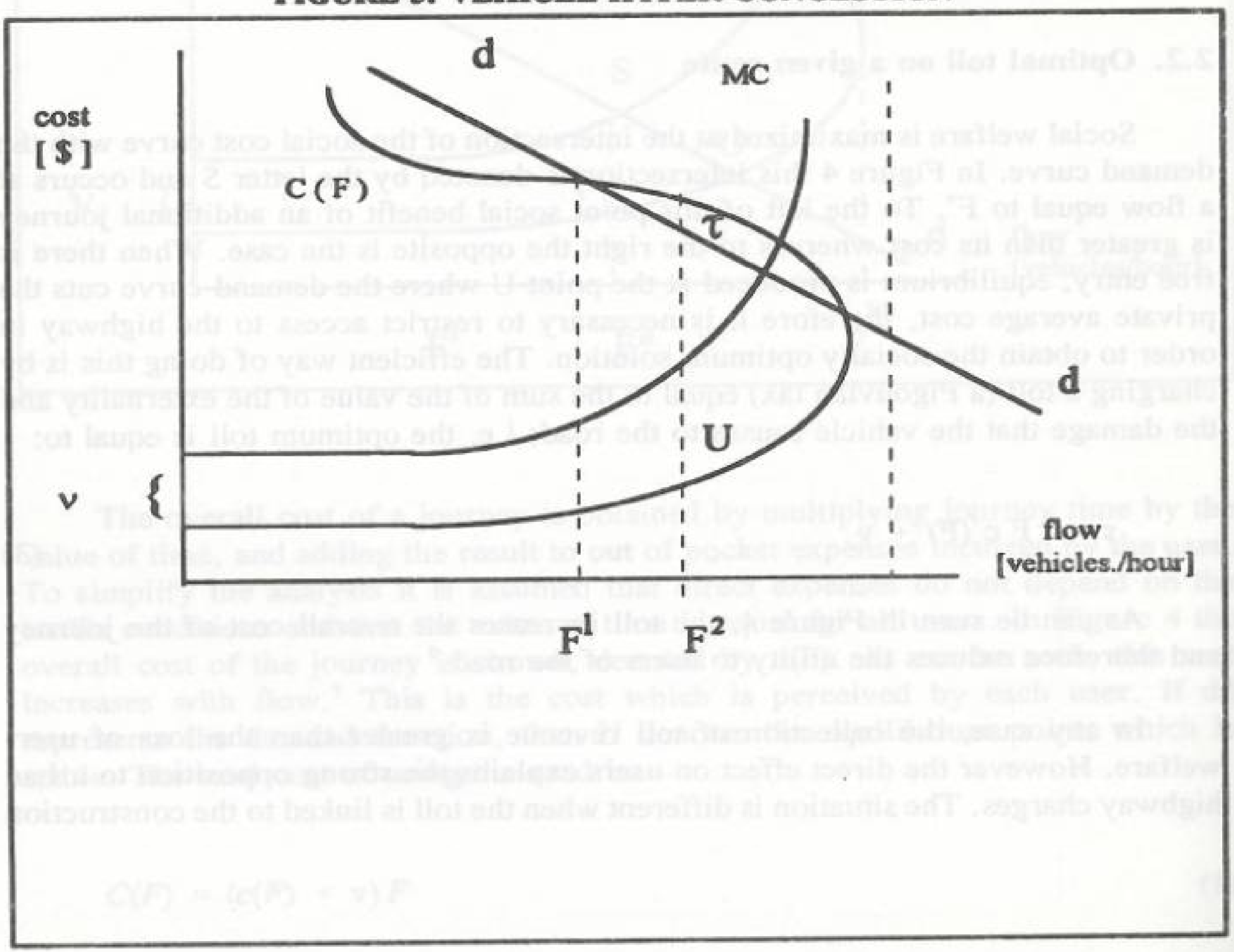
[8] For simplicity we have assumed that this damage is constant. Empirical analysis shows that damage grows aproximately according to the fourth power of the weight per axle (Small and Winston, 1986).

[9] The previous derivation assumes that the value of time is the same for all users. In reality, the value of time differs amoug individuals, and those who have a high value of time will always benefit from the toll.

of a new highway, because all users will be better off with the new road (otherwise they simply would not use it).

Walters (1961) and Schiff (1991) have pointed out that when there is hyper-congestion, the optimal toll not only reduces user cost but also increases total traffic, as can be seen in Figure 5.[10] Indeed, a toll equal to $\tau$, increases vehicle flow from $F^1$ to $F^2$ and reduces overall cost c(F). Although no measurements of this exist, some roads in Santiago seem to display the phenomenon of hyper-congestion (Hau 1992). For that reason a very low toll on an urban highway could produce hyper-congestion. In this situation a higher toll would not only increase social welfare but also the welfare of all users of the road.

**FIGURE 5. VEHICLE HYPER-CONGESTION**




[10] For a description of the dynamics of hyper-congestion see Walters (1961) and Hau (1992).

The congestion rate should only be charged in peak hours. When there is no congestion the socially optimal toll is equal to $\nu$. However, a toll higher than $\nu$ in off-peak hours may be considered when the charge during peak hours is not sufficient to finance the project. Indeed, there are good reasons for public infrastructure to at least be self-financing, i.e. that user-charges pay for the investment and the project's maintenance. When a highway is financed out of the nation's general budget, the distortions caused by the taxes forming the basis of fiscal income need to be considered. Similarly, the transfers which occur within society, when highways are financed out of the general budget, also need to be taken into account. Finally ensuring that projects fulfill private-profitability criteria, constitutes a guarantee that unprofitable projects do not get done as a result of manipulating the value of time in the social valuation of the project.

### 2.3 Tolls and redistribution

Some authors have been worried about the possible redistributive effects of tolls. In the first place it is argued that the tolls will be greater on roads used by people with lower income. The reason is that in roads with higher demand the costs are shared over a larger number of vehicles when the criterion for setting tolls is self-financing. However if a congestion toll is used, the costs of providing the service are not relevant for estimating the toll. Furthermore, the roads with the heaviest traffic are those where there is greatest congestion and therefore where the highest tolls would be charged.[11]

The second argument is that the toll increases the overall user cost, and this particularly affects people of lower income. The intuition is simple: the value of time is greater for people of high income, for which reason they benefit more from a toll which reduces journey time. People of lower income, meanwhile, see their welfare reduced by the toll — especially those who, as a result, stop using the road. In the case of new routes, the above arguments would indicate a preference for charging the lowest tolls possible.

However the redistributive effects are not so evident as indicated in previous paragraphs. In the first place it is necessary to keep in mind people who use public transport. If the income collected in tolls is used to build new highways or to improve the system of public transport, then it is highly probable that their use will increase the welfare of lower-income people, including those who have to stop using the highway due to the toll. Likewise reduced congestion favors public means of transport. In the second place one needs to keep in mind that when there is hyper-congestion, the use of tolls reduces the overall cost of the journey, except probably in those cases where the value of time is very low.

[11] The self-financing requirement could modify this situation in certain cases.

## 2.4. Calculation of tolls in a highway network

The advisability of charging congestion tolls increases when the road is part of a larger network. Indeed, various authors have worked out examples where the construction of new projects does not reduce congestion and can even increase it. Vickery (1969) considers two roads. One is fast but low-capacity and the second is slower but of high capacity, i.e. there is no congestion. Without a toll the traffic would be distributed so as to equalize overall journey costs on both routes. In this case an increase in the capacity of the first road would have no effect on the welfare of the users, unless it was so big as to be able to accommodate all users. The explanation is simple: as long as the capacity of the fast route does not expand sufficiently for the entire vehicle flow to pass through it, journey time will correspond to the slow road. These paradoxes are explained by the externality existing in the use of the congested road. When a toll corrects the externality the paradoxes disappear.[12]

The efficient toll for a highway forming part of a network depends on the situation of the other highways. We illustrate this point with the following example. Highway demand in an origin-destination pair is inelastic. Both points are joined by two roads which are exactly the same. In this case the efficient solution is the imposition of the same toll, whatever its value may be, in both roads. In consequence the charging of tolls on one of the highways reduces social welfare. The intuition of this result is simple. In the socially optimal solution marginal cost should be the same on both highways, otherwise welfare could be increased by transferring users from the road with higher marginal cost to the one with lower marginal cost.

As the roads are identical the marginal costs only become equal when the toll is the same in each. In general demand for the use of highways is not inelastic. Indeed users can choose public transport or travel in off-peak hours. When the demand is elastic, total welfare can increase with the charging of a toll on one of the two roads. Also it is justified to charge a toll on one of the highways when the externality, i.e. difference between social cost and private cost, is greater than on the other highway. In this case, to impose a toll on the higher externality road, equal to the difference between the externalities, increases social welfare, although the most appropriate thing would be to have different tolls on each road (unless on one road there is no congestion, in which case the toll would only have to be imposed on the congested road).

Three lessons can be learned from the above analysis. First, the tendency ought to be to charge for the use of all streets. Secondly the difficulty of determining optimal tolls on a highway which forms part of a network is an argument for

[12] Arnott and Small (1995) present other paradoxes.

permitting a certain flexibility in modifying tolls, so as to proceed empirically (trial and error), approaching the efficient solution, because its calculation in a theoretical model is practically impossible. Likewise, the value of the optimal toll will change with circumstances, for which reason the system of bidding ought to leave a certain degree of freedom for adapting the toll to new conditions. Thirdly in an urban highway, as this is a high-speed road, congestion produces a sharp increase in journey times. In other words the externality is greater on these highways that in the rest of the urban highway network. For that reason it is appropriate to set a toll on urban highways even when other roads are not charged.

### 2.5. The private franchise-holder's toll

Knight (1924) showed that when there is an alternative road, the toll which maximizes the franchise-holder's profits on a highway is that which coincides with social optimum. This author gives general validity to this result, extending it to suggest that by handing over the management of congested highways to private operators their use will be optimized. However, Buchanan (1956) showed that a pre-requisite of this result is that the alternative route should not be congested. The explanation of this result is simple: the travel cost for all highway users remains unchanged and equals the cost of travelling through the non-congested road. Hence the welfare maximization should only take into account the utility of the franchise-holder. Now when the alternative route is congested the toll which maximizes the franchise-holder's profits is greater than the socially optimum (see appendix). Now, when users are heterogeneous with respect to the value that they give to time, it could be that the private toll is below the socially optimum, as has been shown by Edelson (1971). Mills (1981), for his part, showed that this possibility increases with the degree heterogeneity of users and the sensitivity of demand with respect to journey cost.

## 3. FORMS OF AUCTIONING

There are different ways of auctioning the franchise. A first distinction is between those cases where the bidding is according to the toll rate and those where state fixes the value of the toll and auctions the franchise by means of another variable. In the first case the franchise is granted to the bidder offering to charge the lowest toll.

### 3.1. Auctioning by toll

Auctioning an urban highway franchise by the toll has various disadvantages which makes its use inadvisable. In the first place auctioning by toll prevents distinguishing between peak period and off-peak periods and adapting the toll to changing demand conditions. Secondly if the concession is very profitable, the resulting toll from the auction will be below that corresponding to an efficient solution (the congestion toll). When a scarce resource is involved, in this case urban highways, it is necessary to restrict access to it in order to avoid its over use. Limiting access by means of price generates rents. When access is not restricted the rents are dissipated producing a welfare loss (see Schiff, 1991).

The auctioning of highway projects by toll leads to the partial dissipation of the rent. Indeed, the winner of the franchise will only receive what is necessary to cover costs and to compensate his business administration, but not enough to obtain any rent (nor the State). Consequently, if the authority wishes to maximize social welfare it will have to establish tolls for peak hours and off-peak hours which maximize social welfare, and then grant the project franchise to the bidder who is willing to make the biggest contribution.

### 3.2. Auctioning by income or payment

When tolls are fixed by the state there are two ways of auctioning. The first consists of the fixing the duration of the franchise and granting it to the bidder offering the highest payment (or demanding the lowest subsidy). The second alternative proposed by Engel, Fischer and Galetovic (1996) is to grant the franchise to the bidder requiring the least income (in net present value terms) for building and operating the project, in which case the winner of the franchise runs the highway until it has collected the total income required through toll payments. Annual incomes can be updated in accordance with the relevant discount rate for the sector.[13]

Auctioning by income has a great advantage over auctioning by payment. As was mentioned in the introduction, the actions of the authority may have a strong impact on the collection of tolls on an urban highway. Therefore in the first alternative, when income received can be affected by government decisions, investors will use a high discount rate. In the second alternative this risk is much less, because the present value of the total income which the franchise-holder will receive is known. There is a lesser risk, associated with the time the franchise-holder takes to collect the required sum. The longer the time for collecting the desired income, the greater will be the operating and maintenance costs incurred on the road.

An additional advantage of the approach proposed by Engel, Fischer and Galetovic (1996) would be that the state could terminate the franchise early by

[13] Of course there is no history in urban highway franchising, so to begin with one can only aspire to obtaining an approximation of the relevant rate.

paying the operator that part of the income which still had to be collected. However it is necessary to keep in mind that the operator would benefit from the termination of the franchise because he would save on maintenance and operation costs. Therefore the franchise-holder might pressure the authorities to effect the transfer. Something similar occurs when the discount rate that the state places on the auction is below the relevant rate for the sector, as has been emphasized by some experts. When the discount rate used in the auction is greater than that relevant to the sector, the two effects work in opposite directions and it is not clear for which party it is convenient to terminate the contract in advance. Therefore it is necessary to specify better under what conditions the contract can be brought to an early end, in order to prevent opportunistic behavior by either of the two parties.

The longer is the period estimated for the franchise, the greater is the incentive to resolve construction problems in the best way. This motive indicates a preference for prolonged franchises. On the other hand a problem of prolonged franchise is the rigidity associated with unchangeable tolls. But if there is any flexibility for modifying tolls, this inconvenience is reduced. When the franchise is auctioned by income, the duration of the franchise will depend on the speed this is collected. In this case, establishing an initial payment prolongs the duration of the franchise. The payment required could serve to finance urban redevelopment and other transport projects.

### 3.3. Toll flexibility

When the toll is determined by the state, a commitment to keep the toll fixed during the period of franchise can produce excessive rigidity in the system with a consequent loss of welfare. While in theory there is an efficient toll, calculating this *a priori* is practically impossible. However, by trial and error one ought to be able reach a good approximation of its value. Likewise over time congestion and consequently the value of the efficient toll increase. For that reason the authorities ought to have some degree of freedom for modifying tolls over time. On the other hand changes in tolls affect the franchise-holder's income. In particularly falls in toll values will reduce it. When the period of the franchise is fixed, a change in tolls will directly affect the return to the franchise-holder. In the case of auction by income the effect is through changes in the duration of the franchise, and hence in the present value of maintaining and operating the road.

Private agents would be unlikely to participate in an auction where the authority can freely fix the value of the toll. Below, three alternatives are presented in which an attempt is made to reconcile the need for flexibility in the setting of tolls without introducing greater uncertainty in the franchise. A first alternative is that the price paid to the franchise-holder —fixed in the auction— is independent of the user charge. This solution presents a greater difficulty: once the link between toll collection and the income of the franchise-holder is broken, social pressures to change toll rates are very strong. An intermediate alternative is to ensure an average price per vehicle to the franchise-holder but to leave the authority free to modify peak hour and off-peak tolls. Another possibility is to leave the faculty of changing tolls in the franchise-holder's hands, while keeping the average value constant. The two solutions should not differ substantially.

A third alternative is for the authority to fix a maximum price in the auction. The ceiling price could be raised temporarily by the authority but not lowered. To establish a ceiling, such as has been suggested by Merino (1995), has advantages over fixing a price. The franchise-holder has clear rules of the game, because he knows he has freedom to set the price provided it does not exceed the ceiling. If the socially optimal toll were below the ceiling price the impossibility of lowering the ceiling price would produce a loss of efficiency. However, if one starts from a moderate ceiling price, the congestion toll should be increased over time, for which reason the impossibility of lowering the ceiling price should not represent a great problem.

Fixing the price would be superior to setting a ceiling only in the event that the private franchise-holder charged a lower toll than the socially optimum. As was mentioned above, if there is great heterogeneity in the value that users assign to time, it is possible that the toll which maximizes the franchises-holder's profit would be below the socially optimal. However, this possibility seems remote, especially when users of the highway have similar incomes, a situation which obtains, for example when the road joins certain boroughs with the city center.

Perhaps more important is the practical problem of how to share out the greater revenue resulting from an increase in the toll ceiling. In the case where the franchise is awarded by highest payment (lowest subsidy), a rise in the maximum price would favour the franchise-holder. Therefore a system would have to be worked out for sharing the additional earnings resulting from the increase in tolls. One possibility is that that part of the toll which exceeds the initial ceiling would go to the state. But in this case it might not be advantageous for the franchise-holder to raise the toll except in the presence of hyper-congestion. This is where we see one of the great advantages of the auction-by-income method. If an increase in the maximum toll produces an increase in revenue, its principal effect would be to reduce the duration of the franchise-holder's participation, which has advantages for the latter, but of a different order of magnitude to the case of auction by payment.

It only remains to define whether a different ceiling price would have to be established for off-peak times, and consequently a peak-hour timetable. In this case the authority could temporarily raise both maximum prices and extend the peak-hour period. It could be argued that in off-peak hours it would not be necessary to consider different ceiling price, since in the absence of congestion the situation would approximate to one of competition between two different routes. Consequently, the discipline provided by competition on the alternative routes would be sufficient to produce an efficient price. Theory shows that if the alternative routes are not congested, then the toll set by the private operator is the socially optimal. In this case, setting a different ceiling at off-peak times would not be justified.

## 4. THE FRANCHISE-HOLDER'S BUSINESS

In this section we consider the case where the franchise is awarded to the bidder requiring the least income, in present value terms, for constructing and operating the route. In this case although total income is predetermined, there is uncertainty about the duration of the franchise and so also with regard to the total cost of operation and maintenance. Also a situation could arise in which annual revenues were not sufficient to provide this income, but this possibility seems remote given the congestion normally present on urban highways. We start by analysing the franchise-holder's potential income.

### 4.1. Revenues

Besides income for tolls there may be additional incomes arising from fixed-point advertising, from sanctions applied to people using the road without paying in advance, from parking areas next to the road and from other highway services. In the auction process the prices and quality of highway services ought to be clearly defined (e.g. the towing of broken-down vehicles), otherwise charges might be abusive, thereby producing a social welfare loss. Similarly it needs to be decided whether or not these additional revenues are included in the franchise-holder's income. If they are included, the challenge is to supervise that these are not under-reported, for example by means of contracts with affiliated firms. Such supervision represents a cost for the state as well as a possible source of conflicts with the franchise-holder. For this reason it would appear preferable not to include them. Certainly bidders at the auction will take these additional revenues into account when defining their bid.

Not to include all revenues may be inadvisable when auctioning by income. Suppose the incomes additional to toll revenues exceed the cost of maintaining and operating the highway, so the franchise-holder would have incentives to remain operating the route for as long as possible. The way to achieve this could be by reducing toll revenues, for which purpose, for example, a low toll would be charged—probably below the optimum level. In addition there would be a clear incentive to manage the route inefficiently. One solution to this problem is not to count additional revenues, but, in the auction, to set an annual payment from the franchise-holder to the state, corresponding to an estimate of the income arising from the additional revenues.

## 4.2. Electronic charging[14]

The charging of tolls poses certain problems in the urban case, and electronic charging is one alternative. Broadly speaking there are two systems of electronic charging. The first, used in the Hong-Kong experiment, consists of automatic identification of vehicles as they pass between different electronic charge points. For this each vehicle needs to be given a passive responder or some other form of identification. Every so often a bill would be sent to each user on the basis of their road use. The second method which is being tried out in Singapore, uses pre-paid intelligent cards, whose value diminishes every time the vehicle goes past a charge point. The identification system has two disadvantages with the respect to pre-paid cards. It allows knowledge of the movement of each vehicle, which constitutes an invasion of personal privacy. In fact this was the reason for rejecting electronic charging in Hong-Kong. Secondly, it requires a more complex charging system, because bills periodically have to be sent to all users.

The use of electronic charging makes it possible for users to enter the highway without their responder or pre-paid card with them. In order to encourage the charging of the toll by franchise-holder, income should incorporate all traffic even that which did not pay the toll. In other words, potential income —which will be used for contractual purposes— would differ from income actually earned to the extent that certain users did not pay for the use of the highway. As recovering the toll would be the franchise-holder's responsibility, the latter would have to be provided with appropriate instruments for doing so. One possibility is a two-stage charge mechanism for users who use the road without paying in advance. In the first stage, the franchise-holder would attempt to charge the user a relatively low amount, so as to cover additional costs of charging. This would be done by sending a charge slip through the post. If the user did not pay on this occasion, the information would be passed to the local court where the sanctions would be very much higher. In the final analysis the driving license renewal could be linked to the payment of such debts.

## 4.3. Costs

The franchise-holder's costs are basically three. The first corresponds to the construction of the project, the second to its maintenance and the third to its operation. In each of these areas the franchise-holder faces various risks. In construction there are geological risks and also those associated with modifications to public service installations. The State could absorb part of the risk arising from alteration to such installations. The reason is that the State would probably be better placed to negotiate with public service companies the payment for modifying their

[14] In a study by ECLAC (1994) there is a complete discussion on the electronic charging of tolls.

installations. Indeed the government should grant permits to these firms for carrying out the various jobs, although, on the other hand, the state in general is not a good negotiator.

There is also a potential fourth cost associated with the expropriation of land through which the road passes. Expropriation could be realized either by the State or by the winner of the franchise. Given the social problems involved in the expropriation of housing it seems more appropriate for the State to assume this responsibility. In this case various measures would have to be proposed to avoid the expropriation process producing significant delays. In particular, alternative housing should be considered which was attractive for families who would have to abandon their homes. Secondly one would have to avoid the process being delayed by a small number of owners of property where the route passes. For this, different stages could be considered. In the first stage a very attractive offer would be made for a voluntary sale, conditional on all owners accepting. If this offer failed a second attractive offer could be made but not as attractive as the first one, and without the requirement of full acceptance. The third stage would be destined to the legal expropriation of properties not sold in the second stage. In this stage one would try to pay only the commercial value.

## 4.4. Guarantees

In the auction-by-income scheme, the present value of total costs of the highway's maintenance and operation depend on the duration of the franchise. Therefore, one risk which is faced by the franchise-holder is that it takes longer than had been estimated to recoup the pre-established income. As the traffic, and therefore the duration, of the franchise can be affected by the decisions of the authority, this possibility would cause the discount rate used by bidders in the auction to rise. One way of reducing this problem is by establishing guarantees for the franchise-holder.

The guarantee provides security to the franchise-holder in two ways. First, if by actions of the authority or for other reasons the business is worse than expected, losses are limited. On the other hand, given that the guarantee is paid by the state, the government would have an interest in the success of the franchise (see Merino 1995). The government would have to take social welfare into account in the evaluation of its decisions, and this includes the welfare of the owners of the franchise-holding firm. However, redistributive considerations may lead the government to give a low weight to the franchise-holder's welfare in its decisions. The guarantee changes this situation, but an excessive concern on the part of the government for the franchise-holder's success could lead to a reduction in social welfare.

Another motive for giving guarantees to franchise-holders is to facilitate the obtaining of loans in the financial system, which translates into a larger number of bidders and therefore greater competition. Another advantage of guarantees is in reducing the probability of the franchise-holder going bankrupt and as a result the need to renegotiate the contract, because if that occurs the benefits of competitive bidding to a large degree are lost.

Although the purpose of the guarantee is not to transfer to the franchise-holder the uncertainty associated with the actions of the authority, it is in practise impossible to completely dissociate the risks resulting from the authorities' decisions from other risks. Therefore completely eliminating uncertainty provoked by possible future actions on the part of the authority would require carrying out an auction without the risks associated with the operation of the highway (there would still be the construction risk). However it is not good to eliminate all risks from the franchise-holder during the operation of the highway because, in that way, the benefits of private management would be lost.

An alternative guarantee is assuring an annual minimum income. In this way, the franchise-holder would receive a transfer equal to the difference between the minimum guaranteed income (MGI), y*, and the theoretical income (TI) which is obtained by multiplying the annual flows by the respective tolls, that is:

$$Max\ (0,\ y^{*} - p^{p}q^{p} - p^{f}q^{f})$$

were $p^p$ denotes peak price, $q^p$ peak traffic, $p^f$ off-peak price and $q^f$ off-peak traffic. A criterion for determining guaranteed income needs to be defined. This could correspond to a conservative estimate of traffic. It could also be determined by assuring a minimum level of return to the franchise-holder's investment.[15]

To calculate the franchise-holder's income, maximum tolls or the effective tolls charged by the franchise-holder can be used. It does not seem convenient to use the maximum toll. Let's suppose the franchise-holder knows that the toll which would maximize revenue is below the ceiling, which probably indicates the social toll is even lower. The franchise-holder would want to lower the toll, but in this way the theoretical income would increase more than the effective income. Consequently if there were a risk of effective income being below theoretical income, the franchise-holder would abstain from lowering tolls.

[15] Under no circumstances should the cost estimate made by the franchise-holder be used, as the latter would have incentives to over-estimate. The estimate of the construction cost should be carried out by the authority and made known to the bidders prior to accepting bids.

On the other hand if the effective toll is used to calculate theoretical income, and the franchise-holder knows that this is going to be below the minimum income, then it could pressure (punish) the State by charging a very low toll. Furthermore from the franchise-holder's point of view it would be efficient to set the toll equal to zero thereby avoiding the costs of charging the toll. This situation is resolved, at least in part, by guaranteeing only a fraction of the difference between the income and the theoretical income, so that the franchise-holder has incentives to set a non-zero toll and to be efficient in the administration of the road. The guarantee proposed is asymmetric, because in the years when TI was above MGT there would be no transfer from the franchise-holder to the State. The previous problem is resolved using a current account: the transfer the franchise-holder would receive when TI was less than MGT would eventually be paid in the years when the inverse situation occurred. This would be an additional incentive to manage the road efficiently in years when it is estimated that TI is going to be below MGT (especially in the early years). This situation it is relevant because it is possible to imagine that in the early years of the franchise TI would be less than MGT and the situation would be reversed in subsequent years.

A more simple alternative for a guarantee is to fix a maximum period for the franchise. If at the end of the franchise-holder had not recovered the required revenue, it would receive a percentage of the difference between the required revenue and the theoretical revenue. An additional advantage of this alternative is setting a maximum period for the duration of the franchise. Now, what should be the guaranteed percentage is an open question. The greater the guarantee the less the discount rate used by bidders, and so the bids will be more attractive. On the other hand, one needs to consider that the lower the risks, the lower also are the incentives to operate efficiently. In addition there is the risk that, due to state guarantees, projects are carried out which are neither privately nor socially profitable.

When the franchise-holder has incentives to rapidly recover the required income, he will be concerned to operate efficiently, for example broken-down vehicles will be rapidly towed away. On a six-lane highway, instead of keeping three lanes in each direction, the number of lanes in the direction of peak traffic will be increased. Of course these measures imply costs for the franchise-holder. It could be that the incentives are insufficient to incur these costs. In this case one could imagine an annual payment from the franchise-holder. The question is how to determine an optimum payment, considering that the franchise-holder's discount rate will increase with the value.

## 5. FINAL COMMENTS

In the construction of the highway there are various urban problems. One of the important aspects is the availability of parking spaces at the destination. If there is a sharp increase in road supply then parking spaces could become a bottleneck. For this reason the demand for parking spaces should be estimated, and who will be responsible for satisfying that demand established. For example the construction of parking lots could be included in the franchise project.

Considering the need not to cause deterioration in the quality of life in the sector where the highway passes, urban renewal needs to be carried out together with the construction of the road. One possibility is to expropriate the strip alongside the road. This would be used to construct related projects, e.g. parking spaces and buildings which would trigger urban renewal. Although the parking spaces could be part of the road auction, ownership of the buildings would need to be transferred to private hands, so as to obtain the best real estate result. Another alternative is to obtain resources for remodelling, by requiring the franchise-holder to pay a pre-established sum for this purpose. With this sum the first projects associated with urban renewal could be financed.

The construction of buildings would be held back for a later stage depending on how demand expands. But the boundaries of the highway should be such as to facilitate construction or expansion projects. Similarly, one would have to define in the auction the conditions for maintenance of the expansion areas, so that these do not become eyesores. Also it would be necessary to define how the expansion areas would be auctioned. One alternative is to transfer them to the respective municipality on the condition that the latter uses the resources obtained for remodelling the area.

Another aspect which warrants more attention is whether or not heavy vehicle access to the road should be restricted. The cost of constructing a highway to support the passage of heavy vehicles is greater. For example in those parts where the route is dug out, the digging has to go deeper in order to accommodate trucks, and this increases earth movement. In the first urban highway which is going to be auctioned —the *Costanera Norte*— probably 95 percent of users will be automobiles. Consequently, designing the project for the passage of heavy vehicles might be inefficient. Trucks could continue circulating along the roads they already occupy. In addition it would be necessary to prohibit the passage of heavy vehicles during peak traffc hours, for otherwise this would reduce the speed of circulation and, thus, vehicle flow. The reasons are (i) that these vehicles normally move at slower speeds and (ii) they need to be weighed in order to prevent overloading and a consequent deterioration of the road. Moreover, building a highway which permits the passage of trucks implies a greater urban intrusion, for example the excavation of the road would need to be deeper. Finally, there are the accidents that heavy vehicles cause.

Various economists have proposed that when traffic is heavy, it might be more efficient to construct separate highways for automobiles and heavy vehicles. For, otherwise, very high construction standards are required. Indeed, on the one hand one must define a road quality acceptable to automobiles, and on the other hand, one which could support the weight of trucks. This produces a phenomenon which, in the literature, is known as diseconomies of diversity.[16]

Future research ought to study aspects such as the link between road auctions and urban remodelling, the possible exclusivity of highways for light vehicles, and other aspects which might arise in the auction process itself. In this way, a form of auctioning could be developed which would take advantage of the capacities of the private sector in maximizing social welfare.

[16] Soon the construction of the Santiago-Valparaíso route via La Dormida will be put out to tender. As there is already one route for all vehicles linking the two cities, it is probably much more efficient to construct the second only for automobiles. This possibility at least needs to be evaluated.

## APPENDIX

Assume there a two routes joining the same origin-destination pair, which we denote by the letters a and b respectively. Also assume that a toll is only charged on route b. The question is how to determine the optimum toll in this case. The total flow is distributed between the roads, so as to equalize the overall cost on the two routes, so:

$$c_a(F_a) = c_b(F_b) + \tau \qquad (4)$$

The overall cost has two components, the first corresponds to the value of journey time, (and the other direct costs), and the second is the value of the toll (for simplicity we omit $\nu$). We assume that demand, D, decreases with the overall cost of the journey; therefore:

$$F_a + F_b = D\left(c_a(F_a)\right) \qquad D' < 0 \qquad (5)$$

From (4) and (5) it follows that:

$$\frac{dF_a}{d\tau} = \frac{1}{c_a'(F_a) + c_b'(F_b) - c_a'(F_a)\, c_b'(F_b)\, D'} > 0$$

$$\frac{dF_b}{d\tau} = -\left(1 - c_a'(F_a)D'\right)\frac{dF_a}{d\tau} < 0 \qquad (6)$$

$$\frac{dF}{d\tau} = c_a'(F_a)\, D'\,\frac{dF_a}{d\tau} < 0$$

The increase in the toll reduces the traffic along the road with the toll and increases the flow on the other road. If demand is elastic, the aggregate flow declines as the toll increases. In order to carry out a welfare analysis we will assume the marginal utility of income is constant and that revenue from the tolls is handed back in equal shares to users, independently of the route they have used. So social welfare will be given by:

$$W = \int_0^F D^{-1}(x)dx + \tau F_b - c_a(F_a)F. \tag{7}$$

where $D^{-1}$ denotes the inverse demand function.

Differentiating (7) with respect to $\tau$, we obtain:

$$\frac{dW}{d\tau} = -\left(MC_a(F_a) - MC_b(F_b) + (c_b'(F_b)\,F_b - \tau)c_a'(F_a)\,D'\right)\frac{dF_a}{d\tau} \tag{8}$$

If demand is inelastic, that is if $D' = 0$, and the two routes are the same, welfare is maximised when traffic is the same along the two routes, and this requires a common toll. Now, in the general case the optimum toll is given by:

$$\tau = \frac{\left(c_b'(F_b) + c_a'(F_a) - D'c_a'(F_a)\,c_b'(F_b)\right)F_b - F\,c_a'(F_a)}{1 - D'c_a'(F_a)} \tag{9}$$

Reordering the above equation we obtain:

$$\tau = \frac{F_b c_b'(F_b) - F_a c_a'(F_a) - D'c_a'(F_a)\,c_b'(F_b)\,F_b}{1 - D'c_a'(F_a)} \tag{10}$$

So a sufficient condition for the socially optimum toll to be positive is that the difference between marginal cost and average cost be greater on the tolled route. Simplifying equation (10):

$$\tau = F_b c_b'(F_b) - \frac{F_a c_a'(F_a)}{1 - D'c_a'(F_a)} = \tau_b - \left(c(F_a) - MC_a(F_a)\right)\frac{dF_a}{dF_b} \tag{11}$$

where $\tau_b$ represents the optimum toll on route b, if route a were charged at the optimum rate. This expression is a particular case of the general formula developed by various authors (see Winston, 1985).

Below we derive the toll which the franchise-holder would set. His objective is to maximize income, i.e.:

$$\text{Max } \tau F_b, \tag{12}$$

then the franchise-holder's optimum toll is:

$$\tau = \frac{c_b'(F_b) + c_a'(F_a) - c_a'(F_a)\, c_b'(F_b) D'}{1 - c_a'(F_a) D'} F_b . \tag{13}$$

The latter is a generalization of the formula obtained by Fernández (1983) for the single-route case. Note that the optimum toll of the franchise-holder is always positive and greater than the socially optimum toll. We see that if there is no congestion on the non-toll route, in other words if $c'_a = 0$, then the franchise-holder's toll, is equal to the socially optimum toll. The same occurs if demand is totally elastic ($D' = 0$). If the road is unique, the optimum toll is obtained taking the limit when $c'_a(F_a)$ tends to infinity. In this case equation (9) is reduced to equation (3), and equation (13) to:

$$\tau = \tau_b - \frac{F_b}{D'} \tag{14}$$

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