Shaping urban traffic patterns through congestion charging: What factors drive success or failure?

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Abstract:
Congestion costs are emerging as one of the most important challenges faced by metropolitan planners and transport authorities in first world economies. In US these costs were as high as 78 million dollars in 2005 and are growing due to fast increases in travel delays. In order to solve the current and severe levels of congestion the US department of transportation have recently started a program to initiate congestion pricing in five metropolitan areas. In this context it is important to determine those factors helping its implementation and success, but also the problems or difficulties associated with charging projects. In this article we analyze worldwide experiences with urban road charging in order to extract interesting and helpful lessons for policy makers engaged in congestion pricing projects and for those interested in the introduction of traffic management tools to regulate the entrance to big cities.

Keywords: Congestion, Road Pricing, Urban Transportation, Traffic Demand Management.

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I. Introduction

Congestion costs are emerging as one of the most important challenges faced by metropolitan planners and local public authorities in first world economies. In the US, these costs raised to $78 million in 2005 implying important economic loses for individuals and for the national economy, caused by delays and excess fuel consumption. If we add environmental concerns to these economic costs the issue becomes even more severe. In **table 1** we display some data on the costs derived from congestion for U.S. urban areas. As is shown, congestion supposed less than 15 billion of dollars (in terms of 2005) in 1982, and today represents almost 80 billion. Only in one year congestion costs grew more than 7% between 2004 and 2005, leading to severe concerns for local policy makers and transportation authorities.

(insert table 1 around here)

The traditional solution to congestion costs have been infrastructure enlargement and road investments. However, Langer and Winston (2007) recently showed how ineffective is US government spending devoted to lower congestion costs by these means. Their estimates suggest that each dollar spent in highways only reduces road users congestion costs by 11 cents. Their conclusion is that there must be a change in the approach to reducing congestion costs pointing out that unlike spending, road pricing produces benefits without using public financial resources. Also, by comparison, Parry (2002) finds the existence of stronger efficiency gains derived from congestion taxes over other alternative policies.

Fighting urban congestion costs has become an important issue in the agenda of transportation policy making in the U.S. (Geddes, 2007). In this direction, in August 2007, U.S. Transportation Department selected five metropolitan areas among 26 candidates in order to start a nationwide initiative to fight congestion costs by giving subsidies ($848.1 million) that help in the implementation of congestion pricing projects and other traffic management tools. The cities chosen were New York ($354.5 million), Miami ($62.9

million), Minneapolis ($133.3 million), San Francisco ($158 million) and Seattle ($138.7 million); some of them are placed in the highest positions in the ranking of congestion costs in U.S. displayed in **table 2**.

(insert table 2 around here)

In this article we review international experiences on urban congestion charges in order to extract lessons and facts that can provide interesting recommendations and advice to those public authorities actually engaged in congestion pricing projects or those willing to follow the initiatives of successful cities like Singapore, London or Stockholm in order to reduce peak-time traffic in their city centers. Also, in the current US context, this worldwide experiences can help in the determination of those factors driving success of failure in the implementation of urban road pricing.

The rest of the paper is organized as follows. First, some introductory theoretical background is provided in order to understand what is meant by congestion charging and traffic demand in the first section. In the second we review several international and successful experiences with urban congestion charging (and one failure experience) in order to extract general lessons. These lessons for policy makers are placed in the last section of the current article.

II. Theoretical background

The seminal works by Pigou (1920) and Knight (1924) founded the theoretical background necessary to understand congestion charging, and the pioner articles by Walters (1961) and Vickrey (1963) set the basis of the instruments to conduct optimal road pricing using toll implementation. The main intuition behind congestion charging is the internalization of negative externalities (time costs and delays) which are imposed to other road users by an additional driver entering the road. The efficient allocation of traffic is met when the price payed by a road user equals the marginal cost generated to the rest of users. As is supposed by congestion pricing in the short run, infrastructure enlargements are not feasible and the optimal allocation of traffic must rely on toll collection.

Formally, the optimal toll achieving the efficient allocation of traffic given a fixed capacity is computed following the next equation:

$$P = OC + \frac{\partial AC^s}{\partial Q} \cdot Q + EC$$

Therefore, the so-called pigouvian toll **(P)** positively responds to the operational cost **(OC)** of the producer, to the change in the average cost of the Q users **(AC)** by the addition of one more vehicle, and to other externalities produced by the use of the road **(EC)**. In this simple framework we assume that road use does not impose costs related to pollution, noise or accidents to the society **(EC=0)**, in order to focuse the analysis in the congestion problem what is the main objective of urban road pricing projects implemented in the world.

As a result, the additional driver must pay for the costs imposed to the infrastructure which are normally close to zero, except for heavy vehicles, and for the marginal increase in the average costs of the whole group of drivers in the road. The rational of this charge implies that the toll increases with congestion levels since the cost suffered by users is increasing with the quantity of vehicles **(Q)**. On the contrary, when low traffic flows are in place average social costs tends to the costs incurred by the new driver. Thus, specially when the vehicle is light and operational costs can be assumed to be zero, the toll decreases and becomes 0 when no congestion level is reached. The private cost for a new driver remains constant for any $\mathbf{Q} < \mathbf{Q^c}$, what means that every additional road user faces the same cost while the number of vehicles in the road is lower than the congestion volume $\mathbf{Q^c}$. Otherwize, for any $\mathbf{Q} > \mathbf{Q^c}$ the private cost suffered by the additional driver increases with the number of vehicles in the road but does not internalize the costs that are suffering the vehicles already in the road. Thus, the cost which represents for the driver to enter the road is smaller than the marginal cost imposed to the rest of drivers **($MC^p < MC^s$)**. The difference between marginal private costs and marginal social costs grows with Q.

Under this situation, when **$Q > Q^c$** the level of traffic is higher than the optimal volume since additional drivers are not internalizing the costs produced to the rest of drivers. The solution which leads to the optimal volume is to increase the private costs of entering the road with the marginal costs that this decision would generate to the rest of vehicles. This difference between social and private marginal costs for each Q is exactly the optimal toll (P^S) needed to internalize congestion costs. Therefore the level of the optimal toll must vary with congestion levels and vehicle type (if different vehicles differently affect infrastructure costs). This concept is known as Pigouvian taxation and has remained the leading principle in transport economics on road traffic externalities regulation (Button and Verhoef, 1998)

(insert figure 1 around here)

III. Worldwide Experiences on Congestion Charging

In this section we provide a review of the most important experiences in road charging implementation in the world in order to distinguish the common features of these experiences and the possible implications for the US cities. This overview pays especial attention to the forms and results of congestion charging projects, but also takes into account the importance of the political issues concerning this challenge for local governements. Most of the section is devoted to describe and analyze the successful experiences of London, Singapore, Stockholm and the Norwegian cities, but the failure of Edinbourgh is also considered in the last part of the section as a good example of the problems that may face the local authority when implementing the measure.

1. Successful experiences

London

The London congestion pricing was the first important experience and the best known success in reducing congestion costs in European big cities. Since February 2003 it is necessary to pay a fee (neither time-varying nor vehicle-varying) in order to enter the city center during weekdays between 7:00am and 6.30pm, with the exception of motorcycles, public transport vehicles and other particular vehicles like those for disabled people or emergency vehicles.[1] Once the charge is payed it includes unlimited journeys into and around the restricted area. The people living in the city center are almost exempted as well, since they receive high discounts. The area charged has recently been extended in 2007, the price has increased from 5£ to 8£ in three years (July 2005) and is expected to rise until 10£ by the end of 2008.

As a result, right after the implementation private vehicles declined between 15% and 20% in two weeks – 30% in the long run - and significant increases were found in bus use. In fact, according to Transport for London reports, 50% of car reductions were transfers to public transportation, 25% were diverted around the charging cordon, 10% decided to use other private modes like taxi, motorbikes or bicycles and the rest decided to avoid trips or shifted the trip to non-charging hours. Traffic speed improved within the restricted area achieving a 37% increase and delays during peak time dropped about 30% for private vehicles and 50% for buses. In order to compensate this demand increase, Transport for London increased the number of available buses with 300 new vehicles. Regarding environmental impacts, the project achieved significant reductions in greenhouse gases emissions. For instance, CO_2 emissions declined in the charging zone by 16%.

As a matter of fact, the congestion charge influenced the decisions of road users on whether to take a trip, the mode used and the time of the day chosen, but also produced a virtuous circle for bus tranportation according to Leape (2006). This virtuous circle is based on the

[1] The use of a flat charge for the whole period makes sense in the London case since average speeds were similar during the charging period (Leape, 2006).

idea that less congestion increases bus average speed, which at the same time enjoy more passengers and as a result more revenues to improve the system are raised (Small, 2005).

The origin of the measure comes from the political restructuration in the area of London in 2000, when Ken Livingstone (Labour Party) won the elections becoming the new Mayor of the area of London (Greater London Authority) with a platform that included congestion pricing implementation (Litman, 2006). National government (Labour) also supported the Mayor's plan and public consultations reported enough public support to engage the project thanks to the severity of congestion in the city center. On the contrary, the Conservative Party promised the end of the program, receiving support from some labour organizations and motorist clubs. In fact, the City of Westminster council, which was the local authority ruled by conservatives and responsible for governing the borough restricted by the system, was the most difficult obstacle faced, since it challenged the project on the basis that it was unlawful and would produce even more pollution (Banister, 2003). The British High Court rejected that claim.

Nonethless, after some years of implementation the system enjoys popular support and the political opposition is not questioning congestion pricing anymore. In this direction, some business groups also support the system because its costs are offset by its benefits (lower delivery time, employees arriving on time, etc.). Moreover, for most workers in the area the fee represents a really small amount if we take into account the high wages payed in Central London. In this sense, for those working in the restricted area the time advantage can compensate its payment. However, smaller retailers still blame the scheme probably due to political ideology since their relationship with the Mayor has been usually unconfortable, and also may represent a political strategy to gain special treatment (Litman, 2006). However, Quddus, Carmel and Bell (2007) found that congestion charging did not affect overall retail sales in Central London, but some concrete stores could suffer some sale reductions. Indeed, a survey of 500 firms found in 2004 that 72% recognize the effectiveness of congestion charge (Clark, 2004). Transport for London (2005) reports that the scheme was neutral for business as well.

As in other cases, revenues raised thanks to congestion charges are used to fund public transportation investments (80% of total net revenues), but the electronic camera recording system used in the city is quite expensive and a substantial amount is devoted to cover this operational costs. In fact, these costs were higher than expected and net annual revenues were finally half of the expected. Leape (2006) justifies the low net revenue due to the success of the plan in reducing car use, the expensive implementation costs and the extended discounts awarded to several groups of citizens. However, increasing fees overtime cause an increase in revenues that reduces the relative weight of the operational costs. According to Banister (2003) the main beneficiaries from congestion charging are assumed to be commercial vehicles and those still using private cars and enjoying substantial time decreases, but also those who were already using public transportation due to new public investements funded from charging revenues. Road accidents savings are also considered as a gain related to the implementation of the measure and 11% of revenues was also devoted to improve road safety.

To conclude, according to Santos and Fraser (2006) the London congestion charging constitutes an economic and political success due to several reasons. First, it took into consideration the public opinion but avoid the use of referendums to take the decision of implementing the measure – it is not clear the support it would have enjoyed -. Second, a cost-benefit analysis was carried out and also took into account distributional effects. And finally, it was specifically planned for the characteristics of Central London.

Singapore

The experience of Singapore is also well known for its unique lenght and its success in managing traffic according to efficient allocations by using road charges which varies by the time of the day (Olszewski and Xie, 2005). Therefore, the objective of the measure was to manage traffic allocations instead of collecting money and remained as the unique full-scale urban road pricing scheme designed to reduce peak-time traffic in the world for a long time (Olszewski, 2007). Congestion pricing was introduced in Singapore in 1975 when authorities decided to use an Area Licensing Scheme in the center of the city. Later, in 1998, after its successful results from this pricing strategy, they decided to upgrade the system by using electronic road pricing. Charges are payed in the central area between 7:30 am – 7:30 pm in the weekdays, but those entering from 10:00am to 12:00 are exempted. On the other hand, in other radial arterial roads charges are only payed between 7:30am – 9:30am. As was mentioned, tolls vary depending on time but also by vehicle. Olszewski (2007) details how the price varies:

- From 7:30am to 8:00am: $1.50
- From 8:00am to 8:30am: $2.00
- From 8:30am to 9:00am: $3.00
- From 9:00am to 9:30am: $1.00

Congestion cuts were achieved right after the introduction of the Area Licensing Scheme. The traffic was reduced by more than 40% in the restricted area and thanks to the electronic system it was additionally reduced another 15% during the peak time. However, increases of 10% were found during the rest of time slots. Therefore, time shifts are found in traffic congestion due to road pricing. In addition, authorities realized that after the introduction of electronic road pricing, drivers were using alternative roads and other periods of time (Christainsen, 2006; p.80). In fact, after urban charging introduction the share of private cars over total commuters declined from 48% to 29% (Watson and Holland, 1978).

Estimates on the elasticity of demand respect fee levels are established in -0.21 in the short run and in -0.30 in the long run, being the elasticity in the long run a 42% higher than the one in the short run (Olszewski, 2007). Also, public transportation received the benefits from the measure by increasing its average speed making of buses a good choice and consequently increasing trip profitability with the additional demand. Indeed, its use increased about 20%.

Stockholm

Congestion pricing was permanently introduced in the City of Stockholm in August 2007, but a period trial was undertook from January 2006 until July 2006.[2] Charges are placed in the entrance of the city center in the form of two cordon lines where vehicles are charged every time they cross – though some classes of vehicles are exempt of payment-. The fee changes depending on the time of the day and lays between $1.50-3 in the rush hours in the weekdays. No congestion charging applies in the weekend.

The main purpose of the measure was reducing congestion, increasing accessibility and improving the environment, but secondary objectives were more precisely established:

- Reduce traffic volumes on the busiest roads by 10-15%.
- Improve the flow of traffic on streets and roads.
- Reduce emissions of pollutants harmful to human health.
- Improve the urban environment as perceived by Stockholm residents.
- Provide more resources for public transport.
- Better road safety outcomes.

The direct cost of that implementation raised to 3,8 billion SEK and the public transportation was improved by adding 197 new buses, 16 new buslines from the metropolitan area of Stockholm into the inner city and the reinforcement of the existing underground and commuter train lines. Also, more park-and-ride facilities were provided.

As happened in some cities, a referendum on the permanent implementation of congestion charging was carried out on September 2006. In the city of Stockholm 51,3% of citizens supported the project, while 45,5% voted against. The rest were blank or invalid votes. However, the rest of municipalities in the county surrounding the city of Stockholm refuted

[2] In fact the trial started on August 2005 with extended public transport but congestion charges were not implemented until January 2006.

the implementation of this measure – 39% supported the project and 60% voted against- though the Social Democratic party in office announced that only results given in the city of Stockholm were going to be considered. On the contrary, the conservative opposition – Alliance for Sweden - announced in the campaign that their decision would take into consideration the rest of municipalities as well if they win the general elections organized the same day of this referendum. In fact, only one party in the coalition was clearly in favor of the measure. A summary on referendum results is displayed in **table 3**. Results adding votes from the city of Stockholm and the rest of municipalities reported a slight rejection of the project – 53% No votes vs. 47.5% Yes votes-.

(insert table 3 around here)

One possible reason of this political controversial may arise by the institutional power enjoyed by both parties in the county of Stockholm. The Social Democratic Party was ruling the city of Stockholm as the main party in the governing coalition, while the conservative coalition has a strong presence in the councils from the surrounding municipalities. In fact, in 11 out of the 14 of these municipalities where the referendum took place, the conservative coalition was the traditional municipal government enjoying a wide majority.

In **table 4** we provide, by showing correlations, some preliminary evidence on the relationship between the share of votes in the municipal elections for both leading parties in the two coalitions, and the share of votes supporting the implementation of congestion charging. As is shown, there is a positive correlation between the presence of Social Democratic voters in those municipalities and the share of YES votes. The opposite relationship can be identified for the Moderate Party though this is weaker.

(insert table 4 around here)

Indeed, the reason behind the Moderate Party's commitment to consider all municipalities was probably its institutional presence in these councils. To capture this we provide OLS estimates for the following simple regression model:

$$Yes_i = \alpha + \beta \text{ Share Party}_i + \varepsilon_i$$

where we use as dependent variable the share of YES votes in the referendum in each municipality ***i***, and as unique regressor the share of votes for both parties. A constant and random mean zero error terms are also included. The share of party votes used in this regression are the votes related to previous municipal elections (2002) in municipality ***i***, in order to identify the institutional presence of each parties before the referendum. By this strategy we can distinguish the effect of those cities where each party enjoyed more support in order to explain the share of YES votes.

(insert table 5 around here)

As is shown, there is a positive and statistically significant relationship between the presence of Social Democratic voters and the share of YES votes. This means that in those municipalities where Social Democratic Party was in office or had an important presence, the YES option enjoyed more support than in places where this party was residual. On the contrary, the insitutional presence of conservatives is negative and statistically significant as well. Therefore, where the conservatives enjoyed a wide popular support the NO option was chosen the most.

The most interesting point is what happened after elections. National elections were won by the conservative coalition and a new majority arouse in the Parliament. After some months, the new government decided to re-start congestion pricing even having commited to consider the whole county results on the referendum. One political explanation is that they also won the municipal elections in the city of Stockholm, the capital and the most important council in the country, which can be considered a switching district. On the other hand, the rest of the county was traditionally conservative and their majority was consolidated and not threaten in most municipalities. The measure was approved on June 2007.

In spite of its approval, several changes were decided on the use of the revenue obtained. Although these funds were devoted to public transport during the trial stage under Social Democratic government, in the permanent setting of the project the new government decided to use the revenue to invest in infrastructure enlargements rather than in public transport. Moreover, this investments were going to be devoted to improve the outer rings of the city, probably to compensate the outer voters from the decision taken contrary to the promise made.

Results of the measure are more than satisfying if we consider the expected goals. The reduction for the entire congestion charge periods over 24 hours was about 19% and this decrease in traffic across the cordon was largest during the morning and afternoon rush hours – from 6:30 am to 18:00 pm – when passages dropped by 22% on weekdays (Stockholmsforsöket 2006, p. 6). Average journey times also fell in the inner-city and the queuing times dropped by approximately a third in the morning rush and have been halved in the afternoon rush. At the same time, more people – approximately a 6% more than the year before - changed of transport mode by leaving private cars to use public transport, and the number of cars in the park-and-ride facilities grew a 23% as well.

The cases of the island Lidingö, which its only access is the one connecting the island to the city center, and also the access by the E4/Essingeleden bypass, provide the counter-part. These routes remained free of charge due to the lack of free alternatives and have experienced a significant increase of traffic and average travel time.

Another interesting fact from the Swedish experience is that during the period in which public transport was expanded without congestion charges no significant reductions on motor traffic was achieved but this investment is considered necessary in order to make easier to switch from private transport to public after the introduction of charges.

Concerning environmental impacts, the reduction of emissions achieved can be determined between 8% and 14% in the inner-city. On the contrary, for Greater Stockholm the reduction was lower, placed between the 1% and 3%. Greenhouse gas carbon dioxide also dropped by 40% in the inner city while in the rest of the area the decrease was a 2-3%. Besides, road safety was also improved thanks to the measure and the reduction in the number of accidents involving injuries achieved a significant 5-10% in the inner-city meaning the avoidance of about 70 of this type accidents.

Equity effects can also be considered. In fact, it is found that congestion taxes negatively affect (Transek, 2006):

- the inner city more than other areas (they pay twice more than outer residents).
- high-income individuals more than low-income individuals (they pay three times more).
- employed people more than others (they pay three times more)
- households with two adults with children more than other types of households.
- men more than women (they pay 50% more)

However, these are the groups which also enjoy the largest time gains.

Finally, congestion charges only had a minor impact on retail but it is considered too early to extract causalities. Sales were developed under the same pattern than before but transport business – taxis, couriers and tradespeople – receive the benefits from the improvement in accessibility and journey time cuts.

Norwegian cities (Oslo, Bergen and Trondheim)

The use of road charging is also used in some Norwegian cities like Bergen, Oslo and Trondheim in the form of toll cordons. In Oslo the system is always operating, in Bergen the toll is only charged to users between 6am and 10pm on weekdays, and Trondheim decided to charge users from 6am to 5pm. In all cases the toll is not time-varying with the slight exception of Trondheim where after 10am the fee is lower, but heavy vehicles pay double. However, the motivation behind congestion charging was not to achieve an efficient allocation by reducing congestion, but raising money to fund road projects in 1986. The main reason that lead the Bergen's Council to undertake this project was the expected delay of national funds to cover infrastructure needs. The project had to finish in 2001.

This first experience in the country was followed by other important cities like Oslo and Trondheim in 1990 and 1991 respectively, which are in turn the first electronic systems of toll collection. The same rationale behind Bergen's plan was established in both cases, which should be closed in 15 years (Larsen and Ostmoe, 2001).

In this experience most of revenues were devoted to invest in road projects. Only small amounts were invested in public transport, since the law supporting toll collection restricted the use of revenues to invest in road infrastructure. In fact, the only purpose of toll collection was to raise money for these projects and according to Larsen and Ostmoe (2001) traffic management was never an issue. That is why it is not correct to consider these experiences as congestion charging projects and the source of popular opposition. However, fiscal constraints in a moment of enlargement and improvement needs justified from a political point of view the introduction of such a measure.

Once the system was implemented the opposition diminished thanks to the obvious effects on new infrastructure investments which were very visible for the public. However, one interesting aspect of these cases is that the issue was not politically used. Indeed, both main national parties agreed the measure and this diminished the electoral risk of the big parties.

As a result, Norwegian toll cordons were successful in their objective of funding road projects but did not consider any traffic management function. In spite of this, a reduction of about 10% was found in the peak hours at least in Trondheim. In the Oslo and Bergen no traffic reduction was identified. The popularity of the measure has never been significant but the political consensus prevented a failure in the project. Social costs of this measure were not considered and there are reasons to doubt whether this is the most efficient way to raise money by governments.

After these successful experiences other cities introduced the same scheme in the country (Kristiansand, Satavanger, Tønsberg and Namsos) and prospects of introducing congestion charging are possible since the amendment of the Road Act that restricted the use of revenues to fund road projects (Santos and Fraser, 2006; p.267)

2. Failure experiences

Edinburgh

The city of Edinburgh had been developing a congestion pricing scheme for almost a decade when decided to carry out a referendum in February 2005. The scheme proposed was a two cordon congestion zones – charged between 7:00-10:00 in the inner cordon and 7:00-18.30 in the most extensive one- and the daily fare charged to private transport users would be 2 pounds. Revenues were going to be devoted to improve public transport.

Edinburgh citizens rejected the project in a referendum –74.4 % of negative votes– and the council gave up the plan of charging road users. The Councillor Donald Anderson announced after the results that “the idea is now dead and buried for Edinburgh but we are as committed as ever to further improving our city's transport” (BBC news. 22 February 2005). The result also stopped other UK city plans to implement similar congestion charging systems.

Gaunt, Rye and Allen (2007) sent a survey to voters in order to understand the decision process which lead most citizens to reject congestion pricing. Their exploited results show that the principal factor for those rejecting the project was car use, but also the public’s limited understanding of the scheme increased the strength of the opposing vote. Moreover, according to their results, voters were unconvinced that the scheme proposed would have achieved its dual objectives of reducing congestion and improving public transport. The main view was that government was trying to collect money from road users thanks to this charge as a substitute for tax raises and no impacts were expected in the public transport quality. In fact, this was the experience with previous fees and since public transport improvements were not initiated, its users considered that the project would shift more people into the public network damaging its quality. Following the same rationale, McQuaid and Grieco (2005) also consider that reducing congestion was a secondary motive of congestion charging, given the high revenue raising component of the project.

Politically, this issue was also part of the debate between government and opposition and probably this also had an impact on referendum results. The Labour Party and their Liberal Democrat coalition partners in the Scottish executive were supporting the plan – Labour Party was ruling the city of Edinburgh- while opposition parties with the exception of the Green Party, defended a negative vote.

This time the surrounding municipalities like West Lothian, Midlothian and Fife, also controlled by the Labour Party – but in some of them the Scottish National Party was really a threat -, were against the project and claimed that the project was unfair with those living far from the capital. However their political weight was very small in comparison with Edinburgh institutions and were not consultated in the referendum.

Regarding interest groups, those against the project were strongly organized, while the ones supporting the measure and more benefited never did so.

IV. Lessons

From the experiences presented above, there are interesting lessons that can be obtained to help those policy makers engaged in the challenge of implementing congestion charging in their cities or to those interested in traffic management tools. These lessons are characterized in the present section and are divided in three sub-sections. Firstly, we extract the main lessons from the challenge of making road charging acceptable for the public. Secondly, since there is a worry on the distributional effects that the policy may produce, we highlight the main aspects which must be considered by policy makers and city planners on this issue and finally, general results of the experiences described are summarized at the end.

1. Making road pricing acceptable.

The main obstacle to the implementation of urban charges is public acceptance and political support in cities enjoying well developed mass-transit systems (Glazer and Niskanen 2000; Jaensirisak, Wardman and May 2005). These problems on pricing acceptance usually appear due to the difficulty in explaining to the public the application of marginal cost pricing in order to achieve efficiency goals. In fact too much weight has been put to efficiency criterias which are the most difficult to understand and convey for the public (Viegas, 2001). In addition, this lack of understanding and confidence from the public shifts fear to politicians who also see the pricing solution as politically not acceptable, since citizen preferences are major determinants in policy decisions and they turn into alternative ways of controlling car use (May and Nash, 1996).

One important obstacle to achieve user acceptance is the transition from enjoying free access onto mandatory payment for the same access. This access is usually considered by the public as a right since it is generally assumed that demand for driving is highly price inelastic and that road pricing produces unfair effects (Jones, 1998).

To extract interesting lessons on the importance of public acceptance we can collect the experience of Edinburgh which resulted in project rejection due to equity and lack of information problems; and to the Norwegian cities in which the public opposed the measure without success. On the other hand, better acceptance was found in London, Singapore and Stockholm. Probably, the motivation claimed to support urban road pricing, which was the need to fund capacity enlargements in the transport system in those cities, especially in the public transportation, was of great help instead of the traffic management argument in the cases in which congestion is not as severe as was in London. Raising revenues to improve transportation is easier to understand. However, in Norway the fiscal motivation was exactly what lead most peaple to react against the project. Indeed, one of the most important aspects of a congestion charging project is the use given to revenues and its political accountability. In those cases the revenues are used to fund road projects rather to improve local transportation, but in the cases of Stockholm and London the resources are devoted to public transportations. Probably for this reason the opposition decreased after some time.

In fact, Oberholzer-Gee and Weck-Hannemann (2002) argue that the revenues of road pricing can also be used to overcome political resistance since policy makers favor instruments that weaken the government's budget constraint and funds can be returned through compensations. In fact, in all experiences a large list of discounts are awarded to those citizens affected the most.

Again on the use of revenues, some surveys also point out that the public is more prone to support environmental programs rather that traffic management reforms. That is why Jones (1998) defends the importance of claiming for other goals instead of raising money. Therefore, including these measures into environmental packages may help its acceptance (May and Nash, 1996; Oberholzer-Gee and Weck-Hannemann, 2002).

A clear pattern in most experiences is that opposition against congestion charging diminishes after some time. Therefore, trial periods are a good instrument before any referendum. The trial, at least in Stockholm, was a key factor in gaining support for the measure. Another possibility is to impose congestion charges if there is a political agreement that prevents the use of this issue against the goverment, knowing that after some months the public will get used to the measure and opposition intensity will be lowered without electoral consequences. In fact, Shade and Shlag (2003) state that this reaction also appears when the measure is imminent and the opposition is wasteful.

2. Equity effects of road charging

Besides efficiency other objectives are usually pursued by road charging or taken into consideration. Environmental goals and equity are normally integrated in the project and can help in its motivation and justification. Moreover, these other dimensions are basic aspects in the acceptance of road pricing as was previously warned. In fact, Viegas (2001) includes equity in the core of acceptability since this is strongly related to the perception of fairness. The main problem from the equity point of view is the exclusion from access to a range of users not willing to pay the fee established for the use of the road. This range of users is usually the low-income group of citizens who are shifted to other public transport modes.

According to Eliasson and Mattsson (2006) equity effects are important because the magnitude of the redistribution can be so large that it dwarfs the net benefit of the project and secondly because it can result regressive since high-income groups give higher value to their time and may support paying to get time gains (Arnott, de Palma and Lindsey, 1994; Evans, 1992;).[3] Thus, equity in this frameworks "involves not only equality between mode users and between operators, but also the risk of increasing inequalities between users or consumers, and the desire to preserve social or spatial solidarity" (Raux and Sauche, 2004, pp 193)

For this reason it is important to analyze distributional effects and consider the impact of the use given to the revenues in order to compare them with the net welfare surplus. May and Nash (1996) consider that the net effects are crucially influenced by how the revenue from road pricing is used. In this way, Eliasson and Mattsson (2006) consistently find for Stockholm that the net impact of the project is decided by how the revenues are spent. If revenues are devoted to improve public transport the system might be considered progressive,

[3] Eliasson and Mattsson (2006) argue that that this is likely to happen when congestion levels are low or demand is relatively inelastic.

but if funds are devoted to proportional tax cuts the opposite conclusion holds. Also, residents and employees in the city centre are the most affected by the charges, and discounts have been the general solution to this negative impacts on specific groups of citizens.[4]

Therefore, the use given to the revenue raised by tolls becomes a central aspect on equity effects and its perception by the public (Small, 1992). In most experiences this revenue has been devoted to fund public transport supply and Viegas (2001) identifies two advantatges from this policy. First, it reduces the costs (loss of utility) from mode change and second, it favours the low-income group of citizens who are usually the ones using the most public transport. In addition, this policy helps in obtaining a wide public support. Banister (2003) also concludes that charging revenues must be re-invested in the transport system in order to overcome equity concerns favouring the low-income groups of citizens.

Also, it is important to take into account that according to McQuaid and Grieco (2005) the winners from new policies are likely to be less strident than economic losers and this provide some fear to policy makers which prefer to avoid the opposition of interest groups (Fietelson and Solomon, 2004; Harrington, Krupnick and Alberini, 2001).

3. General results

Urban road charging experiences, once implemented, have shown interesting results leading to success in the reduction of peak-time traffic. Therefore, they become a successful tool to manage demand and decrease congestion and environmental costs. In the cases of London, Stockholm, Singapore and even in the Norwegian cities where the goal was not traffic management, this measure provided significant redutions in the congestion costs associated to the entrance of city centers, providing revenue to invest in public transportation or road projects. Moreover, the measure increased average speeds everywhere, improving private and public transport productivity. The revenues helped in order to make more attractive this public

[4] Specific results distinguishing gender suggest that men are more affected than women by the reform.

transportation which at the same time received more passengers and as a consequence more revenues. In fact, modal split is found since a decrease of private cars in favour of public transportation is easily achieved. It is also considered that road pricing improve the environment in the city since reductions in greenhouse gases are found in all experiences. On the other hand, re-routing and the use of other time periods to shift trips are recognized and must be considered by the planner.

The political situation may also play an important role in order to implement the measure as we stated in the Swedish, Scottish and British experiences where the opposition used the issue against the incumbent government. On the contrary, when big parties agree in the need to use prices to restrict traffic, like in the Norwegian cases, the measure is easily introduced in spite of public opposition.

Trial periods are also recommended before any referendum since it is found that opposition against the measure declines after its introduction, especially if the revenues collected can provide better public transport and it is made visual for the citizens. The experiences of Stockholm and Edinburgh in this field are extremely opposite, also was their success. The use given to revenues and the fairness or equity considerations are considered crucial to get the public oppinion support.

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TABLES

Table 1. Congestion costs in 437 U.S. urban areas (1982-2005)

	1982	1995	2004	2005	Change 04/05
Individual Congestion Costs (constant 2005 dollars)	$260	$570	$680	$710	4.4%
National Congestion Costs Congestion cost (billions of 2005 dollars)	$14.9	$45.4	$73.1	$78.2	7.0%
National Travel delays (billion hours)	0.8	2.5	4.0	4.2	5%

Source: Schrank and Lomax (2007).

Table 2. Congestion costs ranking in U.S. urban areas. Top 10 areas in 2005.

Rank	Urban Area	Congestion costs ($Million)	Travel Delay (1,000 Hours)
1	Los Angeles-LBch-Santa Ana, CA.	9,325	490,552
2	New York-Newark, NY-NJ-CT	7,383	384,046
3	Chicago, IL-IN	3,968	202,835
4	Dallas-Fort Worth-Arlington, TX	2,747	152,129
5	Miami, FL	2,730	150,146
6	Atlanta, GA	2,581	132,296
7	San Francisco-Oakland, CA	2,414	129,919
8	Washington, DC-VA-MD	2,331	127,394
9	Houston, TX	2,225	124,131
10	Detroit, MI	2,174	115,547

Source: Schrank and Lomax (2007).

Table 3. Referendum results in the city of Stockholm and in the rest of surrounding municipalities (2003).

Municipality	YES	NO
Stockholm [a]	51.3	45.5
Rest of Municipalities [b]	39.8	60.2

a. Blank and invalid votes represents the remaining 3.2%
b. Blank and invalid votes not available.

Source: Authors'

Table 4. Correlations between shares of party votes in general 2003 elections and share of YES votes in the referendum

Correlations	**Yes**
Share Social Democratic Party (2006)	0.56
Share Moderate Party (2006)	-0.23

Source: Authors'

Table 5 Ordinal Least Squares estimates. Dependent variable: Share of Yes votes Number of observations = 14.

Party votes as explanatory variable	**Share of Yes votes**	**R^2**
Share Social Democratic Party (2002)	0.3644*** (3.77)	0.50
Share Moderate Party (2002)	-0.3024** (-2.28)	0.30

Note: ** Significant at 5%, *** at 1%
Source: Authors'

FIGURES

Figure 1. Social and private marginal congestion costs.