# HOW CAN CITIES HARNESS MOBILITY PRICING TO REDUCE CONGESTION, PROMOTE FAIRNESS, AND SUPPORT INVESTMENT IN TRANSPORTATION INFRASTRUCTURE?

Adrian Lightstone, WSP Canada
Dirk van Amelsfort, WSP Sweden
Karin Brundell-Freij, WSP Sweden
Preeya Shah, WSP Canada
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## 1 Introduction

This paper seeks to provide insights regarding the use of congestion charging as a policy for regulating traffic demand and reducing congestion. Congestion charging has been researched for almost 100 years and the empirical evidence of its application and effectiveness are convincing. However, as an implemented policy, congestion charging is underutilized. This report identifies the primary reasons for this: a lack of understanding and confidence in the effectiveness of congestion charging, and concerns regarding public acceptance and fairness. This paper discusses congestion charging, meaning pricing the use of roads with the objective of reducing the negative impacts car use has on society, including congestion, emissions, traffic safety issues, etc. Although congestion charging typically generates a positive revenue stream which can be used for various investments, it is not usually a primary objective.

## 2 Understanding Congestion Charging

This section discusses congestion from the traffic perspective: what causes congestion and how does it manifest on the streets? This is followed by a discussion regarding congestion from the perspective of economic theory, to understand the link between pricing and reduced congestion.

### 2.1 Congestion Theory - Travel Time

The detrimental effect of congestion is not the queue length but rather the increase in travel time it causes. Travel times are defined by a non-linear relationship between the volumetric flow and travel time on a specific road segment. This means that small changes in demand can lead to significant changes in average travel time. This is shown in Figure 1 where the horizontal axis represents the traffic flow (veh/hour passing a given location on the segment) and the vertical axis represents the travel time (hours). Up to a point, an increase in the volume of traffic on a given segment can be largely accommodated by increased traffic flow, and will therefore impose only marginal increases on the average travel time. However, when congestion begins – the point at which demand exceeds capacity – further increases to demand have large impacts on travel time.

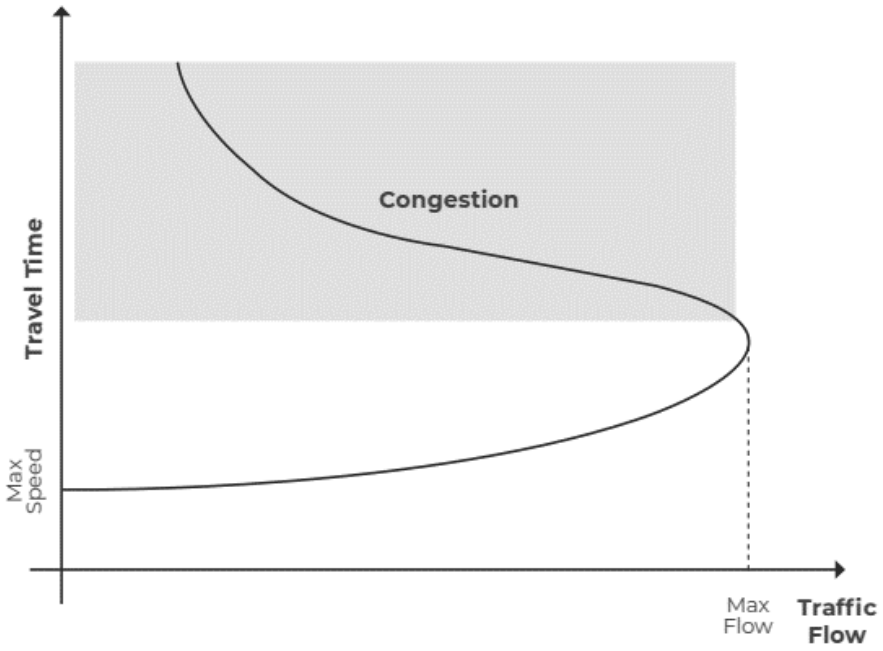


*Figure 1. Non-Linear Relationship Between Traffic Flow and Travel Time*

### 2.2 Congestion Theory – Capacity Drop

Aside from the non-linear relationship between demand and travel time, another critical aspect of road congestion is the drop in road capacity that occurs when congestion builds. A drop in road capacity refers to a situation where the outflow from a bottleneck decreases as traffic enters a congested state (i.e., begins to queue). This can be seen in Figure 2, where the horizontal axis represents the number of cars per lane per kilometer, or density, while the vertical axis represents the flow in vehicles per hour. As more vehicles enter the road, the flow increases initially as vehicles continue to travel at high speeds. Once the number of vehicles on the road becomes too high – i.e., once demand exceeds capacity – congestion will occur, and flows will decrease. The result is a compounding effect in which a road's capacity continues to decrease as demand continues to exceed road capacity.

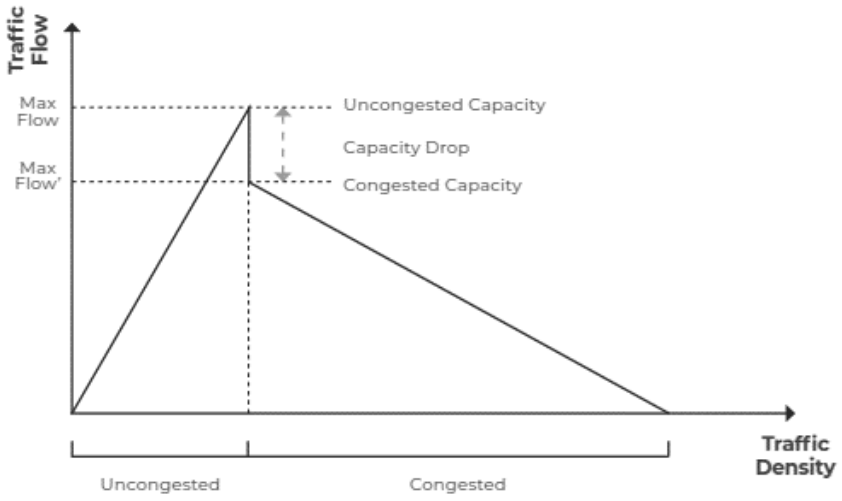


*Figure 2. Capacity Drop Relationship Between Traffic Density and Traffic Flow*

There are various causes for capacity drops, but there is a significant relationship between the speeds of traffic when arriving at the bottleneck and the size of the drop. The lower the arrival speeds, the larger the capacity drop. This implies that the infrastructure, when its capacity is most needed, is underperforming because demand is unmanaged. Road capacity can drop anywhere from 10% to 30% under congested conditions. As capacity drop has a large impact on queues and congestion, many traffic management strategies focus trying to pre-emptively avoid congestion from occurring.

## 3 Congestion Charging Theory

### 3.1 Marginal Cost Pricing – Economic Theory

When making travel choices, people take into account their own direct cost of travelling, but not the cost imposed on society. Travelers generally take into account the experienced congestion, fuel costs, insurance, taxes for road construction and maintenance, but not the societal costs (externalities) of congestion, which include reduced air quality, output of emissions (contributing to climate change), traffic collisions, road wear and tear, as well as noise and vibrations. From an economics viewpoint, failing to account for the full cost of a good or service leads to overconsumption. In 1920, economist Arthur Pigou proposed a tax to correct the price for products in markets where the costs imposed on society are not included in the consumer prices. This concept, called marginal social cost pricing, is the key rationale for congestion charging, and will be discussed in further detail in this section. Figure 3 shows these relationships graphically. The horizontal axis represents the demand for car travel and the vertical axis represents the travel costs. The demand curve is assumed to be linear in this example, but in reality it may not be. As seen in Figure 3, demand increases as travel costs decrease. The "Marginal Private Cost" curve represents the cost each incremental traveler experiences without consideration of the congestion cost they impose on other drivers and the external costs they impose on society. This relationship is non-linear. Where the demand curve and the marginal private cost curve intersect an equilibrium situation exists.

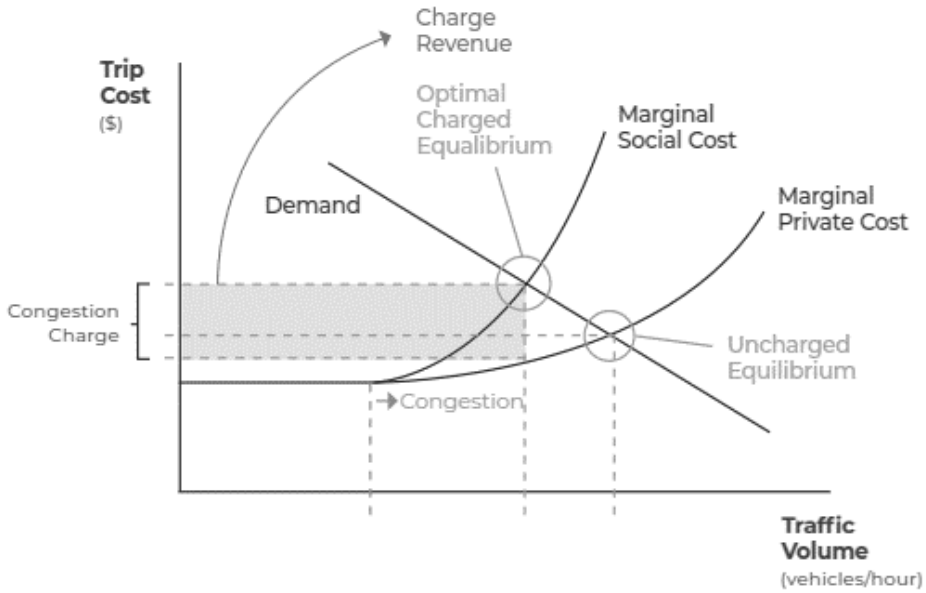


*Figure 3. Principle of Marginal Social Cost Pricing*

However, the costs individuals experience are not equal to the total costs of travel for society and therefore a third curve is introduced. This "Marginal Social Cost" curve shows how the costs to society increase with higher demand for car travel. Since the societal costs are always greater than the private costs, the marginal social cost curve is always above the marginal private cost curve. The marginal social cost curve intersects with the demand curve at a different point where demand is lower and the price is higher. The difference in trip costs between the higher marginal social cost equilibrium and the lower marginal private cost equilibrium determines the "economically optimal" congestion charging level, assuming the goal of the charge is to recover no more and no less than the sum of all externalities associated with driving. Charging exactly that amount implies the costs individuals pay are equal to the costs their choices impose on society. The revenues generated by the congestion charging policy can be calculated by multiplying the congestion charge by the demand level at the marginal social optimum equilibrium.

# 4 Equity and Fairness

## 4.1 The Basic Concepts

The previous sections discussed how congestion charging can be used to reduce congestion. We have shown that a charging scheme has the potential, if properly designed, to generate net benefits to society at the aggregate level. However, these benefits will not be evenly distributed over the population: some people will experience large improvements, whereas others may end up with no appreciable improvements or even worse-off than before the introduction of a congestion charge.

Equity is a common term for the fair and impartial distribution of taxation burden across different groups in society. With respect to congestion charging, equity refers to how the costs and benefits resulting from a charge are distributed over the population. This distribution can be assessed with respect to different categorizations: economic status, demographic status, neighbourhood, or mode of transportation. We make the following distinctions between vertical and horizontal equity, respectively:

- **Vertical equity** deals with the distribution of impacts by income (and other indicators of privilege).
- **Horizontal equity** deals with the allocation between individuals and groups that are (before the policy is introduced) comparable in status and need.

## 4.2 Rawls' Theory of Justice

Perceptions of fairness are individual, and not everyone agrees on which properties of a policy make it fair (or unfair). The American philosopher John Rawls developed a normative theory for the basic traits of fairness: Justice as fairness.[i] Rawls's theory is based on a thought experiment in which people agree about the state of the world, without knowing their own social position. Rawls suggests that under this "veil of ignorance", the following three principles are likely to be agreed on:

- A set of basic rights for everyone;
- Equal opportunities to change and adapt;
- Inequalities should work in favour of the less advantaged.

In congestion charging research, Rawls's framework has been tested and found relevant to understand the public perception regarding the (lack of) fairness of different schemes.[ii]

**Rawls's first principle** discusses the absolute minimum level of rights for a given individual – for example, the notion that everyone should be allowed the basic right to mobility. With regards to congestion charging, overall affordability of charges may be a fairness concern that reflects Rawls's first principle.

In most cases, when concern about the fairness of congestion charging is raised, it relates to how the impacts of the scheme will be distributed over the population – in other words, equity. Rawls's second and third principles both relate to equity.

If a policy treats peer groups inconsistently, without any understandable or acceptable motivation for the differences between them, the policy is likely to be regarded as unfair. Opposition on this ground can be regarded as a reflection of **Rawls's second principle**: everyone should be given the same opportunity to use his or her capabilities. According to Rawls, this principle sets a generic common ground for judgements about fairness: peer groups should not be treated differently for arbitrary reasons.

In the discussion of whether a scheme can be regarded as "fair", one should bear in mind, of course, the current state of the transport system does not necessarily have to be "fair" to begin with. If, for example, people living in a specific area can be identified as "losing out" when a policy is introduced that does not necessarily mean the policy treats them unfairly: it could be that they had unfair advantages to begin with, and an advantageously unfair baseline situation will be mitigated by the policy.

However, sudden and unexpected implementation of a charging policy can be perceived by the public as being unfair, even when it implies improved fairness in the long-run. This phenomenon can also be understood as a reflection of Rawls's second principle: that everyone should be allowed a reasonable opportunity to adapt to new circumstances. People make assumptions about the future conditions of the transport system, based on what they know about the current system characteristics. The assumptions about the transportation system often underpin decisions behind very long-term economic and social commitments (where to live and work, and vehicle ownership, for example). Based on these circumstances, it may be perceived as unfair if the rules of the game are subject to large and rapid changes.

**Rawls's third principle** suggests a policy will be regarded as unfair if it implies a redistribution of resources from the poor to the rich. In some cases it is more relevant to look at the relative (rather than the absolute) effect for different income groups. A tax, for example, is called progressive if higher income groups pay a larger proportion of their income, and regressive if it does the opposite – make lower income groups pay the larger proportion. Progressive taxes are generally seen as more fair than regressive taxes.

How the net impact of a charging scheme will differ for different groups cannot be determined based on their payments alone. How the funds from the charging policy are used and the distributional profile of those expenditures will matter. In Stockholm, it was identified that males with high-incomes were the group who paid the most charges. If the funds were used to develop public transport, which in Stockholm is used more by women and lower income groups, then congestion charging will, in a "life-cycle perspective", imply a redistribution of welfare from those who are better off to lower income groups.[iii] Thus, the direction and size of net equity effects from the introduction of charges depends not only on the design of the scheme itself, but also on how revenue is used. These factors can be adjusted to achieve a system that is not only efficient, but also acceptably fair.

## 5 Public Acceptance

Most congestion charging schemes, if not all, have had to stand at least some public critique. Public opposition is not the same everywhere and the level of opposition typically varies over time. The same distinct dynamic pattern of how acceptance develops has been observed in implementation processes in a number of cities. Early in the process, when the discussion is general and the effects of charging are discussed as abstract concepts, there is typically not much formalized opposition from the public. As congestion charging concepts progress towards implementation, more concrete definitions around the scheme design are developed and presented to the public. This may include definition around the geographical area of charging, toll rates, variance by vehicle type or time of day, etc. The increased definition around congestion charging will typically make many members of the public worried about negative personal consequences, and evoke a vivid public debate. The level of public acceptance will decrease during this phase.

However, after implementation, acceptance will typically increase again. This increase in acceptance can be attributed to a number of factors:

- Travel times improve more than motorists expected;
- Negative consequences (charges paid, mode shift) prove less problematic than what was anticipated;
- People adapt and accept a new status quo, no longer evaluating it as a "change".

This pattern of public acceptance over time, as it relates to congestion charging, is shown in the following figure.

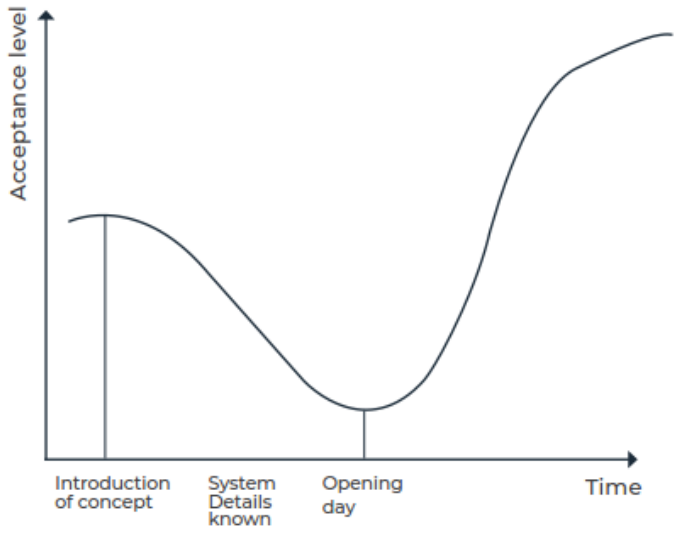


*Figure 3. Typical Dynamic Pattern of Acceptance*

The same basic acceptance pattern is also revealed in the following table, which provides some numbers for acceptance before and after implementation, respectively, from charging schemes in different European cities. The table clearly shows a consistent increase in the level of acceptance over time in all cities, although the absolute level of acceptance varies substantially between cities before as well as after implementation.[iv]

*Table 1. Acceptance of Charging Before and After Implementation in Five European Cities*

| City | Before | After |
|---|---|---|
| Stockholm | 21% | 67% |
| Bergen | 19% | 58% |
| Oslo | 30% | 41% |
| Trondheim | 9% | 47% |
| London | 39% | 54% |

The average level of acceptance, as discussed above, conceals a substantial difference between population segments. As anticipated and perceived, self-interest has been shown to have substantial impact on attitudes towards congestion charging. In general, people support congestion charges if they perceive the charges have been, or expect they will be, beneficial for themselves. Apart from the effect of pure self-interest, the extent to which people approve of charges is also effected by socio-demographic characteristics such as income, gender, and education as well as by their general attitudes and personal values. For example, personal traits which contribute to increased support include: the extent to which individuals trust the intentions and abilities of political authorities and their awareness and concern for environmental issues.

Factors such as car ownership, car use and political values will, in turn, vary between socio-demographic groups such as: type of neighbourhood, income, gender, and education. Therefore, acceptance for congestion charges varies accordingly. The five most important factors affecting public acceptance are summarized as follows[v]:

*Table 2. Factors Affecting Public Acceptance*

| Factors Affecting Acceptance | Impacted Group | Effect on Acceptance |
|---|---|---|
| Experience | People with hands-on experience with congestion charges | ↑ |
| Attitude to government intervention | People with political views that government should intervene as little as possible | ↓ |
| Concern for environmental issues | People with (political) views that environmental problems are severe and need to be addressed | ↑ |
| Value of time | People with higher value of time perceive larger benefits when congestion is reduced | ↑ |
| Frequency of car usage | People who use their cars frequently expect to pay more | ↓ |

Congestion charging is often regarded as politically difficult to introduce. The initial level of public acceptance is often low, and a number of congestion charge schemes investigated around the world have failed to be implemented because of public opposition. From one side of the political spectrum, opposition often comes from the feeling of being over-taxed (and that taxes, generally, have negative impact on the economy). On the other side of the spectrum, opposition is more based on equity concerns and fairness. The fear of initial public opposition is another major reason for lack of political support.

From other perspectives, congestion charging serves as a political opportunity. One reason is the transport sector is often stuck between large investment needs and tight budgets. There is often limited support both for the increase of taxes and for the reallocation of funds from other public sectors, such as healthcare, education, defence, etc. But with a congestion charging policy in place, the transport sector could get an earmarked stream of revenue which could be used to increase the level of investment in the sector.

## 6 Balance Between Effectiveness and Concerns

Which effects of congestion charges are important for the overall assessment of the attractiveness of a charging scheme will vary between user groups. For people who are frequent car-drivers, the desire for shorter travel times and less congestion will be balance against a fear of increased driving costs and also a perception amongst certain groups that urban car-drivers are a 'persecuted' group. For the environmentally conscious, the desire for reduced car traffic and improved urban quality may balance against a concern for adverse effects on vertical equity. For people with libertarian values, the attractiveness of the market mechanism stands against the fact revenue streams will contribute to larger public funds, and therefore more ambitious political decision-making.

As a result, implementation of congestion charging will, for most groups, be connected to both positive expectations of improvements and, on the other, concern for potentially adverse impacts. The balance between these two forces will determine whether the individual will accept or oppose the policy.

From experience, we know that before introduction, this balance will typically lean to the negative side for the majority of individuals. It should be possible to at least reduce the problem of public opposition, through cautious designs which are as effective as possible in generating benefits, while at the same time, limiting the negative impacts to the extent possible.

[i] Rawls, John. 1971. "A Theory of Justice." Belknap.

[ii] Raux, C., and Souche, S. 2004. "The Acceptability of Urban Road Pricing: A Theoretical Analysis Applied to Experience in Lyon." Journal of Transport Economics and Policy, 38(2), Pages 191-215.

[iii] Eliasson, Jonas. and Mattsson, L.-G. 2006. "Equity Effects of Congestion Pricing." Transportation Research Part A: Policy and Practice, 40(7), Pages 602–620.

[iv] CURACAO Deliverable D3: Case Study Results Report, 2009

[v] Hamilton, C.J. 2011a. "Revisiting the Cost of the Stockholm Congestion Charging System." Transport Policy, 18(6). Pages 836-847.