Congestion Charging:

Policy and Global Lessons Learned

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Executive Summary

Understanding Congestion Charging

• The relationship between travel demand and travel time is non-linear which means it does not require large reductions in travel demand (traffic volumes) to achieve substantial improvements in travel times.

• In severe congestion, the capacity of road can drop below its design capacity. By leaving demand unmanaged (no decongestion charging) we accept a lower level of infrastructure performance.

• When making travel choices, people take into account their own direct cost of travelling, but not the cost imposed on society.

• Private car use is underpriced in economic terms. People are not paying the full costs that private car use puts on society (such as emissions, safety, noise, wear and tear, and congestion).

• Congestion charging is an effective instrument to capture societal costs in travel decisions and make the transport system more efficient.

• Congestion charging leads to behavioural responses from the traveler, including switching modes and travel departure times. However, most car drivers tend to stay and pay.

• The congestion reduction effects and societal benefits of congestion charging depend on individual behavioural responses to price changes.

• Demand for travel alternatives will increase and facilitating this may require investment in other modes of transportation, for example transit and cycling infrastructure.

Equity and Fairness

• With respect to congestion charging, equity refers to how the costs and benefits resulting from a charge are distributed over the population.

• Benefits of a congestion charge 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.

• Perceptions of fairness are individual, and not everyone agrees on which properties of a policy make it fair (or unfair).

• Philosopher John Rawls developed a theory for the basic traits of fairness, which can be applied to congestion charging, based on the following three principles:
  • **Principle 1**: A set of basic rights for everyone;
  • **Principle 2**: Equal opportunities to change and adapt;
  • **Principle 3**: Inequalities should work in favour of the less advantaged.

• **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.
• The user-pay principle (people should pay in proportion to how much they use the transport system) and the polluter-pay principle (people should pay in proportion to the problems they impose on others) can be relevant to a non-equitable distribution of the impacts of congestion charging related to Rawls's second principle.

• The sudden and unexpected implementation of a charging policy can be perceived by the public as being unfair. This phenomenon can be understood as a reflection of Rawls's second principle: that everyone should be allowed a reasonable opportunity to adapt to new circumstances.

• 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. How the funds from the charging policy are used and the distributional profile of those expenditures will matter.

What we Know About Public Acceptance from Around the World

• Public acceptance is likely to be low before introduction but could be expected to typically increase after introduction.

• 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 the scheme designs are developed and presented to the public. The increased definition around congestion charging may make people worried about negative personal consequences, leading to lower acceptance levels.

• The lack of acceptance before introduction of a charge may be explained by status quo bias which is overcome by greater public acceptance if the implemented system is well-designed and well-functioning.

• After implementation, acceptance will typically increase, which 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 was anticipated;
  • People adapt and accept a new status quo, no longer evaluating it as a “change”.

Lessons from International Experience

• All congestion charging schemes that have been implemented have had the intention of generating positive effects on congestion and/or emissions.

• Most congestion charging schemes provide a positive revenue stream, which is typically used to fund additional transportation options.

• Even if conceptually attractive, no implemented schemes use time and place differentiated distance based charging due to system complexity and costs at the time of implementation.
1. Introduction

This report 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.

1.1 Defining Pricing in Transport

There are many options and typologies for pricing transport, each with its own policy purpose. The typologies range from fuel taxes to parking charges to vehicle registration fees to dynamic road pricing, and many others. Different cities and regions use various naming conventions, such as road user charging, mobility pricing, road tolls, Electronic Road Pricing (ERP), and others. This document 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.

1.2 Report Structure

This document starts with an explanation of congestion theory, congestion charging theory, and the behavioural responses of users. Section 2 covers the economic theory and traffic engineering perspective of congestion charging. Section 3 presents fairness, equity, and public acceptance issues associated with congestion charging. A selection of international case studies is presented in Section 4, which provides empirical evidence on the effectiveness of congestion charging.
2. Understanding Congestion Charging

The term congestion charging is not limited to dealing solely with congestion; it is a policy measure which can be introduced with the goal of reducing various types of negative impacts from vehicular traffic. However, given that a desire to address congestion is often the primary motive for examining congestion charging, this chapter provides an overview of traffic congestion. Specifically, this chapter 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 Theories

2.1.1 Bottleneck

There is a variety of reasons why congestion occurs on our roads. One of the core concepts associated with congestion is the concept of a bottleneck, where the demand for road space is higher than the available capacity of the road. In a bottleneck, the number of vehicles trying to pass a given point is higher than what the road can accommodate, and as a result, vehicles are left idling in a queue formation. Queues increase in length as long as demand remains greater than capacity and may impact traffic on adjacent roads which were not the cause of the bottleneck.

Consider an example of a 2-lane road with a capacity of 4,000 vehicles per hour where one lane drops off, leaving a bottleneck with a capacity of 2,000 vehicles per hour. The demand for a given peak hour is 3,000 vehicles per hour, which is no problem for the segment before the bottleneck, but too much for the one-lane segment. During the peak hour, a queue will build, adding vehicles at a rate of 1,000 vehicles per hour. If demand drops to zero following the peak hour, it would take 30 minutes (1,000 veh / 2,000 veh/hour = 0.5 hours) for the queue to dissipate. The number of vehicles in a queue in this bottleneck example changes proportionally to the gap between demand (inflow to the bottleneck) and capacity (outflow of the bottleneck).
2.1.2 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 2.1 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. Demand, or traffic density (in vehicles per kilometre), can be best understood as the number of vehicles waiting to pass a given location on a road segment. Since speeds reduce dramatically during congestion, the traffic flow decreases accordingly.

*Figure 2.1: Non-Linear Relationship Between Traffic Flow and Travel Time*
2.1.3 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 2.2, 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 2.2: 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 preemptively avoid congestion from occurring.

In the next section, the concepts of congestion will be linked to congestion charging, where congestion charging has the potential to affect congestion levels in at least three ways:

1) It will reduce demand, making bottleneck delays shorter;
2) When demand (inflow) toward bottlenecks are reduced, queues become shorter, and this reduces the risk of causing collateral congestion on other roads and in other directions;
3) If demand is reduced such that a capacity drop does not occur, queues and delays will be reduced.
2.2 Congestion Charging Theory

2.2.1 Marginal Cost Pricing - Economic Theory

When making travel choices, people take into account their own direct cost of travelling, but often 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 generally 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.

Individuals choose to travel via a given mode based on a set of modal characteristics and travel options. Based on theoretical and empirical evidence, two general behaviours are observable. The first behaviour relates to demand for car use with respect to the cost of travel. If the costs of travel increase, car demand will normally decrease, similar to the price-demand relationship for many non-luxury products. The second behaviour concerns price with respect to traffic flow. As discussed above, travel costs (including travel time) increase as congestion increases with higher levels of demand, in a non-linear fashion. Figure 2.3 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 2.3, 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 2.3: 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.

2.3 Behavioral Change Mechanisms

The congestion reduction effects and societal benefits of congestion charging depend on individual behavioural responses to price changes. It is thus important to understand the behavioural changes people can and will make. In some cases, individuals may not change their travel behaviour and simply adapt to paying the charge. They will therefore pay the marginal social cost of their travel, and the revenues can be used to mitigate the negative societal impacts. For those travelers who do change their travel behavior, their changes in behavior may vary and could include changes in travel activities, such as combining several activities (trip chaining), virtual meetings, changes in destinations, home location, mode of travel, or time of travel, or by changing their route. Not all of these adaptation strategies are equally likely to occur, nor will they occur on the same time frame, nor will they all have the same effect on congestion.

It is important to note that short-term behavioural responses after the introduction of charging will differ from long-term behavioural responses. As a city grows and people move in, out, and around the city, people will decide where to live based on a new status quo with a congestion charging policy in place. Of course, in changing observed behaviour, people are not changing their nature but instead choosing a behaviour that fits the new status quo.

Adaptation strategies will vary depending on transport system characteristics, design, and type of congestion charging system. Strategies vary between motorists, between trips for the same driver, and between days for the same trip. Therefore, transportation planners cannot provide a single “best” adaptation strategy that will suit everyone. However, several alternatives are available, including:

- Making other travel mode alternatives attractive;
- Offering good route choice alternatives “around” the charges (NB: only if those routes do not run an immediate risk of becoming overly congested);
- Allowing for adaptations to departure times by offering uncharged travel during time periods which are less congested.

Long-term adaptation strategies may, potentially, include change of workplace or residence. These location adaptations can be further supported by land use and urban planning policies. As people have more degrees of freedom to adapt, respond, and anticipate congestion charging, the long-term ability to change demand will be greater than the short-term ability to change demand.
The empirical evidence on congestion charging is that once introduced, the most common behavioural adaptation is no reaction at all. The vast majority of trips are carried out with the same mode, destination, route, and departure time as before. Most drivers stay in their car and pay the charge. However, improvements are typically observed when examined at the system level. For those trips that do change to avoid charging, the most common reaction is mode shift, primarily to public transport.

**Figure 2.4** shows the results from a study of how travellers in Stockholm adjusted their travel behaviours as a result of implementing congestion charges. The numbers in the figure represent the number of trips (in thousands) that changed per day. As can be seen, change of mode was the most common reaction (compensation strategy) overall, though change of mode was used almost exclusively for commuting trips, which account for less than half of total daily trips. For other types of trips, re-scheduling, re-routing, and re-structuring of trip chains seem to have been more prominent strategies. In the survey data, these changes were not observable individually and are considered under the “disappeared” category. The changes in travellers’ behaviour tended to be seen as minor from an individual perspective, and therefore people in Stockholm underestimated their behavioural change when they were asked in a survey compared to measured changes in traffic conditions. The trips that switched to public transport represented a non-negligible extra pressure on public transport capacity.

The main lesson learned from the Stockholm case is congestion charging allows travelers to be creative and come up with alternative solutions that neither they, nor traffic planners, may have considered before.

**Figure 2.4 Behavioural Changes to Congestion Charging in Stockholm, Thousand of Trips (Borjesson et al. 2012)**
3. Equity and Fairness

3.1 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.

As humans, residents, and voters, we tend to care about equity and link it to moral and political judgement. We regard some patterns of (re)distribution to be fair, and others to be unfair. Thus, the concept of fairness represents a normative view on equity issues.

3.2 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* (Rawls 1971). 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 (Raux and Souche, 2004).

**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. However, individuals may differ in the arguments they will consider to be an acceptable/understandable motivation for treating peer groups differently. Arguably, both the user-pay principle (people should pay in proportion to how much they use the transport system) and the polluter-pay principle (people should pay in proportion to the problems they impose on others) can be relevant as motivation for a non-equitable distribution of the impacts between groups. Not everyone will, however, accept either principle as a motivation for treating peer groups differently.

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. Eliasson (2016) shows that if congestion charges are regarded as a general contribution to public finances, then the Stockholm congestion charges are a regressive tax (on average, high income earners pay less in proportion to income than people with low income). Looking at absolute payments, however, higher income earners pay higher charges. A study from Tonne et al (2008) on the air quality effects of the London congestion charges also show that London congestion charges were environmentally progressive with larger environmental benefits for the less affluent groups in London.

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. Eliasson and Mattsson (2006) investigated the effects of the congestion charging
scheme on equity in Stockholm. 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.

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.

3.3 What we Know About Public Acceptance from Around the World

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.
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.

Table 3.1: Acceptance of Charging Before and After Implementation in Five European Cities

<table>
<thead>
<tr>
<th>City</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stockholm</td>
<td>21%</td>
<td>67%</td>
</tr>
<tr>
<td>Bergen</td>
<td>19%</td>
<td>58%</td>
</tr>
<tr>
<td>Oslo</td>
<td>30%</td>
<td>41%</td>
</tr>
<tr>
<td>Trondheim</td>
<td>9%</td>
<td>47%</td>
</tr>
<tr>
<td>London</td>
<td>39%</td>
<td>54%</td>
</tr>
</tbody>
</table>

Source: CURACAO Deliverable D3: Case Study Results Report, 2009

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.
Figure 3.2 and Figure 3.3 illustrate this pattern for Stockholm, where congestion charging was implemented on a trial basis in 2006, and permanently in 2007. It was only after the scheme was implemented that the overall public acceptance rate increased to a point where a majority supported the scheme.

Figure 3.2 relates the level of acceptance at different points in time to whether respondents expected (perceived) that congestion charging would be (had been) beneficial. The figure shows:

- All groups, irrespective of whether they thought the scheme was effective, increased their level of acceptance after implementation; and,
- Those who believed the system to be effective were more positive towards charging.

Figure 3.2: Public Acceptance for Congestion Charging Over Time (Stockholm) Based on Perceived Benefits. Source (Eliasson 2014)
Figure 3.3 shows the same pattern relative to auto usage. The figure shows car drivers who (would) pay the most are the least supportive of charging throughout the implementation process, while non-car owners are the most supportive of charging.

*Figure 3.3: Level of Acceptance in Different Groups Over Time (Stockholm), Based on Current Travel Behaviour. Source (Eliasson 2014)*
Apart from the effect of pure self-interest, the extent to which people approve of charges is also affected 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.

The higher a charge is set, the lower the public acceptance level. Additionally, travelers with a higher value-of-time perception have a higher acceptance for congestion charging Hamilton (2011a). Basic political beliefs are also of importance in acceptability for the policy. The policy is not only closely associated with taxes and government intervention but also with positive environmental action. Depending on individual political beliefs, acceptance may either increase or decrease. Hamilton (2011) summarises the five most important factors affecting public acceptance; they are as follows:

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

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.

3.4 What we Know About Political Acceptance from Around the World

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
Congestion charging is also associated with benefits for two sides in a central conflict in the urban development debate. Congestion charging has something to offer (environmental) interests that would like to see stricter car policies to improve urban quality of life and for (economic) interests that would like to see shorter travel times and more fluid vehicle traffic to improve accessibility. Thus, congestion relief is an objective that can be shared by many.

**New York City Congestion Charging Failure**

In 2006, New York City developed a 25-year plan for the city called PlaNYC. The plan aimed to reduce greenhouse gas emissions by 30 percent and reduce the nearly $13 billion costs of road congestion. A key component of PlaNYC was a congestion charging initiative. The intent was to use the congestion charge net proceeds for transportation improvements, such as better train and bus systems.

A Commission was created after the proposal was introduced to the New York State Legislature to examine different approaches to implementing a congestion charge. The 17-member Commission studied the issues and reported back to the Legislature. The Commission held months of meetings and considered a variety of ideas like raising parking rates, creating taxi stands, as well as imposing tolls on East River bridges and less conventional ideas like license plate rationing, under which cars would be prohibited from the area below 86th Street on certain days, depending on their license plate.

Ultimately, the Commission recommended an $8 flat rate daily fee for cars travelling to Manhattan between 6 AM and 6 PM on weekdays. The proposal stated that proceeds from the charge would be used for improving mobility infrastructure. The congestion charging plan gained support through a strategy developed by the mayor, key constituents, elected officials and advocacy groups. There was extensive public outreach and involvement to connect the benefits of congestion charging to improving transportation options and achieving sustainability goals.

Federal funding was made available to support the initiative, pending State approval. To implement the charge, New York City required approval from three legislative bodies: the New York City Council, both houses of the New York State Legislature (Senate and Assembly) and the Governor of New York. While the City Council supported the congestion charging plan, the Assembly was not supportive. The lack of support from the Assembly led to a loss in committed federal funding and as a result the congestion charging plan and bill were unsuccessful.

The opposition in the Assembly came from members who represented the outer boroughs of the city, primarily Queens and Brooklyn. These members viewed the proposed congestion charge as unfair on the basis of it being perceived as a regressive tax. They argued the financial impact on people in their boroughs would be too significant on their incomes leading to vertical equity concerns. The opposition based on vertical equity concerns is related to Rawls’s third principle.

The other main arguments against the charging scheme made by the Assembly focused around the feasibility of using public transit as an efficient alternative to car, whether the travel time savings were worth the cost of paying the charge, and whether the charge would even be effective as a means to decrease congestion in New York City.
3.5 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 balanced 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 that 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. Examples for how this can be achieved include:

- A targeted scheme design which reduces congestion hot spots, local environmental problems and keeps system costs down;

- A responsible use of revenue, including:
  - Compensating groups which are adversely affected by charging;
  - Investing in beneficial public infrastructure, such as improved levels of public transit;
  - Consider the reduction of other sources of public taxes (revenue neutrality).

### Equity and Revenue use for Stockholm

The equity effects of congestion charging have been evaluated in a number of studies for Stockholm. In general, congestion charging is normally regressive as the amount spent on the charges represents a higher proportion of income for lower income households than it does for high income households.

In Stockholm, congestion charges impact lower income groups more in relative terms, despite higher income groups paying more congestion charges. Recent research Kristoffersson et al. (2017) suggests the inequalities arising from congestion charges in Stockholm mainly result from the geographical distribution of where people from different income groups live and work compared to the charging locations. Other underlying factors may be involved as well, for example access to alternative modes of transportation.

Kristoffersson et al. (2017) not only considered the effect of the current congestion charging scheme on different income groups, but also researched the effect of alternative congestion charging policies and the use of revenues to compensate for negative equity effects. This work found that policy measures with higher aggregate welfare gains were also those with higher income inequalities. It also found that from the four alternative revenue distributions they investigated, reduced transit
fares were the best and tax rebates were the worst. Figure 3.4 shows the four revenue redistribution options with three income groups on the horizontal axis and gain per year in Euro on the vertical axis.

**Figure 3.4: Revenue Distribution Across Income Groups by Type**

The research did not attempt to find the “optimal” redistribution of revenues to mitigate negative equity effects and the figures below are in absolute numbers. Relatively speaking, using revenues to reduce the cost of public transportation will lead to larger gains for lower income groups than for higher income groups.

Congestion charging is a well-researched policy, but part of the proof and confidence lies in the empirical evidence of how congestion charging works in practice. Practice is different from theory, primarily because the theoretical optimal pricing scheme cannot practically be implemented. The geographical conditions, legal frameworks and political constraints in cities and regions put limits on the degrees of freedom in system design. It is therefore of interest to understand how policies in practice are implemented from the theoretical start point. This chapter presents an overview on “implementable” pricing typologies as well as summaries of the congestion charging policies implemented in Singapore, London, Stockholm, Milan, and Gothenburg.

There are several design principles for congestion charging. A summary of principles are presented in Figure 4.1 and below:

- **Point Charges**: where vehicles are charged when passing a specific location or using a facility such as a bridge or tunnel;
- **Corridor Charges**: charging for the use of a specific section of road or link in a road network;
- **Cordon Pricing (Toll Rings)**: charge points established at entries/exits to an area;
- **Area Licensing**: charging a fee for using all roads within a specific area. Fees can be charged daily or on a longer basis and may be stricter by only allowing residents’ vehicles or vehicles with a given environmental performance.
- **Network Charging Systems**: charging vehicles for using roads within a specific area. The charge can be based on distance travelled, time of the trip, or duration of the trip.

Parking charges can also be used as a policy instrument that may give effects similar to Area Licensing. In some cases, parking charges can be less challenging to introduce compared to a congestion charging scheme. Many cities already have a legislative framework which allows for local decision making regarding zones, charges and exemptions relating to parking charges. Whereas the introduction and design of a congestion charging scheme would often require new legislation, and the involvement of national authorities. Secondly, most cities already have institutions, technology and infrastructure in place for payment as well as for enforcement of parking charges. In the case of a new congestion charging scheme these would require new investment and additional costs for operation.

However, not all objectives are as easily achieved with parking charges as with a congestion charging scheme. For example, many car drivers may have access to free parking on private grounds (which they own themselves or where parking is provided by employers or shop owners). It may be difficult to target privately held parking with stricter parking policies. Furthermore, it is difficult to formulate a time-differentiated parking charging scheme which targets congestion reduction appropriately. This is because charging for congestion is based on charging the ‘movement’ of a vehicle during congested periods, not the ‘stationary’ position of a vehicle.
The diagrams illustrate different pricing concepts for the same ‘generic’ urban area including:
- Point Charges
- Corridor Charges
- Cordon Pricing (or ‘Toll Rings’)
- Area Licensing Scheme (ALS)
- Network Charging System

The locations where a charge is made is shown in red.

The congestion charging schemes presented below are all part of a wider package of transport policies, i.e. like improving public transport. A wider package of transport policies is an important reason for their success. A lesson for other cities around the world considering the possibility of introducing congestion charging, is that any such scheme ought to be accompanied by complementary measures that will provide some drivers with an alternative to the car.

The five cases also have unique political issues and targets. Different geographical contexts mean the starting point for the scheme designs vary. The local transportation policy also had an impact on designing the schemes. Three of the five schemes are using the same technology, camera-based Automated License Plate Recognition (ALPR). The Singapore scheme is using Radio Frequency Identification (RFID) and the Milan scheme is using Dedicated Short Range Communication (DSRC) as a complement to ALPR. Local conditions, policies, use of revenue, technology makes a difference when studying the characteristics of the schemes.
4.1 International Examples

4.1.1 Singapore Electronic Road Pricing

Background: The world’s first implemented congestion charging scheme was in the Central Business District of Singapore in 1975 in the form of an Area License Scheme. The scheme was a paper-based policy and the charge was fixed for the period of the license. In 1998, Singapore shifted to an electronic scheme, called Electronic Road Pricing, using Radio Frequency Identification (RFID), which made it possible to vary the charge over the course of the day.

The purpose of varying the charge is to maintain speeds of 45 to 65 km/h for expressways and 20 to 30 km/h on other roads. In the first years of the evolved scheme, the charge changed at half-hour intervals, but since 2003 the charge had the ability to change in five-minute intervals. When first implemented, the effects of the charge was thoroughly documented and there was a 44% decrease in the traffic volume.

Goals and Objectives: The objective of introducing the scheme was to ease congestion, which at the time was significant in the central business district. As the charges change periodically, taking into account the current travel times, the effects have persisted since the implementation.

User Fees: As of November 2017, the charges in the Central Business District vary from $0 to $2.80 CAD for passing a charging point. Three complementary transport policies were initiated with the launch of the scheme. These included doubling of downtown parking rates, introduction of a Park-and-Ride scheme and improvement of the commuter bus service. However, the Park-and-Ride scheme was shut down within the first few months of operation due to low usage. Singapore also employs a number of other policies to restrict car ownership, including substantial vehicle levies.

Outcome: When the evolved (i.e., electronic) scheme was introduced, the level of traffic decreased by an additional 10% to 15%; this could be explained by fewer repeated trips as every entry had a cost compared with fixed cost of the Area License Scheme.
4.1.2 Central London Congestion Charging

Background: London has limited road capacity but a high demand for travel. Congestion charging was introduced in London in February 2003 following discussions for several decades. The implemented scheme was similar to the original scheme in Singapore, i.e. a daily license, but electronic from the start using Automated License Plate Recognition (ALPR) cameras for enforcement. The congestion charging zone consists of an area of approximately $22km^2$. In 2007, the charging zone area almost doubled when the Western Extension was added. However, after just four years, the Western Extension was removed due to public opposition.

Goals and Objectives: The aim of the scheme was to reduce traffic congestion. By law, all money raised through congestion charging must be invested in improving transportation in London.

User Fees: The original charge was $8.40 CAD for travel within the charging zone between 7:00 AM and 6:30 PM on weekdays. Currently, the daily charge is $19.20 CAD between 7:00 AM and 6:00 PM on weekdays. Complementary transport policies have been introduced to improve air quality in central London like the low emission zone charge (for heavy diesel vehicles) from 2008 in order to encourage a switch to cleaner vehicles as well as a measure called the T-charge from 2017 of $16.70 CAD (for older vehicles which do not meet minimum Euro emission standards).

Outcome: Traffic volumes have decreased by 16% for all vehicles entering the zone and by 30% for all chargeable vehicles. Additionally, journey speeds and reliability for buses, taxis and bicycles have improved.
4.1.3 Stockholm Congestion Charging

**Background:** The Stockholm congestion tax was introduced on a permanent basis in 2007 after being discussed since the 1990s. The introduction process began with a trial during the first six months of 2006, which was then followed by a referendum in September. The congestion tax trial included improved bus services, extra rail capacity, and park-and-ride. 53% voted in favour of the policy and it was permanently introduced in January 2007. The charge area covers the inner city of Stockholm, larger than just the CBD – it covers around 36 square kilometres and is home to 340,000 people. The technology being used included ALPR cameras to monitor and charge the tax. The ALPR charging points also have Dedicated Short Range Communication (DSRC) installed for future usage of transponders. In 2016, the scheme was extended to also include the western ring road of Stockholm (Essingeleden), which meant that the scheme had a central city and ring road component.

**Goals and Objectives:** The aim of the tax is to reduce traffic on the most overloaded roads, increase the average speed, and reduce emissions of health-endangering pollutants and carbon dioxide.

**User Fees:** The charging points form a zone where eligible vehicles pay the tax for every entry and exit during weekdays between 6:30 AM and 6:29 PM. The tax is varied according to time in prefixed periods of the day. The tax for the central city is $1.70, $2.30, $3.80, and $5.30 CAD depending on the time of day. For the ring road the tax is $1.70, $2.30, $3.30, and $4.50 CAD. The highest amount is paid during the morning and afternoon rush hours. The maximum amount per day and vehicle is $15.90 CAD (which includes tax paid in the city center and the ring road).

**Outcome:** The initial general decrease of traffic flow by 20% has persisted since the scheme was implemented.
4.1.4 Milan Congestion Charging

**Background:** Similar to many other Italian cities, the City of Milan has a small historical city centre. Between 2002 and 2011, Milan exceeded the European standards for particle exhaust, PM10 (Danielis et al. 2011). In 2008, a scheme to control the access of vehicles to the city centre was introduced. The scheme was similar to Singapore’s Area License Scheme in that there was a daily charge to enter the historical city center. The scheme was called ECOPASS and used ALPR cameras for enforcement. The aim of ECOPASS was to reduce the number of high-polluting vehicles. Unfortunately the scheme did not succeed in reducing the number of polluting vehicles as too many vehicles had exemptions from the charge. Therefore, the scheme was renamed and changed in 2012. The new scheme, called Area C, has more focus on combatting congestion (Lehe 2016). The ALPR cameras were then also complemented with DSRC to automate the payment process.

**Goals and Objectives:** The goal of ECOPASS was to reduce the number of high-polluting vehicles on the road, but was not successful. The new Area C scheme is aimed at combatting congestion.

**User Fees:** The charge to enter the historical center on Monday to Wednesday and Friday between 7:30 AM to 7:30 PM and Thursday between 7:30 AM and 6:00 PM is $7.40 CAD. If registered, residents have a reduced rate and there are also special rates for service cars.

**Outcome:** Improved bus services in the city center were part of introducing the scheme. The impact of the scheme shows a general decrease of traffic flow of 34% (all vehicles) and a decrease of 49% for the worst polluters.
4.1.5 Gothenburg Congestion Charging

**Background:** The Gothenburg congestion tax was introduced in January 2013. The City of Gothenburg has significantly different geography from Stockholm, making the pricing scheme design non-transferable. However, the pricing structure, design, and technology show similarities between the cities. The Gothenburg scheme was introduced in conjunction with the improvement of several bus service lines. Initiated by citizens, a local non-binding referendum about the tax was held in September 2014. The referendum was an add-on to the standard national election and 57% of the voters objected to the tax. However, decision makers decided to keep the policy despite the result of the referendum.

**Goals and Objectives:** The Gothenburg scheme has an aim to reduce congestion, finance infrastructure investments in the region, and reduce environmental impacts of road transport.

**User Fees:** The tax scheme consists of charging points forming a cordon zone where eligible vehicles pays the tax for every entry and exit during weekdays between 6:00 AM and 6:29 PM. The tax is varied according to time in prefixed periods of the day. The tax is $1.40, $2.40 or $3.30 CAD depending on the time of day. The highest amount is paid during the morning and afternoon rush hours. The maximum tax amount per day is $9.10 CAD.

**Outcomes:** The effects of the tax show that the traffic volume in general have decreased by 10% across the cordon and by 2.5% vehicle-km in the Gothenburg region.
### 4.2 Congestion Charging – Key Characteristics

<table>
<thead>
<tr>
<th>Location</th>
<th>Implementation Year</th>
<th>Pricing framework</th>
<th>Typical charge for cars</th>
<th>Traffic Volumes</th>
<th>Travel times</th>
<th>Environmental effects</th>
<th>Operating cost</th>
<th>Gross Revenue</th>
<th>Cost-Benefit Analysis</th>
<th>Technology</th>
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<tr>
<td>Singapore</td>
<td>1975 (technology change in 1998)</td>
<td>Charge per day, varied by time and location</td>
<td>1.9 CAD per passage</td>
<td>-44% (1975) and additional -10 to -15% when technology changed</td>
<td>Dynamic rates to maintain speeds between 45-65 km/h (Expressways) 20-30 km/h (other roads)</td>
<td>n.a.</td>
<td>16 million CAD/year</td>
<td>200 million CAD/year</td>
<td>63 million CAD/year</td>
<td>Paper license (1975) replaced by RFID in 1998</td>
</tr>
<tr>
<td>London</td>
<td>2003</td>
<td>Charge per day, additional charge for worst polluters</td>
<td>19.2 CAD per day</td>
<td>-16% all vehicles entering the zone, -30% chargeable vehicles, +25% busses, +13% taxis, +49% bicycles</td>
<td>-30% delays</td>
<td>CO2 -16.4%, NOx -13.4%, PM10 -15.5% within the zone</td>
<td>170 million CAD/year</td>
<td>440 million CAD/year</td>
<td>140-190 million CAD/year</td>
<td>ALPR</td>
</tr>
<tr>
<td>Stockholm</td>
<td>2007</td>
<td>Charge per entry and exit, varied by time of day</td>
<td>5.3 CAD per passage, but max 15.9 CAD per day</td>
<td>-20% across the cordon</td>
<td>-33% delays</td>
<td>CO2 -13%, NOx -8%, PM10 -13% within the zone</td>
<td>25 million CAD/year</td>
<td>150 million CAD/year</td>
<td>100 million CAD/year</td>
<td>ALPR</td>
</tr>
<tr>
<td>Milan (replacing ECOPASS from 2008)</td>
<td>2012</td>
<td>Charge per entry</td>
<td>7.4 CAD</td>
<td>-34% all vehicles (-49% of worst polluters)</td>
<td>-30% delays</td>
<td>CO2 -22%, NOx -10 %, PM2.5 -40%, PM10 -19.3%</td>
<td>34 million CAD/year</td>
<td>35 million CAD/year</td>
<td>20 million CAD/year</td>
<td>ALPR, DSRC</td>
</tr>
<tr>
<td>Gothenburg</td>
<td>2013</td>
<td>Charge per entry and exit, varied by time of day</td>
<td>3.3 CAD per passage, but max 9.1 CAD per day</td>
<td>-10% across cordon, -2.5% vehicle-km in Gothenburg region</td>
<td>-10% to -20% travel time reduction in corridors</td>
<td>CO2 -2.5% within the region of Gothenburg</td>
<td>30 million CAD/year</td>
<td>125 million CAD/year</td>
<td>2 million CAD/year</td>
<td>ALPR</td>
</tr>
</tbody>
</table>

Sources: Singapore Land Authority, Transport for London, Royal Institute of Technology, Swedish Transport Agency, Agenzia Mobilità Ambiente e Territorio, Comune di Milano, City of Gothenburg, CURACAO reports
5. References


