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Congestion charging in the Netherlands: consumer effects & public support

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1. Introduction

1.1 Relevance

Since 2000, congestion of traffic in the Netherlands has grown by about 15%. Especially during periods of economic growth, the amount of traffic jams has grown a lot, whereas during periods of economic decline, congestion seems to decrease (Rijkswaterstaat, 2018). Overall however, we see a pattern of increased congestion, which leads to increased time costs, an increase in traffic accidents and a negative impact on the environment as a whole. The cost of traffic jams and delays has been estimated at 2.3 to 3 billion euros in 2015 (van Meerkerk, Verrips, & Hilbers, 2015). Under a worst case scenario, congestion could increase fourfold between 2010 and 2040. A possible solution to this problem could be a system in which road pricing is introduced: the taxation of road usage (instead of car ownership), which can take different forms.

Road pricing in the Netherlands has been discussed as far back as the late 1980's, when the government started researching the possibilities in order to reduce traffic congestion and promote alternative, more environment friendly modes of transportation. However, up to now, this has not led to the introduction of any road pricing system in the Netherlands. A few inner cities have environment zones, which prevent older, more polluting cars from entering certain city centers but other than that, no measures have been implemented (ANWB, 2018). There has however been talk of possible road pricing throughout the years. In 2008, the parliament adopted new laws that would make the introduction of road pricing possible. However, the actual law implementing road pricing through satellite usage was repealed by the government before the parliament ever voted on it (Eerste Kamer der Staten-Generaal, 2018). In 2012, six political parties out of the ten indicated that they wanted to introduce some form of road pricing, however, the coalition formed by the VVD and the PvdA decided not to introduce it during their term (van Meerkerk, Verrips, & Hilbers, 2015).

In October 2017 the coalition parties (VVD, CDA, D66 and CU) presented their government coalition agreement for the next few years. One of the measures that will most likely be implemented in the coming years will include road pricing for freight traffic, which would have freight traffic pay a tax per kilometer, which will be lower for less polluting trucks (VVD, CDA, D66, & CU, 2017). Clearly, road pricing is still very much a relevant political topic. The next years could see a step-by-step introduction of this system, which is why it is so relevant today to know the scope of the effects of these possible measures.

1.2 Research question

As said, road pricing can take on many different forms. Congestion charging, with varying tariffs depending on the time of day (and thus, the amount congestion on the road) is one form of road pricing which could possibly combat congestion. In the Netherlands, this has been referred to as a *spitstarief*, or peak-tariff. Congestion charging has its obvious positive societal effects, including less congestion (time costs), less pollution (because of less traffic) and less traffic accidents. However, there is also costs that are incurred to road users and costs incurred to construct and operate the different possible systems. Congestion charging could lead to problems with the capacity of the public transport networks, due to people switching modalities because of the costs. It is clear that there are many possible effects. This thesis will specifically focus on the effects on consumers using the road, such as commuters, because consumers have historically played a large role in the possible implementation of road pricing in the Netherlands. Even then, many possible questions remain. How effective would a system of congestion charging be? What were the obstacles in the past? How do people view congestion charging? This thesis will (try to) formulate an answer to these questions in order to give a first indication of the effects that road-using consumers face. The research question is formulated as follows:

> *'What would be the effects of a system of congestion charging on road-using consumers in the Netherlands?'*

One way to answer this question is to look at the possible benefits and the possible negative effects of a system of congestion charging. This thesis makes a distinction between the effects on freight traffic and the effects on consumer traffic, since the focus is on consumer traffic. The following sub-questions are used to answer the research question:

> *'What is the economic theory behind congestion charging?'*
> *'Which systems of congestion charging are currently used in other countries?'*
> *'Why has a system of congestion charging not (yet) been implemented in the Netherlands?'*
> *'What are the (expected) economic effects of congestion charging on consumer traffic?'*

However, as we will discuss in this thesis, public and political support has often been an important factor in the implementation and non-implementation of road pricing measures. The second part of this thesis will focus on the public support for a system of road pricing, to gauge how successful a system would be. The last sub-question is:

> *'Would there be sufficient public support for a system of congestion charging in the Netherlands?'*

1.3 Methodology

This thesis will explore in Chapter 2 the micro-economic theory behind congestion charging. In Chapter 3, different historic and current examples of congestion charging in practice and the reasons for their success or failure will be discussed. In Chapter 4, the current situation regarding congestion and the different historic and current propels for a scheme of congestion pricing in the Netherlands will be examined. In Chapter 5, based on estimated figures of elasticity, the effect of congestion charging to combat this congestion will be estimated for consumer traffic. Furthermore, some information on social acceptance in the Netherlands regarding road pricing will be discussed. To gauge the public support, a survey will be held amongst students in the Netherlands. This group is relevant because a future system of road pricing or congestion charging will affect this group that will have entered the workforce and are likely to be road consumers, and, as soon as a system is designed and tested, requires their public support. Based on the results and results from earlier surveys, the public support for a system of congestion charging will be examined. The exact methodology used for the survey and data analysis will be discussed in Chapter 6. A conclusion will follow in Chapter 7.

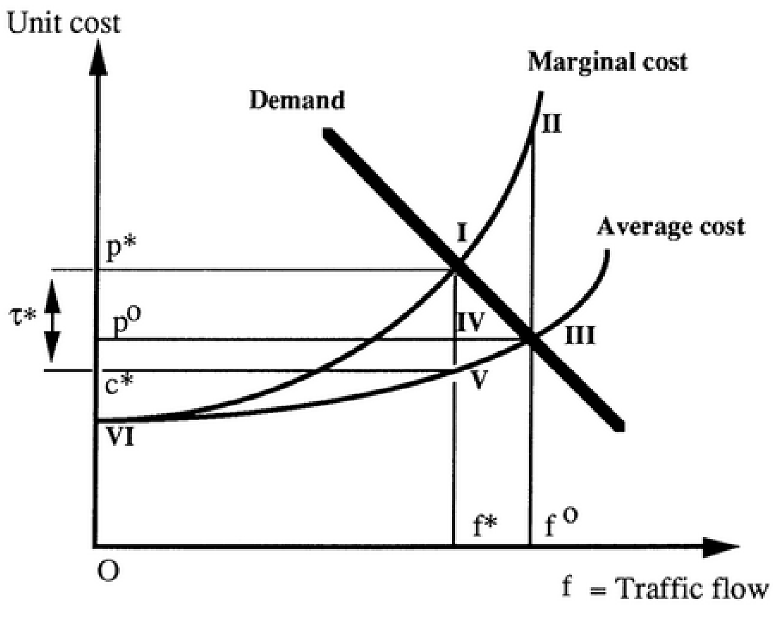
2. Economic theory of congestion charging

In this chapter, the economic theory behind systems of congestion charging will be explained. Firstly, the theory of negative external effects will be explained. Secondly, this thesis will mention the standard theoretical economic framework of how a congestion charge can solve these problems and how, theoretically, a congestion charge could lead to increased welfare.

The economic theory behind congestion charging dates back as far as the works of Pigou (1920) and Knight (1924). They explained the theory of negative external effects. Negative external effects in road usage appear when access to public roads is toll free and there is some manner of congestion present (which is very often the case, especially in the Netherlands). Congestion during peak periods is common in developed and developing countries. Additional road users adding to the congestion only face their own increased time costs, but do not take into account the extra time costs they incur upon other users by increasing the amount of congestion. In other words, they do not face the actual costs that they incur, and thus do not take these actual costs into account when deciding to use or not to use the roads. This leads to an above optimal-level road usage, which is a market failure. On the supply side, fiscal and physical constraints make it increasingly difficult to solve these problems (Hau T. D., 1992).

One way to solve this problem is by charging a toll that internalizes these costs, a so called *congestion charge*. However, congestion charging is often seen as a tax on being stuck in traffic, making it hard to implement without considerable opposition from road users (Rouwendal & Verhoef, 2006). However, in theory, if road pricing or congestion charging is used in an optimal way, a social surplus will arise (Eliasson, 2009). The problem can be represented graphically.

Fig 1. Road-pricing represented graphically. Source: (Johansson & Mattsson, 2012)



In this figure, we see a classic demand curve, with a decreasing amount of traffic as costs go up. Point *VI* is where there are no road users and the average cost of an additional driver is equal to the marginal cost. The equilibrium without any market intervention is found at point *III,* where the demand curve is equal to the average cost each driver faces.[1] Each driver only faces average cost and does not take the marginal costs they might incur into account. The amount of traffic in this case is f^0 and the individuals' costs are found at p^0. At f^0, the marginal costs of every new driver are much higher (point *II*) than the average cost at point *III*. The socially optimal point would be the point where the marginal cost of a new driver crosses the demand curve, which happens in point *I*. The traffic flow is decreased to f^* in this point, and the price would be at p^*. However, without any toll, the average cost of p^0 does not lead to an equilibrium in point *IV,* where f^* and p^0 cross. The difference between the average cost at f^* found at point *V* and the marginal cost found at point *I* is represented as t^*, which would be the price of the toll that would incur the shift from points *III* to *I*. In that case, the market failure is resolved as the costs that road users face are now equal to the costs they incur to other drivers together with the costs they incur to themselves. The drivers will now, because of the tax, face the actual marginal costs they incur as additional road users, instead of their average cost. This leads to an equilibrium with a less traffic.

As Rouwendal & Verhoef (2006) point out, most drivers will be worse off as a result of the toll if that toll is not in some way redistributed. If the revenues are, for instance, spent on the implementation of the system, welfare will most likely decrease, even though some road users with higher time costs might see increased welfare. Redistribution of the revenues play a crucial part in actually increasing welfare. A commonly proposed way to spend these revenues is to decrease the standard flat-rate motor vehicle tax. Hau (1992) concludes that road users, both those that continue to use the road and thus pay the extra tax, as well as the ones that are priced off the road and are forced to use alternatives, such as public transport, will be worse off. Only users with very high time values are theoretically better off without proper redistribution of the road pricing revenues. Adequate redistribution will thus be necessary to increase acceptance for this system amongst users. However, this is purely theoretical. A real system would have shortcomings and could face all kinds of restrictions on the possible charging systems. Also, costs to construct and operate the systems could be larger than the surplus created by the systems (Eliasson, 2009).

In conclusion, a congestion charge could theoretically be used to internalize the negative external effects of road usage. By charging an amount of toll equal to the marginal costs incurred to other drivers, the road user pays the exact amount of decreased social surplus his usage of the road incurs as a whole. Redistribution of the tolls is essential in making sure most drivers are better off. In theory, this could possibly be done by reducing other taxes. In practice however, different shortcomings and problems could come up regarding implementation and operation.

[1] This is because in the original situation, drivers make individual decisions whether or not to use the road, based on the (average) costs they face, without regard for the costs they incur to other road users.

3. Some examples of congestion charging

In this chapter several historic and current systems of congestion charging will be discussed, to see how congestion charges have worked in real world situations so far and to find the biggest shortcomings and problems these systems faced. Firstly, the historic examples of Singapore, Hong Kong and Cambridge will be discussed. Secondly, the Scandinavian systems, especially the system in Stockholm, will be discussed.

Obviously, there are many more examples of road pricing which can be considered as a congestion charge. The flat-rate in London is an example, as well as the systems Gothenburg (modeled after the Stockholm one), Milan and Valetta, among other cities. Not all of these systems will be discussed here, largely because of the similarities. Also, the systems in Milan and London are based on a flat-rate entry tax for vehicles, which seems to be more of an environmental charge than a charge based on *actual* congestion.

3.1 Singapore

The system in Singapore is perhaps the oldest example of a congestion charge.[2] A road pricing system was first introduced in Singapore in 1975. However, Singapore had already introduced an extra tax on private car ownership in 1972, as part of an effort to make car users pay for the full social cost of their car usage. Goh (2002) has provided an extensive overview of the measures taken by Singapore. In 1975, Singapore started with the Area Licensing Scheme (ALS). After consideration of multiple options, the government opted for a standard fee for inbound vehicles during peak periods of traffic (Small & Gomez-Ibanez, 2005). The exact amount of the fee and the vehicles it applied to has changed over the years. To promote carpooling, carpools were exempt from the fee at first, as were commercial trucks and motorcycles. In the early years, collection costs were about 11% of the revenue. Small & Gomez-Ibanez (2005) describe the effects as dramatic, as total traffic during the restricted peak hours initially dropped by 44 percent. Watson & Holland (1978) reported the effects that research by the World Bank produced, and found that the use of carpools and buses increased to 62% of total road usage. However, they also found that, during the earlier periods, commercial truck entry increased by around 124 percent, most likely also due to the exemption for these trucks. Even though the ALS system led to increased speeds in the restricted zone, this was partially dissipated by increased congestion right outside the zone (Small & Gomez-Ibanez, 2005). However, the ALS system showed that road users do respond to pricing incentives when they are big enough.

In the years since 1975, Singapore has tweaked their system and also introduced additional measures to decrease congestion, of which Goh (2002) provides an overview. A few of them had little impact, others were more successful in decreasing road usage. The Vehicle Quota

[2] Toll roads have existed before this time, however, those charges are, in most cases, not meant to combat congestion, but rather to finance road construction and maintenance.

System (VQS) from 1990 introduced a system of having to bid for the right to own a car. In 1995, the road pricing scheme was tweaked to unburden certain bottlenecks. The biggest change came in 1998, when the system was changed to a system of electronic road pricing (ERP), replacing the ALS system. All of these measures were accompanied by other policies, such as increased parking fees in the zones restricted by road pricing, as well as what Goh (2002) refers to as ‘exorbitant petrol taxes’. However, not all of these measures were effective.

Olszewski & Xie (2005) have modelled the effects of the ERP system. The system allowed for varying prices based on the amount of traffic and time of day and also removed the need for employees at passage points. The prices can be adjusted every half hour, increasing step-by-step as congestion increases and decreasing after the peak periods. As Olszewski and Xie (2005) note, there has been research into the elasticity of petrol prices, parking fees and general cost of driving, however this system also gives an opportunity to estimate elasticity with respect to road pricing. For cars, they found that elasticity during peak hours was between -0.106 and -0.195, however, it was considerably less for other types of traffic, such as trucks. However, elasticity during the afternoon peak is considerably higher, reaching -0.265 for all vehicles. Goh (2002) sees the ERP system as promising and mentions that the biggest challenge will probably be public acceptance as the system expands.

3.2 Hong Kong and Cambridge

Singapore was not the first country to have come up with the ERP system, as Hong Kong tested a very similar system between July 1983 and March 1985 to possibly combat the increasing congestion. The amount of private cars was rapidly increasing during this time, when the British were transferring power to the Chinese (Hau T., 1990). The tests results indicated that this ERP system could very well work, but ultimately, it was not adopted due to public resistance to this system, which itself could partially be explained by bad economic conditions (Small & Gomez-Ibanez, 2005).

In 1990, a system of real-time congestion pricing was proposed for the city center of Cambridge, England. The interesting thing about this system is the way the price/tax was to be decided. It was argued that the amount of congestion experienced by any road user was heavily related to the amount of externalities that that person imposed upon others. This was to be measured by a system within the vehicle, that could measure its average speed and the amount of stops made once a car entered the city center of Cambridge. After this system was tested, Smith et al. (1994) argued that a system of congestion specific charging would provide possible greater benefits than a flat-rate system. However, Small & Gomez-Ibanez (2005) note that for both Hong Kong and Cambridge, sufficient public support was missing, which made implementation difficult. Also, the unpredictability of the height of the charge in the Cambridge proposal would have decreased the support for the system.

The reason for mentioning these two examples, that were not fully implemented, in this thesis, is that they both show the importance of public support and the consequences of a lack of it.

3.3 Norway

Norway has had a tradition of financing road construction with tolls (Wærsted, 2005). Some of the more interesting toll systems are the urban toll rings that are in place around the biggest cities in Norway. The first ring was introduced in Bergen, but since then, more cities, including Trondheim and Oslo have followed (Ramjerdi, Minken, & Ostmoe, 2004). These toll rings were not originally meant as congestion charging, but rather as a way to shift the financing burden of the roads between suburban and urban areas (Small & Gomez-Ibanez, 2005). However, the tolls in Trondheim change according to the time of day, which seems to be a form of congestion charging. The system was rather sophisticated, with the ring Trondheim using electronic toll collection. However, since the road has since been financed, the use of the ring was discontinued to keep a political promise to the public. (Ieromonachou, Potter, & Warren, 2006). Small & Gomez-Ibanez (2005) point out that urban toll rings as they exist in Norway & Sweden could possibly be used as a method of congestion charging around bigger cities, even though this is currently not the case (except for the discontinued one in Trondheim). Public support for this kind of road pricing is higher in Norway, due to their long history of road tolling and as such, the urban toll rings did not face the public opposition as much as the systems in the UK (Ieromonachou, Potter, & Warren, 2006).

3.4 Stockholm

The Stockholm toll ring is an interesting example of a functioning toll ring that received a lot of attention around the world. The ring started as a trial in 2006, which also saw an increase in the availability of public transportation options. After a referendum that saw the support of little over half of the Stockholm residents, the toll ring was made to operate permanently in 2007 (Börjesson, Eliasson, Hugosson, & Brundell-Freij, 2012). The system is reasonably simple. To enter the center of Stockholm, one has to pass one of the electronic toll gates that surround a zone. When the system was introduced, this zone housed some 300,000 inhabitants of which 20% commuted to workplaces outside the zone. More than 200,000 people commuted from outside the zone to within the zone (Eliasson, Hultkrantz, Nerhagen, & Rosqvist, 2009). When this zone is entered, the license plate is registered and a bill is automatically sent every month. The height of the charge varies by time of day and cars that are less polluting (such as hybrids or electric cars) pay less or no charge (Börjesson, Eliasson, Hugosson, & Brundell-Freij, 2012).

The effects are quite interesting. Corrected for different external factors there was a reduction of traffic that would have otherwise had to pay the charges of around 30%. The elasticity increased to -0,86 in 2011, starting at -0,70. So far, the size of the effect does not seem to decrease after an initial period (Börjesson, Eliasson, Hugosson, & Brundell-Freij, 2012). Another interesting thing to see is the change in public opinion regarding the congestion charge. Before the initial trial in 2006, support for the system was somewhere around 40%. In 2011, a poll in and around Stockholm showed that support for the charges was around 70%. (Börjesson, Eliasson, Hugosson, & Brundell-Freij, 2012). Public support was not lacking in this situation. Once people perceived the charges to be effective and the negative effects to not be as big as initially expected, public resistance diminished. The Gothenburg toll ring was modeled after the Stockholm one.

3.5 Conclusion

What these examples have shown is that congestion charges can very well be an effective manner to reduce traffic during peak hours. However, the charges are often met with public opposition, especially when charges are perceived to be high or unpredictable and effects are uncertain or redistribution fails. Public acceptance is a problem that is hard to overcome, however, the example of Stockholm shows that if the congestion charging is done in an effective way and the negative effects for road users are kept to a minimum, public opinion can shift. In the following chapters, this thesis will further examine the role of public support.

4. Historic and current proposals in the Netherlands

In this chapter, some historic proposals and the current state of affairs concerning road pricing or congestion charging will be examined. First, a short overview of the most important past plans or proposals will be given, along with the possible explanations for their failure. After that, the current political and societal debate will shortly be discussed to give the reader a sense of the different opinions and clashes that road pricing proposals face in the Netherlands.

4.1 Historic proposals

4.1.1. *Rekeningrijden*

Around the end of the 1980's, traffic around and in the *Randstad* had increased a lot, and congestion was becoming more of an issue. The first real proposals concerning road pricing indirectly stem from the 1977 survey *Structuurschema Verkeer & Vervoer* ('Structural scheme traffic and transportation'). Part 2 of this survey was presented in 1988, during the Paars II-cabinet (van der Sar & Baggen, 2005). In the coalition agreement road pricing was planned to be implemented during that period of cabinet, although it faced some opposition from the Conservative Liberals (VVD) (NRC Handelsblad, 2000). In return, the motor vehicle tax was to be lowered. The project was dubbed *rekeningrijden* ('road pricing'). In the end, political and societal opposition caused the proposal to strand, and the cabinet argued that due to these factors, they would not implement a system in the coming years (Dutch Ministry of Traffic & Water Management; VROM, 1990).

4.1.2 Alternative proposals

After this first real proposal was cancelled, some other proposals passed through the government and the media. Toll roads, congestion charging and increased taxes on fuel to reduce motor traffic. In the end, both the toll road proposal and the congestion charge did not have the political support that they would have needed, and the plans were cancelled once again (van der Sar & Baggen, 2005). There was resistance from multiple sides, such as the lower, regional governments and some of the bigger parties in the parliament.

4.1.3 *Rekeningrijden II*

From 1994 onwards, during the cabinets Kok-I and Kok-II, *rekeningrijden* was discussed once again. The plan was to implement road pricing sometime after the year 2000 and to use lighter measures at first. In 1994, a majority of parliament support the idea of road pricing. The plan was to have electronic and physical toll gates around the biggest cities (Amsterdam, Rotterdam, Utrecht and Den Haag) that would collect a charge during peak hours (van der Sar & Baggen, 2005).[3] Again, lowering the standard motor vehicle tax would be the way of redistributing the gains. The proposal made it into the coalition agreement of 1998, but there

[3] In a sense, this set of proposals has a strong resemblance to the Scandinavian toll rings, as discussed in Section 3.4 of this thesis.

was a lot of resistance from outside the coalition. The ANWB (Dutch motor vehicle owner's association) campaigned heavily against the proposals (NRC, 1999). Several entrepreneurial unions also opposed the proposal. The different provinces, namely Utrecht, were also heavily against the proposals. In the end, there were no implementations or further steps until 2000. As an alternative to this system of congestion charging, a complete road pricing scheme was presented as an alternative in the new National Traffic and Transportation Plan (Dutch Ministry of Traffic and Water Management, 2000). This plan, referred to as *rekeningrijden,* would include congestion charging, toll roads and special paid-lanes, which could in the future be merged to form one sophisticated system: *kilometerheffing*. (van der Sar & Baggen, 2005). After research it was concluded that this system could be in place around 2005. After the fall of the Kok-II government, the first Balkenende cabinet decided not to implement *rekeningrijden* at all in 2002.

4.1.4 'Pay Differently for Mobility'

The report *Anders Betalen voor Mobiliteit* was presented in 2005. The suggested system of road pricing was extensive, with possibilities for congestion charging. In 2007, the plan was adopted by the Balkenende-III cabinet. However, in 2010, the Christian Democrats stopped supporting the plan, removing the necessary political support. During subsequent periods of government, not much effort has been made due to a lack of political initiative by the leading parties.

4.2 Current Situation

During the parliament elections in 2017, there were quite a few parties in favor of some system of road pricing. Among the parties that support a form of road pricing are the Labour Party (PvdA), the Green Party (GroenLinks), the Liberal Democrats (D66) and the Socialist Party (SP) (Algemeen Dagblad, 2017). From the current government coalition, the Christian Conservatives (CDA) as well as the Liberal Conservatives (VVD) are against road pricing, however, the governing parties agreed in the coalition agreement that a road pricing system for freight traffic was to be implemented during the current term. The system was referred to as 'Maut', which is the name of the German road pricing system for freight traffic (VVD, CDA, D66, & CU, 2017). The system will use the same equipment as is used in the surrounding countries (such as Germany and Belgium) and the income will be given back to the transportation sector.

4.3 Public Support

In the past, the lack of public, and perhaps as a result political, support has made it virtually impossible to implement a road pricing system without extensive public outcry and backlash from organisatons for mobility and entrepreneurial organisations (van der Sar & Baggen, 2005). In 2010, the ANWB consulted its 4 million members on the issue of road pricing. 400.000 members replied to the survey. The results showed some support for paying for actual road use instead of car ownership, which 68% said to find fair. However, most people indicated they were not willing to pay more. However, a congestion charge based on actual road congestion was heavily opposed (ANWB, 2010). In 2015, a similar survey was held, with around 2000 respondents. The results were similar. There seemed to be some support for paying for usage instead of ownership, however, the respondents were not as positive about road pricing instead of a flat-rate vehicle tax (Ruigrok NetPanel, 2015). The results of these surveys will be further discussed in Chapter 6, along with the results from the survey.

5. Effects on consumer traffic

In this chapter, the effects of a system of congestion charging on consumer traffic will be discussed. The elasticity of consumer traffic regarding prices and congestion charges play an important role. Firstly, the elasticities for other projects, such as the Scandinavian toll rings will be examined. These could provide an indication for elasticity in the Netherlands, since a real project has not been undertaken as of yet. Then, some estimates regarding elasticity in the Netherlands will be discussed.

5.1 Elasticity of consumers

5.1.1 Estimates regarding consumer traffic elasticity

There are a few estimates regarding the elasticity of demand for road usage. However, estimates have been known to vary widely. Also, elasticity for road usage by consumers is dependent on many variables. On the one hand, a congestion charge will probably decrease demand, however, the lower congestion rate which is the goal of implementing it, might make use of the roads more desirable. Also, changes in behavior might differ in the short and the long run.

Graham & Glaister (2004) published a comprehensive review of some earlier research regarding the topic of elasticity estimates for road traffic. The estimates in this review for variable costs related to car ownership (fuel, but also, traffic times) lay between -1.33 and -0.41 for consumer traffic.[4] Fuel demand with regard to fuel prices, a good example of a variable cost, has an estimated short-run elasticity of -0.25 and an estimated long-run elasticity of -0.77. In the long run, consumers have more options to change behavior (such as changing where they work, where they live etc.), whereas in the short run, these options are more limited. Goodwin et al. (2004) estimate the fuel price elasticity to be -0.30. It is often estimated that half of the marginal driving costs are made up of fuel costs (Börjesson et al., 2012). So it seems that consumers are somewhat susceptible to changes in variable costs of driving. However, what estimates do we have on elasticity regarding road pricing or congestion charging?

Börjesson et al. (2012) have estimated the elasticity as a result of the Stockholm (Sweden) toll ring, which was discussed in Chapter 2. Their estimate of the elasticity of the congestion charge, accounting for external factors, income and even tax deductibility, ranged from -0.70 in 2005 and around -0.86 in 2011. This is higher than the estimated elasticity of marginal driving costs (which are usually estimated at around twice the fuel price elasticity).[5] The authors

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[4] Elasticity refers to the change in demand as a result of a change in prices. If an elasticity is estimated at -0.50, an increase in the price of 10% will result in a change in demand of -5% (=10% x -0.50). Price/demand elasticity is (almost) always negative. A larger absolute value means a larger elasticity and thus a stronger change in demand as a response to a change in prices.

[5] Fuel price elasticity is usually estimated at around -0.30, with some higher estimations in the long run. Half the marginal driving costs are usually estimated to be made up of fuel cost, and the elasticity of the marginal driving costs are usually estimated at double the elasticity of the fuel cost elasticity. If Goodwin's (2004) estimate is correct, this should be -0.60 (= 2 x -0.30). Clearly, -0.70 and -0.86 are larger in an absolute sense, which means consumer's responses to price changes are stronger/larger.

suspect that this is because there are more alternative options, such a a change of route. The authors also state that consumer traffic is probably more sensitive to increased costs than commercial traffic. The average charge per crossing in Stockholm in real terms was 1.28 SEK in 2005. This made up about 39,6% of the average total trip cost of 3.23 SEK. In 2011, the percentage of the charge made up about 33,9% of the total trip cost. However, traffic reduction was about equal when accounted for other factors (-29.8%) (Börjesson et al., 2012).

If these estimates for Stockholm are compared with those found in Singapore and Norway, they seem to be on the high side. The elasticity for Singapore toll points, which are most comparable to the Stockholm system points, are estimated at -0.195 to -0.216 for car traffic (Olszewski & Xie, 2005). The Oslo (Norway) Toll ring has an estimated elasticity of -0.22, the Alesund (Norway) scheme has an estimated elasticity of -0.45 (Jones & Hervik, 1992). A more extensive study based on all Norwegian toll facilities by Odeck & Brathen (2008) came to an average price-toll elasticity of -0.56. However, for 5 bigger toll rings, located around the more urbanised areas, the long-run elasticity was estimated at -0.82, which seems very comparable to the results found in Sweden.

5.1.2 Consumer traffic elasticity in the Netherlands

How well would these numbers represent the effects of a system of congestion charging in the Netherlands? In the Netherlands, price elasticity for fuel demand seems to be lower than most results found in literature, according to the Mobiliteitsbeeld 2017 survey. The fuel price elasticity was estimated to lie between -0.13 and -0.18. (Dutch Ministry of Traffic and Water Management , 2017). Older estimations, such as those by van Groot & Mourik (2008), do find a long run fuel-cost elasticity of around -0.3.

Elasticities for road usage also differ between consumers. Commuters and consumers travelling for business purposes have a significantly lower elasticty than shoppers or ‘other’ drivers. In the Netherlands, long-term elasticity with regard to fuel prices was estimated at around -0.21 to -0.31 for commuters, around -0.06 for business travel and around -0.40 to -0.69 for other trips. Fuel prices of course have different elasticities than congestion chargers, but it does provide a relative indication.

Value of time during travelling differs among different consumer traffic groups as well. Value of time for business travel is estimated at €31.30 per hour, for commuters at €10.16 per hour and for other traffic at €8.24 per hour. (Dutch Ministry of Traffic and Water Management , 2017).

The question that largely remains is the applicability of the elasticity estimates regarding a congestion charge or a toll found in other countries to the congested areas in the Netherlands. To what extent can an estimate of around -0.80 , such as was found in Stockholm, be applied? In their study, Arentze et al. (2004) found a short term estimated elasticty for a theoretical model of road pricing with a flat rate and a congestion charge to be -0.35 to -0.39 in areas where congestion was present, which would indicate a remarkably smaller effect. However, this could be explained due to the fact that (i) a flat rate is always present and (ii) there is a system of redistribution in place.[6] A system with only a congestion charge, where the average charges paid are the same, might have a different, and perhaps larger, effect.

5.2 Effects on consumer traffic

It is clear that the effect of a congestion charge depends on the height of the charge, the total system in place, the alternative options and the elasticity of consumers regarding the congestion charge. Certain average charges could possibly be set as goals, depending of course on the amount of traffic and the charge at different times. In the table below, different possible charges (in percentage of total trip cost) and different elasticities are shown.

Table 1. Reduction of traffic for different elasticities and charges.

Elasticity of demand	-0.8	-0.6	-0.4	-0.2
Amount of charge as % of total trip cost				
20%	-16%	-12%	-8%	-4%
25%	-20%	-15%	-10%	-5%
30%	-24%	-18%	-12%	-6%
35%	-28%	-21%	-14%	-7%
40%	-32%	-24%	-16%	-8%

However, there are more variables at play. However, if Dutch policy makers would aim at a congestion charge that is, on average, the same as the one in Stockholm as a percentage of the total trip cost, around 35%, a reduction of 14% in traffic is very much a likely number, as the study by Arentze et al. (2004) indicates an elasticity of around -0.35 to -0.39. If a system without a flat-rate tax and only a congestion tax which is considered, in which the total amount of charges paid are similar[7], a reduction of consumer traffic of up to 20% might be possbile due to the possible larger elasticity (based on the estimated larger elasticity of only a congestion charge, such as -0.60, which is still lower than the Stockholm figures, and a charge of around 35% of total trip cost).

A congestion charge will most likely reduce 'other' trips, such as shopping, during peak-hours more than it will reduce business travel and commuting. Business travel does not seem to

[6] The authors modelled a reduction of the standard vehicle tax, replacing it (partially) with the variable system of road pricing and a congestion charge. The presence of a flat rate reduces the options to avoid the charge altogether, which in turn leads to a lower elasticity. In the Stockholm example, a higher elasticity was found and possibly explained by the possibilities to avoid the charge by using other roads etc.

[7] The charges during peak periods would be higher in this system than in Arentze et al.'s (2004) system, since the 'congestion-based' part of the tax was smaller in their study. Consequently, the charges during off-peak periods would be lower, and the average charge would be similar.

react strongly to price incentives and will actually be better of due to their higher time values. Business travel during peak hours might increase, due to the relatively high time valuation that these consumers have. Some commuters might switch to public transport, others will keep driving, dependent on the availability of other modes of transportation and their time values. However, since a lot of commuters have fixed working hours, not all will change their behaviour. Some might be better off even, if they perceive a high enough time value. The 'other' category of consumer road users wil, expectedly, change their behaviour most. This could even lead to such a decrease in congestion (depending on the charge and elasticity) that some commuters might start driving during the peak hours.

6. Empirical analysis: the public support amongst students

In this chapter, the public support for congestion charging will be examined. The results are based on a self-conducted survey amongst students studying and living in the Netherlands. The reason for the survey to be self-conducted is the lack of a good, public set of data regarding consumer road users and their preferences regarding possible road pricing mechanisms. In Section 6.1, the survey set-up and the limitations of the survey will be discussed. In Section 6.2 and 6.3, the survey data and the methodology to analyze these data will be presented. In Section 6.4, the results from the data analysis will be discussed. Section 6.5 concludes. Finally, in Section 6.6, a comparison between the results from this survey and the results from earlier surveys will be made.

6.1 Survey set-up & limitations

6.1.1 Survey set-up

To gauge the support for a system of road pricing amongst the student population, a short survey was sent out to students studying in the Netherlands. Gauging the public support amongst students is useful as a system that will be implemented in the next 5-10 years would strongly affect people who are still studying now and who will probably be commuters/road users by the time the system is implemented. Students will also be the group that will have to live with that system for most of their adult life. This makes their support important in the long run.

A survey was made using Google Forms. It consists of eight questions. An overview of the survey's setup is provided in Table 2. Inspiration for the questions was gotten from the ANWB/Ruigrok survey of 2010 (Ruigrok NetPanel, 2010) and the ANWB/Ruigrok survey of 2015 (Ruigrok NetPanel, 2015).[8] The survey link was sent out to approximately 700 students. There were 129 recorded responses, which constitutes a response rate of approximately 18.4 percent.

Questions 1, 2 and 4 are designed to estimate the impact of a road pricing or congestion charging-system on the respondent. For obvious (monetary) reasons, people that do not use a car will be less impacted by a congestion charge. The other questions are largely based on the ANWB survey of 2010, in order to make a comparison possible between the answers of this survey and of the one by ANWB. The fifth question is quite basic, but it does provide an indication of how far road pricing versus flat-rate taxation should go according to the respondents. The sixth question focusses purely on a congestion charge. The seventh question takes it a step further and makes it very specific. The eighth question is designed to give an indication of possible changes in behavior due to road pricing.

[8] Both the 2010 and the 2015 survey were conducted by Ruigrok NetPanel. Both surveys were commissioned by the ANWB, the 2015 survey was a follow-up survey. This second survey had a much smaller scale (401,727 against 2,119). For the purpose of making a clear distinction, the 2010 survey will be referred to as the ANWB survey, and the 2015 survey will be referred to as the Ruigrok survey.

Table 2: Questions used in the survey. Mandatory questions are marked with *.

Question	Answer options
1. Do you have a driver's license?*	Yes/No
2. Do you own a car?*	Yes/No
3. Are you familiar with the term road pricing (kilometerheffing)?*	Yes/No
4. How often do you drive?*	(Almost) everyday / More than once a week / Once a week / Less than once a week / Never
5. It is more fair to pay for car usage rather than for car ownership.	Agree Completely – 1 Disagree Completely – 5
6. I support a congestion-based charge (spitsheffing).	Agree Completely – 1 Disagree Completely – 5
7. The flat-rate motor vehicle tax (motorrijtuigenbelasting) should disappear and be replaced by a system of road pricing (kilometerheffing)	Agree Completely – 1 Disagree Completely – 5
8. I would avoid driving during peak-hours to save money	Agree Completely – 1 Disagree Completely – 5

Not all questions were mandatory. If students were unfamiliar with the concepts asked in the questions, they were told they did not have to answer these questions. The answers to Question 6 and 7 may, as a result, be a little less accurate, since students unfamiliar with the concept of road pricing are probably unfamiliar with congestion charging, too. Most students did answer the questions though.

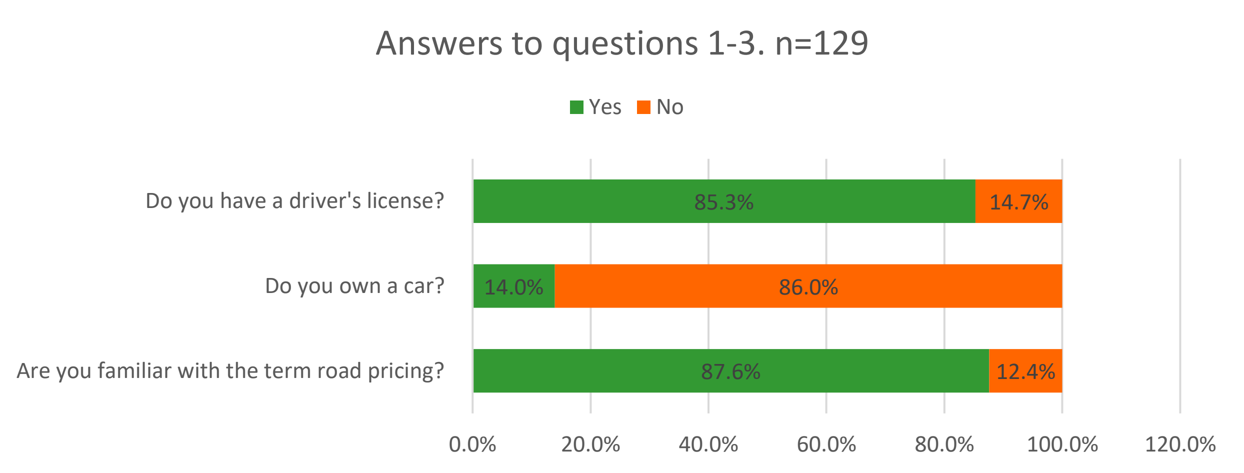
6.1.2 Survey limitations

There are a few limitations to this survey. Firstly, students are only a limited group of *future* road users; most of the current road users are largely not included. Secondly, since the survey was presented as a short survey on car usage and road pricing, a self-selection bias of people who actually drive might be present. Thirdly, besides Question 8, many other behavioral questions could be asked. Fourthly, for a more complete analysis, more background information from the respondents is needed, such as gender, field of study and whether respondents could possibly avoid driving during rush hour. Fifthly, many in-depth or specific questions on road pricing are not included. There are many systems from other countries that respondents may be familiar with. However, the lack of background data and willingness amongst students to fill out long and detailed surveys has led to this, more limited survey being used.

6.2 Survey data

The characteristics of the data gathered through the survey are presented in this section. There were 129 responses. The answers to the first three questions are represented below.

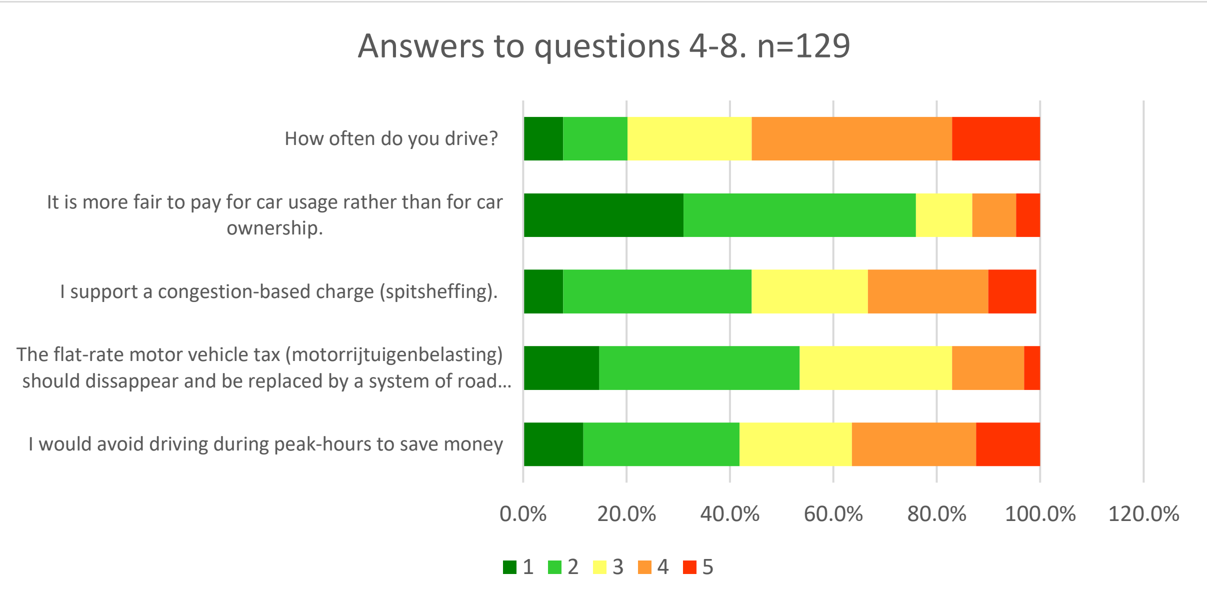
Fig. 2. The answers to Questions 1, 2 and 3.



What is clear from this data is that the lack of familiarity did not have a huge impact, as more than 87% of the respondents were actually familiar with the term. Out of the 12.4% (16 people) unfamiliar with the term 'road pricing', 81.3% had a driver's license, against 85.8% of the people familiar with the term. There was just one car owner unfamiliar with road pricing. The data of these questions were transformed into a binary scale. 'Yes' was replaced with '1' and 'No' was replaced with '0'.

The data on Question 4 ('How often do you drive?') was transformed into a 1-5 scale, with 1 replacing '(almost) everyday' and 5 replacing 'never'. The answers to the last five questions are represented in the figure below.

Fig. 3. The answers to Questions 4, 5, 6, 7 & 8.



Only 20% of the respondents drive multiple times a week and around 45% of the respondents drive at least once a week. It is clear that paying for usage rather than ownership is seen by most respondents as more fair, with more than 70% answering 1 or 2, with an average of 2.1. The other questions do show a slight distribution leaning towards the 'agree' side, however, the differences seem small. 44.2% of respondents support a congestion based charge and 53.5% of the respondents agree with replacing the flat-rate vehicle tax by a system of road pricing. Around half of the respondents would change their behavior, avoiding peak-hours for monetary gain.

6.3 Methodology

6.3.1 Econometric method

For the analysis of the data, the statistical computer program STATA was used. Firstly, the variables were given shorter names, rather than using the entire questions in STATA. The variable names are shown in Table 3. Throughout the analysis, a significance level of 5% *(a = 0.05)* is used along with robust standard errors.

Table 3. STATA variables and types.

Question	**STATA variable *(type)***
1. Do you have a driver's license?*	License *(binary)*
2. Do you own a car?*	Car *(binary)*
3. Are you familiar with the term road pricing (kilometerheffing)?*	Familiar *(binary)*
4. How often do you drive?*	Drive *(ordinal)*
5. It is more fair to pay for car usage rather than for car ownership.	Fairness *(ordinal)*
6. I support a congestion-based charge (spitsheffing).	Congestion *(ordinal)*
7. The flat-rate motor vehicle tax (motorrijtuigenbelasting) should dissappear and be replaced by a system of road pricing (kilometerheffing)	Replace *(ordinal)*
8. I would avoid driving during peak-hours to save money	Avoidance *(ordinal)*

For the analysis, probit and ordered probit models are used. A regular probit model is used for binary outcomes, such as 'Yes/No', and an ordered probit model is used for the ordinal outcomes.[9]

[9] Ordinal outcomes can be ordered in a logical way but the magnitude between the different outcomes cannot be interpreted as such.

The probit model takes the following form:[10]

$$\Pr(Y = 1|X) = \Phi(\beta_0 + \beta_i X)$$

in which *Y* is the dependent variable which can take either the value '1' or '0'. Φ is the cumulative standard normal distribution function, used to calculate the probability *Pr* of *Y* taking on the value '1' for a certain value of *X*. The value found is the corresponding z-value, with which the probability can be found using the cumulative standard normal distribution table. A probit model is based on a normal distribution of error terms. An ordered probit model is similar, but now *Y* can take any positive value, so it can be used for dependent variables that have a natural ranking, such as 'Good-Neutral-Bad' or 'Agree-Neutral-Disagree', etc.[11]

These models will be used for estimating the marginal effects of changes in regressors on the dependent variable. However, interpreting the results found with these tests cannot be done directly, since z-values are found. The effect of a change in one of the regressors (independent variables) on a predicted probability can be calculated by taking the difference between the old predicted probability and the predicted probability with the changed regressor(s) (Stock & Watson, 2012). In STATA, this is done using the *margins* command. From the probabilities indicated through that command at a specific point, the marginal effect can easily be seen and/or calculated.

6.4 Analysis

6.4.1 Familiarity with road pricing

Firstly, the aim was to gauge whether there was a significant difference between people with and people without a license when it came to familiarity with road pricing. A simple probit model was used with 'license' as independent variable and 'familiar' as dependent variable. A *z-value* of 0.47 was found, which is insignificant at the 5% level. This indicates that people with a driver's license were not more or less familiar than people without a license. Secondly, a probit model was used to see if input variable 'drive' had any correlation with 'familiar', since it would be logical to assume that people that drive more may have heard more about road pricing. Since 'drive' is an ordinal variable, and not a continuous variable, dummy variables were used instead for the different scores. Again, no significant results were found, although this could depend on the small sample size. This indicates that within the survey participants, there was no significant difference in familiarity with road pricing between drivers and non-drivers.

6.4.2 Data modifications

In the rest of the analysis, people without a license were dropped from the data. This was done because all of the people without a license never drove according to the data and as such,

[10] See e.g. Stock & Watson (2012).
[11] For a comprehensive overview of the exact mathematical/statistical analysis of the ordered probit model, please refer to Greene (2002), p.736-740.

they have no way of changing their behavior. Also, any system of road pricing would not affect them directly, only through possible external effects.

Furthermore, because of the small sample size and consequently the small size of the different categories of the ‘drive’ variable, the ‘drive’ variable was transformed from a 5-point scale to a 3-point scale, creating the ‘driveb’ variable. This increases the sample size of the different scores. The transformation used is shown in Table 4. The scores were also reversed, to make interpretation of the results slightly more intuitive. The higher the value of ‘driveb’, the more often the respondents drive. If ‘driveb=1’, this will be referred to as ‘1.driveb’ and the same holds for the other values of ‘driveb’.

Table 4. Transformation of the ‘drive’ variable.

drive value	driveb value
1-2	3
3	2
4-5	1

6.4.3 Fairness of road pricing

The first relationship examined is the relationship between the frequency of driving and the perceived fairness of paying for car usage rather than car ownership, which corresponds to Question 5 in the survey. Using an ordered probit model, the marginal effect of an increase in the ‘driveb’ variable on the score of the ‘fairness’ variable is estimated. It is expected that people that drive more, and thus have a higher score of the ‘driveb’ variable, will assign a higher score to ‘fairness’, thus agreeing less. Since our question was ‘It is more fair to pay for car usage rather than for car ownership’, one would expect that people that drive more would be less likely to agree with this (since paying for usage rather than ownership would probably affect them more). The results of this single ordered probit model are presented in Table 5.

Table 5. Probability estimates and marginal effects for ‘driveb’ as input and ‘fairness’ as output.

fairness	1.driveb	2.driveb	3.driveb	2.driveb-1.driveb	3.driveb-2.driveb
1	0.270	0.315	0.233	4.59%	-8.26%
2	0.484	0.478	0.483	-0.57%	0.47%
3	0.110	0.097	0.121	-1.30%	2.39%
4	0.091	0.076	0.106	-1.57%	3.05%
5	0.046	*0.034*	*0.058*	-1.14%	2.36%

Note: Cursive scores are not significant in the marginal effect estimation.

In Table 5, the ‘fairness’ scores of 1-2 indicate some level of ‘agree’, 3 is ‘neutral’ and 4-5 are ‘disagree’. The first three columns contain the expected probabilities for certain fairness scores for the different values of the ‘driveb’ variable. For instance, the probability of a ‘fairness’ score of 1 given a ‘driveb’ score of 2 is 0.315, or 31.5%. The probabilities in the first three columns count up to 1, since the probability of assigning a score to ‘fairness’ is 100% (everybody assigned a score). Based on these probabilities estimated in the first three columns, marginal effects of an increase in the ‘driveb’ variable are computed and given in the last two columns. The fourth column contains the marginal effect of an increase from the base level (‘1.driveb’) to ‘2.driveb’, the fifth column contains the marginal effect of an increase from ‘2.driveb’ to ‘3.driveb’. The marginal effects in columns 4 and 5 count up to 0, since the total probabilities always count up to 1. What is seen however, is an inconsistency between moving between the different values for ‘driveb’. Column 4 and 5 both represent a further increase in ‘driveb’, representing an increase in the frequency of driving. The same direction of marginal effects would be expected. However, the direction of the marginal effects on ‘fairness’ scores is completely opposite.

For example, an increase in the ‘driveb’ variable from 1 to 2 (thus, driving more often), has a marginal effect of 4.59% of assigning a ‘fairness’ score of 1, where a negative effect is expected (since people that drive more are expected to agree less). For ‘fairness’ scores 4 and 5, where a marginal increase in probability is expected when we move from reference group ‘1.driveb’ to ‘2.driveb’, a negative marginal effect is found, of -1.57% and -1.14%, respectively. A possible explanation could be the small size of the sample groups, distorting the outcomes. However, marginal effects when moving from ‘2.driveb’ to ‘3.driveb’ do seem consistent with our hypothesis. The results show that an increase from ‘2.driveb’ to ‘3.driveb’ decreases the probability of a ‘fairness’ score of 1 with around 8.26% and increases the probability of ‘fairness’ scores of 4 and 5 (by 3.05% and 2.36%, respectively).

6.4.4 Replacing the flat-rate tax[12]

The second relationship examined using an ordered probit model is the relationship between the frequency of driving and replacing the flat-rate motor vehicle tax by a system of road pricing. The dependent variable in this model is ‘replace’. The question belonging to that variable output is Question 7: ‘The flat-rate motor vehicle tax (motorrijtuigenbelasting) should disappear and be replaced by a system of road pricing (kilometerheffing)’. Since this would mostly affect avid drivers, it is expected that people that drive more frequently, and thus have a higher ‘driveb’ score, would agree less often, and thus assign a higher score to ‘replace’. The results are expected to be similar, direction-wise, as the results for the ‘fairness’ model, since this would also mostly affect people that drive more often. The results of this single ordered probit model are presented in Table 6.

[12] Question 7 regarding replacing the flat-rate tax is discussed before Question 6 because the analysis for Question 5 and Question 7, including the direction of the marginal effects, is similar.

Table 6. Probability estimates and marginal effects for ‘driveb’ as input and ‘replace’ as output.

Replace	1.driveb	2.driveb	3.driveb	2.driveb-1.driveb	3.driveb-2.driveb
1	0.110	0.156	0.096	4.53%	-5.98%
2	0.375	0.414	0.357	3.90%	-5.67%
3	0.316	0.286	0.325	-3.05%	3.93%
4	0.161	0.122	0.177	-3.93%	5.55%
5	0.038	*0.023*	*0.045*	-1.45%	2.17%

Note: Cursive scores are not significant in the marginal effect estimation.

Table 6 is similar to Table 5. In Table 6, the ‘replace’ scores of 1-2 indicate some level of ‘agree’, 3 is ‘neutral’ and 4-5 are ‘disagree’. The first three columns contain the expected probabilities for certain replace scores for the different values of the ‘driveb’ variable. Again, the scores in the first three columns count up to 1 (or 100%) and the scores in the last two columns, containing the marginal effects, count up to 0.

Moving from ‘1.driveb’ to ‘2.driveb’ increases the probability of a score of 1 or 2 (agreeing with the statement) by 4.53% and 3.90%, respectively, while it decreases the probability of a score of 4 or 5 by 3.93% and 1.45%, respectively. However, moving from ‘2.driveb’ to ‘3.driveb’ results in an opposite and slightly larger marginal effect. Since both moving from ‘1.driveb’ to ‘2.driveb’ and moving from ‘2.driveb’ to ‘3.driveb’ represent an increase in the frequency of driving, this seems to be inconsistent. For higher ‘driveb’ scores, decreasing probabilities for lower ‘replace’ scores and increasing probabilities for higher ‘replace’ scores would be expected. The last column is coherent with these expectations, the changes between ‘1.driveb’ and ‘2.driveb’ are not.

6.4.5 Congestion charging

Thirdly, the relationship between driving and supporting a congestion-based charge is examined. The statement/question relating to this subject is Question 6, ‘I support a congestion-based charge’. Here, one might expect slightly different results. On the one hand, one could argue that avid drivers usually also drive more during rush hours and therefore would pay more of these charges. On the other hand, depending on their time values (also see Sections 5.1 and 5.2), avid drivers might actually be better off because of the decrease in congestion. The results of the ordered probit model using ‘congestion’ as dependent variable are presented in Table 7.

Table 7. Probability estimates and marginal effects for ‘driveb’ as input and ‘congestion’ as output.

congestion	1.driveb	2.driveb	3.driveb	2.driveb-1.driveb	3.driveb-2.driveb
1	0.080	0.080	0.087	-0.01%	0.70%
2	0.371	0.370	0.381	-0.02%	1.10%
3	0.209	0.209	0.208	0.00%	-0.15%
4	0.238	0.238	0.230	0.02%	-0.86%
5	0.102	0.102	0.094	0.02%	-0.78%

This table can be interpreted similarly to the previous ones. For this model, there is as good as no difference between the probabilities for the different scores of the 'driveb' variable. Apparently, the answers between the different 'groups' of drivers are quite homogenous for this question. An explanation could lie in the considerations described at the start of this subsection.

What is also interesting is the complete change in the direction of marginal probabilities compared to the previous two questions. Since we see positive effects from 2.driveb to 3.driveb for the scores of 1 and 2 and negative marginal effects for scores 3-4-5, there is a slight indication that people that drive more are also slightly more likely to support a congestion-based charge. The marginal effects in this model appear to be small, however.

6.4.6 Avoiding peak-hours

The fourth relationship to be examined is the one between frequency of driving and the willingness to avoid peak-hours. This model is based on the answers of Question 8: 'I would avoid driving during peak-hours to save money'. It is expected that drivers would generally try to avoid driving during peak hours if it would save them money. The expectation is that people that drive more would be more likely to agree with this, since they would be the ones affected most by any measure of congestion charging. However, different time valuations affect this as well, since a lower rate of congestion during those hours could incentivize them to keep driving, regardless of the possible charge. To examine this, another ordered probit model was run with 'driveb' as independent variable and 'avoidance' as dependent variable. The results are presented in Table 8.

Table 8. Probability estimates and marginal effects for 'driveb' as input and 'avoidance' as output.

avoidance	1.driveb	2.driveb	3.driveb	2.driveb-1.driveb	3.driveb-2.driveb
1	0.112	0.081	0.130	-3.14%	4.89%
2	0.326	0.286	0.343	-3.99%	5.68%
3	0.219	0.220	0.215	0.13%	-0.44%
4	0.231	0.261	0.215	3.08%	-4.64%
5	0.112	0.152	0.097	3.92%	-5.49%

The last two columns of Table 8 show, once again, the inconsistency already visible in the previous models. The marginal effect of moving from '1.driveb' to '2.driveb' is completely opposite from the marginal effect of moving from '2.driveb' to '3.driveb'. Moving from '1.driveb' to '2.driveb' has a negative marginal effect on the likeliness of agreeing with the statement, which is inconsistent with the expectation. On the other hand, moving from '2.driveb' to '3.driveb' is inconsistent.

6.4.7 Adding car ownership as independent variable

Also, the marginal effect of owning a car was examined. The marginal effect of car ownership on the other answers to the survey, namely the scores given to the different statements, is expected to be negative: car owners generally drive more than non-car owners and are more affected by any change in the system.

To examine this relationship, the four previous ordered probit models were run again, however this time dummy variables for car ownership were added (0.car = ‘No’, 1.car=’Yes’). Marginal effects of owning a car versus not owning a car were computed, to see what impact car ownership has on the probability for assigning certain scores. These marginal effects are presented in Tables 9-12.

Table 9. The marginal effects of owning a car on the scores assigned to ‘fairness’ by ‘driveb’.

fairness	1.driveb	2.driveb	3.driveb
1	-6.58%	-7.32%	-6.50%
2	-0.62%	0.88%	-0.77%
3	1.99%	2.09%	1.97%
4	2.81%	2.54%	2.83%
5	2.40%	1.81%	2.47%

Table 10. The marginal effects of owning a car on the scores assigned to ‘replace’ by ‘driveb’.

replace	1.driveb	2.driveb	3.driveb
1	-9.01%	-15.53%	-14.84%
2	-23.40%	-20.79%	-21.29%
3	-1.19%	9.31%	8.42%
4	19.07%	18.74%	18.96%
5	14.51%	8.26%	8.75%

Table 11. The marginal effects of owning a car on the scores assigned to ‘congestion’ by ‘driveb’.

congestion	1.driveb	2.driveb	3.driveb
1	-2.31%	-2.41%	-2.76%
2	-4.56%	-4.50%	-4.24%
3	0.22%	0.32%	0.65%
4	3.18%	3.23%	3.36%
5	3.48%	3.36%	2.98%

Table 12. The marginal effects of owning a car on the scores assigned to ‘avoidance’ by ‘driveb’.

avoidance	1.driveb	2.driveb	3.driveb
1	-3.94%	-3.21%	-5.00%
2	-5.26%	-5.54%	-4.52%
3	0.05%	-0.69%	1.02%
4	3.93%	3.39%	4.35%
5	5.22%	6.06%	4.14%

These tables can be interpreted as follows. For instance, in Table 9, for drivers in group 2 (2.driveb) the likeliness of answering ‘1’ to the statement about ‘fairness’ decreases by 7.32% when the respondent owns a car. The other results can be interpreted in exactly the same way. For all of the questions, we see that car owners are less likely to ‘agree’ (and assign a lower score) and are more likely to ‘disagree’ (and assign a higher score), with relatively smaller effects for ‘neutral’. This is in line with our expectation.

The largest marginal differences between car owners and non-car owners are found for the ‘replace’ variable, presented in Table 10. Owning a car makes respondents between 9.01% and 15.53% less likely to assign a score of 1 (strongly agree) and between 20.79% and 23.40% less likely to assign a score of 2 (agree) to the statement on replacing the flat-rate motor vehicle tax. On the other hand, car owners are up to 19.07% more likely to assign a score of 4 (disagree) and up to 14.51% more likely to assign a score of 5 to this statement than non-car owners. Note that due to the fact that the sample size of car owners is small (only 18 respondents own a car), the scores may well be the result of this.

6.5 Conclusions from the survey

There are a few conclusions to be drawn from the survey. Firstly, people that drive more than once a week (3.driveb) are more inclined to disagree with the questions concerning fairness and replacing the flat-rate tax (Questions 5 and 7) and more inclined to agree with the question on avoiding peak-hours (Question 8) than people that drive only once a week or less. This is in line with our expectations. Also, car owners (relative to non-car owners) tend to be less likely to agree with any of the statements in the survey, marginally speaking, with the largest differences found regarding replacing the flat-rate motor vehicle tax.

There are some inconsistencies in the results, mainly the opposite marginal effects between moving from 1.driveb to 2.driveb and from 2.driveb to 3.driveb. An increase from 1.driveb to 2.driveb almost always gives an opposite marginal probability change compared to an increase from 2.driveb to 3.driveb. So, going from (almost) never driving to driving once a week has an opposite effect on the assigned scores as going from driving once a week to driving more than once a week. That seems inconsistent. This could be a result of the small sample size (n=129) and/or of any of the limitations mentioned in Section 6.1.2.

The many limitations on the survey data seem to cause the results to be insignificant and inconsistent. A larger sample size is necessary to find results that might be both significant and consistent. There is of course the possibility that, in fact, driving more or less does not change your opinion about these issues, in the same way that millionaires vote for socialist or green parties.

6.6 Comparison to other surveys

As mentioned before[13] there have been two surveys conducted amongst Dutch road users (ANWB, 2010 and Ruigrok, 2015) concerning the possible implementation of a system of road pricing. Although the data of these surveys are not publicly accessible, results have been published. Some differences and similarities between the results in these two surveys and the results in this thesis will be discussed in this section.

Regarding the overall fairness of paying for car usage rather than ownership the results found in the ANWB (2010) and Ruigrok (2015) surveys are quite similar: 66% to 68% support this statement. In this thesis' survey, 76% (strongly) agreed with this statement. Overall, there seems to be consensus regarding the fairness of paying for usage. Another question of which the results can be compared concerns the replacement of flat-rate taxes by a system of road pricing. In our survey, 53.5% (strongly) agreed with this statement, whereas Ruigrok (2015) found that between 41% and 44% supported this. In the ANWB survey, respondents that drove more had more negative attitudes towards road pricing and congestion charging. Similar indications were found in this thesis. Differences are found as well. While the respondents of the survey used for this thesis seem ambivalent towards a congestion charge, with 44.2%

[13] See Sections 4.3 and 6.1.1.

supporting the idea and 32.6% opposing it, the respondents of the ANWB survey rejected this idea strongly (ANWB, 2010). Overall, it seems that respondents of the survey used in this thesis have a more positive attitude towards the principle of road pricing and/or congestion charging than the respondents of the ANWB and Ruigrok surveys. Reasons for that might be that the survey used in this thesis did not have as many car owners and regular drivers and/or commuters as respondents. Also, students are generally well-educated and might have stronger opinions about environmental issues.

Though having searched extensively, other studies computing marginal effects of, for instance, driving more and/or car ownership on preferences regarding road pricing have not been found, so a comparison regarding the marginal effects and their size/direction cannot be made.

7. Conclusion

In this thesis, the effect of a system of congestion charging on consumer road users and the public support for congestion charging in the Netherlands was examined. Congestion is a large economic and social problem that could possibly worsen in the coming years. Therefore, finding a solution is important. Different aspects of a system of congestion charging have been discussed in the previous chapters to find an answer to the research question:

> *'What would be the effects of a system of congestion charging on road-using consumers in the Netherlands?'*

There are differences between groups of consumers regarding the effects a system of congestion charging would have on them. Consumers travelling for business have higher time values than commuters, which in turn have higher time values than 'other' road users. Consumers with high time values might benefit from the lower levels of congestion and will (gladly) pay the charges imposed, while consumers with lower time values might decide not to drive during peak hours. There are many different possibilities, all with different effects. This is one of the reasons why it is so difficult to estimate effects of a single system. Using figures found in Stockholm and different estimations for the elasticity levels found in different reports, there is some indication that traffic could be reduced by 20% in the Netherlands in the medium-long run, in which people are able to change their behavioral patterns, depending on the height of the charge. There are strong indications that sufficient public support is a necessity for road pricing or congestion charging to work. Communication about the benefits and costs and a clear redistributive system is key in convincing the avid driver that congestion charging and/or road pricing would be beneficial.

The results of a self-conducted survey showed that the future generation of road users, the current students, seem to support road pricing as a more fair way of charging road users. There is some indication that people that drive less (and thus could be expected to pay less with a road pricing system) have a higher level of support for a possible system. Car owners appear to have more negative attitudes toward road pricing.

The exact effects of a system of congestion charging are hard to gauge and depend on a huge variety of factors, such as other modalities and the possible redistribution of the gains from the system. What seems clear from historic examples and examples from other countries is that public support is a necessity, whatever system is implemented. If a Dutch system follows the Stockholm example, being a system which was designed carefully and had sufficient public support from the start, it might be quite successful. Although the 2010 ANWB survey indicated a lack of support for a system of congestion charging, the Stockholm example has shown that public support can shift, if a system is implemented with clear goals and input from the public (Börjesson et al., 2012). The system used in Stockholm might be an inspiration to Dutch policy makers. If a similar system could be implemented around the Netherlands' busiest roads, implementation is done carefully and the expected effects are clearly explained, public support could rise and a long-awaited road pricing system could finally be reality.

There are some shortcomings to this thesis. Firstly, there are more examples of road pricing, congestion charging or toll systems around the world. While this thesis focused on the most applicable ones, there have been projects in, for instance, the United States that could have been included as well. Secondly, road pricing in the Netherlands has proved to be such a vast political file that not all information, specifics of test projects and political discussion could have been discussed in this thesis. Thirdly, this thesis focused mostly on the effects of consumer road users of a system of congestion charging. However, there are many other direct and indirect effects. A system of road pricing in any form would have effects on, among other things, freight traffic, public transport, the environment, traffic incidents and car ownership.

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