Travel demand management policies:
A comparison between 'Park & Ride' and 'Congestion pricing' according to their transportation and non-transportation benefits and drawbacks.

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Abstract

For the past decade travelers have experienced increments in traffic and transport policy makers are challenged to solve these problems of transportation. There are a few transportation demand management policies to increase awareness of traffic and hence make travelers switch to more sustainable modes of transport. This literature review evaluates and compares park and ride with congestion pricing, two policies that have been researched abundantly. Results show that congestion pricing is more effective than park and ride when implementation is done appropriately, because congestion pricing is more constrained to the social, political and legal contexts of the place of implementation. Thus transport policy makers should be aware of these contexts in their decision making process to make sure that the most effective transport demand management policy is implemented.

1. Introduction

Throughout the last decades transportation is becoming increasingly important because the demand to transfer goods and capital is rising at an increasing pace, thus demand for transportation space is increasing too. However space is finite and roads cannot be extended infinitely, especially in highly condensed urban areas where space is even more limited than in rural areas. When cities become too agglomerated there is a higher chance for traffic congestion to occur, fortunately there are many ways to tackle this problem. Nonetheless the question is which one of these policies is the most effective and under what circumstances should a certain traffic congestion policy be implemented? These are enquiries that cities nowadays face, and answers are becoming ever more complex since alternatives for solving traffic congestion are growing.

The aim of this study is to compare two congestion reduction policies: 'Park & Ride' and 'Congestion pricing'. These policies are increasingly being implemented by cities today, examples include park and ride facilities in Rotterdam and across the United States, the London congestion charge zone, the Stockholm congestion tax and the Singapore Area Licensing Scheme , to name a few. Both policies are analyzed by studying their transportation and non-transportation benefits and drawbacks. These will be discussed to evaluate and compare the effectiveness of each policy. Hence the following research question:

To what extent is park and ride more effective than congestion zone pricing when evaluating both their transportation and non-transportation benefits and drawbacks?

This thesis is a literature review which focuses on empirical studies of renowned authors on the field of transport economics and policy. These works will help with the assessment of the effectiveness of both park and ride and congestion pricing. The benefits and drawbacks can be either micro or macro effects of these policies. Were macro refers to the effects caused to the general population of a city or region, and micro is a personal effect to a single road user.

The structure of this literature review is very straightforward. After the abstract and the introduction, the first chapter discusses the transportation benefits for both policies, followed by the transportation drawbacks of both policies. The second chapter discusses the non-transportation benefits of both policies, followed by the non-transportation drawbacks of both policies. A summary table is provided with an overview of the literature, followed by conclusions and policy recommendations. Finally, limitations of this analysis is provided.

2. Transportation effects

Through the implementation of travel demand management strategies, transportation benefits and drawbacks arise. There is abundant empirical research focusing on the transportation effects when a park and ride facility is built or when a congestion pricing scheme is implemented. Following are the transportation benefits and drawbacks.

2.1 Transportation: Benefits of Park & Ride

Park and ride facilities bring about several transportation benefits. The main objective of a park and ride facility is to reduce traffic congestion which is discussed first. This in turn reduced energy consumption and reduces automobile air pollution. These three transportation effects are benefits when a park and ride facility is constructed.

2.1.1 Reduced traffic congestion

It is evident that the foremost objective of park and ride facilities is to reduce traffic congestion. Especially traffic going towards the city center by incentivizing travelers to take public transportation or car pool to their destinations. It his study Noel (1988) suggests that park and ride facilities are worthy transport nodes to manage transportation accumulations. Yet it is essential that these park and ride facilities are correctly situated to be able to manage transportation flows as efficiently as possible (Noel, 1988). The author also illustrates that park and ride facilities located far away from cities tend to be more efficient and used more by travelers (Noel, 1988). Cox (1982) also found that park and ride facilities relieves congestion if the park and ride facilities are located correctly. By allowing travelers to switch their transportation preference, park and ride facilities result in a transfer of car users to public transportation (Cox, 1982).

However, not all empirical evidence agrees with the aforementioned findings. Meek et al (2008) found that there is not enough evidence to proof traffic reduction is indeed achieved by park and ride facilities. Plus the authors highlight the hardness to measure how much traffic a specific park and ride facility has reduced (Meek *et al.*, 2008). Finally, a 1998 English Historic Towns Forum (EHTF) conference revised a 1993 empirical paper that analyzed the implementation of park and ride facilities (EHTF, 1993). The conference stood positive towards traffic reduction by park and ride facilities, yet the reduction is largest if park and ride facilities are part of a package of travel demand management strategies. Empirical results show park and ride facilities are able to reduce traffic, yet traffic reductions is also dependent on several other factors such as location of the park and ride facility or if the implementation forms part of a greater bundle of traffic reduction strategies.

2.1.2 Reduced energy consumption

Other than reducing traffic congestion, park and ride facilities have other yet more indirect objectives. Reducing energy consumption is a noteworthy outcome when travelers start to use park and ride facilities. Passengers start to change their behavior and are diverted from low or single occupancy vehicles towards higher occupancy vehicles. In his paper Noel (1988) notes that this travel switch is associated with a more efficient use of energy. The author continues that as the number of high occupancy vehicles on the road increases the less energy is consumed per traveler (Noel, 1988). Reduced energy consumption by car sharing is also supported in an empirical study by Noland *et al*. (2006), were efficient places to start car sharing is at park and ride facilities.

In an alternative empirical study, Minnet & Pearce (2011) define carpooling as a park and ride system but instead of travelers switching to public transportation, they would switch towards other own vehicles instead. According to the authors this type of park and ride system will save energy consumption because less vehicles are ridden, total vehicle kilometers travelled (VKT) is reduced because of an increase in vehicle occupancy and therefore energy consumption is decreased (Minett & Pearce, 2011). Yet the authors argue that energy reductions are greater with the traditional park and ride schemes because travelers ride even higher occupancy vehicles such as buses, trains, metros. Going back to Noel's study, he agrees that energy consumption is reduced the most when public transport (highest occupancy vehicles) is used. The author concludes that energy consumption is reduced even more if park and ride facilities are located near rail transit that works on electrical power coming from non-petroleum sources (Noel, 1988). Finally, in both Parkhurst (2000) and Noel (1988) studies the authors agree that energy consumption from transportation is reduced if park and ride facilities are built close to the end of trips at residential areas because travelers change from single to high occupancy vehicles sooner in their journeys. As a result energy consumption reductions can be achieved with park and ride facilities, whether it is used to encourage the use of public transportation or for carpooling purposes.

2.1.3 Reduced automobile air pollution

Separate from the two abovementioned benefits of park and ride facilities, a new and more recent objective has acquired more attention and importance. The need to reduce automobile air pollution is a recent development especially supported by environmentalist groups in our society. In a study were the development of Scottish park and ride schemes is analyzed, Cairns (1998) explains that from the 1990s onwards travelers started to be more encouraged to use park and ride facilities because of the growing importance to reduce air pollution to protect our environment. The author concludes that park and ride facilities in Scotland have prevented big increases in automobile air pollution throughout the years yet not at the level authorities expected (Cairns M. , 1998). Whereas in his study Noel (1988) confirms that it is possible to achieve a reduction in urban center pollution, were an alternative study by Dickins supports this argument by arguing that park and ride facilities achieve more healthy and clean environments (Dickins, 1991).

Besides, automobile cold starts at the central business district for the return trip create significant amounts of pollution, yet these can be reduced by locating park and ride facilities outside the city center, essentially redirecting pollution outwards (Noel, 1988). In a study in the Netherlands, Mingardo (2013) also explains this redirection of pollution however concludes that park and ride facilities located on remote locations decrease vehicle emissions while peripheral locations increase emissions. This conclusion is in line with the deductions by Parkhurst (2000) mentioned before, were reduction in energy consumption is mostly achieved if the park and ride facilities are built more remote (closer to residential areas). Also, park and ride facilities linked to electrical public transportation reduces even more air pollution because electric modes of transport do not have a source of pollution, especially if the electricity is generated from renewable resources (Noel, 1988).

Finally, the aforementioned benefit that park and ride facilities reduce traffic congestion results in a more constant flow and speed of cars, as a consequence air pollution is also reduced because of reduced changes in vehicle speeds (Noel, 1988). Hence park and ride facilities can reduce automobile air pollution yet can also prevent larger increases of it without actually reducing the total amount of air pollution. It further depends on what type of transportation the park and ride facility is linked to and the location the facility is built.

2.2 Transportation: Benefits of Congestion pricing

As mentioned earlier congestion pricing is a travel demand management policy to reduce traffic, especially inner city traffic. There are a few transportation related benefits of such a policy yet there are two that are most prominent and are discussed the most in modern literature. These are the reductions of automobile air pollution and congestion. This review focuses particularly in the inner city because congestion pricing is usually set to prevent the excessive movement of vehicles towards the city center.

2.2.1 Reduced inner city congestion

On the one hand, the main objective of congestion pricing is to reduce traffic congestion yet it is approached much more directly than park and ride: If you want to access the inner city you must pay a pre-determined fee, there is less room for making your own choice as in park and ride. One of the most prominent examples is the London congestion charging zone implemented in 2003, which has had several and generally positive effects on traffic and congestion. In a report by Transport for London, the congestion charging zone decreased traffic volume by 15% and congestion, defined as time spent in traffic, was reduced by 30% in the year of implementation (TfL, 2004). In his study, Poudenx (2008) also reassures this by understanding that the obligation to pay a fixed fee in congestion charging does reduce traffic in the inner city. In another empirical study evaluating the London congestion charging zone, speed levels in the inner city raised from 14km/h to 17km/h (21% rise), thus suggesting reduced inner city congestion has been achieved in London's case (Santos & Shaffer, 2004).

Congestion charging has also been implemented in Stockholm and in 2006 a trial charging took place to understand its effects it had on the Swedish population. In their study, Eliasson *et al.* (2009) explain that traffic reductions inside the cordon (charging zone) fell by 22%, which is much higher than the 10-15% expected by traffic forecasters. Evidently, the charging zone in Stockholm also brought positive environmental effects which are discussed later on. The congestion zone in Stockholm was set in place in 2007 and traffic reductions attenuated over time. A study by Börjesson *et al.* (2012) explain that the price elasticity of traffic decreases over time and therefore travelers are more willing to pay the price of the congestion charge. This explains the sudden drop of traffic the year after the congestion zone was implemented and smaller increases of traffic in subsequent years (Börjesson *et al.*, 2012).

There is also evidence from California, were in the Los Angeles region congestion tolls were placed to reduce traffic from highways and the inner city by making travelers switch to more sustainable travel. Results showed that congestion and traffic was reduced in the inner city, yet congestion was especially reduced on highways were the tolls were placed (Small, 1983). As a result, there is enough evidence that congestion charging has positive effects on the reduction of inner city congestion, yet traffic reductions might not be prolonged throughout the years. Travelers will choose to enter the zone depending on the price they have to pay, thus travelers entering the zone value the benefits for entering higher than the lost value from paying the entrance fee. Policy makers should take this into account as to not create social unrest from too high fees, yet high enough to have impactful reductions in traffic and congestion.

2.2.2 Reduced inner city automobile air pollution

On the other hand, one of the more recent arguments for the implementation of congestion pricing comes from environmentalists who aspire a reduction of inner city automobile air pollution. In his study, Giuliano (1992) clearly explains that air pollution has been one of the main arguments for congestion pricing. In politics, air pollution has increased its importance as an argument to implement travel demand management solutions, especially congestion pricing. Therefore reduced air pollution is used by environmental lobbyists to promote congestion pricing (Giuliano, 1992). Yet this argument must be evidenced by tangible data. According to results, the London congestion charging zone has decreased the amount of most of the pollutants in the charging zone. In a study by Beevers and Carlsaw (2005) the congestion charging zone in London reduced total NO_x emissions by 12%, total particulate matter (PM_{10}) by 11.9% and total carbon dioxide levels by 19.5% between 2002 and 2003 (Beevers & Carslaw, 2005). This evidence suggests that congestion charging schemes can help meet targets of air pollution reduction set by the UK government, and potentially increases the attractiveness of congestion zone regimes.

In another study, Tonne *et al.* (2008) estimated that the London congestion zone has increased 183 years of life per 100,000 population inside the charging zone, partly due to lower air pollution levels. This also accounts for the greater London area where there is a total increase of 1888 years of life per 100,000 population (Tonne, Beevers, Armstrong, Kelly, & Wilkinson, 2008). Evidently these life span increases do not only source from reductions in air pollution, yet it partly does. Therefore suggesting that reductions in air pollution are beneficial at the social level.

A similar study done at the Stockholm congestion charging zone showed that a yearly total of 20-25 lives are saved in the inner charging zone that are directly associated to health issues from automobile air pollution (Eliasson, Hultkrantz, Nerhagen, & Rosqvist, 2009). In larger Stockholm the total amount of lives saved yearly is 25-30 related to air pollution health issues. These studies suggest that air pollution reductions are real in the inner city when a congestion charging zone is implemented. Examples such as London and Stockholm confirm that reductions in automobile use are directly related to the reductions in inner city air pollution, and hence to the improvement of health and increases in lifetime especially for the inhabitants of the city were the congestion charge has been implemented.

2.3 Transportation: Drawbacks of Park & Ride

Park and ride facilities do not only bring about benefits such as reduced traffic congestion, yet transportation drawbacks are also part of the picture. These downsides can prevent policy makers to implement park and ride as a travel demand management strategy. For example, rather than reducing traffic, park and ride can possibly relocate traffic to other areas. Besides park and ride can potentially generate unintended effects. These are discussed further.

2.3.1 Traffic re-location

Park and ride facilities must be located efficiently to reduce traffic congestion yet even in the best locations traffic reduction does not necessarily hold true. As described in his study, Noel (1988) describes that park and ride facilities may reduce traffic but new travelers are attracted because either the location of the facility is optimal for them or because the decreased congestion encourages them to travel. Therefore, areas that were not impacted by congestion might be affected by it now because of the increased number of travelers, and therefore traffic is redirected instead of reduced (Noel, 1988). In addition Parkhurst (2000) in his study illustrates the importance of the location of a park and ride facility to efficiently reduce traffic. However, the author concludes that park and ride facilities tend to redistribute traffic instead of reduce traffic (Parkhurst, 2000). The author also determines some reasons behind the transferal of traffic when a park and ride facility has been build. Parkhurst (2000) explains that some travelers divert towards the facility, some are stimulated to increase their number of trips because of the efficiency of the facility, and others, who only used public transport before, start using their cars to travel to the park and ride facility. These are unintended effects of park and ride facilities which are discussed later.

Furthermore, Meek *et al.* (2008) in their work explain the importance of locating park and ride facilities so that travelers use them as efficiently as possible. When these are located correctly traffic can be reduced, yet more predominantly is redirected towards the park and ride sites (Meek, Ison, & Enoch, 2008). These traffic relocation figures were studied in Oxford and redirection of total traffic from radial routes towards the facilities was 17% (Huntley, 1993) and

25% (Mathew, 1990). Finally, purely theoretical mathematical models can give clues to the possible suggestions for practical outcomes. In their study, Pineda *et al.* (2016) take park and ride facilities as nodes in the transportation network. In their model, the more random these nodes are set, the larger is the dispersion of flows and thus travel times tend to rise. This model gives hints towards how to set a network of park and ride facilities and advocates that optimal park and ride schemes to reduce traffic tend to be challenging achievements (Pineda, Cortés, Jara-Moroni, & Moreno, 2016). As a result, traffic redirection can be a huge challenge for policy makers because new traffic is created in undesired areas. Policy makers should therefore pay attention with new implantations of park and ride facilities so as to reduce traffic instead of re-locating it.

2.3.2 Unintended effects

As discussed, park and ride facilities can potentially divert traffic to undesired areas, this diversion can be caused by unintended effects of park and ride facilities. In several of his works, Graham Parkhurst sheds light to the possible dis-benefits and unintended effects that arise from the construction of park and ride facilities. Parkhurst (1995) primarily discusses that park and ride facilities do not necessarily reduce traffic congestion because some undesired effects take place when a new facility is built. In general terms the construction of new facilities can create new travel and prevent the traffic reduction objective to happen (Parkhurst, 1995); this was also evidenced in a study by Parkhurst and Stokes (1994) in Oxford and York. Firstly, travelers re directing their routes away from the city center and towards park and ride facilities are not reducing traffic congestion but are re locating traffic to pre unaffected areas (Parkhurst, 2000).

Secondly, Parkhurst (2000) also discusses that new park and ride facilities create new trips because of the effectiveness to travel through the facility. This idea is supported by Mingardo (2013) that new trips are generated conceivably because park and ride facilities decreased costs of travel. Thus either new travelers join the transportation system or preexisting travelers make more trips towards the city center through park and ride facilities (Mingardo, 2013). Thirdly, Parkhurst (2000) likewise argues that traffic increases because travelers that used to make their whole trip by public transport now choose to travel by car to the park and ride facility. In his study in the Netherlands, Mingardo (2013) reinforces Parkhurst that there are travelers who used to switch transport modes to travel to the city center though now make the trajectory to the park and ride facility by car. Thus creating new transport and increasing traffic (Mingardo, 2013). It is especially these unintended effects that cause new traffic and increase congestion in places where there was none before. There are also place specific unintended effects such as the abstraction from bike use when a facility is available in the Netherlands (Mingardo, 2013). However this can be argued for the Netherlands, quite possibly Denmark too, because these are countries where there is a predominant usage of bicycles. Essentially unintended effects come down to either the creation of new travel, or travelers altering part of their travel routes from sustainable travel to car use.

2.4 Transportation: Drawbacks of Congestion pricing

Congestion pricing has a few benefits as mentioned earlier, yet all travel demand management strategies have drawbacks too. In the case of a congestion zone, traffic is redirected out of the congestion zone and creates chaos outside the delimited zone. Also, public transportation is not always capable to take the new travelers that have switched from car use to public transportation.

2.4.1 Traffic increase outside congestion zone

Evidently less traffic will enter when a congestion zone is established. This has already been discussed in the benefits section of congestion zone, were inner city congestion is reduced after implementation. However, some of this traffic is redirected to the outside zones of the congestion area, thus generating traffic outside the congestion zone. For the congestion zone in London, transport for London (TfL, 2004) expected congestion increases in the inner ring road (IRR). The IRR are the roads delimiting the zone and are not part of the charged area, mainly focused towards travelers that have origins and destinations outside the congestion zone. Congestion of the IRR indeed rose by 4% and congestion of most roads right outside the zone also increased (Santos & Shaffer, 2004). In his study, Poudenx (2008) agrees with Santos and Shaffer that congestion outside the zone has increased, however states that these congestion increases have been satisfactorily managed. For example, green lights for the IRR were increased by 1-2 seconds, whereas green lights of radial roads were decreased by 1-2 seconds because of lower traffic expectations (Santos & Shaffer, 2004). Therefore in the case of London, increased congestion did happen after the implementation of the zone, yet these were to a large extent managed appropriately.

For the Singapore Area Licensing Scheme (ALS) case, the first ever congestion charging zone implemented in 1975, congestion outside the zone also occurred. In their book section road pricing for congestion management Small and Gómez-Ibáñez explain (1997) that the 6 square kilometer congestion zone did reduce congestion levels yet congestion levels mainly increased outside of the zone. The authors argue that this is largely because of fewer road infrastructure outside the zone and that further road improvements should be established to dissipate congestion problems outside the zone (Small & Gómez-Ibáñez, 1997). A final illustration of this drawback is revealed by the congestion pricing zone in Stockholm, were the cordon is the limit area of the congestion zone. In their study Eliasson *et al.* (2009) illustrated that ring roads outside the cordon on average increased their traffic by 1% in 2006 compared to pre implementation level of 2005. However, bigger traffic increases happened in both the Essinge bypass (4%) and Southern Link (10%), both connecting the southwest suburbs with the southeast suburbs of Stockholm (Eliasson, Hultkrantz, Nerhagen, & Rosqvist, 2009). As a result, studies in London, Singapore and Stockholm show that increases of traffic congestion outside the zone is almost certain. Yet, fortunately a range of solutions exist to reverse this, such as the implementation of longer times for green lights or the construction of road infrastructure outside the charging zone.

2.4.2 Public transportation capability

Furthermore, congestion zone pricing eliminates great amounts of pressure on traffic and congestion in the inner city. However, pressure on public transportation grows because travelers who switch from car use to public transport expect it to work as or almost as efficiently as a car (Mackett & Edwards, 1998), especially in modern or “smart” cities were an well-organized net of public transportation is strongly related to higher levels of wealth (Caragliu, Del Bo, & Nijkamp, 2011). In his paper, Giuliano (1992) understands that congestion pricing is mostly accepted when the zone has an effective and well expanded public transportation network. Therefore the system must be capable to carry all the extra passengers who make the switch. A study on urban public transport develops a model where it attempts to predict the interplay between congestion on the roads and congestion inside public transport (Tirachini, Hensher, & Rose, 2014). When a congestion zone is implemented traffic is relocated towards public transportation due to higher costs of entering the congestion zone. This suggests that the pressure on public transportation rises, hence it must be capable to handle extra transportation demand.

3. Non-Transportation effects

Travel demand management strategies not only convey transportation benefits and drawbacks, though a few non-transportation benefits and drawbacks arise too. In this section these are discussed for both congestion pricing and, park and ride.

3.1 Non-Transportation: Benefits of Park & Ride

As mentioned before, park and ride facilities bring forward several benefits to their users. Transportation benefits of park and ride have already been discussed. Following, this review distinguishes the most significant non-transportation benefits of park and ride, mainly user comfort and cost savings. These benefits are strongly associated to the individual level, in other words, to the benefits a single traveler experiences. Additionally, at the macro level, increased accessibility is a benefit of park and ride.

3.1.1 User comfort

To start off, user comfort can potentially be one of the most prominent benefits of park and ride facilities if provided correctly. In his paper, Noel (1988) discusses that user comfort comprises not only the convenience and comfort of travelling, yet also time savings and reduction in travel. When park and ride facilities are located near to the end of trips, close to the home of travelers, travel time is reduced if transportation connections are good enough (Noel, 1988), regardless of the type of park and ride facility- carpool, vanpool, or public transportation. Time savings are especially recognized for work trips because normally these are made in peak hours were traffic is most abundant. Yet there is a more personal benefit which is the general improvement of travel comfort. Especially directed to those travelers who state that comfortableness has to improve in the alternative travel mode for them to alter their own travel behavior (Shirgaokar & Deakin, 2005). While also directed to those travelers who feel that driving to their destinations is monotonous and has turned into a boredom routine (Noel, 1988).

Therefore, park and ride facilities are attractive to these. Therefore, the encouragement of park and ride facilities to pool travelers, especially in cars, habitually transforms the work trip in to a more enjoyable and social ride (Noel, 1988). Thus park and ride facilities can help induce increased levels of comfort in their users and hence change travel behaviors. However not all authors include user comfort as a benefit in their studies because it is challenging to place a monetary value to it, as for instance users hardly place a monetary value to the time saved for a trip.

3.1.2 Cost savings

On the other hand, cost savings are crucial for travelers who make daily trips to their destinations. This is a personal benefit because it deals with incentivizing travelers financially to alter their travel behavior. In his paper, Noel (1988) explains that there is a combination of a few elements that result in cost savings for travelers. As drivers pool at park and ride facilities their exposure to accidents is shared among the group and therefore are less prone to cover fully the costs if an accident occurs. Thus lower VKT levels induces insurance companies to lower their premiums (Noel, 1988), this is one of the means by which travelers save costs. Also travelers share fuel costs, regardless of carpooling or public transportation, since pooled groups now travel in a single vehicle (Noel, 1988). These costs can be significant if pooling and the use of park and ride facilities is employed on a daily basis.

Another way that park and ride facilities save costs for travelers is the avoidance of inner city parking costs (Parkhurst, 2000). This is due to the nature of parking policy were inner city parking is more restricted and therefore is typically more expensive (Marsden, 2006). Accordingly travelers are incentivized to switch and make use of park and ride facilities if the overall parking costs are cheaper than before. Finally, travelers who make use of park and ride facilities reduce the amount of depreciation of their own vehicles because total VKT is reduced. Hence decreasing vehicle maintenance costs and potentially increasing the resale value of their vehicles (Noel, 1988). As a result there are a few ways in which users of park and ride facilities save costs, and therefore conveys personal financial benefits to all travelers.

3.1.3 Improved accessibility

An additional benefit of park and ride is improved accessibility. As park and ride facilities are implemented, road users start using public transportation more. In his study Parkhurst (2000) explains that park and ride increase the alternatives for transport. Individuals now travel with different modes of public transport such as bus or rail, depending on where the park and ride is located (Parkhurst, 2000). Some individuals even switch to cycling or walking to reach the park and ride centers (Mingardo, 2013). Hence the increase of alternatives improves public transportation accessibility to remote areas and at the same time decreases traffic pressure on the roads. Reduced traffic on the roads and the convenience of using a car will increase the perception of accessibility on the roads and potentially creates new traffic (Mingardo, 2013). Yet this is a drawback of park and ride which has been discussed earlier. Also, Noel (1988) explains that park and ride facilities increase the transit patronage because typically provide a cost effective way of transport. Yet also accessibility of public transport is improved when parking lots are provided at the peripheral areas of cities (Noel, 1988). Therefore there is a big incentive for travelers to use these facilities, benefiting all kind of travelers. As a result, park and ride facilities decreases pressures on the road and incentivizes travelers to use public transport and alternative modes of transport. Hence improving accessibility for current travelers and encouraging new travelers to travel because of the improved accessibility.

3.2 Non-Transportation: Benefits of Congestion pricing

Furthermore, there are two more prominent non-transportation benefits of congestion pricing. The implementation of a congestion zone lowers the pressure for real estate and development industries to emphasize on traffic reduction. It also brings forward revenue were some sectors of society profit. These are discussed below.

3.2.1 Real estate and development industry

To begin with, agglomeration and traffic congestion usually occur as cities develop and grow. As a result, policy makers and municipalities must take action to solve traffic congestion by using different methods. In some cases land areas are downzoned to prevent further development and reduce incoming traffic to the inner city (Serkin, 2016). Therefore restricting the real estate and development industry to progress and start new projects. Similarly, municipalities may also set traffic reduction requirements to companies when these have new plans for construction projects in the inner city (Cairns et al., 2008), or require these companies to subsidize and fund ongoing traffic demand management policies (Giuliano & Wachs, 1992). Hence showing that pressures are imposed on the real estate and development industry rather than the public sector (traffic operators and policy makers).

However the imposition of congestion pricing turns this around. As in the aformentioned transportation benefits, if a congestion zone is set in place traffic reductions are reduced in the inner city. Therefore, the shift moves pressures to reduce traffic congestion towards the public sector, whereas the burden to reduce traffic for the private sector is relieved (Giuliano, 1992). As a result the responability to monitor and enforce a travel demand mangement policy lies on the public sector, hence the public sector is liable for inner city traffic reductions. Therefore, as congestion pricing focuses on traffic reductions, companies who want to implement new projects do not face competitive disadvantages from traffic reduction requirments or fees imposed by the public sector. Finally, exisiting companies in the inner city may support an intensification in project development if a congestion zone were to be implemented.

3.2.2 Revenue benefiters

On the other hand, a second benefit is that congestion pricing as a travel demand management policy raises revenues because of the imposition of fees to incoming cars. In a study of the Stockholm congestion charge, Börjesson *et al.* (2012) explain that one of the main objectives of the charge is to raise revenue for future transportation projects. This indeed happened and after 5 years of implementation, revenues were already used for new road investments and transportation developments (Börjesson, Eliasson, Hugosson, & Brundell-Freij, 2012). Also, the authors explain that in a simple theoretical model the charges applied would make all users worse off because either they choose the second best travel alternative or they pay the price of the fee. Yet the model predicts that the revenues from the congestion charge are enough to compensate all the users given that these are re-invested to the advantage of the population (Börjesson, Eliasson, Hugosson, & Brundell-Freij, 2012). However, the authors note that the Stockholm congestion charge did not fulfill expectations of road users because revenues were invested to a larger extent in public transportation rather than in road user projects such as the promised ring-road. Hence congestion pricing should, beforehand, be displayed to the public both as a package of different charges and that revenues will be used for transportation infrastructure that is beneficial for the most amount of travelers (Small, 1992).

Another empirical study conducted in London concluded that revenues fell far short from predicted values, just under half (Leape, 2006). The author demonstrates that traffic objectives have been met and that no loss has been incurred, meaning that the implementation has been successful in spite of lower than expected revenues. The following ten years revenues will be assigned to the investment and improvement of public transportation within the London area (Leape, 2006), a different plan than Stockholm were the focus was on the road motorists. All in all congestion charging brings forward revenues which can further be invested in transportation projects which travelers should be able to recognize and apprehend.

3.3 Non-Transportation: Drawbacks of Park & Ride

Future users of park and ride facilities must be attracted by enjoying the most benefits possible. However, there is also the political side when implementing park and ride facilities, and lobbyists use the following non-transportation drawbacks as arguments to prevent the implementation of these facilities.

3.3.1 Financial costs: Breaking-even

The first non-transportation drawback found in the literature is the difficulty for park and ride facilities to recuperate the investment made. In his study, Noel (1988) shows that park and ride facilities can bring forward cost ineffectiveness because occasionally parking fees are not enough to recover investment costs. Not only the recovery of building costs, yet costs of maintenance and costs of operation as well (Noel, 1988). Though good planning and strategic position of park and ride facilities may alleviate cost ineffectiveness. For instance placing a facility alongside a public transportation network will attract more users because it increases the amount of transport options a traveler can choose from, and therefore increases revenue to cover costs (Karamychev & van Reeven, 2011).

Noel agrees that locating a park and ride station close to a heavy demanded rail station decreases cost ineffectiveness because more users are inclined to park their vehicles there (Noel, 1988). Besides, keeping parking fees to a minimum or even for free induces higher cost ineffectiveness, however increases amount of users. Higher amount of travelers pooling usually means both reduced environmental costs (Cairns M. , 1998) and reduced energy costs (Parkhurst, 2000), hence cost ineffectiveness could be recovered at the social level. Yet it depends on policy makers what amount of fees are implemented to recover costs at the private or social level. As a result investors of park and ride facilities face the challenge to recover costs of implementation though there are several ways to maintain this cost ineffectiveness to a minimum.

3.3.2 Efficiency of park and ride

Furthermore, the efficiency of a park and ride facility in terms of location with respect to public transportation and the amount of parking spaces is crucial for the development of more sustainable transport. These two challenges are faced by policy makers today and are very closely linked to the aforementioned drawback: break-even with costs. These two must be implemented in the most effective way possible to attract more users and reduce cost ineffectiveness. On one hand bigger transportation nodes are normally more agglomerated which prevents growth and construction of new facilities around (Caragliu, Del Bo, & Nijkamp, 2011). Therefore policy makers tend to incline to less crowded transportation nodes because costs are lower (Karamychev & van Reeven, 2011) however the catchment of users would not be optimal. The location of a park and ride facility is crucial, yet also a challenge, since policy makers strive for effective facilities that do not incur too high costs. Therefore, choice location to implement such a travel demand management solution has high levels of bargaining and the decision making process might be timely (Duncan & Christensen, 2013).

On the other hand, the amount of parking space needed for poolers is a big challenge for park and ride developers. Schlag and Schade (2000) studied six different European cities (including Athens, York and Madrid) and argued about traffic demand management solutions. Travelers rated "not enough parking space" with a 3.16 out of 4 as a problem perception (Schlag & Schade, 2000), the second highest problem perception after "traffic jam". This suggests that policy makers must be aware that enough parking space should be provided, otherwise the perception of the facility will not show positive public acceptability. Hence this is the second challenge that park and ride facilities face in terms on efficiency.

All in all policy makers for park and ride facilities must find a balance between cost effectiveness, public acceptability and the efficacy of the park and ride facility. Thus policy makers could potentially increase their lobbying power by choosing a suitable location close to an important transportation node, or providing sufficient parking space. Accordingly increasing the chances of the park and ride to be an effective policy.

3.4 Non-Transportation: Drawbacks of Congestion pricing

Finally, congestion pricing also brings forward a few non-transportation drawbacks. This especially because it is a policy that does not necessarily benefit everyone, and could take time plus money to implement. Thus policy makers must consider all factors that play in the implementation process of congestion pricing, especially how travelers will react towards fairness and equity issues.

3.4.1 Implementation process

The implementation procedure of a congestion pricing scheme may be costly and timely. As a first example, the implementation costs of the London congestion charge scheme resulted to be twice as expected (Leape, 2006). This is a significant drawback because governments are normally very cautious about making such big investments in transport projects. In the case of London the congestion charging was employed through a partnership between public and private enterprises (Siemiatycki, 2004). This increased the amount of lobbying to implement the congestion charge and therefore increased costs and time for implementation.

The Stockholm congestion charge is also a clear example that the implementation process of a congestion charge is a challenge that governments face. The charge first entered a trial period from January to July 2006 which already raised the costs of implementation (Eliasson, 2008). Of course this trail period was needed to test the impacts of the charge however it is a drawback because it increases the overall costs. Then a 2007 referendum followed were Stockholm and neighboring municipalities voted for the implementation of such a charge, which resulted in additional costs to the Swedish government (Börjesson, Eliasson, Hugosson, & Brundell-Freij, 2012). Finally the vote was to keep the congestion charge. Therefore the Stockholm congestion charge had to go through public bargaining and also take into account the public opinion, which resulted in additional costs to finally implement the charge.

As a result congestion charging schemes can take some time to implement and therefore rises costs of the process of implementation were Stockholm and London are the two most prominent examples. Politics and the legal framework of countries makes it difficult to implement such a policy, as compared to park and ride were implementation is easier from a political and legal point of view.

3.4.2 Fairness

When congestion pricing is implemented it can benefit many users, however it can also be considered unfair for some and unequal for others. In a review of congestion pricing, authors Larson and Sasanuma (2010) explain that such a policy can trigger unfairness. Road users who live in suburbs usually have poor public transportation options to go to center and hence commit to travel by car because it is more convenient. The authors argue that with the implementation of a congestion pricing scheme it is these travelers that find it more unfair because they will have to incur more costs than travelers who live in places were the use of public transportation is more accessible (Larson & Sasanuma, 2010). This is important for policy makers because it evidences that everyone should be considered when a congestion pricing scheme is implemented.

In another study, Yu *et al.* (2016) show that equity concerns of congestion pricing can increase the support of the public if it motivates policy makers to implement a well-structured scheme that offers solutions to groups that feel unequal. Larson and Sasanuma (2010) suggest the following three solutions to reduce this sense of unfairness. First, increasing the efficacy to reduce congestion by showing the public that alternative means are implemented to reduce congestion, such as parking regulations or road repairs. Second, policy makers should show that revenues are actually being used for public transportation improvements. Third, by offering and facilitating sub urban travelers alternative means of travel such as ride sharing, or discounts (Larson & Sasanuma, 2010). All in all fairness of congestion pricing must be of crucial importance for policy makers and must be dealt with thought through solutions to the interest of the general public.

3.4.3 Equity

Other than fairness of congestion pricing, equality also plays a significant role in the implementation of congestion pricing. According to Larson and Sasanuma (2010) congestion pricing may be rejected by the public if citizens identify some type of discrimination against, for instance, the poor or elderly. In the case of congestion pricing the fee impacts a poor road user more than a richer road user (Larson & Sasanuma, 2010). This means that policy makers have to understand the proportion of low and middle income travelers who use cars to commute in the area of implementation.

A survey conducted in 2003 by Schaller Consulting for Transportation Alternatives concluded that most travelers coming into Manhattan were wealthy, therefore a toll to enter Manhattan would have little impact on low income travelers because most were already using public transport (Schaller Consulting, 2003). For instance if the proportion of poor travelers coming into Manhattan by car was larger, implementation would cause more inequality. Hence a big challenge that policy makers face today is to get the correct overview of the transportation data, hence providing a correct impression of what equity impacts the congestion pricing scheme will have, and as a result making more accurate decisions on fees and areas of implementation.

4. Conclusion, policy recommendation and limitations

To help the reader and myself, two summary tables are provided that summarize the findings and sources of this literature review. Table A summarizes the benefits and Table B the drawbacks.

Table A		**Park and Ride**	**Sources**	**Congestion C.**	**Sources**
Benefits	**Transportation**	- Reduced traffic congestion	(Noel, 1988) (Cox, 1982) (EHTF, 1993)	- Reduced inner city congestion	(TfL, 2004) (Poudenx, 2008) (Santos & Shaffer, 2004) (Eliasson *et al.*, 2009) (Börjesson *et al.*, 2012) (Small, 1983)
		- Reduced energy consumption	(Noel, 1988) (Noland *et al.*, 2006) (Minett & Pearce, 2011) (Parkhurst, 2000)		
		- Reduced automobile air pollution	(Noel, 1988) (Cairns M. R., 1998) (Dickins, 1991) (Mingardo, 2013)	- Reduced inner city automobile air pollution	(Giuliano, 1992) (Beevers & Carslaw, 2005) (Tonne *et al.*, 2008) (Eliasson *et al.*, 2009)
	Non-transportation	- User comfort	(Noel, 1988) (Shirgaokar & Deakin, 2005)	-Real estate and development industry	(Serkin, 2016) (Cairs *et al.* 2008) (Giuliano & Wachs, 1992) (Giuliano, 1992)
		- Cost savings	(Noel, 1988) (Parkhurst, 2000) (Marsden, 2006)		
		- Improved accessibility	(Parkhurst, 2000) (Noel, 1988) (Mingardo, 2013)	-Revenue benefiters	(Börjesson *et al.*, 2012) (Small, 1992) (Leape, 2006)

Table B		**Park and Ride**	**Sources**	**Congestion C.**	**Sources**
Drawbacks	**Transportation**	- Traffic re-location	(Noel, 1988) (Parkhurst, 2000) (Meek *et al.,*2008) (Huntley, 1993) (Mathew, 1990) (Pineda *et al.,* 2016)	- Traffic increase outside congestion zone	(TfL, 2004) (Santos & Shaffer, 2004) (Small & Gómez-Ibáñez, 1997) (Eliasson *et al.*, 2009)
		- Unintended effects	(Parkhurst, 1995) (Parkhurst & Stokes, 1994) (Parkhurst, 2000) (Mingardo, 2013)	- Public transportation capability	(Mackett & Edwards, 1998) (Giuliano, 1992) (Tirachini, Hensher, & Rose, 2014)
	Non-transportation	- Financial costs: Breaking-even	(Noel, 1988) (Karamychev & van Reeven, 2011) (Cairns M. R., 1998) (Parkhurst, 2000)	- Implementation process	(Leape, 2006) (Siemiatycki, 2004) (Eliasson, 2008) (Börjesson *et al.*, 2012)
		- Efficiency of Park and ride	(Caragliu, Del Bo, & Nijkamp, 2011) (Karamychev & van Reeven, 2011) (Duncan & Christensen, 2013) (Schlag & Schade, 2000)	- Fairness	(Larson & Sasanuma, 2010) (Yu *et al.*, 2016)
				- Equity	(Larson & Sasanuma, 2010) (Schaller Consulting, 2003)

4.1 Conclusions

Overall both park & ride and congestion pricing reduce traffic, energy use and pollution, and can be efficient traffic demand management policies if implemented correctly. From empirical studies the efficiency of park and ride facilities depends predominantly on the location and the type of public transportation to which it is connected. As for congestion pricing studies have shown that efficiency depends largely on the capability of public transportation and the public acceptability of the policy.

At the end it comes down to how the public transport is capable of dealing with the extra demand, and both policies depend on public transport. Both policies try to restrict the use of the car in the inner city and should make it worthwhile for travelers to switch transportation mode. Therefore, investment in one of the policies should noticeably come along with investment in alternative means of transport. Especially for congestion pricing were tackling traffic is done directly through the implementation of a zone were travelers have to pay. Some road users will switch to public transport because their cost to use public transport is lower than the cost to pay the fee. Whereas, on the other side, park and ride tries to solve the problem in an indirect way because travelers are not forced to pay a fee, it is optional to use park and ride facilities.

As a result, both policies do reduce traffic congestion however congestion pricing reduces it by a larger margin because it is a fee that travelers are required to pay. Congestion pricing reduces inner city traffic by around 15% (London) to 22% (Stockholm) whereas park and ride facilities decrease it by around 2% to 5% (Oxford, York & Krakow[1]). Besides park and ride struggles with breaking even because parking prices are usually not enough to cover investments of the facilities. Whereas when it comes to recovering revenue, congestion pricing also performs better because, from the few examples such as London and Stockholm, they show that it is possible to make revenue and use it to finance future transport projects. Also, park and ride facilities create unintended affects such as the creation of new travel, or even re-locates traffic elsewhere. Whereas congestion charging shows traffic increases outside the zone and the possible inability of public transportation to deal with extra traffic. However empirical studies show that the few

[1] (Szarata, 2003)

examples of congestion pricing have dealt with these problems satisfactorily. Therefore, from the analysis of both transportation and non-transportation benefits and drawbacks it can be concluded that congestion pricing is to a certain extent more effective than park and ride. Hence, the research question ***'To what extent is park and ride more effective than congestion zone pricing when evaluating both their transportation and non-transportation benefits and drawbacks?'*** is answered.

4.2 *Policy recommendation*

Furthermore, it is of significance to mention what this study should mean for future transport policy makers. Firstly, policy makers should recognize that congestion pricing is more effective than park and ride in many aspects, however only if applied correctly. Applying correctly implies a good market analysis were breaking even the investment is achievable and were social equity and social fairness are considered. As discussed previously, congestion pricing can be ineffective in places were fairness or equity has a big impact on transportation mode switch. The policy will become less effective if there are too many travelers who cannot afford the fee or are more prone to bear the full cost of the fee, it could even cause a referendum to take place. Besides, policy makers should also comprehend that in some countries lobbying plays a larger role in the implementation process of congestion pricing, or the legal framework prevents to a larger extent the implementation of it. Whereas the implementation of park and ride facilities usually require less political and legal lobbying.

Therefore policy makers should understand the social, political and legal contexts and drawbacks of the place of implementation, thus should only consider congestion charging if these can be correctly managed. To end with, park and ride facilities should be considered by policy makers if traffic reductions are not of crucial importance and if investments can be adequately subsidized, because these facilities reduce traffic to a lesser extent than congestion charging and recovering costs is more challenging too.

This review has a few limitations which bound the significance of the results. To begin with, the analysis of this paper focuses on traffic demand management strategies used in developed countries. Therefore, conclusions drawn in this review might not translate to all countries. Also, there are more transport and non-transportation benefits and drawbacks for both policies yet there is no enough empirical studies to back up and validate the results. Thus further research on these policies would give deeper insights and improved deductions. Finally, this empirical paper focuses on both park and ride and congestion pricing, therefore the scope of discussion is less profound and detailed. A study focused on only one of these two traffic demand management policies would have more thorough conclusions.

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