The implications of implementing congestion pricing in Chicago

Steven Wester
S2034298
23-06-2016
Master Economic Geography
University of Groningen

university of groningen

Abstract

In this master's thesis the project of implementing congestion pricing in Chicago is researched. Congestion pricing has been implemented in several cities throughout the world, including some cities in the United States. The Chicago Metropolitan Agency for Planning (CMAP) is researching the possibility of implementing congestion pricing in Chicago. The reason for this is that in the current situation drivers are not paying the full cost of their use. The strategy of congestion pricing is to include this congestion externality by making drivers pay a fee, so they can use an express lane with free-flow traffic on the highway. There are different forms in which congestion pricing can be implemented: zonal pricing, cordon pricing and a facility-based scheme. This facility-based scheme can be divided in High Occupancy Vehicle lanes, High Occupancy Toll lanes and managed lanes. By showing examples of congestion pricing in Minnesota and California, an attempt is made to show the factors Chicago should keep in mind by the implementation of congestion pricing. The current proposal in Chicago is to first implement congestion pricing on the Stevenson Expressway.

With the use of the theoretical background and the empirical findings hypotheses have been stated to research the implications of congestion pricing in Chicago. These hypotheses have been tested by conducting interviews with experts on the topic. Also, a quantitative data analysis has been executed in order to see which highways are the most congested in Chicago and where there is the most demand for congestion pricing. In the results it is shown that most congestion occurs on the Kennedy Expressway and the most demand for congestion is in the neighborhoods along the Edens Expressway. Despite these facts the congestion pricing project on the Stevenson Expressway has a good chance to succeed because of visible benefits and low costs. The results of the hypotheses show that a facility-based scheme would be the best option for Chicago, with a dynamic-based pricing scheme. Also, it is shown that alternative modes of transport for people with low values of times have to be provided when congestion pricing is implemented. The relation between congestion pricing and land-use, as well as the relation between congestion pricing and different prices on highways of Chicago because of income segregation, are complex questions which are discussed in this thesis. Further research has to show what the exact effects of these two influences on congestion pricing is.

Key words:
Congestion pricing - Congestion externality - Zonal pricing – Cordon pricing – Facility-based scheme – Dynamic-based pricing scheme – Value of time – Income segregation

List of Abbreviations

I-55 =	Stevenson Expressway
I-90=	Jane Addams Memorial Tollway
I-90/94=	Kennedy Expressway
I-94 North=	Edens Expressway
I-94 South=	Dan Ryan Expressway
I-290=	Eisenhower Expressway
CBD=	Central Business District
CMAP=	Chicago Metropolitan Agency for Planning
ETL=	Express Toll Lanes
HOV lane=	High Occupancy Vehicle lane
HOT lane=	High Occupancy Toll lane
IDOT=	Illinois Department of Transportation
MPC=	Metropolitan Planning Council
SOV=	Single Occupancy Vehicle
USDOT=	United States Department of Transportation

Table of Contents

Chapter 1 Introduction to the topic

To introduce the topic of congestion pricing, first of all the general background of what congestion pricing is and why it can be implemented is explained in the first paragraphs. After that some processes will be explained in more detail. These processes include the different ways to implement congestion pricing and some examples of cities which have already implemented congestion pricing. Also the proposed way to implement congestion pricing by the Chicago Metropolitan Agency for Planning (CMAP) is important. All these processes will be explained in more detail in the theoretical framework and empirical framework. In the research design section, the problem, goal and main research questions are proposed. Finally, the methodology and conceptual model explain the way how this research will be conducted and how the important theories will be linked to the data collection.

Motivation for the research

Congestion pricing is a topic which has been introduced slowly worldwide during the last few decades. It is becoming a more promising option for transportation policymakers to address urban traffic-congestion problems (Ecola & Light, 2009). It has been advocated by transport economists and traffic planners as an effective instrument to reduce the congestion in big cities (Eliasson, 2008). The concept of congestion pricing has first been introduced in Singapore, later followed by London and Stockholm. In the United States there were in first instance a lot of proposals rejected, because congestion might be inequitable (Ecola & Light, 2009). Since then a few congestion pricing projects have been implemented throughout the United States, for example in Minnesota and California (Cao & Munnich, 2012; Sullivan, 2000).

Congestion pricing works through a set of policies which are implemented to make sure the costs which exist because of congestion are covered. Congestion costs are the costs with which individual travelers impose delays on others. Most of the costs of traffic congestion are born by travelers collectively but, because individual travelers impose delays on others, they do not pay the full marginal social cost of their trips and therefore create a negative externality (De Palma & Lindsey, 2011). This negative externality which is now created is a loss to the economy. To cover this externality congestion pricing can be introduced. Congestion pricing is a way of internalizing the extra costs which each individual makes because of extra congestion they cause for others. The internalisation of these costs work through the concept of supply and demand (Chicago Metropolitan Agency for Planning, 2010).

According to the Federal Highway Administration (2008) congestion pricing makes sure that congestion will decrease because it becomes more attractive for travelers to travel during off-peak periods. By making sure people will choose to travel at different times or by a different transportation mode the highway system will work more efficient with less congestion.

Different forms of congestion pricing

Congestion pricing can be introduced in different ways. There are four categories which can be divided (De Palma & Lindsey, 2011).

- Facility-based schemes
- Cordons
- Zone schemes

The facility-based schemes can be divided in three different categories as can be seen in figure 1.1: HOV (High Occupancy Vehicle) lanes, HOT (High Occupancy Toll) lanes and Express Toll Lanes (ETL). In HOV lanes only cars are allowed with two or more passengers, in HOT lanes all cars are allowed but cars with one person have to pay and cars with two or more persons travel for free. And for the last option all cars can travel in the managed lane, but they all have to pay (CLTV, 2016).

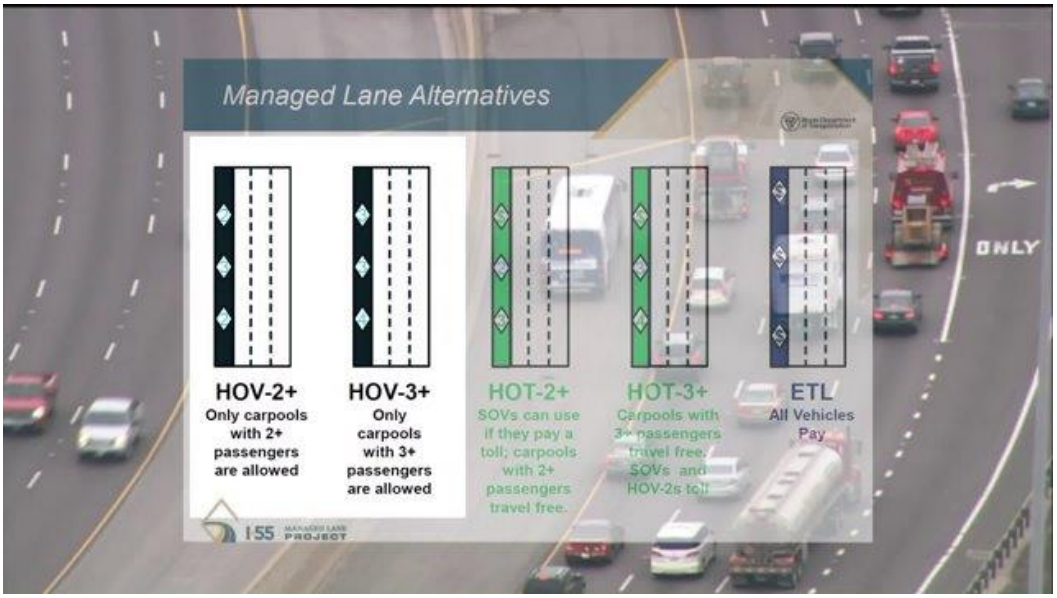


Figure 1.1 The different options for facility-based schemes. (CLTV, 2016).

Another option which has been introduced in Stockholm is the concept of cordon pricing (De Palma & Lindsey, 2011). In this congestion pricing method there are several control points and drivers have to pay a dynamic toll price when they cross the control point.
In a zonal scheme a driver has to pay a fee for driving in a particular zone. So the difference with the cordon pricing system is that in a zone scheme a driver doesn´t necessarily have to cross a boundary to pay the tax (De Palma & Lindsey, 2011).
The price of the tolls for all systems may vary for different times of the day. This is called the degree of time differentiation, which is sometimes referred to as a fourth way of implementing congestion pricing. Although since this principle can be applied in all other schemes, it is therefore not a scheme on its own. Most of the systems have higher prices in rush hours. The managed lanes can set the price in such a way that the managed lane will never be congested (CMAP, 2010). Also, a different price can be set because of different incomes in different areas (Harris & Shaikh, 2011).

Congestion pricing in Chicago

The government of Illinois has implemented congestion pricing as one of its main transport strategies for 2011-2040 in order to reduce congestion and to contribute to a productive regional economy (Chicago Metropolitan Agency for Planning, 2010). Especially around the city of Chicago this is a relevant topic. In some regions in the United States congestion pricing has already been implemented. Chicago could learn from these other regions. According to CMAP the highway system is currently in such a bad condition that it should implement congestion pricing to keep pace with other industrialized and emerging economies around the world (Chicago Metropolitan Agency for Planning, 2010). Because of rising national construction costs and stagnating gas tax revenues something has to be done to bridge this gap as can be seen in figure 1.2.

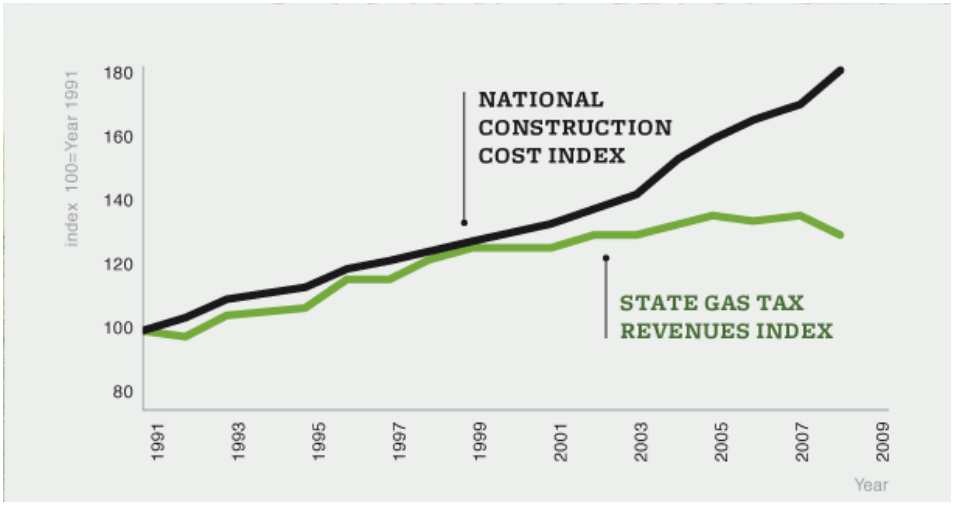


Fig 1.2. National construction costs of highways and state gas tax revenues in the last twenty years. (Chicago Metropolitan Agency for Planning , 2010)

With the mechanism of congestion pricing, the gap between the construction costs and the gas tax revenues has to be closed. The Chicago Metropolitan Agency for Planning has submitted a proposal for congestion pricing on the interstate 90, the Jane Addams Memorial Tollway, but this was not selected for funding by the US transport department. The agency is also studying strategies in order to decrease congestion in the whole Chicago region.
A Study of Skosey & Zucchero (2010) proposed congestion pricing on the Jane Addams Memorial Tollway (I-90), Kennedy Expressway (I-90/I-94) and Stevenson Expressway (I-55). According to CMAP (2012) congestion pricing would be implemented on five different highways, which can be seen in figure 1.3. Also the Eisenhower Expressway (I-290), Elgin O' Hare and the IL-53 were added. The Kennedy Expressway was not added in this plan, because there were only projects researched for congestion pricing eventually on which extra lanes were already added, and where congestion pricing will be implemented on top of the extra lanes (CMAP 2016, interview).

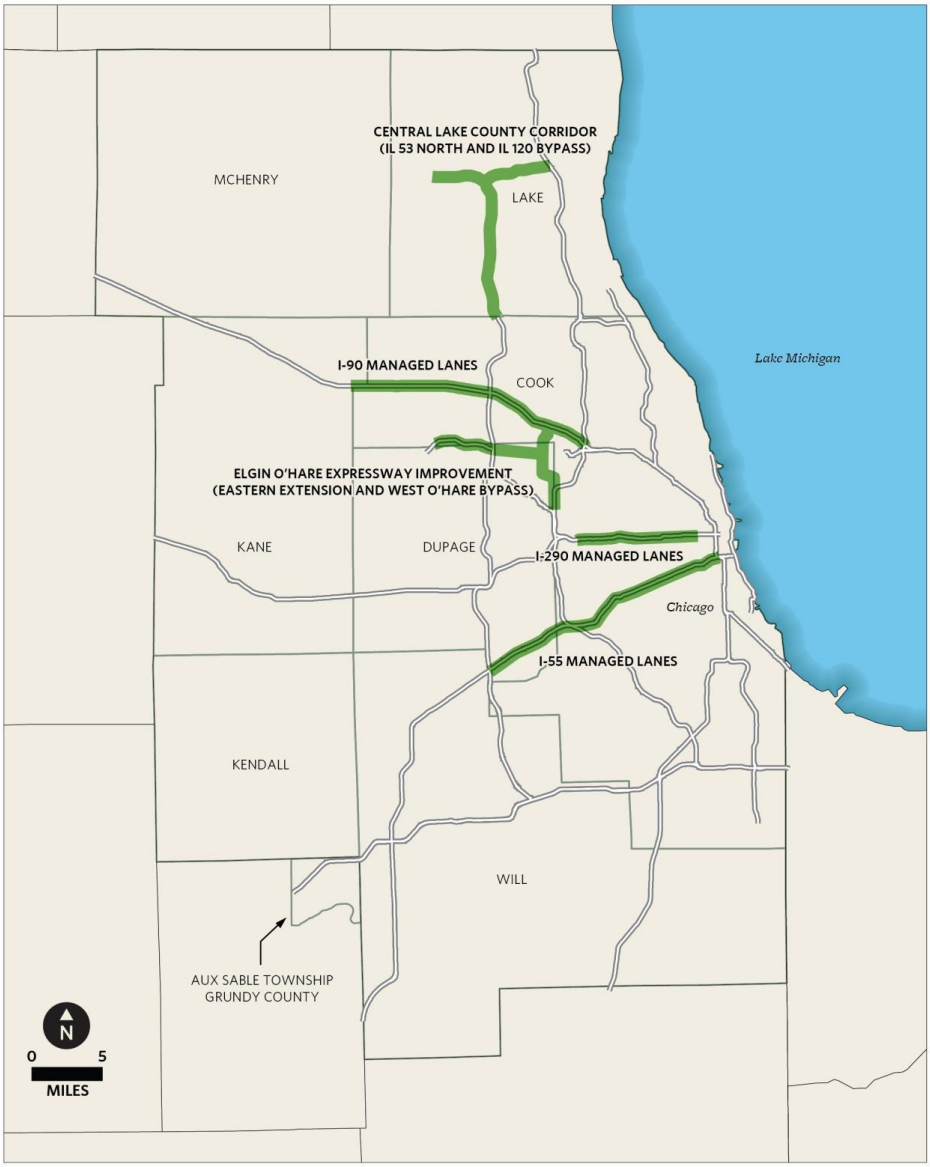


Fig. 1.3 The proposed highways for implementing congestion pricing in 2012 (CMAP, 2012).

According to the CMAP (2016, interview) eventually only on the Stevenson (I-55) and Eisenhower (I-290) congestion pricing will be implemented. On the other highways extra lanes will be built, but because these extra lanes will add extra capacity, there is no need any more to implement congestion pricing. On the Stevenson and Eisenhower there is still enough demand for congestion pricing after adding new lanes (CMAP 2016, interview).

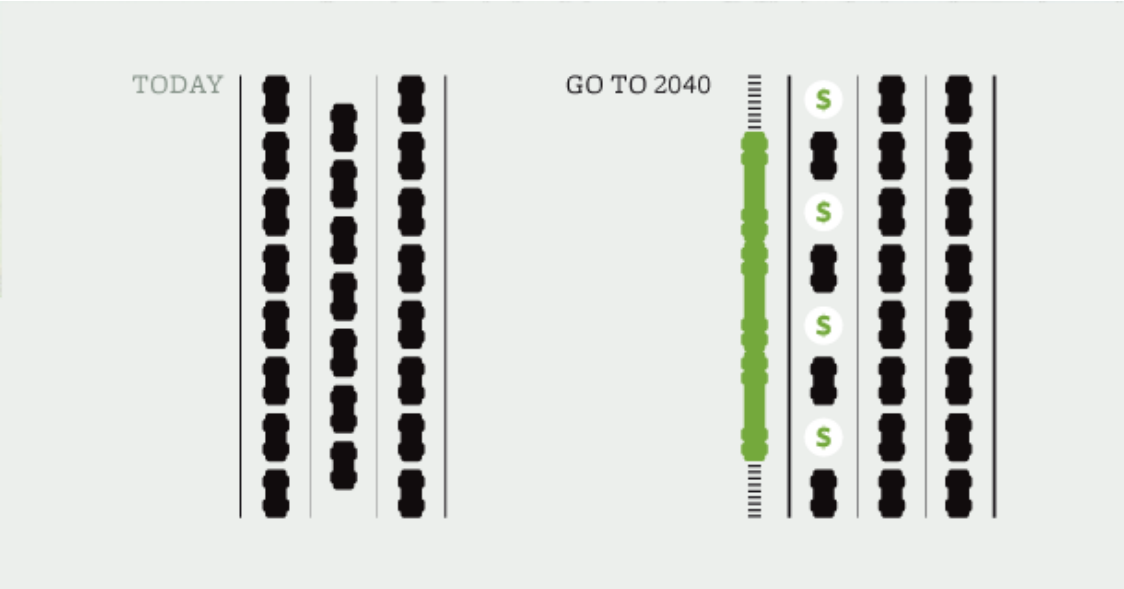


Fig. 1.4 The practical outcome of the congestion pricing system. (Chicago Metropolitan Agency for Planning , 2010)

In the new situation which the CMAP has proposed for 2040 the left lane will be a managed express lane. This means that the agency wants to set a dynamic price, so that traffic on the managed express lane will never be congested. Also, the CMAP is willing to invest more in public transport, which is shown by the green train, so more people will choose for this type of transport. With these actions congestion should be reduced.

Congestion pricing in other American cities

Chicago will not be the first city where congestion pricing will be implemented. Other cities where it already has been implemented include Los Angeles, Miami, Minneapolis and Seattle (Metropolitan Planning Council, 2010). Chicago can learn from how congestion pricing has been introduced in these cities, therefore this will be discussed in this thesis. As shown in figure 1.5 below Illinois is one of the states where congestion pricing is under study. Other states besides the just discussed cities where congestion pricing is implemented are Utah, Colorado, Texas, Georgia, Virginia and Maryland.

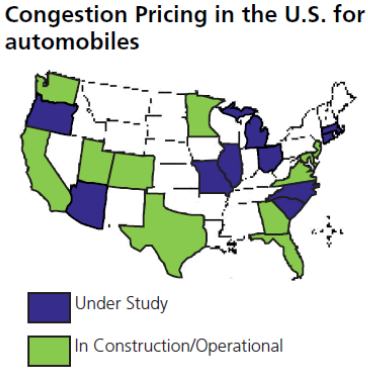


Fig. 1.5 Congestion pricing in the United States (Metropolitan Planning Council, 2010)

Research Design

Research problem

In the current situation users of the Illinois highway system are not paying the full cost of their use. Because investments in road building and adding lanes could not keep up with the population growth and land use patterns that have supported car use in the Chicago metropolitan area, congestion has become the biggest cost in the highway system. Gas taxes, vehicle registration fees, and tolls are used almost exclusively for activities like resurfacing and reconstruction, yet other costs remain unaccounted for. Decades of road building and adding lanes to existing facilities have not kept pace with population growth and land use patterns which continue to prioritize the automobile over other modes. More and more people live in low-density neighborhoods which are only accessible by car. Also, it is not clear in which way congestion pricing can best be implemented in the city of Chicago. The HOV, express lanes, zonal and cordon pricing schemes all have positive and negative impacts.

Research goal

The main objective of this thesis is to investigate whether congestion pricing is an adequate instrument to reduce congestion in the Chicago highway system. In order to see if it is an adequate instrument it is important to look at the pitfalls and experiences from other cities. It is also important to look at demographic and spatial economic characteristics and what their influence is when the best way to implement congestion pricing is chosen. Income segregation can play an important role just as the accessibility and use of public transport facilities. Furthermore, it is important to look at how congested the highways in Chicago are at the moment to see which roads are in the biggest need for congestion pricing and on which highways it can create the most benefits. The goal is to reduce congestion to a level where drivers can engage in other activities that, unlike sitting in traffic, prove to be productive to the regional economy.

Research question

What are the implications of congestion pricing in Chicago and what would be the best way to implement congestion pricing?

Subquestions

1. What is congestion pricing and in what different ways can it be implemented?

2. What are typical demographic and spatial economic characteristics for the Chicago Metropolitan Area and how should these be taken into account when congestion pricing is implemented?

3. How crowded are the highways on the Chicago highway system at the moment and which highways are at the moment in the biggest need for measures like congestion pricing?

4. What are, taken all factors into account, the implications of congestion pricing in Chicago?

Structure and methodology of the remainder of the thesis

Now that the topic of congestion pricing is introduced, the methodology and the remainder of the thesis will be explained. In the next chapter, key theories regarding congestion pricing will be discussed. This includes theories about congestion costs, value of time, land-use, the effects of road pricing and the effects of road investments. At the end of this chapter the conceptual model of this thesis will be presented. Then the methodology of the thesis follows in chapter 3. For the methodology interviews and a data analysis will be used. The data analysis focuses on the search for the most crowded highways around Chicago and the areas with the biggest need for congestion pricing in the Chicago Metropolitan Area. The interviews have been divided in two rounds. One of the main goals of the first round of interviews is to get to know the actual phase of the implementation of congestion pricing in Chicago. The second round of interviews is used to test hypotheses. These hypotheses have been stated with the use of the first round of interviews, the theoretical background and with chapter 4, the empirical framework. This empirical framework explains different forms and examples of implementing congestion pricing and the proposed way of implementing congestion pricing in Chicago. The hypotheses will be presented in chapter 5. In chapter 6, the way of analyzing the data for this thesis is explained, In chapter 7 the results of this thesis will be presented. These results include the results of the data analysis and the results of the hypotheses which have been tested with interviews. With these results the conclusions of thesis will be drawn in chapter 8. Finally, the discussion and recommendations for further research will be presented in chapter 9.

Chapter 2 Theoretical Background

Introduction to theoretical background

The theoretical background of this thesis starts with a short discussion about what congestion pricing actually is and what can be achieved by introducing congestion pricing. After this short discussion, theories about congestion costs and transportation costs will be discussed. Those theories are important to understand what congestion pricing is aiming at. The theoretical background is divided in six main sections: Congestion costs and why road pricing is needed, transportation costs and land use patterns, land use and congestion pricing, effects of road pricing, effects of road investments and income segregation and tolls. At the end of this chapter the conceptual model will be presented. The goal of this chapter is to provide the key theories on the topic of congestion and especially congestion pricing.

What is congestion pricing?

Over 50 years ago Willam Vickrey already made the proposition that the pricing practices in the sector of urban transportation are conducive, irrational and out of date. In almost all other sectors an attempt is made to differentiate prices for peak and off-peak services. For example, movie theatres are more expensive at night than during the afternoon (Vickrey, 1963). To manage the extra demand in rush hours congestion pricing has first been introduced in Singapore in the 1970s (Chatterjee, 2014). Congestion pricing is a way of internalizing the extra costs which each individual makes because of extra congestion they cause for others. The internalisation of these costs work through the concept of supply and demand (Chicago Metropolitan Agency for Planning, 2010).

So congestion pricing is a way to include a price for road users, which is now paid for one part by the government and for another part by less economic growth (Chicago Metropolitan Agency for Planning, 2010). Because the demand to use the road is higher during a rush hour, the price to use the road should be higher during the rush hour (Metropolitan Planning Council, 2010). Congestion pricing is in such a way different than other demand management policies in the way that it encourages drivers to adjust their behaviour in several aspects: By their number of trips, destination, mode of transport, time of day and route on the short term and sometimes in the long-run also decisions on where to live and work (De Palma & Lindsey, 2011). Congestion pricing is a concept that has been introduced in several forms in several countries.

Congestion costs and why road pricing is needed

Traffic congestion starts to threat economic prosperity and quality of life around the world (Nie & Yin, 2013). According to Goodwin (2004) congestion is defined as the impedance vehicles impose on each other, due to the speed-flow relationship, in conditions where the use of a transport system approaches its capacity. Goodwin (2004) states that when the traffic flow comes close to its carrying capacity any incident on the road has a disproportionate effect.

When congestion occurs it will cost time, and this time will cost money, so congestion costs are created. Most of the costs of traffic congestion are born by travelers collectively but, because individual travelers impose delays on others, they do not pay the full marginal social cost of their trips and therefore create a negative externality (De Palma & Lindsey, 2011). This is the concept of congestion costs. According to Vickrey (1963) rush hour use of the road is seriously underpriced even if the motorists pay the full price for the urban road facilities. Two types of congestion can be distinguished: recurrent and nonrecurrent (Sweet, 2011). The recurrent congestion will occur when the demand for the road exceeds the capacity, whereas nonrecurrent congestion happens due to random events as bad weather, or construction sites. One can say that for the nonrecurrent congestion the capacity of the road falls, so that the road becomes faster congested, in the same way as the recurrent congestion, only with a lower capacity. In figure 2.1 the speed flow curve explains the occurring congestion (lower speed) related to the amount of traffic.

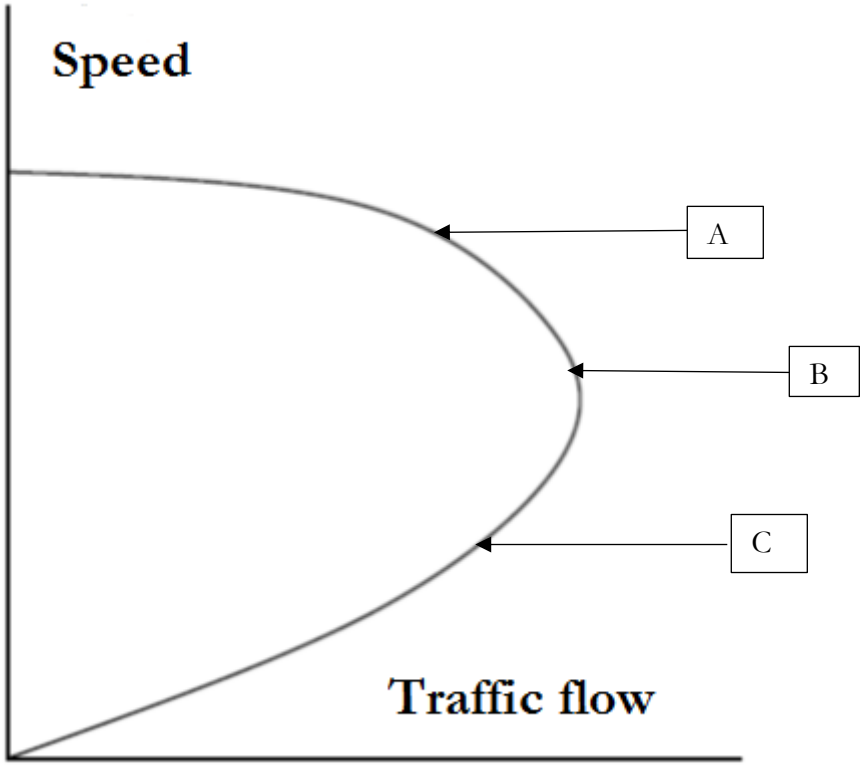


Fig. 2.1 The speed flow curve (Goodwin, 2004).

This curve starts at the top speed in the situation where there is no congestion. When there comes more traffic on the road the maximum capacity of the road is approached, which causes a slower speed. When the capacity is reached, at point B, every incident and problem has a disproportionate effect (Goodwin, 2004). After the maximum capacity is reached the congestion causes that less vehicles can pass this point per minute. Therefore the speed decreases as well as the amount of traffic that can pass this point, which is the situation at point C. This situation is also called hypercongestion (Arnott, 2013). The speed flow curve is about the congestion situation for all users of the road for a certain time on one particular place. The congestion situation can also be modeled for the costs of the congested situation and the individual choices regarding these costs. This situation is shown in figure 2.2.

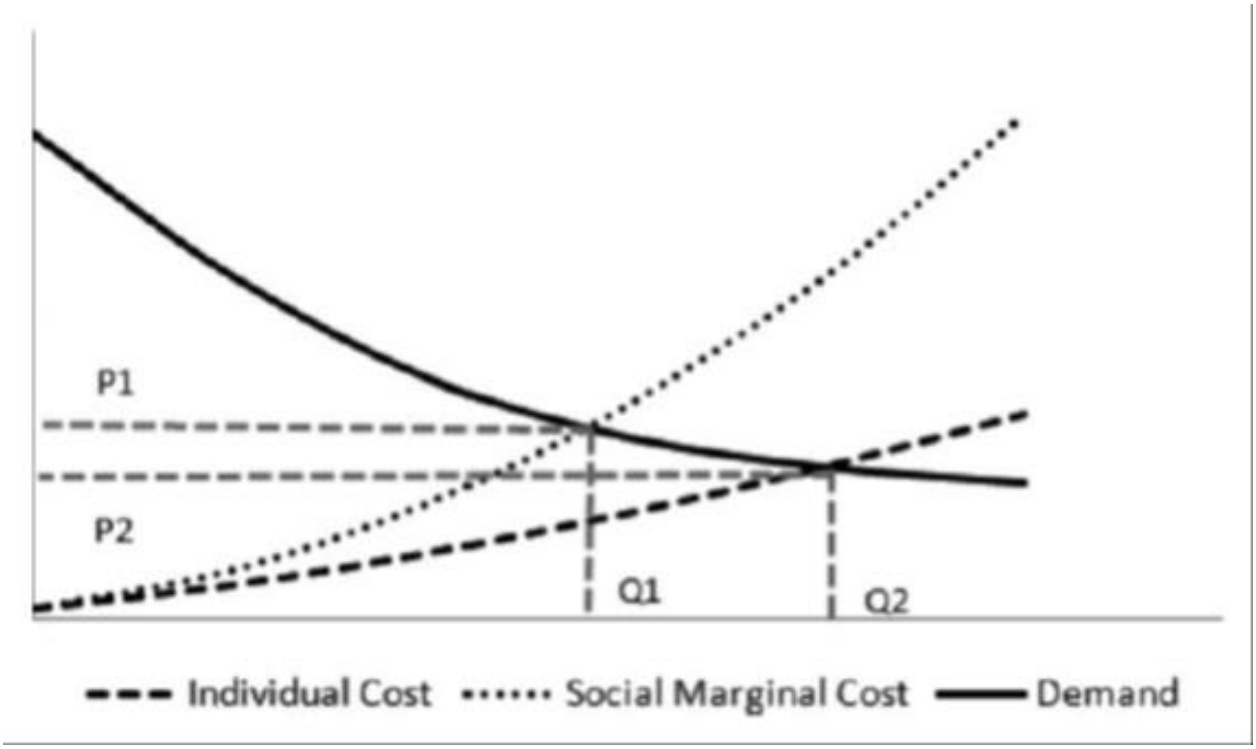


Fig. 2.2 Marginal and average travel costs in a congested situation (Sweet, 2011).

As shown in Figure 2.2, an individual travels until his own individual benefits meets his individual costs, which happens in the point Q2, P2. The individual costs of congestion will increase not as fast as the social marginal costs of congestion. This means that the individual still travels at the point where it is not beneficial for the society anymore. In point P1, Q1 the social marginal costs meet the demand, but the individual traveler will still drive in this situation, which means the part between Q1 and Q2 causes a loss for the society. This figure is close related to the tragedy of the commons, which will be explained in the next section.

Congestion costs and the tragedy of the commons

The concept of congestion costs is closely linked to the tragedy of the commons. The tragedy of the commons arises according to Ostrom (2008) when it is difficult and costly to exclude potential users from common-pool resources that yield finite flows of benefits. As a result of which those resources will be exhausted by rational, utility-maximizing individuals rather than conserved for the benefit of all. In the context of congestion costs the highway is the common-pool resource, which is free in the current situation. Although the highway has a finite capacity the individual is still better off using the highway, despite the fact that the marginal costs of this extra user are bigger than the marginal benefits.

Cole & Dodis (2012) have studied the tragedy of the commons in relation to congestion costs. They argue that there will be a high demand for uncongested roads, and this demand will fall for congested roads. There is an additional problem occurring because the less congested the road is the less users benefit, but the higher the quality of the road will be. According to Cole & Dolis (2012) only the last fraction of the population who use the highway make sure that the road becomes fully congested and thus that the overall net benefit decreases. When this last portion of users will shift to a different transport mode or a different time the net benefit will increase again. So using the highway has to become less attractive, by for example congestion pricing, to reduce the amount of congestion.

Effects of congestion costs on the economy

The economic costs of congestion exist because the mobility of travelers is decreasing because the accessibility of travelers also decreases (Sweet, 2011). Figure 2.3 helps to understand how congestion can damage the economy.

Figure 2.3 The calculation of the economic costs of congestion (Goodwin, 2004)

The figure above shows the economic costs of congestion. This method has been the most general method to calculate these costs in the last decades (Goodwin, 2004). The total congestion delays can be calculated by the time difference because of congestion, multiplied by the volume of traffic. To see how the total congestion delays causes economic costs, the value of time is important. This concept will be discussed in the following section.

In the economic literature there is a difference in first- and second order impacts on the economy (Sweet, 2011). The first-order impacts are those that derive immediately from travel outcomes, like travel delay, schedule delay and travel time unreliability. The first-order impacts are subject to the value of time of individuals and their abilities to adapt their travel behavior. The second-order impacts are concerned with a change in accessibility patterns, changing inter-urban competitiveness and changing household and business location decisions (Sweet, 2011). The second-order impacts are the long term effects of congestion, which deals with changing economic activities because of congestion.

The second-order impacts of congestion cannot be addressed in an easy way, this is because the congestion problem is not easy to solve. Downs (1992) divides the congestion that occurs because of the following four main factors: population and employment growth, higher rates of automobile use, relatively fixed and finite road supply, and underpriced travel costs. All those factors deal with political and socioeconomic processes which are complex problems. One of these complex problems is underpriced travel costs, for which congestion pricing might be a solution.

The value of time

Vickrey (1969) was already concerned with the value of time. The value of time can be different for different persons, but also for the same person at different times. Vickrey argues that when road pricing is introduced the trips with a low value of time will be excluded from the road, which will result in a lower amount of congestion. So the value of time is important to understand the ways congestion can be influenced when road pricing is introduced. A negative consequence of road pricing and the lower value of time trips being excluded, is that poor people are often the ones who will be excluded, because they have generally a lower value of time (Vickrey, 1969).

There are many different opinions among researchers of how to calculate the value of time, ranging from virtually nothing till factors higher than the regional wage rate (Rouwendal & Nijkamp, 2004). According to Rouwendal & Nijkamp (2004) the value of time is equal to the opportunity cost of the time spent to travel, which is almost always related to the wage rate. But it is still hard to calculate this opportunity costs because of a few factors. It is not clear which amount of travel delay results in lost productivity. An employee may decide to leave his house 15 minutes earlier because he knows there is a traffic jam which takes 15 more minutes to pass (Sweet, 2011). Also, when people are facing congestion during their leisure time there will be no effect on the productivity. There is certainly a value of time associated with traveling for recreational purposes but this does not contribute to the productivity. When there is an increase in congestion in a region it is therefore logical that people move closer to their work in the long term to make sure the travel time will be the same, because of their value of time (Sweet, 2011). The value of time may be different for different people and different times of the day, and according to Palma & Lindsey (2011) even for different trip durations and it would also be higher during congested travel conditions. Harris & Shaikh (2011) argue that because of income segregation there are different values of time for different neighborhoods. All these factors make it hard to determine the optimal toll price.

Differences in congestion costs

Dewees (1979) found that the literature on congestion costs misses empirical evidence of the right calculation of congestion costs. Dewees (1979) found that there are big differences in congestion costs or roads within the same areas. He also found that the congestion costs during the morning peak hours are very high compared to other times of the day. This might be because when commuters arrive late for their work this will have a negative impact on the productivity, because of less working hours. In the evening rush hour, commuters go back home, which is only at expense of leisure time, which has in general a lower value time, which means lower economic congestion costs.

Agglomeration effects and congestion

The essence of the agglomeration theory is that because of falling transaction costs due to physical proximity, the individuals or firms gain more positive externalities and a higher productivity (Fujita and Thisse 2002). But because of the higher productivity and so more economic activity and because the firms are located closer to each other which creates higher densities, the traffic congestion will increase (Graham, 2007). The impact of traffic congestion on the transportation network causes reduced marginal benefits of agglomeration, which can eventually lead to diminishing marginal economic growth in cities. The manufacturing firms were the first industry which witnessed the reduced marginal benefits of agglomeration due to

congestion (Graham, 2007). This industry relies heavily upon the input of raw materials which often have to be transported over long distances. Other industries, like the finance, insurance and real estate services are way less affected by traffic congestion (Graham, 2007).

This line of arguments suggests a toll price would help to regain the agglomeration benefits because the toll would reduce congestion. On the other hand, when a toll is introduced, this will affect the supply of labor (Vandyck & Rutherford, 2013). The toll will attract less workers in the region, they may decide to look for a job in another region. Also, a high tax on labor would lower the optimal toll price, because the lower demand due to the taxes has to be compensated. So there are both negative and positive externalities of congestion. The toll price which is equal to the congestion externality is called the Pigouvian toll (Vandyck & Rutherford, 2013). Overall, commuters may gain from a congestion toll, since it improves the allocation of workers over different regions (Vandyck & Rutherford, 2013). But it is important for policymakers to consider all the positive and negative externalities before implementing the toll.

Transportation costs and land use patterns

Another factor that has to be considered in the congestion theory, is the land use in relation to changing transportation costs because of congestion. Increasing levels of congestion result in lower accessibility, which has an effect on the land price or the land use (Sweet, 2011). This process can be understood by the use of bid-rent theory.

Bid-rent theories in relation to land use have first been developed by Von Thunen and have further been developed by Alonso (1964). According to the bid-rent theory competitors all have different needs for proximity to the city center, which creates different bid-rents for every industry. Since the proximity in the theory is measured by the ease of travel, congestion can have an effect on the travel costs and can therefore shift the bid-rent curve (Sweet, 2011). So the maximum bids can be changed because of the congestion, and therefore also the optimal land-use can change. In figure 2.4, the different bid-rent curves for different industries is shown. When the maximum bids change, there are other industries who offer the maximum bids, resulting in changed land uses (Sweet, 2011).

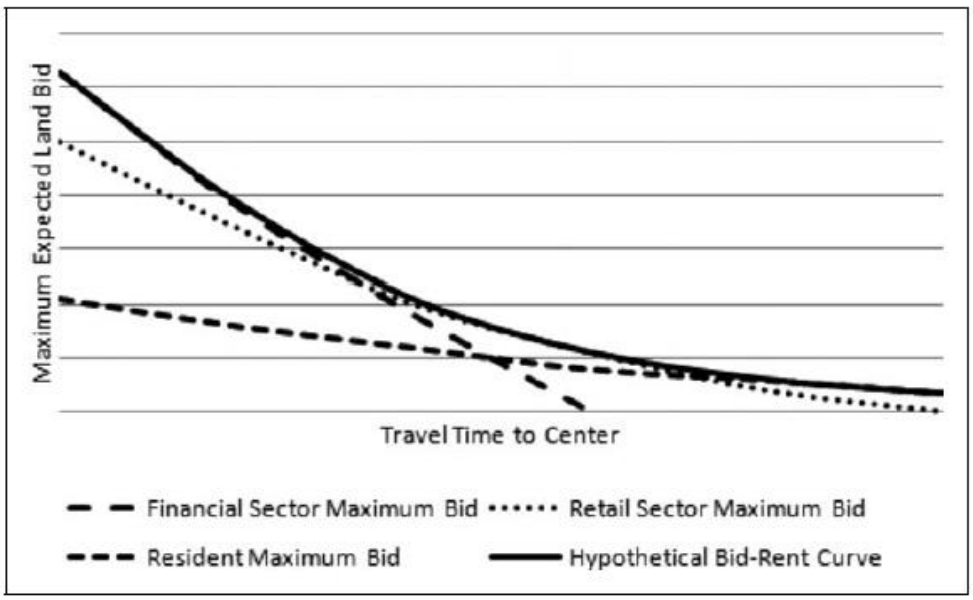


Fig. 2.4 The effect of transportation costs on the maximum bid for land use (Sweet, 2011)

Land use and congestion pricing

Congestion pricing can also have an effect on the travel costs. For one part, there will be a reduction in travel costs because of lower amounts of congestion. On the other hand the toll which is charged in a congestion pricing scheme means that the travel costs will be higher. Studies on this topic have found different results (Sweet, 2011). Some studies indicate that congestion pricing will create higher densities and others suggest more dispersed land uses. In this section these studies will be discussed.

Gubins & Verhoe (2014) argue that congestion forces commuters to leave their houses earlier in the morning to be in time for their job. This means people can spend less time in their houses than in a situation without congestion. Individuals who live in a larger house value their time in their house higher than individuals living in smaller houses, is their assumption. In a situation with more congestion people can spend less times in their houses so more people will choose to live in a smaller house. When road pricing is implemented, there will be less congestion, so people can stay longer in their houses. This means that road pricing has a positive influence on the land consumption of people (Gubins & Verhoe, 2014). Which means that the city territory grows. Similar effects happen when the travel speed limits in free-flow increases and when the bottleneck capacity expands. It is doubtful whether this line of argumentation has a big effect in real life, and so it is more realistic that the value of time spent in houses has only a minor correlation with the choice of the residence location for people.

Also Anas & Rhee (2007) argue that cities will be more dispersed because of congestion pricing. When some roads are tolled, people will try to find jobs located in other parts of the city located next to roads which are not tolled. Most of these locations are at the edge of the city. Since in most congestion pricing schemes only a few roads in a city are tolled. When people search for locations at the edge of a city, this means the city will get more dispersed (Anas & Rhee, 2007). Other studies have found that land-use will be more concentrated because of congestion pricing (Langer and Winston, 2008; Wheaton 1998; Brueckner, 2007). Langer and Winston (2008) have studied the marginal benefits of congestion pricing in ninety metropolitan areas in the USA, by using a structural model of housing prices, spatial distribution, commuting times and congestion.

According to Langer and Winston (2008) congestion pricing causes higher travel costs, which means that new developments will be created closer to the city center in order to reduce the transportation costs. The results of these developments are shown in figure 2.5. They also found that with congestion pricing affordable rents for poorer people would decrease and that poorer and richer people would live closer together and that overall welfare will increase. Wheaton (1998) concludes that higher densities due to congestion pricing create a higher welfare. He questions whether jobs should be concentrated in one center and argues that it would be better to have jobs in polycentric city structures.

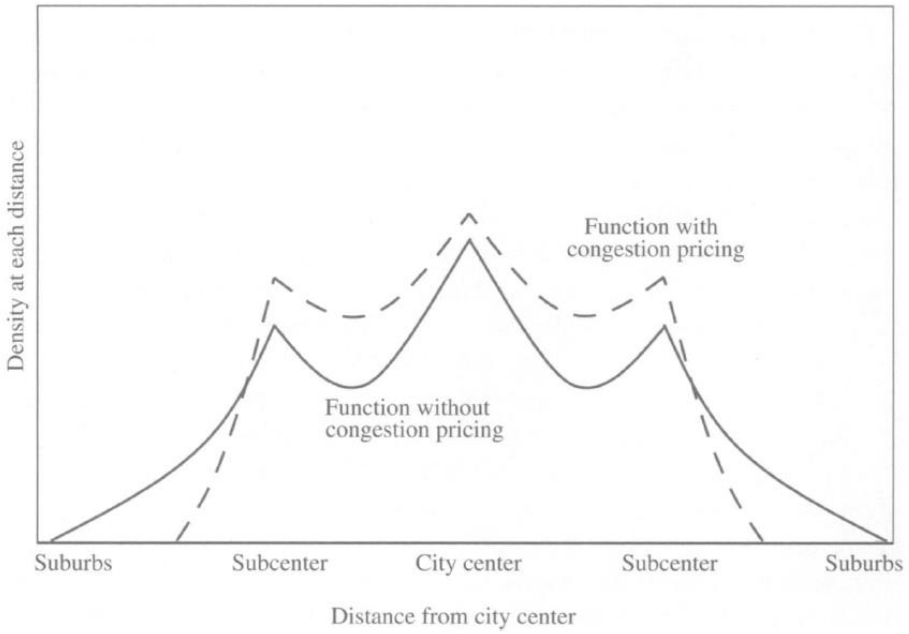


Fig. 2.5 The relationship between density and the distance to the city center (Langer and Winston, 2008)

In figure 2.5 the relationship between land-use and congestion pricing is shown according to Langer and Winston (2008). The choice for the distance between people's jobs and houses has been a free choice during the last decades in America, which implied that many people started to move to the suburbs. So, policies in America indirectly encouraged a more dispersed land-use. According to the MPC (2016, interview) congestion pricing is the first real instrument in America to let people pay more who live further away from their job, which can lead to a more dense land-use. So, congestion pricing can be seen as an instrument to get more control on land-use in American cities, which may be helpful in trying to limit the dispersed land-use of American cities.

Effects of road pricing

Setting the optimal toll

Vickrey (1969) already advocates for road pricing, because it is a good way to make the transportation system more efficient. It provides an optimal adjustment in the short run, but is also important for long term effects. The literature on road pricing has shown that the marginal external social cost of an additional vehicle, the gap between Q1 and Q2 in figure 2.2 can be calculated in such a way that an optimal toll is created. By doing so a Pareto improvement in the efficiency of road using can be achieved (Dewees, 1979). Creating an optimal toll is relatively simple when there is only one route option, but tolling one road also has indirect effects on other routes (Vickrey, 1969). These other routes may become more attractive, so that traffic will use these roads instead, which means the original way of calculating the optimal toll is not possible anymore. Nie & Yu (2013) also argue that it is difficult to set an optimal toll in a realistic setting, but the toll price also only benefits the ones who value the decrease of congestion higher than the toll which needs to be paid.

Reducing traffic and congestion

According to Arnott (2013) congestion can come to a point where the traffic flow starts to fall, which means that congestion costs start to become even higher, like the situation in figure 2.1. This also means that congestion pricing policies have a bigger effect in such a situation. Therefore time-varying congestion pricing can work well to deal with congestion, especially in the downtown area. He also argues that a cordon pricing scheme would be a good way to prevent downtown traffic jams. Harris & Shaikh (2011) state that congestion taxes increase the cost of driving relative to the cost of public transit. So an important effect of congestion pricing is that it not only discourages people to drive, but it also encourages them to use a different kind of transport mode, which is most of the times, public transport. By dynamic toll prices congestion pricing discourages driving especially at the times where the density of other drivers is the greatest. Also the demand of traffic changes even more due to dynamic prices (De Palma & Lindsey, 2011). Because of higher prices during rush hours more people will want to avoid these times. On the other hand, there might be an effect that because of these higher prices the congestion reduces, which attracts people to start driving during rush hour, because the travel times will be lower than in the situation without congestion pricing.

Changing accessibility

Gutierrez et al. (2011) argue that a road pricing policy has an effect on accessibility in several ways. First of all, when road pricing is introduced, the travel costs will become higher, which leads to a reduced accessibility. On the other hand, road pricing will decrease congestion, which will lead to less travel times and a higher accessibility (Gutierrez et al, 2011). So, congestion pricing has different effects on accessibility. These effects can be different for different type of actors, like firms and households, but can also be different for high and low incomes. As accessibility influences mobility, road pricing can also affect mobility in the short, medium and long run. Short term effects include for example changes in department time and route selection. Whereas in the medium and long run people may change their shopping location or might even get a different job or change their house location (Gutierrez et al, 2011). Another effect of road pricing in this context is that pollution will be reduced when the public health impact is the greatest (Harris & Shaikh, 2011). This is because during rush hour there are more pedestrians on the street, when the amount of cars will decrease the most at this time of the day, it will boost the public health the most, since all pedestrians will inhale less emissions.

Complications of road pricing

According to De Palma & Lindsey (2011) the theory of congestion pricing suggests that congestion tolls should be differentiated by vehicle type, road link, time of day, real-time traffic conditions, trip purpose, and local conditions such as pricing of public transit services or other transport modes. But in practice, it is not possible to let the toll vary for all these different factors. One thing is that it is hard because of political acceptability reasons. According to De Borger & Proost (2012) an optimal form of implementing congestion pricing is different in political economy. They also showed that congestion pricing is most of the times perceived more positive after implementation than in the ex-ante situation. The economic literature also suggests that all drivers have all information needed to make the optimal choice in their driving behavior, but this is not the case (De Palma & Lindsey, 2011). So all the factors have to be taken into account, otherwise congestion pricing may perform badly, but it is impossible to set different tolls for all these different factors.

Effects of road investments

Since congestion pricing in Chicago is part of new road investments it is also important to discuss this topic. The effects of new road investments are different for different types of investments. In the United States, especially the Interstate Highways have contributed to marginal increases in economic growth and in productivity (Fernald, 1999; Sweet, 2011). These massive investments of the interstate highways have improved the regional accessibility and mobility. Newer investments in the infrastructure of the United States especially reshaped the economic geographies of regions and created net benefits only for local areas. Especially industries which are sensitive to transport investments and traffic congestion benefit from new investments (Fernald, 1999). These industries are vehicle-intensive industries, like for example manufacturing firms.

Road widening doesn't work

In Chicago, the way to implement congestion pricing takes place by using a new lane on an existing highway. On this new lane congestion pricing is implemented as a managed express lane. Road widening projects between 1993 and 2008 in the United States have been evaluated by the Texas Transportation Institute. The conclusion was that road widening doesn't help to reduce traffic congestion in the long term. According to the Metropolitan Planning Council (2008) road widening first has a decreasing effect on congestion. But after some time the demand for this road will grow, because of less congestion and shorter travel times. So after ten years the road is as congested again as it would be without building a new lane. This is shown in figure 2.6.

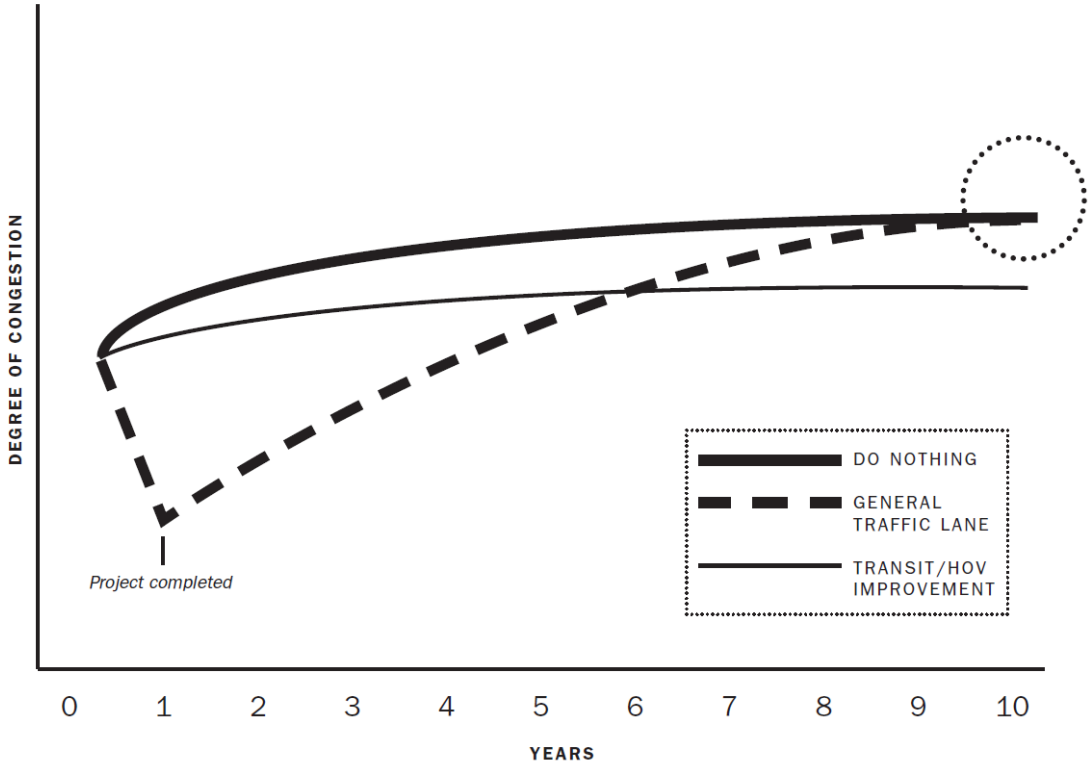


Fig. 2.6 The effect of road widening on highways (Metropolitan Planning Council, 2008).

Another point which the figure presents is that improvements in HOV lanes or in transit will have a long term effect, in such a way that because of these investments the amount of congestion decreases relatively to doing nothing and adding an extra traffic lane.

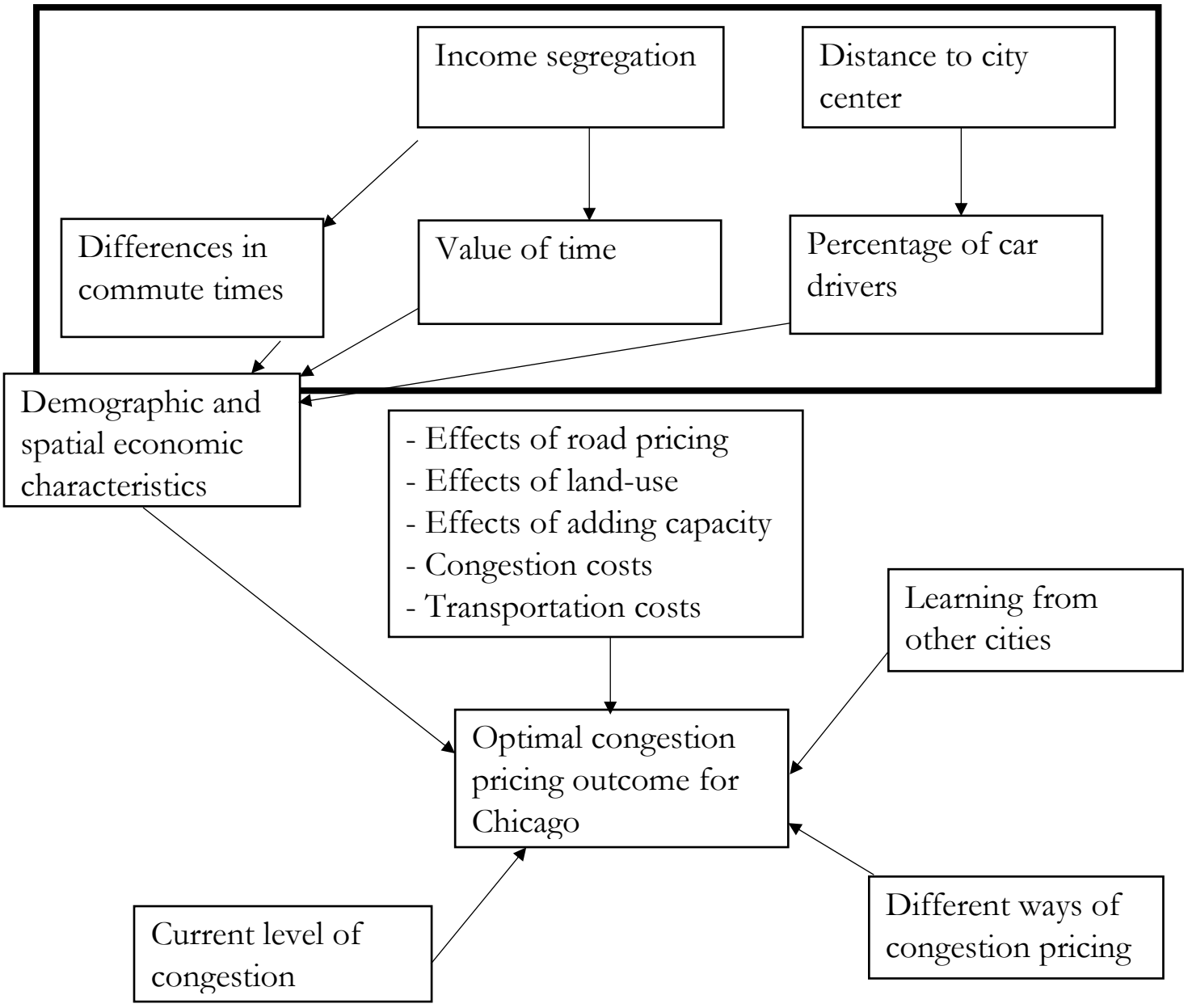
Income segregation and tolls

In most cities in the United States people are segregated by income (Harris & Shaikh, 2011). This segregation takes place between the center and suburbs and between different areas of the city. This income segregation means that low-income people drive most of the times on the same roads as other low-income people, who often have a lower value of time than richer people. Since the value of time is part of the congestion externality the optimal toll price will be different for roads in low-income areas than for roads in high-income areas. So when the toll prices for these two neighborhoods are the same the roads where more low-incomes drive will be overpriced and the roads where richer people drive will be underpriced and this leads to inefficient outcomes. Low-income people in general make more use of public transport, because the live in the city center where more public transport is provided (Vandyck & Rutherford, 2013). So subsidies for public transport and subsidies for travel by car will benefit people from different income classes.

Conceptual model

The conceptual model of this thesis is presented on the next page. In this conceptual model the most important factors that influence the optimal outcome of congestion pricing are linked to each other. On the top of the page factors that form demographic and spatial characteristics are described. One of the key processes in this context is the income segregation. This income segregation influences different factors like the value of time for each neighbourhood and differences in commute times. The value of time is influenced by the average wage rate. The distance to the city center influences the percentage of car drivers. These three factors are the demographic and spatial characteristics that influence the optimal congestion pricing outcome. Just below this box the main effects of the theoretical background are presented. These general effects all influence the outcome of congestion pricing. The current level of congestion is another process that influences the optimal congestion pricing outcome, since the current level of congestion is important on the highways in Chicago is important in deciding on which highway congestion pricing should be implemented. Finally, processes like the ideas that are adapted from other congestion pricing projects in different cities and the different ways in which congestion pricing can be implemented influence the optimal congestion pricing outcome for Chicago.

Conceptual model



Chapter 3 Methodology

Introduction

In this chapter the forms of data collection which are used in this thesis will be discussed. These forms of data collection will first be justified and then explained. Two different kinds of data collection have been used in this thesis. The first is interviews and the other is a quantitative data analysis. Both of these data collection methods will be described in this chapter.

Justifying of methodology methods

In this section the relevance of the data collection methods for answering the research questions will be explained. For this thesis structured interviews, interviews with hypotheses and a quantitative data analysis have been conducted. This data analysis focuses on the search for the most crowded highways around Chicago and the areas with the biggest need for congestion pricing in the Chicago Metropolitan Area. This will be explained in the last section of this methodology. Structured interview consists of relatively strict interview guides and a strict sequencing of questions (Hopf, 2004). Hypotheses are used in scientific research for three reasons (Meinefeld, 2004):
- It reveals and controls the prior knowledge on the topic of the researcher.
- It provides a link between the available knowledge on the topic and the contribution that the research makes to this topic.
- It structures the research in such a way that the theoretical framework has to be presented before the hypotheses.

The hypotheses are especially useful, since they are structuring the thesis in a logical way. The quantitative data analysis is used in this thesis to visualize the congestion situation and the need for congestion pricing in different areas of Chicago. The use of both quantitative data and qualitative data will eventually lead to the answer of the main research question and the goal of the combination of these two approaches is to have stronger arguments for answering the main research question, since these approaches are complementary.

The research questions have been presented in chapter 1. The first research question is answered with the use of relevant scientific literature. In the theoretical background is explained what congestion pricing is and in the empirical chapter the different forms of congestion pricing will be explained. The second research question is discussed in the empirical chapter and in the data analysis part of this thesis. In the empirical chapter these factors will be explained in the section about demographic and spatial economic factors. The factors that have eventually been used in the data analysis have been discussed in chapter 6, the data analysis. The third research question is answered in chapter 6, the data analysis and in chapter 7 results. For this question congestion data has been used, which will be explained in the section data analysis. The results of this data analysis are presented in chapter 7. The last research question will be answered with the use of the hypotheses which will be presented in chapter 5. The results of these hypotheses will be discussed in chapter 7. Finally, the main research question will be answered in chapter 8, the conclusions.

Interviews

For the methodology of this thesis interviews with experts on the topic of congestion pricing have been conducted. For one part policymakers have been interviewed, like people working for the Chicago Metropolitan Agency (CMAP) and Metropolitan Planning Council (MPC). For another part interviews have been conducted with researchers from different universities. First of all, an interview with CMAP has been done in order to see if the Go To 2040 report was still up to date. This interview was very useful for several reasons. First of all, more information was provided about the phase of the congestion pricing project in Chicago. In the Go To 2040 plan there were no specific highways researched where congestion pricing would be implemented. After the interview it was clear that the main proposal for congestion pricing would be on the Stevenson Expressway. There were also some other important findings from the interview, like the context of infrastructure projects in the USA, the adaptation of other congestion pricing projects in the USA and also other experts on the topic of congestion pricing were mentioned. Three other structured interviews with experts on topics which are relevant for the context of Chicago in regard of congestion pricing have been conducted. This first round of interviews has been used in chapter 4, the empirical analysis. When the theoretical background and empirical chapter were completed, hypotheses have been stated based on these chapters. These hypotheses have been tested by interviewing six other experts on the topic of congestion pricing. The hypotheses will be discussed in chapter 5 and the results of these hypotheses will be presented in chapter 7.

Ethical issues for interviews

Because of the large distances of travel in the USA, not all interviews could be in person interviews. Also some interviewees preferred a telephone interview. Some interviewees thought it was naturally to have a telephone or skype interview instead of an in person interview. For all interviews attempts have been made to arrange an in person interview, but this was not always possible because of the distances or busy schedules. Interviewees lived for example in Kansas and New York. In total, four out of 10 interviews were telephone or skype interviews. The recording quality of one telephone interview was not good enough to include in the thesis.

According to Bloom & Craptree (2006) there are four ethical issues regarding interviews:
- Reduce the risk of unanticipated harm
- Protecting the interviewees information
- To inform the interviewee about the nature of the study
- To reduce the risk of exploitation

These four ethical issues have been taken into account by asking everybody if it was permitted to record the interviews and to use the results of the interviews in this thesis. The results of these interviews have not been used in another relevant way than in this thesis.

Data Analysis

In this thesis a quantitative data analysis has been executed with the use of SPSS and GIS. Two different datasets have been used, which will be explained in more detail in chapter 6. The reason why this data analysis is used is to visualize the congestion situation in Chicago and the need for congestion pricing. The article of Harris & Shaikh (2011) is interesting for this data analysis, since this articles uses a similar approach and similar data. Both of these persons have for this reason also be interviewed to get more insight in their approach. Especially Harris (2016, interview) has provided information on how to work on the analysis of demographical and spatial economic characteristics in the context of congestion pricing.

Chapter 4 Empirical Findings

Introduction

In this empirical chapter practical issues regarding congestion pricing will be discussed. These practical issues include different forms of congestion pricing, experiences from other cities and the plans of implementing congestion pricing in Chicago. The goal of this empirical framework is to make clear how congestion pricing can be implemented, what Chicago can learn from these past experiences and how it adopted these experiences in its own plans. Also spatial economic and demographic characteristics which are relevant for Chicago will be discussed.

Different forms of congestion pricing

As discussed in the introduction there are three main ways of implementing congestion pricing and there is a method to set different prices for different times, the degree of time differentiation. These are facility-based schemes, cordon pricing and zonal pricing. For all these three different forms of congestion pricing, degree of time differentiation can be used.

Facility-based schemes

The option which the Chicago Metropolitan Agency for Planning has proposed is a form of a facility-based scheme, named managed express lanes. There are three main different forms to implement facility-based schemes: HOT lanes (High-Occupancy Toll lanes), HOV lanes (High-Occupancy Vehicle lanes) and schemes where all drivers have to pay. They will all be discussed. There is a difference between the HOT lanes of Minneapolis and California and Chicago, which is that in the current studies for Chicago high-occupancy vehicles also have to pay for using the express lane (CMAP, 2012; Skosey & Zucchero, 2010; CMAP 2016, interview; MPC 2016, interview).

Managed express lanes where everyone needs to pay

As discussed, managed lanes can be implemented by charging a fee on one particular lane (De Palma & Lindsey, 2011). This kind of facility is being implemented in Atlanta (Georgia Department of Transportation, 2013). In the managed lane all cars are allowed, except for trucks sometimes (CMAP, 2012). The high-occupancy vehicles (HOVs) have to pay the same price as the single-occupancy vehicles (SOVs). Most of the times such lanes are implemented when there was no HOV lane already on the particular road (MPC 2016, interview).

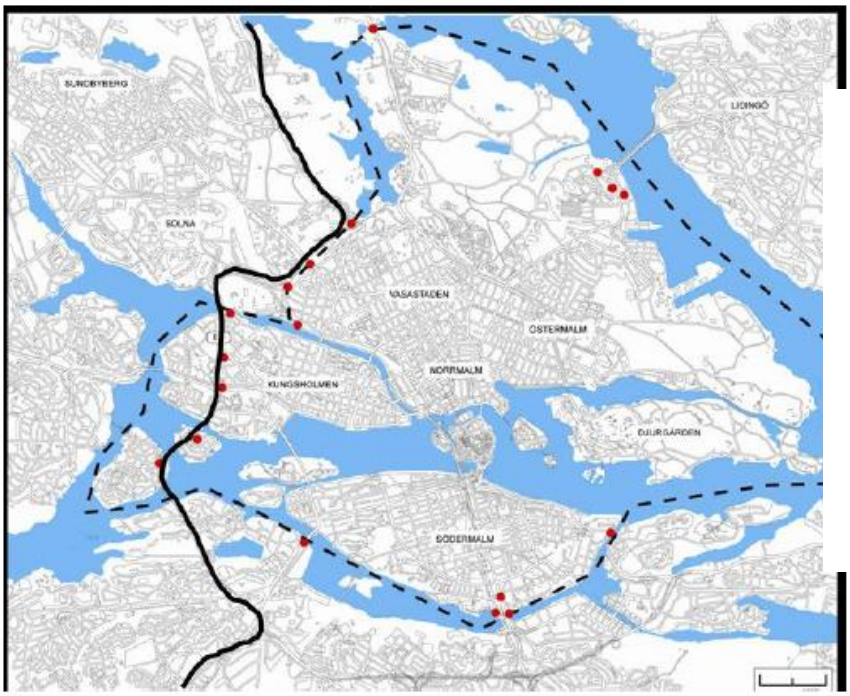
HOT and HOV lanes

In an HOT lane all vehicles can use the facility, but the HOVs can use the facility for free, whereas SOVs have to pay a toll (De Palma & Lindsey, 2011). In this HOT lane model a premium price is charged to use one particular lane. Most of the cities work with a system that High Occupancy Vehicles can use the lanes for free. It depends on how much people there are in the car if the vehicle can use the express lane. The system in which the HOT lane works is different for different cities. For example in California on the SR-91 there should be at least 3 people in one car to use the HOT lane for free, in Minneapolis on the I-394 the amount of people is 2. Single person cars can also use the express lanes but they have to pay a fee in order to use the lane. The other lanes can still be used free of charge (Ecola & Light, 2009). In some cases an existing lane will be transformed into a HOT lane, in other cases an additional HOT lane is

added next to the existing highway. What has happened a lot in the United States is that existing HOV lanes have been transformed into HOT lanes (US Department of Transportation, 2015; Federal Highway Administration 2, 2008). The difference between a HOV lane and a HOT lane is that in a HOT lane SOVs can use the lane by paying a premium, whereas in an HOV lane SOVs are simply not allowed.

Cordons

Another option which has been introduced in Stockholm and Singapore is the concept of cordon pricing (De Palma & Lindsey, 2011). As discussed in the introduction, in this congestion pricing method there are control points and drivers have to pay a dynamic toll price when they cross the control point.



6:30-7:00	10 SEK
7:00-7:30	15 SEK
7:30-8:30	20 SEK
8:30-9:00	15 SEK
9:00-15:30	10 SEK
15:30-16:00	15 SEK
16:00-17:30	20 SEK
17:30-18:00	15 SEK
18:00-18:30	10 SEK

Fig 3.1 The cordon area in Stockholm and on the right side the dynamic toll prices on different times (Eliasson, 2008).

In the case of Stockholm, only a little amount of the revenues of the cordon system was spent directly on the improvement of the road system or even the public transport system, which meant that the majority of the Stockholm citizens was feeling a loser in this system (Eliasson, 2008). Also, the majority didn't think the time which can be won by the system was worth the price. On the other hand, after a while about 35 percent changed their minds about the project and became more positive towards it. Also, further research found that cordon pricing experienced to be a social surplus and that the investments will be recovered in about 4 years (Eliasson, (2009). According to Shaikh (2016, interview) cordon pricing has been successful in London and Stockholm.

Zonal schemes

In a zonal congestion pricing scheme a driver has to pay a fee for driving in a particular zone. So the difference with the cordon pricing system is that in a zone scheme a driver doesn´t necessarily have to cross a boundary to pay the tax. These zones can be defined by natural boundaries such as mountains and rivers or by infrastructural elements, like roads, bridges and tunnels (De Palma & Lindsey, 2011). Another main difference between a cordon pricing system and a zone scheme is the fact that in a zone scheme travelers have to pay for an entry permit, this can be for one day for example, whereas in cordon pricing system travelers pay per crossing (Maruyama & Sumalee, 2007). In London a zone system has been introduced in 2003 (De Palma & Lindsey, 2011). Some critics in London argue that road pricing is double charging, and for that reason unfair, since motorists also have to pay registration and fuel taxes (Litman, 2006). Also, it would be unfair to low-income groups who have to travel to central London by car. The winners and losers of the system in London have been listed by Litman (2006).

Winners	Losers
• Downtown bus riders. • All transit riders (due to increased funding for improvements). • Taxi riders and drivers. • Motorists with high-value trips. • Most city center businesses. • Overall city productivity. • Pedestrians and cyclists.	• Motorists with marginal-value trips. • City center businesses that depend on low-cost weekday car access. • Residents and motorists in border areas who experience spillover impacts. • City center parking revenue recipients.

Fig. 3.2 Winners and losers of the zone scheme system in London (Litman, 2006).

Another group of losers are the residents who live close to the entrance of the zone for two reasons. One reason is that they have to pay to get to the city center, and another reason is that citizens might park their car in these neighborhoods, since they think it is too expensive to travel into the center by car. From this point they can continue with another transport mode. Besides the losers there are also a lot of winners, who are listed in the table above.

Degree of time differentiation

Tolls can vary in price during the day, as in the case of Stockholm, see figure 3.1. Flat tolls are constant over time, an example of this case is London, where the same price is charged on weekdays and is free of charge during the weekend (De Palma & Lindsey, 2011). There is also a form of adjusting pricing, this is only used for some facility-based schemes. In this system the price for a managed lane increases when there is more congestion on the road. Since the degree of time differentiation is not a system on its own and it can be applied in all other three methods, it is a different method than the other three, though not less important.

Congestion pricing in other American cities

Introduction

As discussed in the introduction, congestion pricing has been implemented in several American cities. In this part the outcomes of a few congestion pricing projects will be evaluated. Especially the congestion pricing projects in California and Minnesota will be studied. These projects will be studied in more detail, because they are influential projects. The SR-91 project in California was the first congestion pricing project in the United States (Sullivan, 2000). The project in Minneapolis on the I-394 is the most similar to the proposed project in Chicago (CMAP 2016, interview). In the last decades several states have implemented congestion pricing, as discussed in the introduction.

Most of the congestion pricing projects in the United States are HOV lanes which have been transformed into HOT lanes (US Department of transportation, 2015). As can be seen in the figure below, projects in Atlanta, Los Angeles, Miami and Minneapolis have used this approach.

Atlanta	Los Angeles	Miami	Minneapolis	San Francisco	Seattle
Oct. 2011	I-110 in Nov. 2012; I-10 in Feb. 2013; Express Park in May 2012.	Dec. 2008 northbound; Jan. 2010 southbound.	Phase 1 in Sept. 2009; Phase 2 in Nov. 2010.	Sept. 2011	Dec. 2011
Tolling					
HOV to HOT lane conversion on I-85 (Express Lanes).	HOV to HOT lane conversion on I-10 and I-110 (ExpressLanes). A second HOT lane was added on I-10. Also, demand-based parking pricing (LA Express Park™).	HOV to HOT lane conversion on I-95 (95 Express). Also added a second HOT lane in each direction.	HOV to HOT lane conversion and addition of new HOT lanes on I-35 W (MnPass). Also added priced dynamic shoulder lane.	Demand-based pricing of city-owned on-street and off-street parking spaces in 7 pilot areas (SF*park*).	Variable tolling on SR 520 Bridge.
Increased HOV requirement from 2+ to 3+.	Maintained existing HOV requirements, 2+ on I-110 and 3+ during peak periods on I-10.	Increased vehicle occupancy requirement from 2+ to 3+.	Maintained 2+ carpool occupancy requirement.		Registered vanpools and buses ride for free.
Carpools required to register and use toll tag.	Carpools required to register and use switchable transponder.	3+ carpools required to register and display special decal but no transponder.	Carpools do not need to register or use transponder.		Registered vanpools and buses required to use transponder.

Fig. 3.3 Implementation of congestion pricing in six different US cities. US Department of transportation (2015)

The other two cities, San Francisco and Seattle have used different kinds of congestion pricing. San Francisco has implemented a form of congestion priced parking and Seattle used variable toll prices for the entire road SR 520 bridge (US department of transportation, 2015). In four of these six cities where congestion pricing was implemented as a converted HOV lane, Atlanta was the only city where it was implemented on an existing lane. Prices for managed lanes differ throughout the country, and there is also a big variation on individual lanes throughout the day as is shown in figure 3.4. The expected average toll rate for Chicago will be between 0,15 and 0,30 cents per mile.

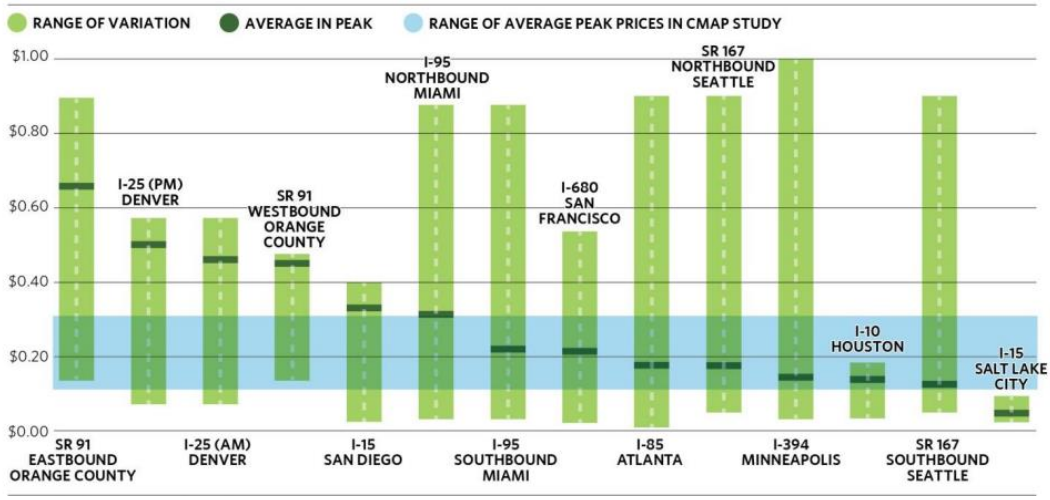


Fig. 3.4. Prices in US dollars for different US managed lanes (CMAP, 2012)

Congestion pricing in Minnesota

Project description

In Minneapolis a HOT lane facility has been opened on the I-394 highway. This highway runs from the western suburbs of Minneapolis to the city center. This is also shown in figure 3.5. In first instance it was difficult for the project to get public support, which was the reason the proposal was first turned down in 1997 (Munnich & Loveland, 2005). Eventually with clearer communication strategies and the help of key stakeholders the project could go on. The HOT lane facility was originally a HOV lane, but was transformed into an HOT lane. Whereas carpools, motorcycles and buses benefited from the HOV lanes, SOV drivers complained about the underutilization of the HOV lanes. The Minnesota Department of Transportation concluded that HOT lanes would be the best solution, since carpools, motorcycles and buses can still use the road, and SOV vehicles can use the toll lanes (Janson & Levinson, 2014).

After congestion pricing was implemented on the MN-394 it was also implemented on the I-35 (Munnich, 2008; US Department of transportation, 2015). Munnich (2008) suggests that in the future it should also be possible to toll existing capacity on the highways in Minneapolis. He praises the methods of London and Stockholm because congestion was reduced dramatically in both cities, but doubts whether it is possible to implement it in the United States, since there is a lot of resistance against tolling existing capacity instead of adding new lanes (Munnich, 2008; CMAP 2016, interview).

Fig. 3.5. Congestion pricing in Minneapolis at the I-394 and the I-35 (Federal Highway Administration, 2010).

Positive and negative outcomes

The Institute of Public Affairs (2016) had proposed four goals for congestion pricing on the I-394. To improve the efficiency of the road, to maintain free-flow speeds in the managed lane, to use the revenues for improvements on the highway and transit corridor and to employ new technologies for pricing. The first three goals have been reached and the last is still being studied. More than 60 percent of the Metropolitan area supports the toll lanes and over 90 percent of the users support the extra lanes (Metropolitan Planning Council, 2010). Cao & Munnich (2012) have found that in Minneapolis congestion pricing has reduced travel times and is economically justified. Another benefit is that the highway has become safer in the 10 years after HOT lanes have been implemented. In Minneapolis the travel time savings were not considered the most important sources for the benefits, since Minneapolis is not one of the most congested in the USA (Cao & Munnich, 2012). In this case, safety benefits were eventually the biggest benefit for the congestion pricing system. Still, travel times have decreased, since even in the non-tolled lanes there was an increase in speed of about 6 percent (Metropolitan Planning Council, 2010). Janson & Levinson (2014) found that when prices are raised in this flexible tolling scheme, demand grows on the I-35 and I-394, which means drivers sometimes pay between 60 dollars and 120 dollars per hour. These prices are significantly higher than the average value of time. Minneapolis also has the highest peak prices for the use of managed lanes in the United States, which can be as high as one dollar per mile (CMAP, 2012). According to Janson & Levinson (2014) people not only pay for time savings, but also for factors as reliability and they expect time savings to be bigger when the prices are higher.

Lessons for Chicago

According to Munnich (2013) the following lessons have been learned from congestion pricing in Minnesota:

- Political leadership is necessary
- Public will support projects if they can see benefits
- Pricing projects must work from day one
- Effective outreach, education and marketing are critical for success
- Pricing projects are more likely to generate support if linked to transit improvements

These lessons are especially linked to the political support which is necessary to implement congestion pricing. Another aspect is the similarity between the implementation of congestion pricing in Minneapolis and Chicago. In Minneapolis a managed lane has been implemented on the shoulder lane of the highway US Department of Transportation (2010). This is also the proposal for implementing congestion pricing in Chicago (CMAP 2016, interview). According to the CMAP (2016, interview) the proposed project in Chicago can best be compared with the project in Minneapolis since in both projects shoulder lanes are converted to managed lanes. In both projects the left shoulder is/will be used to convert to a managed lane as shown in figure 3.6.

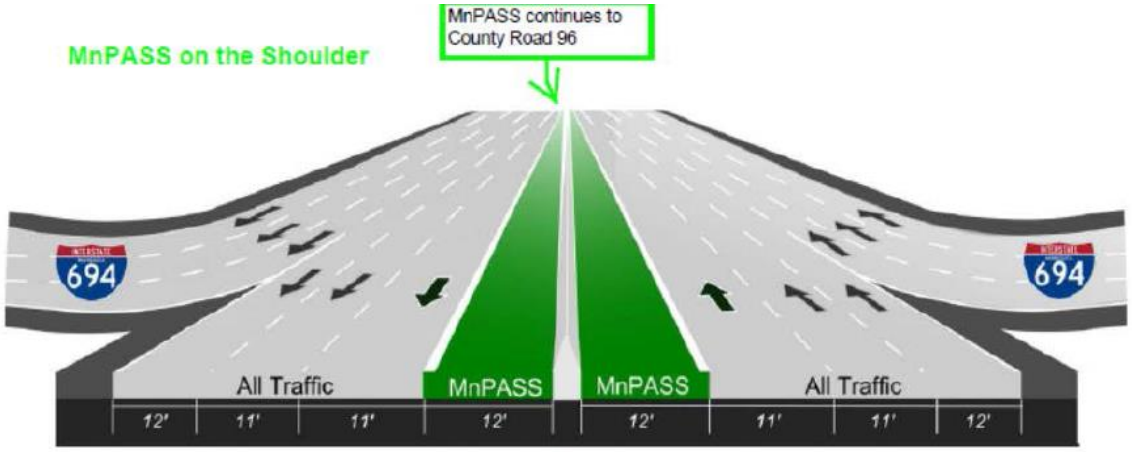


Fig. 3.6. Implementing congestion pricing on shoulder lanes in Minneapolis (Douma, 2015)

In the peak periods drivers can use these inside shoulders on the I-35 in Minneapolis when they pay the toll, outside peak hours they will be closed, so the lane can be used for enforcements. Some critics think it is not a good idea because of safety reasons during an accident, or because it is not possible to enforce violators of the toll lane to stop on the left shoulder (Douma, 2015). Now police officers have to let them stop on the right shoulder during rush hours. But in general the shoulder option has been positively perceived and is now researched as an option to implement on the I-35 east (Douma, 2015). Also because the safety benefits were the biggest in the Minneapolis case, it can be said that implementing congestion pricing on shoulder lanes has no safety disadvantages.

Congestion pricing in California

Project description

The SR 91 is a state highway in California, with two toll lanes in each direction and four general purpose lanes (Sullivan & Burris, 2006). There are no intermediate exits or entrances. Also on this road, the toll levels are dynamic in order to manage the demand for the road. The facility was opened in 1995, and just before opening the highway usually had a delay of 20-40 minutes during the rush hour. Because of the added toll lanes the delay on the free lanes also decreased after opening to less than 10 minutes in first instance, but after 2000 the congestion on the free lanes was back on the level of before the implementation of congestion pricing (Sullivan & Burris, 2006). This is in line with the findings of the Metropolitan Planning Council in the theoretical background, that road widening doesn't work. In the corridor of the SR 91, there are also both trains and buses operating, but together they account for less than 1% of the highway traffic (Sullivan & Burris, 2006).

Positive and negative outcomes

Also in California, where congestion pricing is implemented as a HOT lane facility on the State Route 91, there are positive results with more and more people who are willing to pay for a premium lane (Sullivan, 2000). Most of the commuters don't want to pay for the toll every trip but the number of people using the lane is increasing. The report of the Department of Civil and Environmental Engineering did show that the use of the toll lane varies significantly with income, gender, age and other characteristics, of which being female is the strongest factor in favour of using the HOT lane (Sullivan, 2000). Despite the success of congestion pricing on the State Route 91, congestion has increased on the other free lanes and on other highways in the region. Whereas the speeds on the express lanes are around 60 or 65 mph, the speed on the free lanes is no more than 20 mph during peak hours (Federal Highway Administration, 2006). The toll revenues have been able to pay for the construction costs of the express lanes.

Also, On the I-10 and I-110 in Los Angeles express lanes were added as new capacity next to the existing lanes (US Department of Transportation, 2015). This caused an increase in the amount of vehicles, which caused that the travel times in the morning peak direction increased, although they had become less in the afternoon. Overall, the travel times became less on the I-10. On the I-110 the travel times stayed around the same time (US Department of transportation, 2015).

Lessons for Chicago

According to Sullivan & Burris (2006) most benefits from the implementation of congestion pricing came from travel time savings. Because the travel time savings were such a crucial part of the benefits the value of time was a key factor in calculating the benefits. Gordon et al (2015) found that the prices for the toll lanes increased dramatically since congestion pricing was implemented. In 1998 the tolls varied from $0,60 to $3,20 whereas prices have increased to $9,55 during Friday afternoon rush hour. This might be because of a growing demand for the road, so congestion increases on the free lanes (Sullivan & Burris, 2006). This leads to a higher price on the toll lanes. This higher price can have a negative impact on the equity, since it excludes poorer drivers (Vickrey, 1969; Ecola & Light, 2009). Also there has not been improvement of the transit share in the region (Sullivan & Burris, 2006). This example shows that Chicago should be careful

with implementing congestion pricing and investigate future demand for the roads. Since road widening has often a temporarily congestion reducing effect, it is wise to invest the revenues of congestion pricing in public transport, since this has a long term effect (Metropolitan Planning Council, 2010).

Congestion pricing in Chicago

Proposed implementation

As discussed in the introduction, Chicago has proposed congestion pricing as one of the main transport strategies for the next decades (CMAP, 2010). The Chicago Metropolitan Agency for planning has studied this plan in their Go To 2040 strategy. The plan to implement congestion pricing was arising from the fact that road users are not paying the full cost of their use at the moment (CMAP, 2010). At the moment the gas taxes, vehicle registration fees and tolls are just enough to cover the costs of resurfacing and reconstruction. And so drivers do not pay for other road costs. Especially the costs of congestion is a thing where drivers do not pay for at the moment, so that's one of the main reasons that congestion pricing will be implemented. Congestion pricing has a lot of support of politicians in the Chicago region, but many civilians in the region are critical.

There have already been a few proposals of congestion pricing in Chicago, which have been neglected. The CMAP had already made a proposal for congestion pricing in 2007 together with the Illinois tollway and the Illinois Department of Transportation to implement congestion pricing on the Jane Addams Tollway (I-90) but this was not selected for federal funding (CMAP, 2010). The Metropolitan Planning Council (MPC) has investigated implementations of congestion pricing as well, they studied the impact of cordon pricing in Chicago (MPC 2016, interview). But cordon pricing would not work according to the MPC, because of a lack of congestion in the CBD, congestion is more a problem in the surrounding areas (MPC 2016, interview; MPC, 2008). The MPC has also studied the implementation of express lanes on existing highways, and found that congestion pricing would work out best on the The Jane Addams Memorial Tollway (I-90), Stevenson Expressway (I-55) and Kennedy Expressway (I90/I94) (MPC, 2010). According to Nie (2016, interview) congestion pricing could best be implemented first on the highways which are already toll roads, by a higher toll fee during the rush hours.

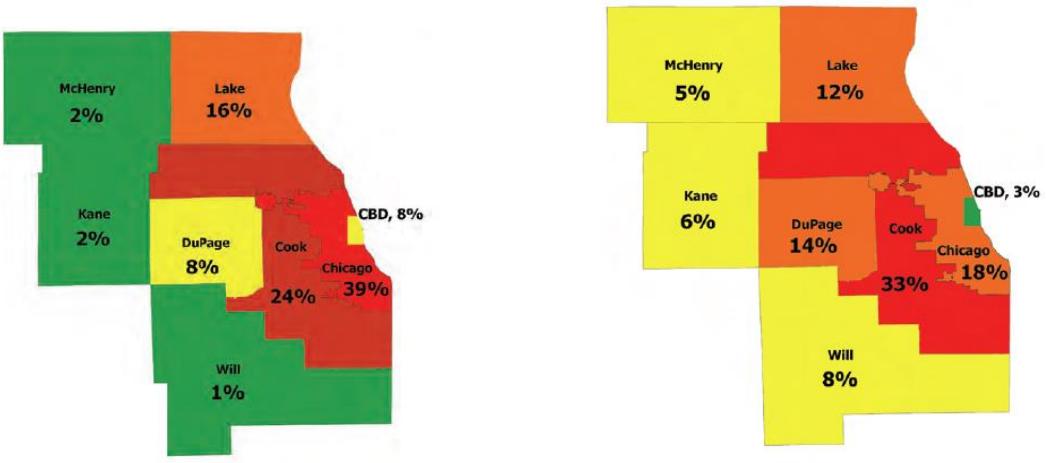
In 2012 the CMAP has proposed to implement congestion pricing on five different locations as discussed in the introduction: The Jane Addams Memorial Tollway (I-90), Stevenson Expressway (I-55), Eisenhower Expressway (I-290), Elgin O' Hare expressway and the IL-53. The CMAP has only researched to implement congestion pricing on highways which are currently under project. This was because these 5 highways would be expanded anyway, so congestion pricing could be implemented as an addition to the current projects. The 5 highways that the CMAP has studied are all currently under project and will all be expanded with one or more lanes. So, the CMAP has done research whether it was still needed to implement congestion pricing after capacity was added to these highways. In first instance the 2012 research concluded that congestion pricing would be a good strategy to implement on all of these five highways (CMAP, 2012). But more detailed research showed that there would be less congestion, due to the added capacity, in the future than was expected on three of these roads, which means congestion pricing was not worth implementing anymore because of too less demand (CMAP 2016, interview). At the moment the

Stevenson and Eisenhower Expressway have been proposed by the CMAP for the implementation of congestion pricing (CMAP 2016, interview). So the two proposed highways to implement congestion pricing are not the most congested roads in the Chicago region, but the most congested roads which will be expanded. On the most congested highway in Chicago, according to a recent study by the American Highway Users Alliance even the most congested road in the US (Chicago Tribune, 2016), the Kennedy Expressway, congestion pricing will in first instance not be implemented. Both the MPC and CMAP think congestion pricing would work better on this road, but because the other two roads are being expanded, it is cheaper to implement congestion pricing on these roads (CMAP 2016, interview; MPC 2016 interview).

The plan to implement congestion pricing is a recommendation of the CMAP and has just been proposed by the Governor of Illinois, Bruce Rauner (CLTV, 2016; Illinois Government News Network, 2016). Right now the first proposal for congestion pricing only includes a managed lane on the Stevenson Expressway (I-55). When this project works out well and is widely accepted by the people in Chicago, there will probably be more highways where congestion pricing will be implemented (CMAP 2016, interview; MPC 2016, interview). According to the CMAP and MPC the Stevenson Expressway is the best road to implement congestion pricing in Chicago, because it already has a shoulder lane, which is now only used by buses, which can be used to convert into a managed express lane. When this project works out well and congestion pricing is widely accepted in Chicago it is possible to implement congestion pricing on other highways (CMAP 2016, interview; MPC 2016, interview). The MPC and CMAP are both in favour of a variable toll during rush hours on the Stevenson Expressway (CMAP 2016, interview; MPC 2016, interview).

Congestion situation in Chicago

Congestion in Chicago has grown five percent annually in the last thirty years (CMAP 2016, interview). Whereas the average commuter spent 18 hours per year in traffic jams in 1982, this percentage has grown to 71 hours in 2012. And since it is expected that the Chicago area will grow with over 2 million people in the next 30 years congestion is expected to grow even more (CMAP 2016, interview). It is important to understand how this congestion arises in order to be able to know the best strategy to deal with congestion. The MPC (2008) calculated the total cost of congestion in Chicago, which was at the time 7,3 billion dollars per year and would grow to over 11 billion dollars in 2030. The amount of jobs which could be created when there was no congestion was 73.000. According to the MPC (2008) there is a big difference in where the congestion in Chicago occurs and where it originates as can be seen in the figure below. As can be seen in the figure, most of the congestion occurs in the city of Chicago around the CBD district. Also the surrounding area in Cook County accounts for a big share in the total congestion for Chicago. Together they are responsible for 63% of the total congestion in Chicago. The percentage of where congestion originates is relatively bigger in the suburbs. So the drivers who are living in the suburban counties are responsible for a bigger share of the congestion, but they are only faced with congestion when they drive closer to the city center. Because there is a higher demand for these roads, since there are a lot of roads which merge close to city center, and because there are a lot of commuters traveling to downtown for their jobs.



Legend of the figure:

- 0-5% congestion
- 5-10% congestion
- 10-20% congestion
- 20-30% congestion
- 30-40% congestion

Figure 3.7 Where congestion occurs in Chicago (left) and where it originates (right). MPC (2008)

Income segregation in Chicago

As discussed in the theoretical background, the value of time can be different for different people, and often poorer people have a lower value of time, since they have lower wages (Vickrey, 1969). For this reason Nie (2016, interview) says that poor people are tolled off. When these poorer people live together in the same neighborhood, roads in these neighborhoods can have a lower average value of time than roads in richer neighborhoods. This income segregation has grown rapidly in Chicago, as can be seen in figure 3.8. The middle class of incomes between 75 and 125 percent of the metropolitan median almost disappeared in 2012. The poorer neighborhoods are mostly located on the south and west side, and the richer neighborhoods are mostly located on the north side. So the values of time will be different for these neighborhoods and so for the roads in these neighborhoods, as will be discussed in the next section.

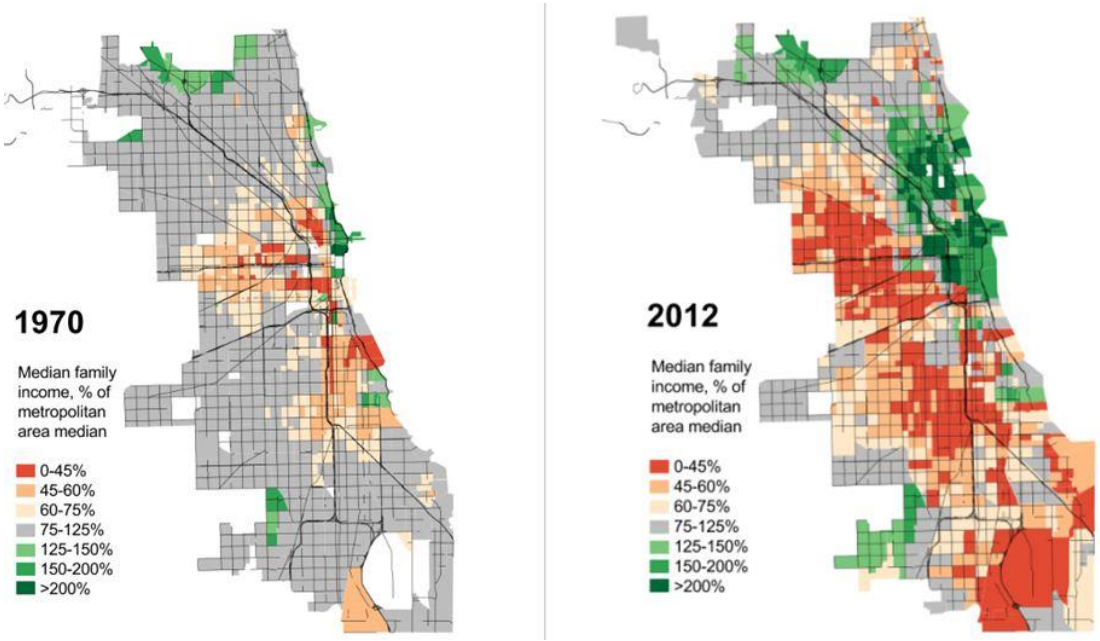


Figure 3.8 The income segregation in Chicago in 1970 and 2012 (University of Chicago, 2016).

Demographic and spatial economic factors related to congestion pricing in Chicago

To research the best way of implementing congestion pricing, not only the current congestion situation, is relevant, but also other spatial economic and demographic factors (Harris & Shaikh, 2011). In order to decide which demographic factors and spatial economic factors are important when congestion pricing is implemented, especially previous models from congestion pricing literature are used. Harris & Shaikh (2011) have compared the public transport option with a driving option in Chicago and in this way they have made a well-fitted model, in which for every spoke there is a driving option as well as a public transport option. They also conclude that the right way to implement congestion pricing depends on its city's characteristics, in which income segregation and the way of public transport (train or bus) are very important. Because more congestion caused by individual drivers will make bus traffic slower. But the other way around bus traffic will go faster if more people are willing to take the bus (Harris & Shaikh, 2011). According to Sullivan (2000) income, gender and age are important characteristics in the context of congestion pricing. Also the distance to the downtown, the specific highway (since some highways are more congested than others) and income, can influence the ideal type of transportation.

When there are different values of time in different neighborhoods there will be different values of time for the highways in these neighborhoods, as discussed in the previous section. When there are different average values of time for the highways in Chicago there will be different optimal taxes. Harris & Shaikh (2011) have conducted such a research. The results are shown in the table below, where it can be seen that in some neighborhoods the optimal tax is twice as high as in other neighborhoods.

Highway	Highway location	Optimal tax	Daily cost with optimal tax	Daily cost with second-best tax	% Increase in cost	Daily cost with no tax	% Increase in cost
Eden's	North	$16.50	$ 4,125,611	$ 4,142,174	0.40	$ 5,191,728	26
Lakeshore Drive North	North	$12.50	$ 3,400,250	$ 3,403,670	0.10	$ 4,004,464	18
Kennedy	West/North	$12.25	$ 3,145,495	$ 3,146,042	0.02	$ 3,744,418	19
Eisenhower	West	$13.75	$ 4,880,364	$ 4,886,537	0.13	$ 5,819,767	19
Stevenson	South/West	$10.75	$ 3,321,758	$ 3,322,117	0.01	$ 3,965,291	19
Dan Ryan	South	$ 6.75	$ 2,948,763	$ 2,963,268	0.49	$ 3,182,417	8
Lakeshore Drive South	South	$ 7.00	$ 2,975,095	$ 2,985,607	0.35	$ 3,209,937	8
Total		$11.00	$24,797,334	$24,849,415	0.21	$29,118,022	17

Figure 3.9 Optimal taxes for different highways in Chicago (Harris & Shaikh, 2011).

Chapter 5
Hypotheses based on theoretical background and empirical findings

Introduction

In this chapter seven hypotheses will be presented about the implications of congestion pricing in Chicago, which have been derived from the theoretical background and the empirical findings of this thesis. First the hypotheses will be presented, and thereafter the argumentations for these hypotheses will be discussed. After this chapter, the hypotheses will be tested by interviewing experts on the topic of congestion pricing.

Hypotheses

Hypothesis 1

The characteristics of Chicago show that the best form to implement congestion pricing is a facility-based scheme.

Argumentation

As Harris & Shaikh (2011) conclude, the right way to implement congestion pricing depends on its city's characteristics. The characteristics of a city which can be affected by congestion pricing include the land-use of the city, the income segregation, accessibility and the current level of congestion which exists because of these characteristics, as discussed in the theoretical background. Arnott (2013) argues that a cordon pricing scheme can work out well in a city with a lot of congestion in the downtown area. The MPC (2016, interview) has conducted a research to investigate the implications of a cordon priced scheme in Chicago and found that, because of the lack of congestion in the CBD district cordon pricing is not a good idea for Chicago. There is more congestion at the highways surrounding the CBD (MPC, interview 2016).

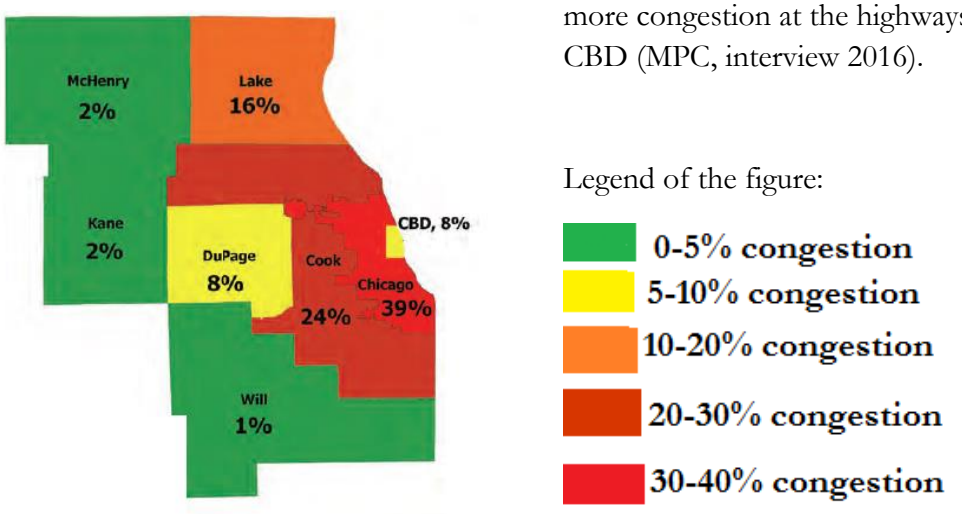


Figure 4.1 Where congestion occurs in Chicago. MPC (2008)

As can be seen in the figure above, most of the congestion occurs in the city of Chicago around the CBD district. Since the congestion pricing schemes of zonal pricing and cordon pricing is more focused on reducing congestion in the CBD and facility-based schemes are focused on reducing traffic and so creating free-flow traffic on highways surrounding the CBD, it is therefore expected that facility-based schemes work out better in Chicago.

Hypothesis 2

In Chicago, congestion pricing will cause more new developments closer to the city center which will result in a more densely built city.

Argumentation

As discussed in the theoretical background, Langer and Winston (2008) have found that congestion pricing causes higher travel costs to the city center. When the travel costs get higher, it will make living in the suburbs less attractive. So more developments will be created close to the center. The MPC (2016, interview) argue that congestion pricing is the first method in Chicago to price the decision for people to choose the distance between their jobs and houses. The bigger this distance is, the higher the price, which means that people are more likely to start living closer to their jobs which are often located in the city center.

Hypothesis 3

A dynamic pricing scheme has to be implemented in Chicago in order to maintain free-flow traffic on the express lane.

Argumentation

The optimal toll is the price where the negative externality of the marginal social cost of an additional vehicle on a road is equal to the toll price (De Palma & Lindsey, 2011). De Palma & Lindsey (2011) also state that congestion tolls should be differentiated by vehicle type, road link, time of day, real-time traffic conditions, trip purpose, and local conditions such as pricing of public transit services or other transport modes, which has also been discussed in the theoretical background. These factors and situations all have a different value of time. And this value of time is important in setting the optimal toll price as discussed in the theory (Goodwin, 2004). The value of time can be different for different persons, but also for the same person at different times. (Vickrey, 1969). As can be seen in the figure below, the toll price can vary dramatically during the day because of this value of time. In the case of Minneapolis it can vary between 0,05 dollar and 1 dollar (CMAP, 2012). One of the main goals of the congestion pricing project in Chicago is to maintain free-flows on the highways and especially on the express lanes (CMAP 2016 interview; MPC, 2016 interview). Therefore it is crucial to have a dynamic toll price in order to manage the traffic in such a way that the demand for the express lane will remain stable.

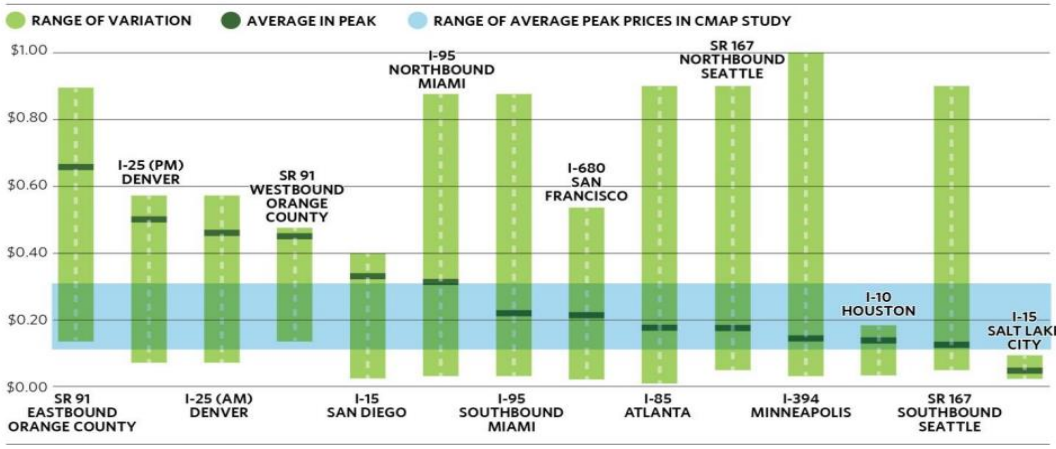


Fig. 4.2 Prices in US dollars for different US managed lanes (CMAP, 2012)

Hypothesis 4

When congestion pricing is implemented on added lanes to have more capacity and no other measures are being taken, this will only reduce congestion temporarily.

Argumentation

As discussed in the theoretical background, road widening first has a decreasing effect on congestion (MPC, 2008). But after some years the demand for this road will grow, because of less congestion and shorter travel times. So, generally, in seven to ten years the road is as congested again as it would have been without building a new lane. This has also happened in the case of the express lanes on State Route 91 in California. The delay on this highway first decreased after opening, because of more capacity. But after 5 years the free lanes were on the same congestion level again, as before the express lanes were added. First the tolls for the entire road varied between $0,60 and $3,20, whereas prices increased during the years to a level of $9,55 during Friday afternoon rush hour (Sullivan & Burris, 2006). Such a high toll price indicates that the time savings are very big when drivers use the express lanes, and so the level of congestion on the toll free lanes must be extremely high.

Hypothesis 5

The current proposal for congestion pricing in Chicago has a good chance to succeed, because of the visible benefits and low costs.

Argumentation

Besides the theoretical optimal implementation of congestion pricing it is important to look at the political background of the project, and what this means for the implementation of the project. As discussed in the theoretical background, De Borger & Proost (2012) have found that an optimal form of implementing congestion pricing is different in political economy. The case of Minneapolis showed that the public will support the projects if people can see the benefits and that it should work from the first day on, which means that the benefits should be visible from the first day on. In the current proposal, congestion pricing in Chicago will be implemented on a shoulder lane of the Stevenson Expressway. This lane is now only allowed to be used by buses, which causes that the lane never reaches its capacity. At this moment drivers can be frustrated during traffic jams, because they are not allowed to use the shoulder lane (MPC, 2016 interview). This was also the case in Minneapolis, where HOV lanes were used. Because the capacity was not reached on the HOV lane it has been converted into an HOT lane. When an express lane is added, cars are also allowed to use the shoulder lane, which means that the actual capacity of the road grows. In this case the benefits of congestion pricing are clearly visible for the users, which means that there is a big chance that the public will support the project.

Hypothesis 6

Despite a lack of support for different toll prices for different highways because of income segregation, it is likely to be the outcome due to more demand for express lanes in richer neighborhoods.

Argumentation

As Vickrey (1969) discussed, the value of time can be different for different persons. The value of time is related to the wage rate. So poor people have in general a lower value of time than richer people. Since Chicago is a segregated city based on income, as discussed in the empirical findings, the value of time will be different in different neighborhoods. So, the value of time on highways in poorer neighborhoods is lower than in richer neighborhoods (Harris & Shaikh, 2011). According to the CMAP (2016, interview) and MPC (2016, interview) the toll prices will not be different on different highways because of political reasons. The richer and more powerful people will not allow that prices will be higher on their highways. So in first instance the same price will be introduced when congestion pricing is implemented on more highways. But because of differences in value of time in the neighborhoods, there will be more demand for the express lanes in richer neighborhoods (MPC 2016, interview). Since the main purpose of the congestion pricing project in Chicago is to maintain free-flow traffic, the prices for the highways in richer neighborhoods will turn out to be higher, because of the economic principle of supply and demand.

Hypothesis 7

Investments in public transit on top of congestion pricing are crucial to create a more effective, sustainable and equitable system and gain more support.

Argumentation

As discussed in the theoretical background and stated in the argumentation for hypothesis 4, road widening has only a temporarily effect, whereas the effect for public transport investments also holds in the long run (MPC, 2008). In the case of the State Route 91 in California, the public transport accounts only for 1% of the highway traffic (Sullivan & Burris, 2006). And since the toll lanes are now operated by a private enterprise, the revenues will not go to public transport (Gordon et al, 2015). Now there is a situation where the free lanes are more congested than before. Also the prices for the express lanes have risen to a very high peak level, because of the travel time savings. This higher price can have a negative impact on the equity, since it excludes poorer drivers, because they generally have a lower value of time (Vickrey, 1969; Ecola & Light, 2009; Shaikh 2016, interview). Also there has not been improvement of the transit share in the region (Sullivan & Burris, 2006), whereas this transport mode is generally more used by poorer people (Vandyck & Rutherford, 2013). So, Chicago should be careful with implementing congestion pricing. Since road widening has often a temporarily congestion reducing effect, it would be wiser to invest the revenues of congestion pricing in public transport, since this has a long term effect (Metropolitan Planning Council, 2008). The case of Minneapolis also showed that congestion pricing projects are more likely to gain support if they are linked to transit improvements (Munnich, 2013).

Chapter 6 Data Analysis

Introduction

In this chapter the analysis of the data will be discussed. In this thesis two different forms of data analysing have been used. One of these methods consists of the interviews which have been conducted for this thesis. The other method is a quantitative data analysis. In the results and conclusion chapters the two different methods will be linked to each other. In this chapter the quantitative data analysis will be discussed first and then the interviews.

Quantitative data analysis

For the quantitative data analysis two sources of data have been used, the first is a dataset from the website www.city-data.com. This dataset provides information on zip code level about a lot of factors. These factors are the same for every zip code: population, population density, cost of living, percent male and women, people who finished high school and/or their bachelor, average commute time, unemployment, average age, income, house value, amount of cars per household, transportation mode to work, distance to the Chicago Loop by car and the highways per highway with the fastest commute time. As stated in the methodology of this thesis, the article of Harris & Shaikh (2011) is interesting for this thesis, since similar data is used in this thesis to analyze the impact of congestion pricing in Chicago. In figure 1 of the appendix the data from www.city-data.com is shown. All the data related to spatial economic and demographic characteristics comes from this website and almost all data is from 2012, except for the population density, this data comes from 2010. The other dataset which is used in this quantitative data analysis comes from the Chicago Metropolitan Agency for Planning. This data consists of so called highway congestion scans for all highways CMAP is investigating for the implementation of congestion pricing. This dataset is available at www.cmap.illinois.gov. (Chicago Metropolitan Agency for Planning, 2016). This data can be seen in figure 2 of the appendix. The dataset from the CMAP contains factors that indicate average levels of congestion for both AM peaks and PM peaks on the main highways of Chicago, as well as the total congested hours of the highways in Chicago. These highways have all been divided into a few sections with their own average levels of congestion, this means the congestion level is more precise for every highway section. This congestion data has for every factor two different moments for which there is data available, for almost all cases this is 2007 and 2011, for a few cases it is 2007 and 2009 or 2009 and 2011.

Goal of the data analysis

The goal of this data analysis is to see which highways have the most benefits from a policy like congestion pricing. With the combination of demographic, spatial economic and congestion data this will create a map in which can be seen in which areas of Chicago there is the most demand for congestion pricing. This data analysis contributes to the thesis by adding a quantitative method to the arguments which come from the hypotheses. Since CMAP has proposed five different highways where congestion pricing can be implemented it is useful to test if these highways are in the biggest need for congestion pricing. It might also be the case that other highways are more congested at the moment. The argument will be made in this chapter that the current congestion situation is not the only factor that influences the need for congestion pricing. These factors will be discussed in the next section.

Factors included in the data analysis

In the introduction of this chapter the factors which are included in the data analysis have shortly been listed. In this section the factors will be discussed. For every zip code used in the data analysis relevant data regarding congestion pricing has been selected. For a few zip codes not enough relevant data has been found to use in this analysis. This is the case for example for the O'Hare international Airport area on the northwest side of the city, simply for the reason that there are now residents in this area. The data for zip codes close to the downtown area has been left out of the analysis, since it is faster for these people to use the arterial roads to get to downtown. Unfortunately, there is no congestion data available for the arterial roads. These areas have been left blank on the eventual maps. The first factors which have been incorporated in the dataset are demographic factors, like population, gender, age and population density. Also spatial economic factors of a region have been used in the dataset, including cost of living, education, unemployment, income and housing values. The other factors in this dataset are linked to transportation: the commute time, amount of cars per household and the transportation mode have been included. Finally the distance to the city center and the fastest highway to get to the city center have been used in the analysis. This has been done by the use of google maps. In this way for every zip code the fastest road to the city center is calculated. This fastest highway is then linked to the highway congestion scan sections from the dataset from CMAP. In this way the spatial economic and demographic data from the zip codes is linked to the congestion data, with this combination the congestion pricing index can then be calculated. The way how this index is calculated is discussed in the next section.

Calculation of the congestion index

The congestion data consists of three important parts: The travel time index, the planning time index and the congested hours index. This congestion index is the average factor of the travel time index, the planning time index and the congested hours. The travel time index is about the average extra travel time during peak hours, by dividing the total travel time during peak hours by the free-flow travel time. The planning time index is about the reliability of the highway sections during peak hours. The congested hours are the amount of hours that the section of the highway travels at less than 50 mph. Most of the highways in the city have been divided into different sections, since some sections of the highway are much more congested than other sections. Unfortunately, this was not possible for all highways. The congestion index is visualized for every zip code. As discussed in the previous section, the zip codes have been linked to the fastest highway that will bring the residents to downtown Chicago.

Calculation of the congestion pricing index

The congestion pricing index consists of four factors, these four factors are:

- Congestion index
- Average household income
- Average commute time
- Percentage of people that drives by car to their job.

All these factors have been given the same value of 1, so the congestion pricing index is the average value of these factors. In the next section is explained why these particular factors have been chosen.

Congestion pricing index linked to the theory

As discussed in the methodology, the article of Harris & Shaikh (2011) has been used as an example for the data analysis which has been executed in this thesis. Also the interview with Harris (2016, interview) contributed to the choices which have been made for the factors in this data analysis. The first component which is important is the value of time. As discussed in the theoretical background, the value of time is related to the wage rate (Rouwendal & Nijkamp, 2004). The idea in the article of Harris & Shaikh (2011) was that the trips with a higher value of time will make use of a congestion pricing facility. The lower value of time trips are being tolled of the road (Nie 2016, interview). So, since the value of time is related to the wage rate, the average income per zip code is an important factor for deciding in which neighbourhood there is more demand for congestion pricing. According to Harris (2016, interview) the wage rate has been included in the Harris & Shaikh (2011) analysis for similar reasons. Harris & Shaikh (2011) have also used census data to see people's average commute times and their transport modes. The idea is that people with higher commute times are willing to pay more in order to reduce their travel time, since the use of a congestion priced facility will reduce their travel time more significantly. The percentage of car drivers for every zip code has been included, because people who drive their car generally have a preference for driving their car (Harris & Shaikh, 2011). Another argument for this factor, is that in a region with a lot of car drivers a congestion pricing lane can have a bigger effect in reducing the amount of car drivers than in a region where there are already a lot of transit users. Finally the congestion index has been used for the congestion pricing index, since the current level of congestion is crucial for the potential of congestion pricing.

Execution of the data analysis

Both datasets have been manually transformed into a Microsoft excel file from the two websites. After this the data has been put into SPSS and GIS. Not all data was directly recognized as the right sort of variable by the programs SPSS and GIS. This is why some variables had to be adjusted in order to use it in these programs. Besides the two datasets also two different maps have been used from the website www.arcgis.com. One of these maps contains data of all the zip codes in the United States, the other map contains the data of all highways in the United States. Since the data analysis is linked to all the highways in the Chicago Metropolitan System, it is relevant to implement this data in the map. The demographic and spatial economic data doesn't contain coordinates of the zip codes, this data had to be joined to the zip code map. First the excel file was imported to the GIS program. In order to join the two datasets in the right way the data type had to be the same. Since this wasn't the case a new field had to be added in GIS in the ZIP code file in order to make the join successful. The excel file that contains both the congestion data and spatial economic and demographic data was put into SPSS. In SPSS a new variable was created, that is called the congestion index. The outcome is different for each highway sector, as discussed in the previous sections.

Analysis of the interviews

For this thesis 10 interviews have been conducted with professionals in the research subject of congestion pricing. Four of these 10 interviews have been used to get to know general information on the topic of congestion pricing. These interviews have already been used in the chapter of empirical findings. The last six interviews have been conducted in a more structured way with seven hypothesis which were proposed to the experts, as discussed in the methodology. The results of these interviews will be discussed in the topic results. Unfortunately, the quality of recording of the interview with Gregory Newmark was not good enough to understand, so this interview will not be used for this analysis. The experts who have been interviewed for this thesis are:

Date	Person	Organization
02/02/2016	Tom Murtha	Chicago Metropolitan Agency for Planning
02/15/2016	Sabrina Shaikh	University of Chicago
02/19/2016	Marco Nie	Northwestern University
02/19/2016	Peter Skosey	Metropolitan Planning Council
03/17/2016	**P.S. Sriraj**	**University of Illinois Chicago**
04/12/2016	**Joseph Schwieterman**	**DePaul University**
04/13/2016	**Jorgen Harris**	**University of Chicago**
04/19/2016	***Gregory Newmark****	***Kansas University***
04/26/2016	**Tom Murtha**	**Chicago Metropolitan Agency for Planning**
04/27/2016	**Bumsoo Lee**	**University of Illinois Urbana-Champaign**

Figure 6.1: List of interviews used for this thesis. Will not be used in this thesis.*

The persons who are named in bold cooperated with the hypotheses interviews and the other persons were interviewed for the general background of this thesis. The persons are mainly from universities, although they are all from different universities. Also two people from planning agencies have been interviewed, Peter Skosey and Tom Murtha. In the results, each of the hypotheses will be discussed, and all opinions will be analyzed for all of the interviews.

Chapter 7 Results

Introduction

In the previous chapter the way of analyzing the data has been discussed. In this chapter the results of these analyses will be discussed, as well as the relevance of this analysis. The goal of this chapter is to answer the research questions 2 and 3 which have been stated in chapter 1. This chapter will also contribute in answering the main research question. In this chapter first the relevance of the analysis will be discussed, then the results of the quantitative data analysis are discussed and finally, the results of the interviews will be discussed.

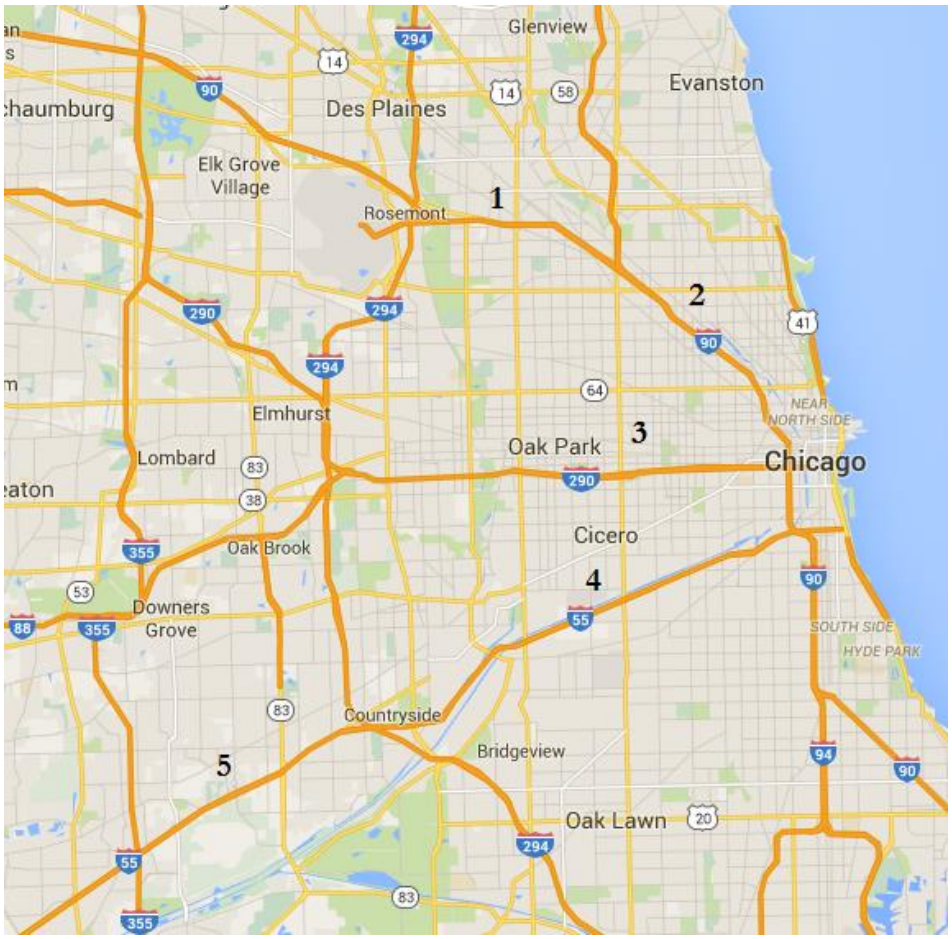
Quantitative data analysis

Relevance of the data analysis

In chapter 6 the relevance of the factors which form the congestion pricing index has been discussed. In this section the relevance of this quantitative data analysis will be explained. With this analysis there can be seen in which zip codes there is the most demand for congestion pricing, based on the congestion pricing index. So, there can be seen on which highways congestion pricing can get the most revenues. It is not the aim of this analysis to show on which highway congestion pricing can be implemented the best, but where there is the most demand for congestion pricing and where it is needed the most. Where congestion pricing can be implemented the best depends on a lot of other factors. These factors include political support, the current situation of the road surface and the costs of implementing congestion pricing (CMAP 2016, interview). This analysis is relevant because the demand for congestion pricing is visualized for all zip code areas in Chicago and it can also be seen which highways are the most congested.

Congestion in Chicago

As can be seen in figure 3 of the appendix and in figure 7.1 of this chapter, the Kennedy Expressway I90/I-94, on the northwest side of the city has the highest congestion index of all the highways in the Chicago Metropolitan Area. In figure 3 of the appendix it can be seen that the section of the highway between the I-190 and I-94 has the highest congestion index of all highways in the city. Another section of this highway has the second highest congestion index of the city, the section between the I-94 and the city center. This is in line with the article of the Chicago Tribune (2016), that the Kennedy Expressway is the most congested highway, as discussed in chapter 3. Although it has to be said that this analysis of congestion in Chicago is based on the year 2011 and the Chicago Tribune based its article on 2015. As can be seen in figure 7.1, the other most crowded highway sections in the top 5 are situated on the I-290 and I-55. The Stevenson Expressway, where congestion pricing is planned to be implemented, has a high level of congestion, but not as high as the Kennedy Expressway and some sections of the Eisenhower Expressway. CMAP (2016, interview), Nie (2016, interview) and MPC (2016, interview) all make the argument that congestion pricing would work the best on the Kennedy Expressway, because of the high levels of current congestion. The level of congestion on the Stevenson Expressway is still higher than the level of congestion on most highways in the city.



Legend
1 = I-90 Kennedy Expressway (I-190 to I-94 Edens Split)
2 = I-90/94 Kennedy Expressway Local Lanes (I-94 Edens Split to I-290)
3 = I-290 Eisenhower Expressway (Wolf Road to Halsted Street)
4 = I-55/Stevenson Expressway (Lakeshore Drive to I-294)
5 = I-55 (I-294 to Veterans Parkway)

Figure 7.1: The five most congested highway sections of Chicago.

Most of the congestion in the Chicago Metropolitan Area occurs on the highways surrounding the downtown area of Chicago, as can be seen in figure 7.2. This is in line with the results of the MPC (2008), which has shown that most of the congestion in Chicago occurs around the downtown area. Unfortunately, there is no data in this analysis on the level of congestion of the zip codes inside the downtown area, since the fastest routes to downtown are not the highways for these areas. It can also be seen in figure 7.2 that most of the congestion in Chicago occurs on the Northwest side of the city, although this level falls dramatically for areas further away from downtown Chicago. Also, the level of congestion drops in general for areas further away from downtown, especially in the suburbs. In figure 7.2 and figure 7.3 the outcomes of the GIS and SPSS analyses are visualized. The results for figure 7.3, the congestion pricing index will be discussed in the next section.

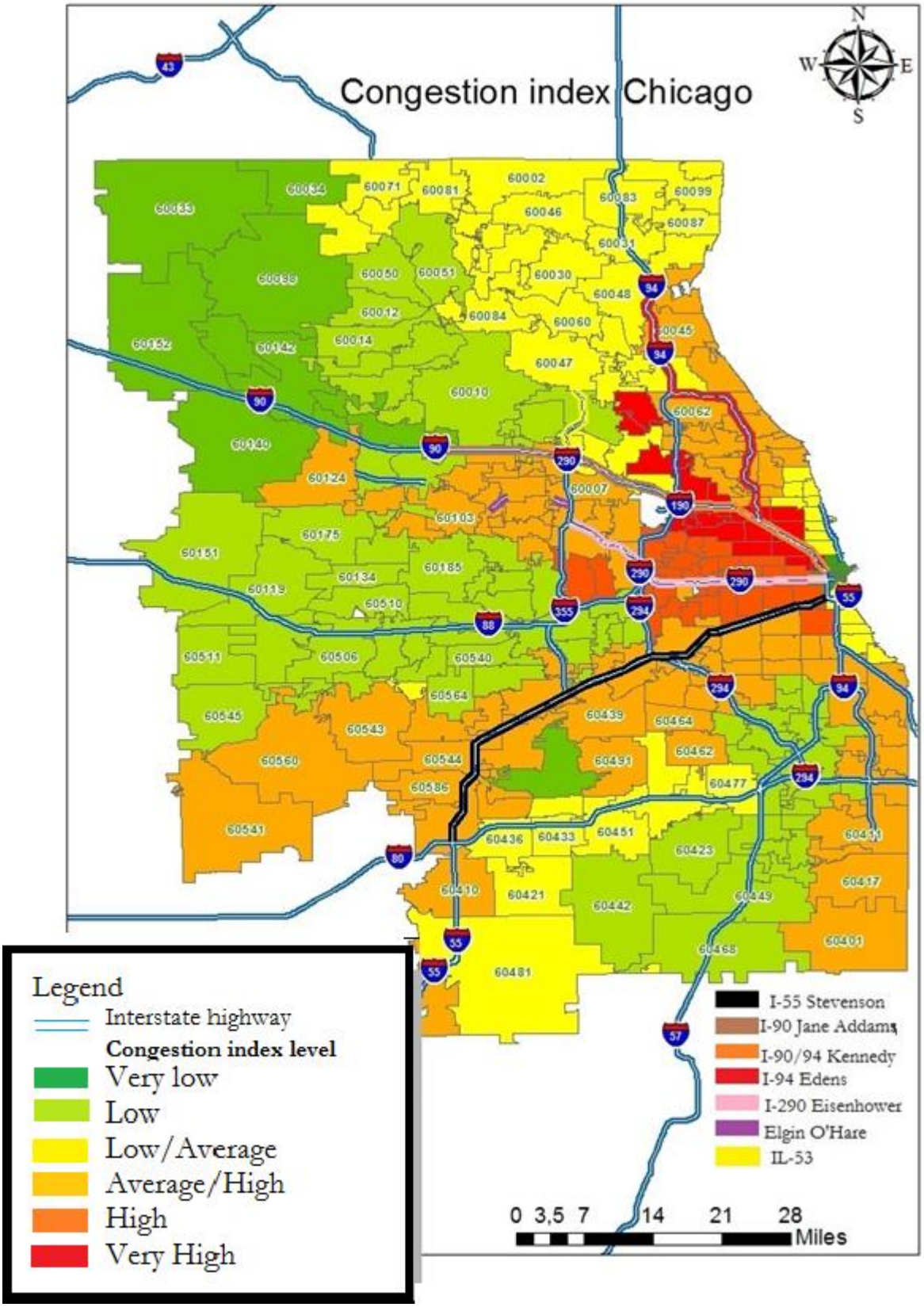


Figure 7.2. The congestion index for all zip codes of Chicago visualised in GIS.

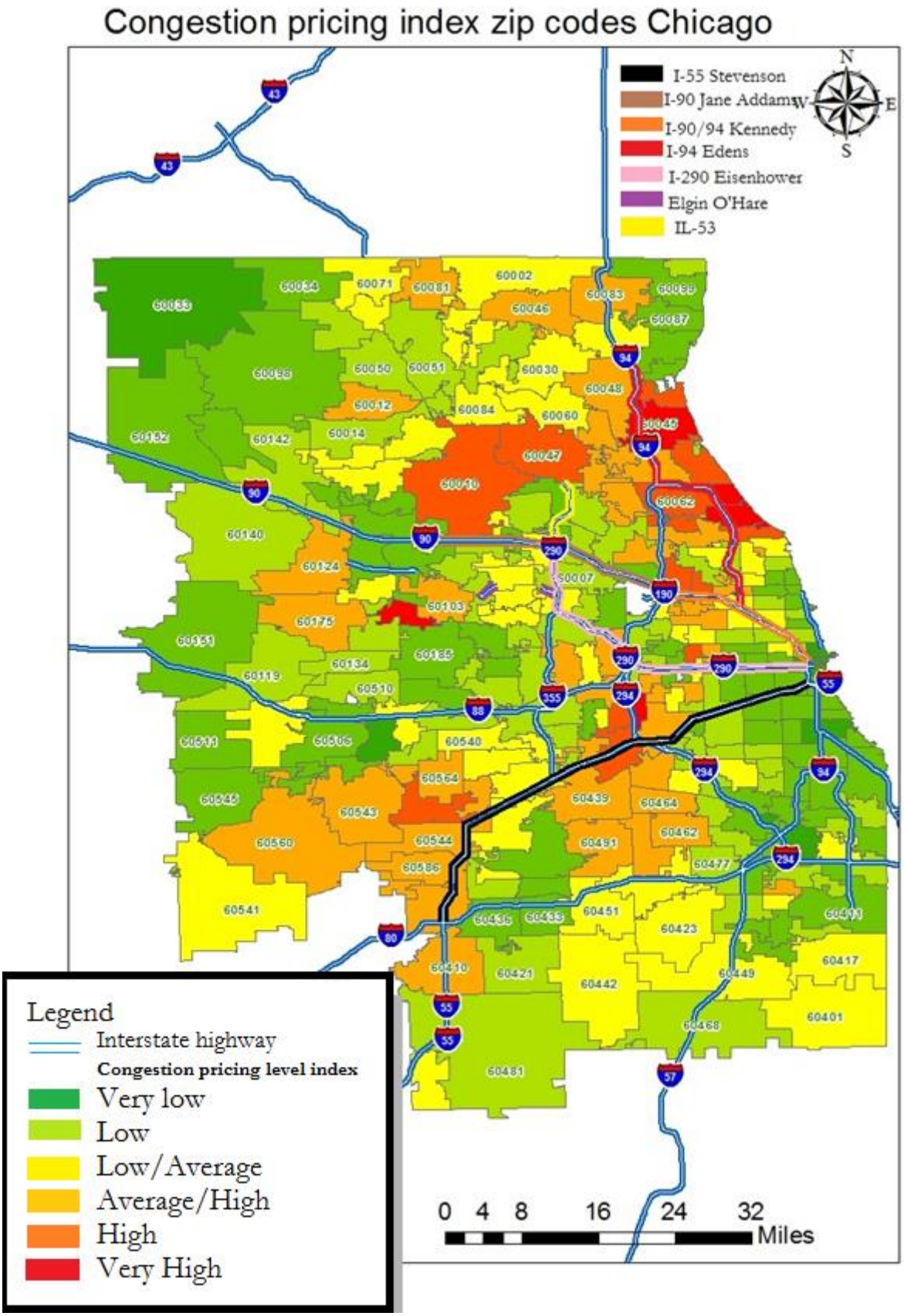


Fig 7.3. Congestion pricing index for the city of Chicago

Results of the congestion pricing index

In figure 7.3, the congestion pricing index of Chicago is visualized. As discussed in the previous chapter, this index is based on the congestion index, the percentage of people per zip code that use a car to go to work, income per zip code and commute time. What becomes clear out of this figure is that the congestion pricing index is higher in most zip codes on the north side of the city than on the south side of the city. Further away from the city in the suburbs the effect becomes more diverse. The fact that in the north side there are more zip codes with a higher congestion pricing index seems logical, since more high-income people live in this part of the city, as discussed in chapter 3. Since these people have in general a higher value of time, they will benefit more from congestion pricing than people in other parts of the city, meaning that there is a higher demand for congestion pricing. This also correspondents with the findings from Harris & Shaikh (2011). Harris & Shaikh (2011) have concluded that the highest optimal congestion tax is on the Eden's Expressway (I-94) on the North Side of the city. This highway has a pretty high congestion index and also has the highest congestion pricing index on this map. In the south side of the city where the average incomes are pretty low, the congestion pricing index is also pretty low. The I-94 Dan Ryan Expressway on the south side of Chicago shows low values of the congestion pricing index for every zip code. This is also in line with the conclusions of Harris & Shaikh (2011) and hypothesis 6, which has been proposed in chapter 5.

The congestion pricing index of the area of the Stevenson Expressway is pretty diverse. On some sections closer to the city center there are some areas with low indexes, but in the suburb areas there are some areas with a pretty high index of over 6000. This has probably also mainly to do with income, since the high income areas in this part of the Chicago region are located in the suburbs. Another reason why values may be higher in the suburbs, is that typically more people in the suburbs use their car to go to work, as can be seen in figure 4 of the appendix. It can also be seen that the values of the congestion pricing index for the zip codes located along the Kennedy Expressway are still quite high.

Limitations of the data analysis

There are two limitations of this data analysis. The model for the congestion pricing index assumes that all traffic drives towards downtown. Since the congestion data which is used, contains the data of all the highways that move towards the city center, but not for the side of the road that moves in the opposite direction. The first limitation is therefore that the highway which is used in the analysis doesn't necessarily match with the highway people use to get to their jobs. Since not all people have to go to the city of Chicago for their job. Although, since congestion pricing itself is also aimed at traffic to downtown this is not a big concern. The second limitation is that most people travel on different sections of the highway, this is not adopted in the model, since this would get too complicated. In practice the sections of the highways closer to downtown contain cars coming from different highways, but this was too complicated to incorporate in the model. So for people with a high income it doesn't matter if a congestion pricing facility is opened on the beginning of their travel to the city center or in the end. In the analysis only a calculation has been made in their own zip code and which highway is situated in this zip code.

Interview results

In this section the results from the interviews are presented, this will be done for every hypothesis separately so the outcomes from the different interviews can be discussed for every topic. The following interviews will be used for these hypotheses:

- P.S. Sriraj
- Joseph Schwieterman
- Jorgen Harris
- Tom Murtha
- Bumsoo Lee

Hypothesis 1

The characteristics of Chicago show that the best form to implement congestion pricing is a facility-based scheme.

When it comes to the issue of implementing a cordon pricing or a facility-based scheme, almost all experts are in favor of a facility-based scheme. Only Harris (2016, interview) is in favor of congestion pricing with a cordon based scheme for two reasons. The first reason is that with a facility-based scheme, trips will be segregated on the base of the value of time. This will have a negative impact on the equity and the free lanes next to the express lanes might become more congested, like in California (Federal Highway Administration, 2006). The other reason why a facility-based scheme might not work is that people will make use of the arterial roads instead of the highways, so a spillover effect of congestion is created. The other four experts are all in favor of a facility-based scheme. Some of them have similar arguments for this. One of the reasons is that the central business district is not the only part of the city that is congested. As Schwieterman (2016, interview) states:

[…] The worst congestion in Chicago is not happening in the downtown area, it is on expressways on choke points around the city. (Schwieterman 2016, interview)

According to Schwieterman (2016, interview) the worst congestion occurs on the highways around the central business district and Lee (2016, interview) says that the area of Chicago is too spread out for cordon pricing. Another reason why a cordon would not be a good option is the question of how big would the cordon around Chicago be? This is a complicated question, without an easy answer. The fact that that the implementation of a cordon is more complex than a facility-based scheme is another reason why most experts are in favour of the facility-based scheme. Sriraj (2016, interview) thinks the feasibility is the main reason why a cordon pricing scheme wouldn't work, since it has a big influence on the lives of people. According to Murtha (2016, interview) a facility-based scheme is easier to implement in Chicago, but a cordon scheme can be added eventually, so a network of congestion pricing facilities can be created.

Hypothesis 2

In Chicago, congestion pricing will cause more new developments closer to the city center which will result in a more densely built city.

This hypothesis contains mixed answers, since it is a complicated issue. Murtha (2016, interview) says there are so many different interactions related to this hypothesis. And because there are so many interactions it is hard to predict what the overall effect will be. In general, a few different effects have been noticed by several experts. One of the effects is that due to congestion pricing people will more often use public transport. Schwieterman (2016, interview) and Harris (2016, interview) support this idea. According to Schwieterman (2016, interview) this can create transit oriented development, which results in a more densely built city. Harris (2016, interview) defines two processes that are going on in this context. On one hand the congestion toll might not be high enough to let the high income people switch to public transport. This will mean their mobility will increase, because the low and middle income people will switch to public transport, because for their value of time the congestion toll is too high. So with less people on the road, the mobility increases. The other process is that there are still a lot of people who switch to public transport, so there will be more demand for transit. This may lead to economies of scale, where the frequency of the transit is increased, because of the higher demand, trains can now go every 10 minutes, instead of every twenty minutes.

Another important argument has been made by Sriraj (2016, interview), Murtha (2016, interview) and Lee (2016, interview). It depends on where the jobs are if the city will become more dense. And congestion pricing can decentralize the economic activities. Because the congestion toll will be aimed at the traffic going to downtown, this may stimulate economic activities and jobs to locate in other nodes in the suburbs of Chicago. Sriraj (2016, interview) mentions that most poor people live in the inner city, whereas their jobs start to move to the far suburbs, and most of these locations are not accessible with public transport. So they still have to go by car. Murtha (2016, interview) points at the improved mobility, because of the implementation of congestion pricing. Since the congestion priced lane will always have free-flow traffic, so there will be improved mobility and reliability. This means people can move faster over longer distances to jobs that are further away. If people are willing to pay the congestion fee this may result in a more spread out city. Sriraj (2016, interview) thinks the sprawl of Chicago is almost an irreversible process and says:

[…] Chicago is almost as sprawled as possible. (Sriraj 2016, interview)

But the overall opinion is that in the long term more people might switch to public transport, because of the congestion fees. This may result in transit oriented development and eventually a more densely built city, but only in the very long term.

Hypothesis 3

A dynamic pricing scheme has to be implemented in Chicago in order to maintain free-flow traffic on the express lane.

Whereas the previous hypothesis was pretty complicated, this hypothesis is more straightforward. All experts agree that congestion pricing has to be done with a dynamic pricing scheme. According to Sriraj (2016, interview) this is the true spirit of congestion pricing. There is a discussion however about dynamic in a sense that the price can be adjusted at any moment depending on the demand for the express lanes. The other dynamic pricing scheme is with rates

which have a standard price for every hour of the day, as implemented in the Stockholm case in chapter 4. The concern is that people might be scared off because of changing prices all day (Harris 2016, interview). But Harris (2016, interview) then continues by mentioning that the people who are actually using the express lanes are more informed about the tolling system than people who don't use the expressways to go their job. Murtha (2016, interview) thinks that when a congestion fee would be implemented on all lanes, standard prices for particular times would work better. But since the goal of express lanes is to have free-flow conditions always, the pricing scheme has to be dynamic (Murtha, 2016). Schwieterman (2016, interview) & Sriraj (2016, interview) agree on this point. Only Lee (2016, interview) thinks a pricing scheme with standard rates for particular times works better, because otherwise people would get confused. He thinks it would work better to revise these rates every two or three months.

Hypothesis 4

When congestion pricing is implemented on added lanes to have more capacity and no other measures are being taken, this will only reduce congestion temporarily.

For this hypothesis, all experts have a strong opinion. Three of them support this hypothesis, while the other two disagree. Sriraj (2016, interview), Harris (2016, interview) and Lee (2016, interview) think the demand for the extra capacity will eventually catch up with the extra capacity for the extra lane. Sriraj & Harris both mention the fact that it is proofed in the literature that congestion will always come back to the same level with added capacity. Sriraj mentions that the express lane will never be congested when the price is high enough. But this should not be the goal of congestion pricing, he thinks. The main goal is to improve the overall mobility, so the free lanes should also take a profit from the implementation of congestion pricing. When congestion pricing is only implemented to improve the mobility over the express lane this would be inequitable (Sriraj 2016, interview). Harris (2016, interview) has a similar argument by saying that congestion pricing would improve mobility for people with a higher value of time, compared to an additional free lane, but for people with lower values of time it would improve mobility less. Lee (2016, interview) is in favor of converting existing lanes into express lanes, as he says:

[…] Adding more highway capacity will make more people drive. This has been the transportation policy in the USA for a long time, now we are turning into a more sustainable and alternative way. It might be better to invest in different modes of transit. (Lee 2016, interview)

Murtha (2016, interview) & Schwieterman (2016, interview) disagree with these opinions. Schwieterman says that for every 10 percent added capacity, there will only be 8 percent more traffic. This is in contrast with the opinions of Sriraj and Harris, and figure 2.6 of the theoretical background. Murtha argues that with congestion pricing the additional demand can be managed so free-flow speeds can remain. But he doesn't mention the free lanes in this argument.

Hypothesis 5

The current proposal for congestion pricing in Chicago has a good chance to succeed, because of the visible benefits and low costs

Most of the experts agree on the fact that this project is not too complicated to implement. As Murtha (2016, interview) states it as an 'easy win'. The experts think two topics are the most important in this context, political will and public support. For the last topic it is very important that the Pace buses are using the shoulder lanes at the moment. The public can therefore see that not all the capacity is being used. As Lee (2016, interview) states that at the moment the shoulder lane is underutilized, and therefore congestion pricing on that shoulder lane will be easier to accept for the public. Harris (2016, interview) still sees an issue when the buses and private automobiles use the same lane. Since the cars who pay for the express lane, do this so they can move at free-flow speed. Harris says that the buses will accelerate slower and in general also move slower than cars, which can be an issue. Therefore he thinks the benefits might not be that high, but the project does have low costs. Schwieterman (2016, interview) mentions that still has to be determined if there is political will for the project but thinks it is an excellent proposal, Murtha (2016, interview) doesn't see any clear losers in the project and thinks there is a very big chance for the project to succeed. Schwieterman (2016, interview) does see a missed opportunity of not implementing congestion pricing first on the tollway system of Chicago, since it is even easier to implement higher prices there during rush hours.

Hypothesis 6

Despite a lack of support for different toll prices for different highways because of income segregation, it is likely to be the outcome due to more demand for express lanes in richer neighborhoods.

This hypothesis has been partly based on the research of Harris & Shaikh (2011). Therefore it is not surprising that Harris (2016, interview) agrees with this hypothesis. The other experts have some criticism regarding this hypothesis. Sriraj (2016, interview) & Schwieterman (2016, interview) both argue that this doesn't mean people from the wealthier neighborhoods on the north side don't drive on the highways at the poor south side. This has to be researched with a focused survey, according to Sriraj. Harris doesn't agree on this point, but since no survey has been done yet, it can't be said who is right. From an economical point of view Schwieterman, Harris and Lee agree with the hypothesis. Schwieterman argues that the toll should be higher for richer people in order to change their behaviour and switch to public transport. Harris (2016, interview) states:

[…] If you build express lanes on every highway in Chicago and you charge the same toll for every highway, there is no doubt in my mind that the lakeshore drive coming from the north and the 94 coming from the north will have a lot more demand than the Dan Ryan and the lakeshore drive south, there is just no question. (Harris 2016, interview)

Harris (2016, interview) argues it might be difficult to implement this for political reasons, but when dynamic priding is implemented based on demand for the road, this price difference is not set because of differences in income, but because of differences in demand it would be more efficient. And so then it might become politically accepted he argues. Murtha (2016, interview) is doubtful that the research of Harris (2016, interview) holds water, he thinks that there might be some subtle changes between the north and the south side, but it is very speculative he thinks.

Hypothesis 7

Investments in public transit on top of congestion pricing are crucial to create a more effective, sustainable and equitable system and gain more support.

All experts agree that alternatives have to be provided for congestion pricing, especially for people with lower incomes. Some think that investments in public transport are not the only solution. Sriraj (2016, interview) says people should not be disadvantaged because other people are benefiting. Therefore the public transit has to be improved, but also the arterial roads. For every highway with a toll or with congestion pricing, the parallel arterial roads should be improved as well in order to improve the overall mobility of the region. Schwieterman (2016, interview) thinks this hypothesis is true in Chicago, because there is already a good public transport system, so this can be a good alternative. This would not be true in Florida for example he says, where there is not such a public transport system. Harris (2016, interview) & Lee (2016, interview) think this hypothesis is true, since at the moment there are a lot of low income car drivers who need to have an alternative, otherwise this project can't be supported, Lee adds to this. Murtha (2016, interview) also thinks alternatives have to be provided for lower income people, like the buses who can use the congestion priced lane.

[…] We have already seen the express bus lanes on the Stevenson. This has caused a dramatic increase in bus volumes, so they had to increase the bus service to be able to deal with the increased demand. (Murtha, 2016)

Chapter 8 Conclusions

In this master's thesis, research has been done on the subject of congestion pricing in Chicago. This subject has been addressed in different ways. In the theoretical framework theories about congestion costs, value of time, agglomeration effects and congestion, effects of land use, effects of road pricing and effects of adding road capacity have been explained. In the empirical framework the different forms of implementing congestion pricing have been this discussed and lessons from congestion pricing in California and Minnesota have been learned. After this, hypotheses have been stated based on the findings in the empirical and theoretical framework. These hypotheses have been tested by conducting interviews, these results have been presented in chapter 7. A quantitative data analysis has been executed in order to see which highways are the most congested at the moment, and to see in which zip codes there is the most demand for congestion pricing. All these processes were needed in order to answer the main research question, which will be done in this chapter. The main research question of this thesis is:

What are the implications of congestion pricing in Chicago and what would be the best way to implement congestion pricing?

This research question implicates that there are different implications of congestion pricing and these will all be discussed. But first, the best way to implement congestion pricing will be discussed. This will both be done with the hypotheses which have been proposed in chapter 5. At the end of this chapter there will be a reflection on the research questions.

Best way to implement congestion pricing in Chicago

As discussed in the empirical framework there are different ways to implement congestion pricing: zonal, cordon and facility-based pricing. This thesis was mainly focused on cordon pricing and facility-based pricing. In these schemes there can be dynamic pricing or pricing in which there are standard rates for every different hour. In chapter 5, the hypotheses, it has been stated that facility-based schemes would work better in Chicago. The reason for this was that the city characteristics and especially the level of congestion outside the CBD of Chicago show that a facility-based scheme with express lanes on the highways is favorable. The results show that almost all experts are in favor of a facility-based scheme for similar reasons as just explained. Experts also question the feasibility of cordon pricing, since it is more complex to implement. The quantitative data analysis also shows that the most congested highways are located around the CBD district, also unfortunately in this analysis there was no data available for the CBD itself. The fact that almost all experts are in favor of congestion pricing with facility-based schemes means that the first hypothesis can be accepted.

When it comes to the pricing of the express lanes, the results show that only Lee (2016, interview) prefers a scheme where there the prices don't adapt to the real-time level of congestion. All other experts think a dynamic pricing scheme would work better for the express lanes, for the main reason that the goal of congestion pricing is to always have free-flow conditions on the express lane, and this can only be achieved with a dynamic pricing scheme. This was also one of the main points why this hypothesis was stated. Since all but one expert agree on this hypothesis, it can therefore be accepted.

Reflection of the Stevenson Proposal

The two just discussed hypotheses are both in favor of the current proposal for congestion pricing on the Stevenson Expressway, since it is a facility-based scheme with dynamic pricing. The congestion index, of which the results have been discussed in chapter 7, shows that the level of congestion on the Stevenson Expressway is high, but not as high as on the Eisenhower and Kennedy Expressway. When the implementation of congestion pricing would only depend on the current level of congestion, the Kennedy Expressway would be the best option. In this thesis also a congestion pricing index has been introduced, which shows that there are mixed results for the areas around the Stevenson expressway. According to this index the highest demand for congestion pricing is on the Edens Expressway on the north side of the city. CMAP acknowledges congestion pricing could work better on other highways in Chicago than the Stevenson Expressway, like the Kennedy Expressway (CMAP 2016, interview; MPC 2016, interview). The reason why the CMAP wants to implement congestion pricing on the Stevenson Expressway is because of the low costs and because the highway has to be rebuild anyway (Murtha, 2016). The results of the hypotheses in regard of this proposal show that all experts are generally positive about the CMAP proposal for congestion pricing on the Stevenson Expressway, because it is an easy win, because of the low costs and the visible benefits and because the shoulder lane is underutilized at the moment. So there is a big chance the public will be positive about congestion pricing on the shoulder lane.

Other implications of congestion pricing

Other implications of congestion pricing include changing land use patterns because of congestion pricing, changing congestion because of added road capacity, different prices because of income segregation and investments in congestion pricing. The hypothesis regarding changing land use patterns contains mixed results, on one hand people are stimulated to use public transport more often, on the other hand mobility will increase on the expressways because of a free-flow congestion priced lane, meaning that people can travel longer distances in the same time, which makes it more attractive to live far away. Because of these mixed opinions this hypothesis cannot be accepted. The fourth hypothesis about adding capacity also shows mixed results. The argument that this is proved in the literature, is used in favor of the hypothesis, but it is also used against the hypothesis. Since there is no overall consensus regarding this hypothesis, it cannot be accepted. The sixth hypothesis also caused a discussion among the experts. From economical point of view most experts agree with this hypothesis, there should be more demand for congestion pricing on the north side of the city. The congestion pricing index also shows the highest values for the index on the north side of the city, along the Edens Expressway. Harris & Shaikh (2011) also found the highest optimal price for congestion pricing on this highway, meaning that along this highway there would be the most demand for congestion pricing. Despite these facts, the experts are mostly skeptical about this hypothesis. Since people who live on the north side can still drive on the south side, other experts think this hypothesis is farfetched. Two of the five experts eventually agreed with the hypothesis, meaning that it cannot be accepted. The last hypothesis regarding investments in public transport on top of congestion pricing was unanimous accepted by all the experts. All experts agree alternatives have to be provided for people with lower values of time in order to improve the overall mobility. People should not be disadvantaged because other people are getting benefits from congestion pricing.

Answering the research questions

In this section the research questions which have been stated in chapter 1 will be answered. There is not one answer for this research question, since there are a lot of different implications of congestion pricing. The best way to implement congestion pricing, is somewhat more straightforward. As an answer to the first research question, congestion pricing can be implemented as zonal pricing, cordon pricing, and a facility-based scheme, for which there are different variants: HOV lanes, HOT lanes and managed lanes. All of these options can include a dynamic pricing scheme. In this thesis it has been found that a facility-based scheme is the best option for Chicago with a dynamic pricing scheme. The current proposal for congestion pricing on the Stevenson Expressway is not the best proposal, in a sense that it is not the most congested highway at the moment and there is also not the most demand for congestion pricing on the Stevenson Expressway. But the current proposal is likely to succeed because of visible benefits and low costs, and is therefore a good first congestion pricing project in Chicago. For the second research question the factors average household income, average commute time and percentage of people driving to their jobs, formed the congestion pricing index together with the congestion levels on different highways. For the third research question it can be concluded that there is some significant congestion going on, since the Kennedy Expressway is the most congested of the country (Chicago Tribune, 2016). According to the congestion pricing index, the Edens Expressway is in the biggest need for congestion pricing.

Other important implications for congestion pricing in Chicago are concerned with the value of time, land-use and alternative modes of transportation. Since the value of time has a big impact on people's decision to use express lanes, trips with different values of time are segregated, as discussed in the theoretical framework. This means something has to be done to prevent congestion pricing from being inequitable. All experts agree that alternative modes of transportation should therefore be provided. The impact of congestion pricing on the land-use is a complex process, since there are a lot of factors influencing this process in different ways. Therefore it cannot be concluded that there is a relation between congestion pricing and the density of Chicago.

Finally, the last implications for congestion pricing in Chicago have been learned from other cities. The lessons from Minnesota and California that Chicago should keep in mind are that congestion pricing should be supported by the public from day one in order to succeed, and political leadership is needed to achieve this. Also, there are no safety disadvantages of implementing congestion pricing on the shoulder lane. From the California case it has been learned that demand will rise for the added capacity of the express lanes, leading to a higher price. This was also the reason that congestion on the free lanes had grown and was worse than before the implementation of congestion pricing. According to Sriraj (2016, interview) the goal is to improve the overall mobility, so the mobility on the free lanes should also rise. In order to achieve this the prices should be lower for the express lanes and alternative modes of transport have to be provided, like public transport.

Chapter 9 Discussion and recommendations for further research

In this chapter the theoretical framework, research methods and the results will be reflected upon and discussed. At the end of this chapter recommendations for further research will be given.

Discussion

There is already a large body of literature on congestion pricing in the research field. In the theoretical framework an attempt has been made to include the most important theories on the implications of congestion pricing by discussing several factors that can influence congestion pricing. This literature review is limited to general theories in the field of economic geography, infrastructure and congestion theories. There is a lot of more technical literature available about congestion pricing, but this is not included since this was not relevant for the remainder of the thesis. Since there is not a lot of literature available on congestion pricing in Chicago, lessons from other cities that can help Chicago by implementing congestion pricing have been included. Also interviews were absolutely necessary to get a detailed picture of the process of implementing congestion pricing in Chicago.

The use of hypotheses for this thesis gave a clear structure to this thesis. This was useful in a way that these hypotheses could be reflected in the results and conclusion. A disadvantage of this strategy was that less attention was paid to the topics which were not included in the hypotheses in the results and conclusions. The amount of interviews which were used for the hypotheses could have been a bit more. In this aspect it was unfortunate that the recording quality of one interview was not good enough to include in the thesis. The interviews which were conducted before the hypotheses were stated were very useful for the remainder of the thesis.

The data analysis was a useful addition to this thesis, although it has to be said that there are some limitations of the model, as discussed in chapter 7. The fact that all of the congestion data was based on downtown commuters was a limitation, although congestion pricing is also mainly aimed at reducing the traffic that goes in the downtown direction. Another limitation of the model is that it can't be said that the people who are living on the north side of the city never drive to the west or south side. The congestion pricing index analysis shows the demand for congestion pricing for the zip codes where people live, and this doesn't necessarily have to mean that these people are driving most often or always on the highway section closest to their house. But since there was no data available about where people driving in relation to where they live it was impossible to include this in the thesis. Finally, the fact that there was no data available on downtown congestion was a limitation, since this analysis was therefore not able to contribute to the discussion about whether a cordon around downtown could be effective.

Recommendations for further research

There are several factors that can be recommended for further research after the writing of this thesis. The first is the relation of land-use and congestion pricing. There are a lot of different views on this topic in the literature, as well as among the experts who were interviewed for this thesis. In this thesis this topic is discussed globally, which gave mixed results. Some people think that because of congestion pricing transportation costs will rise, which means people start to move closer to their jobs or to use public transportation. These things generally lead to a denser city. On the other hand, people think that because of congestion pricing congestion will decrease, leading to shorter commute time, so people can live further away from their job. A more in-

depth study to this topic can be useful. Another recommendation for further research is a survey that Sriraj (2016, interview) proposes where residents in every neighborhood are asked about their willingness to pay for congestion pricing and their daily travel patterns. Without this survey it is hard to draw conclusions about differences between optimal toll prices between the north and south side of the city. The last recommendation for further research is about the revenues of congestion pricing. According to Murtha (2016, interview) there are institutional barriers when the revenues of congestion pricing are used for public transport, because congestion pricing is often executed with a public-private partnership. This makes it hard to have a transfer from congestion pricing revenues to public transport. This should be investigated, since the use of revenues of congestion pricing for alternative modes of transportation is crucial for congestion pricing to succeed (Shaikh 2016, interview).

References

Literature

- Alonso, W. (1964) *Location and Land Use: Toward a General Theory of Land Rent*. Cambridge, MA: Harvard University Press.
- Anas, A. Rhee, H. (2007) *When are Urban Growth Boundaries not Second-Best Policies to Congestion Tolls*? Journal of Urban Economics Vol. 61 Pp.263–286.
- Arnott, R. (2013) *A bathtub model of downtown traffic congestion*. University of California Transportation Center.
- Bloom, B. & Craptree, B. (2006) *The qualitative research interview*. Medical Education Vol.40 Pp. 314–321.
- Brueckner, J. K. (2007) *Urban Growth Boundaries: An Effective Second-Best Remedy for Unpriced Traffic Congestion?* Journal of Housing Economics Vol. 16 Pp. 263–273.
- Cao, X. & Munnich, L. (2012) *Benefit and Cost Analysis of the I-394 MnPASS Program*. Center for transportation studies. Pp. 1 tm 40.
- Chatterjee, S. (2014). *Who can reduce traffic without building more roads? A comparative analysis of the cost-benefit debate and the proposed congestion pricing of roads in Delhi.* HeinOnline. Vol. 5. Pp. 110 m 128.
- Chicago Metropolitan Agency for Planning (2010) *GoTo2040 Comprehensive regional plan. Invest strategically in transportation Chicago metropolitan area* Pp. 246 tm 287. Also referred to as CMAP (2010).
- Chicago Metropolitan Agency for Planning (2012) *Congestion Pricing: An Analysis of the Go To 2040 Major Capital Projects.* Pp. 1 tm 22. Also Referred to as CMAP (2012).
- Cole, R. & Dodis, Y. (2012) *Bottleneck Links, Variable Demand, and the Tragedy of the Commons*. Wiley Periodicals, Inc. Networks Vol. 60 No.3, Pp.194–203.
- De Borger, B. & Proost, S. (2012) *A Political Economy Model of Road Pricing.* Journal Of Urban Economics. Vol. 71 Pp. 79-92.
- De Palma, A & Lindsey, R. (2011) *Traffic congestion pricing methodologies and technologies.* Transportation Research Part C 19 Pp.1377–1399.
- Dewees, D. (1979) *Estimating the Time Costs of Highway Congestion*. Econometrica, Vol. 47, No. 6, pp. 1499-1512.
- Douma, F.P. (2015) *Interstate 35E MnPASS Managed Lanes Extension: Little Canada Road to County Road 96 Pre-Implementation Study.* Center for transportation studies.
- Downs, A. (1992) *Stuck in Traffic*. Brookings Institution.
- Ecola, L. & Light, T. (2009) *Equity and congestion pricing: A review of the evidence.* Transportation, space and technology.
- Eliasson, J. (2008) *Lessons from the Stockholm congestion charging trial*. Transport Policy 15 Pp. 395 tm 404.
- Eliasson, J. (2009) *A cost–benefit analysis of the Stockholm congestion charging system*. Transportation Research Part A 43 Pp. 468 tm 480.
- Federal Highway Administration (2006) *Congestion Pricing: A Primer*. US Department of Transportation.
- Federal Highway Administration (2008) *Congestion Pricing* U.S. Department of Transportation.
- Fernald, J. G. (1999) *Roads to Prosperity? Assessing the Link between Public Capital and Productivity.* The American Economic Review Vol.89 Pp.619–638.
- Fujita, M. & Thisse, J. (2002) *The Economics of Agglomeration: Cities, Industrial Location and Regional Growth*. Cambridge: Cambridge University Press.
- Georgia Department of Transportation (2013) *Southside Atlanta I-75 Express Lane Project Highlights $288 Million In New Georgia DOT Mobility Improvements.*

- Goodwin, P. (2004) *The economic costs of road traffic congestion.* ESRC Transport Studies Unit University College London. Pp. 1 tm 26.
- Gordon, P. Moore, J. Pan, Q. Richardson, H. Cho, S. & Williamson, C. (2015) *The Economic Impacts of SR-91 and I-5 Corridor Improvements* in Regional Economic Impacts of Terrorist Attacks, Natural Disasters and Metropolitan Policies. Springer International Publishing Switzerland. Pp. 175 tm 194. Referred to as Gordon et al, 2015
- Graham, D. J. (2007) *Variable Returns to Agglomeration and the Effect of Road Traffic Congestion.* Journal of Urban Economics Vol. 62 Pp. 103–120.
- Gubins, S. & Verhoef, E. (2014) *Dynamic bottleneck congestion and residential land use in the monocentric city.* Journal of Urban Economics Vol.80 Pp. 51–61.
- Gutierrez, J. Garcia-Palomares, J. Condeco Melhorado (2011) *Spatial impacts of road pricing: Accessibility, regional spillovers and territorial cohesion.* Transportation Research Part A Vol. 45 Pp. 185–203. Referred to as Gutierrez et al, 2011.
- Harris, J. & Shaikh, S. (2011) *Value of time clustering and the efficiency of destination-based congestion pricing.* Environmental Practice. Vol. 13 No.1.
- Hopf, C. (2004) *Qualitative interviews: an overview.* A Companion to qualitative research. SAGE Publications. Pp. 203-208.
- Janson, M. & Levinson, D. (2014) *HOT or not Driver elasticity to price on the MnPASS HOT lanes.* Research in Transportation Economics Vol. 44 Pp.21 tm 32.
- Langer, A. and Winston, C. (2008) *Toward a Comprehensive Assessment of Road Pricing Accounting for Land Use. Brookings-Wharton papers on Urban Affairs.* Washington, DC: Brookings Institution Press.
- Litman, T. (2006) *London Congestion Pricing: Implications for Other Cities.* Victoria Transport Policy institute.
- Maruyama, T & Sumalee, A. (2007) *Efficiency and equity comparison of cordon- and area-based road pricing schemes using a trip-chain equilibrium model*, Transportation Research Part A, 41. Vol.7 Pp. 655-671.
- Meinefeld, W. (2004*) Hypotheses and Prior Knowledge in Qualitative Research.* A Companion to qualitative research. SAGE Publications. Pp. 153-158.
- Metropolitan Planning Council (2008) *Moving at the speed of congestion: The True Costs of Traffic in the Chicago Metropolitan Area.* Referred to as MPC (2008).
- Metropolitan Planning Council (2008) *Opportunity knocks.* Policy agenda.
- Metropolitan Planning Council (2010) *The Road Less Traveled: Exploring Congestion Pricing in Chicagoland.* Pp. 1 tm 17. Referred to as MPC (2010).
- Munnich, L. & Loveland, J. (2005) *Value Pricing and Public Outreach Minnesota's Lessons Learned.* Transportation Research Record: Journal of the Transportation Research Board, No. 1932, pp. 164–168.
- Munnich, L. (2008*) Minnesota's Proposal for Urban Partnership Agreement Case Study of Political and Institutional Issues in Congestion Pricing.* Journal of the Transportation Research Board, pp. 15–20.
- Munnich, L. (2013) Public Perceptions of Congestion Pricing in Minnesota and Europe: Loss Aversion, Complexity and Framing. Transportation Research Board.
- Nie, M. & Yin, Y. (2013) *Managing rush hour travel choices with tradable credit scheme.* Transportation Research Part B Vol. 50 Pp. 1–19.
- Ostrom, E. (2008) *Tragedy of the commons.* University of Indiana. Pp 1 tm 4.
- Rouwendal, J & Nijkamp, P. 2004. *Living in Two Worlds: A Review of Home-to-Work Decisions.* Growth and Change Vol. 35 Pp.287–303.
- Skosey, P. & Zucchero, R. (2010) *Chicago region congestion pricing study.* Metropolitan Planning Council, Illinois Tollway.
- Sullivan, E. (2000) *Continuation study to evaluate the impacts of the SR 91 value-priced express lanes final report.* Department of Civil and Environmental Engineering.
- Sullivan, E. & Burris, M. (2006) *Benefit-Cost Analysis of Variable Pricing Projects: SR-91 Express Lanes.* Journal of Transport Engineering. Vol.132 No.3. Pp 191 tm 198.

- Sweet, M. (2011) *Does traffic congestion slow the economy?* Journal of Planning Literature. Vol. 26 No.4 Pp.391-404.
- US Department of transportation (2015) *Contemporary Approaches in Congestion Pricing: Lessons Learned from the National Evaluation of Congestion Pricing Strategies at Six Sites* Office of the Assistant Secretary for Research and Technology Federal Highway Administration.
- Vandyck, T. & Rutherford, T. (2013) *Regional Labor Markets, Commuting and the Economic Impact of Road Pricing.* University of Leuven.
- Vickrey, W.S. (1963) *Pricing in Urban and Suburban Transport* The American Economic Review, Vol. 53, No. 2 pp. 452-465.
- Vickrey, W.S. (1969) *Congestion theory and transport investment. The American Economic Review.* Vol. 59 No. 2 Pp. 251-260.

Websites

- Chicago Metropolitan Agency for Planning (2016) congestion data http://www.cmap.illinois.gov/mobility/roads/cmp/performance-measurement/scans. Consulted between 03-02-2016 and 09-06-2016. Referred to as Chicago Metropolitan Agency for Planning, 2016.
- Chicago Tribune (2016) Accessed via http://www.chicagotribune.com/news/ct-kennedy-congestion-met-20151123-story.html on 29/02/2016.
- City data of Chicago (2015) http://www.city-data.com/city/Chicago-Illinois.htm.l *Consulted between 13-10-2015 and 18- 11-2015.*
- CLTV (2016) http://cltv.com/2016/02/04/express-lanes-proposal-for-stevenson-expressway/ *Consulted on 23-02-2016.*
- Federal Highway Administration 2 (2008) *Transportation Value Pricing Projects in the United States.* Accessed via http://www.ecy.wa.gov/climatechange/2008CATdocs/IWG/tran/082208_value_pricing_projects_in_us_for_t3.pdf on 26-02-2016.
- Federal Highway Administration (2010) Road Pricing: Resources. Accessed via https://www.fhwa.dot.gov/ipd/revenue/road_pricing/resources/webinars/webinar_082310.aspx on 26-02-2016.
- Illinois Government news network (2016). Accessed via http://www3.illinois.gov/PressReleases/ShowPressRelease.cfm?SubjectID=2&RecNum=13482 on 29/02/2016.
- Institute of Public Affairs (2016). Congestion pricing in Minnesota. Accessed via http://media.metro.net/projects_studies/expresslanes/images/minnesota.pdf on 26-02-2016.
- University of Chicago (2016). Accessed via http://www.uchicago.edu/features/students_maps_illuminate_urban_policy/ on 29/02/2016.
- US Department of Transportation (2010) "I-35W MnPASS" – I-35W, Minneapolis, MN, HOV to HOT Conversion and Shoulder to HOT Conversion Project. Accessed via http://ops.fhwa.dot.gov/freewaymgmt/publications/documents/nrpc0610/workshop_materials/case_studies/minneapolis_i35.pdf on 26-02-2016

Interviews

- CMAP (2016) interview with Murtha, T. (2016) interviewed at 02-02-2016. Referred to as (CMAP 2016, interview).
- Murtha (2016) interview with Murtha, T. (2016) interviewed at 26-04-2016. Referred to as (Murtha 2016, interview).
- Harris, J. (2016) interviewed at 13-04-2016. Referred to as (Harris 2016, interview).
- Lee, B. (2016) interviewed at 27-04-2016. Referred to as (Lee 2016, interview).
- MPC (2016) interview with Skosey, P. (2016) interviewed at 19-02-2016. Referred to as (MPC 2016, interview).

- Nie, M. (2016) interviewed at 19-02-2016. Referred to as (Nie 2016, interview).
- Schwieterman, J. (2016) interviewed at 12-04-2016. Referred to as (Schwieterman 2016, interview).
- Shaikh, S. (2016) interviewed at 15-02-2016. Referred to as (Shaikh 2016, interview).
- Sriraj, P.S. (2016) interviewed at 17-03-2016. Referred to as (Sriraj 2016, interview).

Appendix

Data Analysis figures and tables

Districts	Population (2010)	Density (square mile)	Cost of living	Gender (%male)	Education (high school)	Education (bachelor)	Time to work	Unemployment	Age	Income
Downtown north (60602)	1,463	16,809	106.9	44.6%	100.0%	72.1%	17.9 min	0.6%	32.4	$184,179
Downtown South (60604)	570	4,483	108.0	54.2%	97.9%	85.1%	28.6 min	7.1%	54.0	$134,908
Downtown mid (60603)	493	6,087	112.2	41.3%	100.0%	86.3%	20.6 min	6.7%	26.1	$183,116
Chicago Loop (60606)	2,308	10,917	107.2	56.1%	99.1%	89.8%	24.8 min	1.1%	30.9	$120,832
New East Side (60601)	11,110	25,184	109.8	49.8%	98.7%	79.6%	22.4 min	3.4%	36.6	$130,699
West Loop (60661)	7,792	25,003	106.9	48.5%	98.8%	85.7%	27.2 min	4.8%	31.0	$96,194
River North (60654)	14,875	26,129	109.0	48.1%	97.7%	82.6%	23.5 min	7.8%	32.8	$134,995
Museum Campus (60605)	24,668	20,052	108,3	48.2%	95.2%	75.1%	27.4 min	5.3%	33.1	$103,524
Moody Bible (60610)	37,726	33,041	107.9	45.6%	96.0%	71.0%	26.4 min	6.3%	34.3	$104,943
Northwestern University (60611)	28,718	36,005	109.5	46.1%	99.2%	81.6%	24.6 min	8.0%	39.5	$179,953
University village (60607)	23,897	10,833	106.9	48.4%	94.6%	74.3%	27.7 min	8.2%	30.6	$91,815

no vehicle per household	1 vehicle	2 or more	Total cars	Average house value	Alone in car to work	Carpooling	Public transport	Bicycling	Walking	Work at home	Distance to center
61,6%	32,0%	6,5%	294	$325,700	16,6%	0,0%	18,4%	0,0%	63,5%	1,5%	500 m
19,1%	48,9%	31,9%	141	$528,100	33,8%	1,5%	10,2%	0,0%	44,0%	10,5%	750 m
34,2%	41,7%	24,2%	120	$643,800	19,7%	0,0%	15,5%	0,0%	60,4%	2,1%	900 m
18,6%	70,1%	11,4%	819	$338,800	20,7%	2,4%	19,1%	0,7%	44,3%	9,0%	900 m
21,2%	64,7%	14,2%	2173	$494,200	24,8%	13,4%	3,1%	1,5%	44,0%	5,3%	1,5 km
14,6%	72,1%	13,3%	1762	$340,400	27,3%	4,0%	20,3%	1,5%	39,7%	5,1%	1,5 km
25,1%	59,5%	15,4%	4275	$404,100	26,2%	1,3%	15,1%	0,8%	43,2%	6,4%	1,6 km
21,3%	62,0%	16,7%	6140	$344,300	32,7%	4,8%	29,5%	1,8%	18,9%	9,5%	2,1 km
23,3%	58,5%	18,2%	8903	$396,600	24,8%	3,2%	35,3%	2,0%	21,4%	7,5%	2,2 km
29,1%	55,0%	15,9%	9324	$464,400	27,9%	3,0%	19,8%	0,8%	35,1%	7,6%	2,7 km
5,2%	69,7%	24,9%	5640	$340,000	39,0%	3,7%	26,9%	2,8%	21,2%	4,7%	3,7 km

Fig. 1. Example of the demographic data from www.city-data.com for all zip codes in the downtown area

	Free-Flow Travel Time (2007)	Free-Flow Travel Time (2011)	Average AM Peak-Period (2007)	Average AM Peak-Period (2011)	AM Travel Time Index (2007)	AM Travel Time Index (2011)	Average PM Peak Period (2007)	Average PM Peak Period (2011)	PM Travel Time Index (2011)
Elgin-O'Hare Expressway East-Bound	5,64	5,6	9,27	8,2	1,64	1,46	6,17	6,08	1,08
Elgin-O'Hare Expressway West-Bound	5,53	5,59	6,36	6,32	1,15	1,13	8,49	7,78	1,39
I-90/Jane Addams (I-294 to Elgin Avenue) East-Bound*	22,72	23,41	29,07	28,14	1,28	1,2	26,52	25,63	1,09
I-90/Jane Addams (I-294 to Elgin Avenue) West-Bound*	22,19	23,6	23,43	25,06	1,06	1,06	26,94	29,19	1,24
I-90/Jane Addams Memorial Tollway (I-290/IL-53 to to I-294) East-Bound_	11,06	11,25	15,18	13,84	1,37	1,23	15,95	14,27	1,27
I-90/Jane Addams Memorial Tollway (I-290/IL-53 to to I-294) West-Bound_	10,89	11,07	12,18	11,62	1,12	1,05	15,05	13,35	1,21
I-90/Jane Addams Memorial Tollway (IL-31 to I-290/IL-53) East-Bound_	13,01	13,09	16,3	16,99	1,25	1,3	13,75	14,04	1,07
I-90/Jane Addams Memorial Tollway (IL-31 to I-290/IL-53) West-Bound_	13,04	13,67	13,57	14,2	1,04	1,04	16,06	17,18	1,26
I-90/Jane Addams Memorial Tollway (Boone County Line Road to IL-31) East-Bound_	21,58	21,29	22,26	22,09	1,03	1,04	22,16	22,18	1,04
I-90/Jane Addams Memorial Tollway (Boone County Line Road to IL-31) West-Bound_	21,89	21,38	22,85	22,85	1,04	1,07	22,68	22,6	1,06
IL-53 (Lake Cook Road to I-90) South-Bound	6,1	6,4	9,32	7,6	1,53	1,19	10,34	7,23	1,13
IL-53 (Lake Cook Road to I-90) North-Bound	6,12	6,41	8,3	7,35	1,36	1,16	8,2	7,45	1,18
I-55/Stevenson Expressway (Lakeshore Drive to I-294) South Bound	15,94	16,3	20,88	21,97	1,31	1,35	34,02	35	2,15
I-55/Stevenson Expressway (Lakeshore Drive to I-294) North-Bound	15,76	16,33	36,15	30,67	2,29	1,88	22,81	23,12	1,42
I-55 (I-294 to Veterans Parkway) South-Bound	11,42	11,4	15,02	14,6	1,31	1,28	22,92	19,04	1,67
I-55 (I-294 to Veterans Parkway) North-Bound	11,4	11,44	21,24	19,6	1,86	1,67	19,57	17,26	1,51
I-290 Eisenhower Expressway (Wolf Road to Halsted Street) East-Bound	12,88	13,06	30,31	27,51	2,35	2,11	30,02	28,13	2,15
I-290 Eisenhower Expressway (Wolf Road to Halsted Street) West-Bound	13,05	12,79	23,81	22,03	1,82	1,72	32,1	30,13	2,36
I-290 Eisenhower Extension (I-90/Jane Addams Tollway to I-294) East-Bound	15,63	15,55	20,91	19,65	1,34	1,26	28,64	26,56	1,71
I-290 Eisenhower Extension (I-90/Jane Addams Tollway to I-294) West-Bound	15,57	15,52	20,42	18,47	1,31	1,19	21,31	21,18	1,36
I-290 (Wolf Road to I-355/IL-53) East-Bound_	10,59	9,33	14,12	14,9	1,33	1,6	16,16	16,95	1,82
I-290 (Wolf Road to I-355/IL-53) West-Bound_	9,84	9,54	13,65	11,8	1,39	1,24	16,13	13,17	1,38
I-290 (I-355/IL-53 to I-90/IL-53) East-Bound_	6,21	5,96	7,75	6,64	1,25	1,11	10,75	7,47	1,25
I-290 (I-355/IL-53 to I-90/IL-53) West-Bound_	6,12	5,89	6,88	7,06	1,12	1,2	7,14	7,12	1,21
I-90/94 Kennedy Expy Local Lanes (I-94 Edens Split to I-290) East-Bound	7,88	8,38	17,94	19,76	2,28	2,36	14,25	17,24	2,06
I-90/94 Kennedy Expy Local Lanes (I-94 Edens Split to I-290) West-Bound	8,08	8,25	18,64	17,6	2,31	2,13	20,28	16,67	2,02
I-90 Kennedy Expressway (I-190 to I-94 Edens Split) East-Bound	4,85	4,85	11,98	10,09	2,47	2,08	16,88	15,66	3,23
I-90 Kennedy Expressway (I-190 to I-94 Edens Split)	4,88	4,82	12,87	10,45	2,64	2,17	10,29	20,08	2,09

*2007-2009

_2010-2011

Figure 2. Congestion data for the highways in Chicago

Expressway section	Average congestion
I-90 Kennedy Expressway (I-190 to I-94 Edens Split) East-Bound	16,59
I-90/94 Kennedy Expressway Local Lanes (I-94 Edens Split to I-290) East-Bound	14,58
I-290 Eisenhower Expressway (Wolf Road to Halsted Street) East-Bound	12,66
I-55/Stevenson Expressway (Lakeshore Drive to I-294) North-Bound	10,91
I-55 (I-294 to Veterans Parkway) North-Bound	10,53
I-94 Edens Spur to I-90 Eastbound	10,1
I-94 (I-80 to I-57) West-Bound	9,85
I-290 Eisenhower Extension (I-90/Jane Addams Tollway to I-294) East-Bound	9,05
Lake Shore Drive (Hollywood Avenue to Jackson) South-Bound	8,76
I-94 Edens Spur to I-294 East-Bound	8,57
Lake Shore Drive (Marquettte to Roosevelt) North-Bound	7,76
I-80 (US45 to Kedzie Avenue) East-Bound	7,31
I-90/Jane Addams Memorial Tollway (I-290/IL-53 to I-294) East-Bound	7,3
I-57 (I-94 to I-80) North-Bound	6,88
I-90/Jane Addams Memorial Tollway (IL-31 to I-290/IL-53) East-Bound	6,35
I-355 (I-55 to I-88) North-Bound	5,76
IL-53 South Bound	5,66
I-88/Reagan Memorial Tollway (I-355 to Mitchell Road) East-Bound	5,37
I-88/Reagan Memorial Tollway (I-355 to I-294) East-Bound	5,32
I-90/Jane Addams Memorial Tollway (Boone County Line Road to IL-31) East-Bound	4,33
I-355 (I-80 to I-55) North-Bound	4,24

Fig.3 Congestion index of highway sections in Chicago

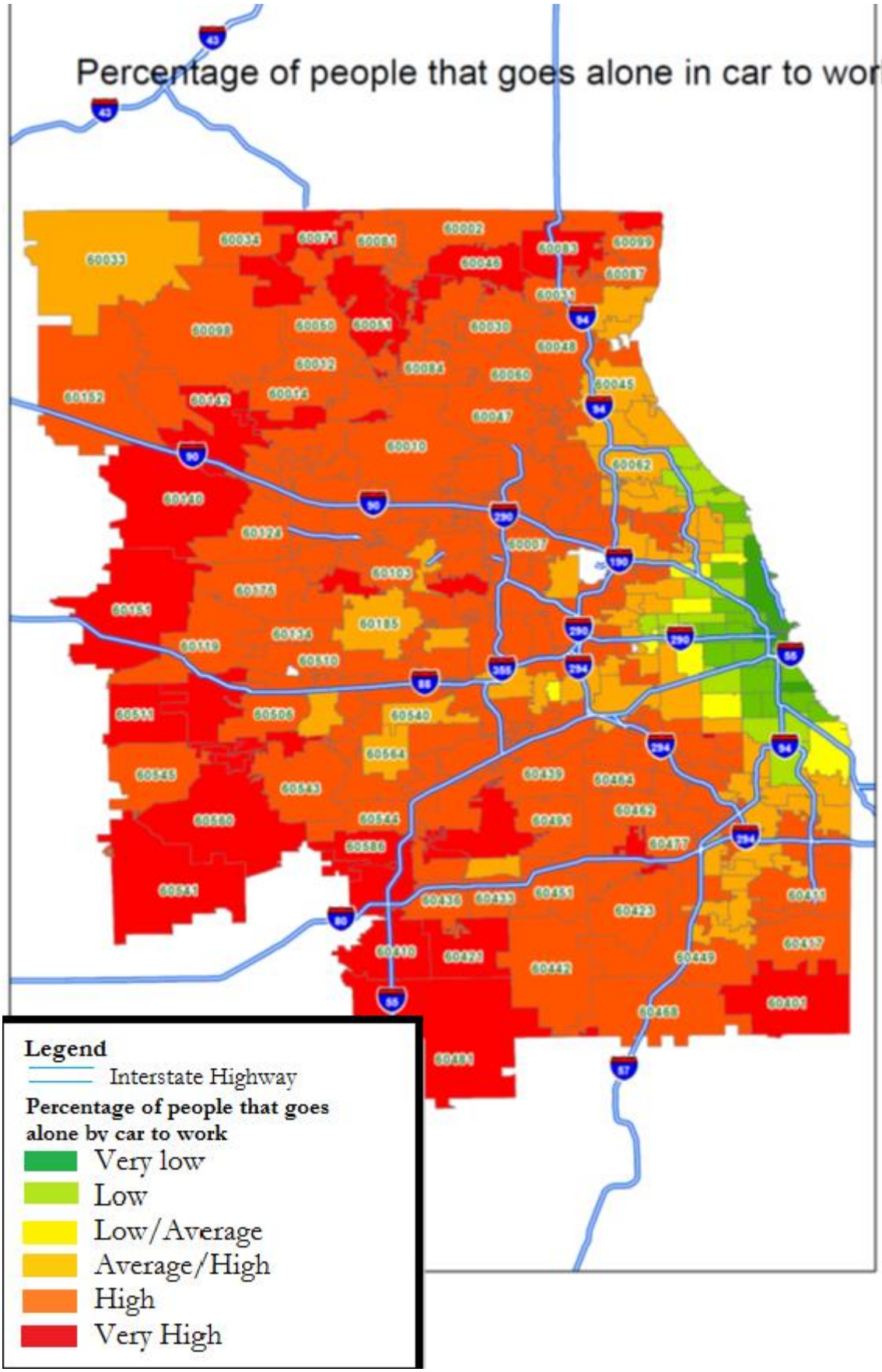


Figure 4. Percentage of people in Chicago that goes by car to work.

Interviews

Interview Guides

For this thesis three different interview guides have been used, the first one has been used for the first interview with CMAP. The second interview guide has been used for the other structured interviews with Sabina Shaikh, Marko Nie and Peter Skosey. The last interview guide was used for the hypotheses interviews

Interview Guide CMAP
Tom Murtha

Initial phase of implementing Congestion pricing in Chicago In

Congestion pricing is at the moment a recommendation of the CMAP. What are the next steps before congestion pricing can be implemented?

The GoTo 2040 plan it is stated that the main reason for implementing congestion pricing is that the stagnating gas state revenues are not able to keep up with the rising construction costs to deal with congestion. Were there also other reasons to implement congestion pricing?

Were there in first instance also other alternatives to deal with congestion other than congestion pricing?

Congestion pricing and highway sections

According to the CMAP website, there are 5 main sections to implement congestion pricing on the I-55, I-90, I-290, IL-53 and the Elgin O'Hare Expressway. What were the main reasons that these sections have been chosen as the proposed roads where congestion pricing will be implemented?

Are there more road sections which have been researched to implement congestion pricing, but just didn't make it?

What factors have been taken into account for choosing the proposed sections? (Like potential benefits, current congestion)

Congestion pricing and equity

According to the CMAP website low income people will probably use the express lanes a little bit less, but will still use them when they need to. How have these calculations been made?

Still, the low income people probably will only be able to use the express lanes when they are in a big need. Might it also have an effect on a growing segregation in the city?

Who is paying for the congestion pricing project? Can it be financed from state gas revenues or will other more general taxes also be used?

There might be a chance that there is only a specific group of people who will use the congestion pricing lanes. Wealthier car owners who live close to the congestion pricing sections. Can this have an influence on the resistance of other people?

Congestion pricing and benefits

Are the sections which have been proposed for express lanes the sections with the highest potential benefits? Or are they also other factors which play a role?

Is it already clear how the revenues of congestion pricing will be spend? Will there be a part of the revenues of the project that goes to the improvement of public transport?

How long will it probably take before the benefits will meet the costs of the project?

Final question

Is there more data from the Chicago Metropolitan Agency available on the topic of congestion pricing in Chicago?

Interview guide congestion pricing
Structured interviews
Sabina Shaikh, Marco Nie and Peter Skosey

Different forms of implementing congestion pricing

What do you think of the different forms of congestion pricing (Zonal, Cordon, Tolled Express lanes, HOV lanes)? Which of these forms work out the best and why?

Which form of congestion pricing would work out the best in Chicago do you think and why?

Congestion pricing in other American cities

What do you think of the impacts regarding the congestion pricing project on the SR91 in California? What can Chicago learn from this project?

What do you think of the impacts regarding the congestion pricing MnPASS project in Minneapolis? What can Chicago learn from this project?

Are there other projects which you think were successful? And for which reasons?

Do you think a HOT-lane works better than a managed express lane or the other way around? And for what reason?

Congestion pricing in Chicago

Which indicators do you think are important to decide on which highways congestion pricing can be implemented, and why are these important?

According to an article of Harris and Shaikh (2011) there are different optimal tolls for different highways, with higher tolls in richer parts of the city. What do you think of this idea and can it be implemented?

Recommendations of the CMAP

The CMAP has recommended to implement congestion pricing on the Eisenhower and Stevenson expressways. According to your 2010 presentation on congestion pricing the biggest revenues would be at the Jane Addams highway and Kennedy Expressway. What do you think of the fact that congestion pricing has not been recommended for these highways by the CMAP?

Congestion pricing will in first instance only be implemented on roads on which there is currently a project of building extra lanes. Do you think it is necessary to implement congestion pricing on new lanes instead of keeping the existing lanes?

Can you think of other highways in Chicago where congestion pricing can work out better than the highways on which there is currently a project? And if so, why do you think it will work better on this/these road(s)?

Final question

All in all, do you think congestion pricing is an adequate instrument to deal with the congestion problems in Chicago and why?

Interview guide
Hypotheses interviews
P.S. Sriraj, Joe Schwieterman, Jorgen Harris, Tom Murtha and Bumsoo Lee.

Hypothesis 1

The characteristics of Chicago show that the best form to implement congestion pricing is a facility-based scheme.

Hypothesis 2

In Chicago, congestion pricing will cause more new developments closer to the city center which will result in a more densely built city.

Hypothesis 3

A dynamic pricing scheme has to be implemented in Chicago in order to maintain free flow traffic on the express lane.

Hypothesis 4

When congestion pricing is implemented on added lanes to have more capacity and no other measures are being taken, this will only reduce congestion temporarily.

Hypothesis 5

The current proposal for congestion pricing in Chicago has a good chance to succeed, because of the visible benefits and low costs.

Hypothesis 6

Despite a lack of support for different toll prices for different highways because of income segregation, it is likely to be the outcome due to more demand for express lanes in richer neighborhoods.

Hypothesis 7

Investments in public transit on top of congestion pricing are crucial to create a more effective, sustainable and equitable system and gain more support.

Interview Transcripts

Tom Murtha
Chicago Metropolitan Agency for Planning
15-05-2016

Introduction
Tom Murtha is a senior at the department of Policy & Programming at the Chicago Metropolitan Agency for Planning. As a policymaker his main interest lies in the field of congestion pricing. He has worked for years on this topic and has contributed to the highway congestion scans, which have been used for the data analysis of this thesis. This is the first interview with Tom Murtha, the second interview will be focused on the hypotheses. For this interview we have agreed on an in person interview at the headquarters of the Chicago Metropolitan Agency for Planning in the Willis Tower.

Goal of the interview
The goal of this interview is to become more familiar with the topic of congestion pricing in Chicago. So far only literature has been used for this thesis, so interviews are a useful tool get more inside information of the topic.

Process of implementing congestion pricing
These are major capital projects, which have a timeframe of more than 10 years. All roads have their own project. The I-290 project has been identified in 1995. The IL-53 project has already been identified in the 1960's, but was for a long time opposed by communities. The I-90 project has been identified in 1997. The I-55 is a recent project. So, the timeframe for these projects take decades. The plans consist of the project itself and congestion pricing has been adopted in those plans. Congestion pricing was implemented as a strategy to manage the roads. They have been adopted in the plans, with strategic recommendations and now they are object to additional study. On I-55 and I-290 the Illinois department of transportation is looking closely to implement congestion pricing. The CMAP can't just pick one option and study this, we have to look at a lot of alternatives. For the I-290 different options like managed express lanes, single express lanes and HOV express lanes have been researched. And they have selected the one which makes most sense, and in this case that will be one express lane.

Congestion pricing in Chicago
Our regional models have indicated that all the projects could use congestion pricing, but more detailed studies showed that there was less congestion than our models indicated. During the initial implementation of that project, congestion pricing won't be a part of that. There wasn't enough congestion to price, and it's kind of a policy question that you've got, so there is regional resistance from taking existing capacity and pricing it. So, basically adding a toll, what might be a very expensive congestion toll to a lane that's right now free, there's a lot of pushback against that. So, when you add new capacity, you toll that new capacity and you can better optimize it. So, in this case there is congestion on I-90, when we would have implemented congestion pricing on the existing lanes, the pricing may have been enough to diminish the congestion, then there's no need anymore for congestion pricing. But, volumes may grow, and the tollways are built in such a way that they can toll it in a later day.

Congestion pricing doesn't come close to paying for the new capacity. So, new capacity is very expensive. The Jane Addams project is about 5 billion dollars, and the Elgin O'Hare project as well. Pricing at the peak for some vehicles is simple, it makes the operation for that lane work, but the revenues are very small compared to the price of the project. So people talk about the money that comes from congestion pricing, but in fact as long as we speak about expressed tollways, where most of the traffic isn't even tolled it just simply doesn't make a big difference. That having been said, if congestion pricing works then you can use it to maintain capacity a lot better than an unmanaged lane. So, a congested lane, that might run 20-30 miles per hour, the capacity of that might only be a thousand or twelve hundred vehicles, if you have a road running at 45 or 55 miles per hour, would be 1800 vehicles per hour, so when the road is congested you lose capacity at the very point at which most vehicles need that capacity. You price it, so high speed and high capacity are maintained. So these are the sort of issues they're thinking about, for both the Elgin O Hare and the I-90 the short term decision is to differ congestion pricing, because it is not needed, all this new capacity obviously needs for congestion pricing, that won't be the case for the I-55 and the I-290. The I-290 and I-55 have very high levels of congestion and the I-90 and Elgin O'Hare have high levels, but not that high.

Cordon pricing vs. Expressways

There are different ways to implement congestion. Some of the proposals to implement congestion pricing involve perimeter pricing (cordon pricing) like they have in London, rather than an expressed tollway you would put meters around the loop and people going into the loop would pay extra costs. That had been considered by the city and has been submitted as a proposal, but it was never voted on by the council. Cordon pricing is an overall means of managing overall demand for travel, but it doesn't have necessarily the operational benefits. Remember how I told about the managed express lanes, where you can set the price to maintain the speed at the right level. Cordon pricing doesn't have that impact. It isn't a very specific system. On the expressways we are prioritizing mobility on the Interstate routes, toll lane pricing would at least allow some traffic to drive through at high speeds. That's a benefit of an expressed lane over a cordon priced project. The disadvantage of the expressed lane is that the revenues go to paying for that additional lane, you can't take toll lane revenue and give to a transit system. The city of Chicago maintains most of the roads but not the expressway, so it's a jurisdictional question.

Public transport in Chicago

A lot of the expressway traffic is not directed to the city center, but just to go through, so that's also an issue. It is true that the cordon around the CBD would have the impact of probably improving transit mode share for the CBD. But that's not cost free. So, like a lot of cities during the peak period Chicago has a transit congestion problem. So you can stand on a blue line platform, as the train comes in, but there's not enough room to get in the train. So it would be good to have more people going with public transport, but it requires more service, and that's expensive. But still this is an open question.

Initial phase of implementing Congestion pricing in Chicago

Just adding additional lanes was an alternative for congestion pricing, but also managing the expressway better in other ways. So, if there is a crash, clearing the crash quickly, managing the traffic so secondary crashes don't occur, so quick clearance. Managing special events, so providing travel information, so everybody understands what the traffic times are, so travelers

can choose to divert around it. These things help, but they're not sufficient, so adding congestion pricing is still needed.

Congestion pricing and highway sections

We did look at a broader set of projects that were underway, there were other projects that were analyzed in our travel demand projects, which didn't make the cut. Well, there are some roads where this is a problem, but these were not considered because congestion pricing could only be implemented on existing projects. MPC commissioned a study to pick existing lanes and price these, they proposed to implement this on Kennedy I-94. They did a study and their preliminary results were that it would be beneficial, but again the problem is that tolling existing lanes is difficult to pass because of political reasons. Technically, there are huge advantages of doing so, but politically it is a big ask.

Congestion pricing and learning from other cities

We were impressed with the 91 express lanes in California, because afterwards there was better safety, better highway performance, more capacity. The areas of concern are probably the popular politic aspect, so what does the agreement with the concessionaire, are you really giving an advantage to this private road operation, when you really need to build a road down there. But the agreement prohibits that, because they don't want competition, so making sure that a private enterprise gets a fair profit, but not more than a fair profit. Also controlling the risk of traffic, so building needs facilities assuming a volume of traffic, and you may get revenues from that facilities that you can use to help pay for the project. The problem is when it is with a private enterprise in particular, who takes the risk, when the traffic doesn't grow, when there isn't the demand which you thought there was.

I guess we'll be looking towards cities like Miami, Seattle, Washington, Houston where congestion pricing is now being implemented. In Minneapolis congestion pricing was implemented on the most constrained and really going towards low cost, with a shoulder lane which would be congestion priced. This is actually closest to the Stevenson expressway, so this would be the best comparison. Miami is more a capital intensive project. But you know, they're both places where it worked out well.

Congestion pricing and equity

People with lower incomes often have less choice for choosing their jobs, which means they are tied to certain schedules and they have to travel over a bigger distance because of the spatial mismatch of jobs and housing, so right now with limited capacity and no choice but to face congestion or to go by low speed transit. The folks that are most often using the low speed transit are the ones with lowest income. It is true that a priced express lane will be less attractive to the lower income people, but there may be an economic cause to use a priced facility, for example people who need to get to their job on time, who may need to get to day care to pick up their child, this also accounts for the lower incomes. So the idea is to provide more economic choice so people can decide what's most appropriate for them. So what we've read about the experience from other towns doesn't indicate that those facilities are just for rich people, but for people with a variety of incomes depending on their needs. But it is an issue that needs to be addressed and there are a lot of ways to address it. First, we invest in better transit on the expressed toll lanes, stimulating carpooling to use the expressed toll lanes. It is good to look at other cities and how the facilities work over there in general.

Congestion pricing is typically paid by car registration fees, gas taxes, usually for the highway improvements local residents don't have to pay directly. So there are local costs, but the costs for the highway improvements will be paid by the state and USDOT, local governments may have to pay for facilities at the side of the roads. We have occurred a lot of resistance against congestion pricing itself, mostly against the fact that they're building new highways itself, like IL-53. This proposal has been changed, but it is still a project although many local residents don't want it. The opposition to those new roads is often very locally.

Congestion pricing and public transport

Our policy is that express bus lanes and express toll lanes go together. Because you have better service, right now the buses on the highways are also facing congestion, so one thing we've done is adding shoulder lanes on the Stevenson expressway, so they're able to bypass the congestion. So their reliability has improved dramatically and the speeds really improved, they have attracted more riders and they have added more buses. We have a lot of commuters who use the buses who live about 40 or 50 minutes from the city center and with these buses on express lanes the time decreased a lot to get into the city center.
We are actually funding with the CMAP some Park & Ride facilities and bus facilities along I-55 and I-90. So with buses on expressways we want to set up a suburban based network, going on high speeds.

There are institutional barriers towards a transfer of money from the toll roads to public transport, and I don't think it's been entirely worked out. I am sceptical, because the revenues won't cover the costs of building the road. And what we did on the I-90, was using other money to facilitate the express bus lane, we didn't use the toll money for this. We're chronically short of revenues, so the policies try to find a way to do that, but again there's so many barriers to actually transfer the money of a highway project to public transport. I am really sceptical that it can happen.

Practical issues of congestion pricing

The Kennedy Expressway would be the best road for the implementation of congestion pricing. We don't have an active capital project on that road, it has just been rebuilt in 1993, so we're not going to tear that road up, to reconstruct it with a new lane when other roads have pavement which lies there more than 50 years. If we have success with these other congestion pricing projects and people actually see the benefits then congestion pricing might be implemented on this road, at least then there's a more reasonable argument.

They built the roads looking for a time plan of 40-50 years. So right now, we don't really need congestion pricing, but the problem is that the pavement is often the problem, when it's 50 years old, it's falling apart. If you have to rebuild it, do you rebuild it to what you need right now, or do you look forward to 20-30 years? And the answer is almost always that you have to build for the future.

Costs of congestion pricing

When you look at the total costs, which we would have to pay almost all anyway, simply because we have to rebuild the roads. I don't know if we have such a specific thing as a benefit cost ratio. When you talk about all the benefits, like the economic development because of better traffic reliability, decreased travel times. The short answer is that we don't really know, that's the truth.

Sabina Shaikh
University of Chicago
15/02/2016
Telephone interview

Introduction

Sabina Shaikh is lecturer at the University of Chicago. She is specialized in Economics, Public Policies and the global environment. She was the supervisor of Jorgen Harris and contributed to the article 'Value of time clustering and the efficiency of Destination-based congestion pricing.' Since this article is used as one of the key articles in this thesis, it is interesting to hear the opinion of Sabina Shaikh on the topic of congestion pricing. Therefore, she is familiar with the topic of congestion pricing, but not very specialized in the kind of analysis which has been executed in the paper. For this interview we have agreed on a telephone interview on the 15th of February.

Purpose of the interview

The purpose of this interview is to get a better view of the main issues related to the implementation of congestion pricing. Therefore this interview can be used when the hypotheses for this thesis will be stated.

Main findings from the interview

Sabina Shaikh is not particularly in favour of zonal pricing, cordon pricing or express lanes, but thinks it depends on the level of the fees what system works out the best in Chicago. Zonal and cordon pricing have been successful in Europe she says, in Stockholm and London. It has the positive effect of reducing traffic in the city center. It works well as an instrument for people who work in downtown and live in the suburbs. They are likely to switch to an alternative transportation mode when cordon pricing or zonal pricing is implemented. Although the idea has to be rethought when it would be implemented in Chicago, and has to be made more simple. For example with priced parking.

The concept of express lanes is useful according to Shaikh. Express lanes can best be implemented on a state-level, as it has an impact on a state-wide level. Whether congestion pricing on express lanes is a good idea for Chicago depends on the traffic peaks on the highways in Chicago and especially alternative routes which are offered to people.

Shaikh thinks low income people will switch to public transportation when congestion pricing is implemented, because congestion pricing might be inequitable. Therefore she thinks it is very important to offer alternative modes of transportation when congestion pricing is implemented, of which public transport is the main mode.

Marko Nie
Northwestern University
19/02/2016

Introduction

Marko Nie is an associate professor of civil and environmental engineering at the Northwestern University in Chicago. Nie has published several articles on congestion pricing, which is his main research subject. In this thesis the following article has been used: *Nie, N & Yin, Y. (2013) Managing rush hour tradable choices with tradable credit scheme. Transportation Research Part B Vol. 50 Pp. 1-19.*
For this interview we have agreed on a in person interview at the office of Marko Nie at the Northwestern University.

Purpose of the interview
The purpose of this interview is to get a more detailed view on congestion pricing in Chicago and especially to get a better view of the opinion of researchers on the implementation of congestion pricing in Chicago.

Findings from the interview

Pushback for congestion pricing

There is a lot of pushback in the US for congestion pricing for a number of reasons, people think this is just another tax, which it is not, people think it is unfair because they have a different value of time. You are basically discriminating people by income, poor people are tolled off. So people think it is unfair, so for these reasons it is hard to implement in the US. I think there is a consensus in academia that it is a good idea, generally speaking. It has improved efficiency.

Different forms of congestion pricing

So, one of the congestion pricing forms are High Occupancy Toll Lanes. There are already High Occupancy Lanes, but these are not very well used. These lanes used to be called HOV lanes. We wanted to improve the carpooling rate, but it wasn't very successful. Across the whole country the HOV lanes were underused, there is very little traffic on the carpool lanes, whereas the rest of the road can be extremely crowded, especially in California.

So the HOV lanes are already there. Politicians can therefore easier implement congestion pricing on these carpool lanes. That is how the USA is trying to implement congestion pricing. If you add a new lane and you make it a toll lane, there might be bigger support compared to implement a toll on the entire road. In countries where there are extreme congestion problems like in China, even there it is extremely controversial to implement congestion pricing. There is no city in China so far which has implemented congestion pricing, even in a country like China, where the government has a lot of power. They are also not able to put it off. There is so much pushback from the people.

Cordon pricing can work in some places, it depends on geography and topology. In Singapore it works very well because they have a well-defined downtown area. It's a fixed amount of money that you have to pay. Singapore was the first city in which congestion pricing has been implemented. In 1998 they implemented the Electronic Tolls, so since then they started to price it in a dynamic pricing scheme. When you charge a different toll on different roads for different

times, this sounds like a good idea, a way with which you can create an optimum toll price. But I think this is not going to work out. For cordon pricing it is likely that you move out the congestion from the city center to the areas around the city center. People will start driving to the edge of the cordon and then take public transit.

So, the optimal goal is to encourage people not to drive at all. But this requires very restrictive measures for example to let only certain people allow to drive on certain days. So, typically you will not be allowed to drive one day out of five. But this won't work in America, because the infrastructure is organised in such a way that people have to use their car. What can be done is letting people allow to buy the right to drive from other people. But still it is extremely doubtful if this would be possible to implement in the political environment of Chicago and the United States in general.

The case of congestion pricing in Chicago

Chicago has a few choke points. So I would put a higher toll on those choke points. Chicago already has the toll system with a tollway authority. But this toll is not aimed at reducing congestion, their goal is to get money. If we can increase this toll that already exists in the rush hour, this would have a better effect. At the moment there is a big congestion problem in Chicago. If I depart from this place at 7.30 it is going to take me almost one and a half hour to get to the downtown. Especially the point where the Edens Expressway and the Jane Addams Memorial Highway merge to the Kennedy Expressway is extremely congested. Even the highway which goes in the opposite direction is very crowded in the morning. So my idea is to set a toll in the rush hours on all the lanes. One can argue that this is unfair to people with lower incomes, but people only pay for driving during rush hours when they have to. Other people will not drive or drive on the arterial roads if they don't have be on time somewhere. Any policy would hurt some people and benefit some people. If it is somehow possible to collect money and to redistribute this money in a way that everybody is better off, this would be pareto-efficient.

Congestion pricing on the Stevenson Expressway can definitely work. I think what we need is just a peak time toll. But still congestion pricing is much easier to implement on tollways, because the system is already there. There is no need to change the actual infrastructure, you just need to change the toll rates, that's very easy to implement. If it is only built on the regular freeways you would have to build all the infrastructure. I don't think toll ways are that congested anyway, it is much better than the regular freeways. Especially the highways close to the city center are quite congested. The roads close to the city center are always very crowded, because there is a lot of traffic going in and out. One of the problems with these roads is the ability to absorb traffic is limited in the city center by the signals. This is one of the major problems, congestion happens at the choke points in the city, not really on the freeways, that's the main problem. And when the congestion starts to spread on the freeways, this will happen very quickly, all the way to the merge points of the Kennedy and Edens Expressways. So, I think a peak time toll will definitely help from a technical point of view. I'm not sure if we need a toll after the rush hours.

Chicago has a loop detector system. You can get this CMAP network data. You can also try the national travel survey. CMAP has also done their own survey. I think it is hard to implement income in a congestion pricing analysis, but it is very interesting in Chicago because people live segregated based on their income. But there are some complications when the factor income is incorporated in the analysis, like multi-class. There could be a significant effect of income and segregation linked to the demand for congestion pricing. I would support the idea for peak time

tolls, but a uniform toll for all highways, because a discriminated toll is even harder to be accepted I think. It makes sense, theoretically, but people from the north side will definitely complain.

I think it is easier to accept for people when they are allowed to drive for free with two or more persons in one car. Encouraging people to carpool without charging them is a good idea I think, because of the potential to reduce the amount of cars of the way, so I would support this idea for HOT-lanes. In Chicago there is not enough space for this HOT-lane, especially on the most congested roads. There are reverse lanes on the Kennedy Expressway, even those lanes are very congested. When the existing lanes will be turned into toll lanes, this will worsen congestion dramatically.

Congestion pricing in other cities

Unfortunately, I am not very specialized in the congestion pricing projects of Minnesota and California. Maryland has also implemented congestion pricing, just like Texas. In Maryland a kilometer toll will be implemented, this will probably work out very well. This is a fair system and the revenues can be used to invest in the highway system. Currently, we are funding the highway system with a fuel tax, which doesn't work very well. Basically, this toll can just be calculated. The costs of maintaining and expanding the highway system can be calculated and then there has to made sure that everybody shares these costs. And the share for one person, depends on how much you drive. Oregon already did a couple of pilot studies and it worked out pretty well, it is just political will. The US should definitely do this, because the US transportation system is broke. When this system is implemented, congestion pricing can be added on top of this system. It might take 10 years to implement such a system, but it is definitely doable.

Congestion pricing ideas for the future

In some decades from now everyone will probably drive an automatic car and there is no need anymore to own a car, when people can just order a car when they have to go somewhere. That's actually another thing, because transport modes are changing rapidly. Transport is at the moment at a major intersection that could profoundly change the world. When I would be a policymaker I would wait with investments until technological process has been made.

When the money is collected for congestion pricing this money can go to public transport, so the poor people can make use of a better public transport system, this is the traditional way of dealing with this equity issue. Another idea is the concept of tradable credits. In this system the government will just charge your credit, but this is tradable. So poor people can choose to sell their credit when they don't need to drive. They are being tolled off the road, but they will be compensated with this money. Hopefully, this option will create a better equity. Rational poor people will just take the money instead of still drive in the peak hours.
And sometimes these congestion pricing schemes are very expensive to operate, so there is no money left to invest in public transport. Sometimes it is not even enough to pay for the project itself. Hopefully, technology will be improved so this toll system can all be done automatically.

Peter Skosey
Metropolitan Planning Council
19/02/2016

Introduction

Peter Skosey is the executive vice president of the Metropolitan Planning Council. He has had a key role in the progress that the MPC has made in the last decades. He works on transportation issues in the city of Chicago, of which congestion pricing is one of the aspects. The MPC has done research on congestion pricing in Chicago in 2010. For this interview we have agreed on an in person interview at the headquarters of the MPC in downtown Chicago.

Goal of the interview

The goal of this interview is to contribute to the general knowledge of congestion pricing and visions on the topic of congestion pricing in Chicago.

Different forms of congestion pricing

I think all forms of congestion pricing can work, in the right circumstances, when we did that 2010 research, one of the primary reasons we did, was to see whether cordon pricing was a good idea for the city of Chicago. Part of what we determined as a result of that is that based upon of the facts of congestion in the city, and basically the lack of congestion that we had in the central bussines district, that cordon pricing would not be a good strategy for us. In fact the level of congestion on our arterial road ways as well as our highways was evenly shared, so it's not just a matter of restrictive access, or it wasn't even that was where the greatest amount of congestion was occurring. Now there are still people looking at cordon pricing because it raises a lot of money, but we don't believe that raising money is the most important of congestion pricing. First and foremost it is about managing the demand and smoothing out the peaks, if it makes money that´s great and then that money can be used, we would use it first for the maintenance of the system, and then what is remained can be used to invest in transit services.
So cordon pricing for Chicago, we don't think is a good approach, we are quite fond of the linear pricing. As far as HOT, HOV, or just straight managed lanes. HOT and HOVs have kind of fallen out of vogue, we are not so concerned about high occupancy, but more about managing the flow, so we can create congestion free traffic. Texas has some managed lanes, Virginia, Miami and Maryland. And so I think we've moved away from that concept, and rather just implement dynamic pricing in a lane, and give people the choice to use the free or the managed lane. That was the proposal that was just one and a half week ago for the I-55. I-290 and the Kennedy Expressway are certainly good viable next case opportunities, but the 55 is actually going to happen.

Expanding the cordon area

It is again the question, what are you managing for? It depends on how big you draw the circle or where you draw the circle, the congestion is already evenly distributed, so the only reason then would be to get people out of their cars and get them on to transit, but we have this problem here in Chicago that we have a big office core in downtown, but we also have office development in Rosemont and Oak Brook, so would a cordon pricing have the effect of driving development out to these other nodes? And that's something people would be concerned about and given cordon pricing is not the best approach, that's a change I'm not too excited about to take. I wouldn't want to drive development away, you put development out in Oak Brook in

Schaumburg, those areas are not well served by transit and the only way to get there is to drive.

Congestion pricing in Chicago

Setting the price based upon the income of the region is probably not the right way to go. I think what might end up happening is, the price should be based on keeping free-flow traffic, and since the people on the north side are willing to pay more for avoiding the congestion, the price might end up being higher than for people on the south side of the region. So let first and foremost move the cars at 55 mph in that managed lane, not the socioeconomic circumstances in which those lanes reside. I think people who need to arrive on time will pay for the managed lane and other people don't. Most of the research I've seen about people who use congestion priced lanes, there isn't a big disparity between people. I always like to say poor people value their time as much as rich people. There is more instances where you could imagine people of lower economic status can't be late for work, they get penalized more than a white penalized office worker who arrives at 9.10. So I see it really working across socio economic classes.

Proposal for implementing congestion pricing in Chicago

What we need in this region is to just get it somewhere, we should show that it works to implement congestion pricing. Putting it on the I-55 first makes sense, because there is already a shoulder lane which we can convert to that managed lane. So the costs are relatively cheap compared to other highways. So as a first case test pilot I think it is a right way to go, I think there is a lot of opportunity on the Kennedy highway, it has the reversible lanes, but it would be really hard to take them away from people and make managed lanes out of them. This would cost us a lot of political support. This first proposal is about adding something new, so we're not taking anything by pricing the shoulder, because there is no one driving on the Shoulder today. So I think as a good first case it is great, because we're giving the people something new, they see that it works, they will think it is wonderful. And then we will have support to implement it on more highways. A different point of view is when you look at what is the most congested corridor in the system it is not the I-55. But because it has the least barriers to implement it, it is the best choice. So again I think the first step is that it got to be a free lane, but when people see it works and we get the support I would like to think and I hope that we can start managing all lanes. There is no way why the entire toll system couldn't be managed with dynamic pricing. But for political reasons it is difficult. In long term I'd like to see that, but I'm just trying to think pragmatically.

The effects of road widening

If you widen a road it is on average back to the same congestion in less than 10 years, 7 years. So you probably finance it for 30 years, so you pay 7 years for improvement and then 23 years you pay for nothing. So that's the problem with that approach. With the managed lanes you guarantee through pricing that you create a free-flow. Again very important also to provide alternatives, so to provide transit, that's gotta be key factor for all approaches. But also you have people thinking differently about land-use decisions. If it's going to cost them 10 dollars to drive in every day, maybe they will think of moving closer to their jobs. In America we haven't priced these decisions very well, most people have basically seen them as a free choice. So a lot of people moved to a far suburb, because the house prices are cheaper but they don't factor in the transportation costs. And with congestion pricing, people will have to pay the full transportation costs. So this is about maybe finally getting that land use equation to balance a little better.

The future of congestion pricing in Chicago

I think the I-55 lane, if that becomes our first test case for managed lanes, it is estimated that it would cost 420 million dollar to pay the project. Let's assume the tolls only cover the maintenance and operation of the toll lane. The I-55 is only the first step and when we get to the point that congestion pricing is accepted in the region, and then for example the toll highway authority implements it on all the lanes, then there will be some significant benefits. So that's the scenario of the future you want to move to.

And when it comes to the point that it is being accepted and we can start implementing congestion pricing on existing capacity, and maybe not even the entire highway, but taking a lane out of the Eisenhower for example, we only have to pay the tollway infrastructure, and then maybe that starts to generate additional benefits for transit. So it's not something that's going to happen right away, but after some time it is definitely possible that more benefits will be created so the revenues can go to public transport.

P.S. Sriraj
University of Illinois Chicago
17/03/2016

Introduction

P.S. Sriraj is Interim Executive Director, Director of the Metropolitan Transportation Support Initiative (METSI) and Research Associate Professor at the Urban Transportation Center at the University of Illinois at Chicago. For this interview we have agreed on an appointment in the office of Mr. Sriraj at the University of Illinois Chicago.

Hypothesis 1.

The characteristics of Chicago show that the best form to implement congestion pricing is a facility-based scheme.

Let's take the HOT and HOV lanes, that's something they can definitely look into. When they're experimenting with the I-55, it's going to be managed lanes eventually. So, there are two issues here. One is whether any of these will be feasible. Let's first address the feasibility of any of these proposals. I think the single lane specific corridor is a lot easier to manage than a cordon, which makes life a lot more difficult for many people. Just because the jurisdictions that you have to come across, this gives a lot of more issues than just operating on a single corridor and applying it there. Now, there is one big issue, that if you take away an existing lane then this will have an effect on the rest of the population with respect to capacity. So I think on the I-55, they're looking at taking the shoulder and using that. So, at the moment the shoulder is used for maintenance and Pace is using the other shoulder for the buses. So what happens in case of emergency, I don't know how the logistics are going to be worked out. I would go for the corridor with the single lane corridor instead of the cordon, just because of the feasibility, it's easier.

And then with a cordon, there is the question of what would be the cordon? This really varies on who you talk to. Some people might say it is Wacker on the north and Congress on the south and it can extend all the way to Halsted in the West in some studies that I've seen. The CBD itself is a messy place, because of the lack of parking and there are a lot cars. That's not the only area that needs to be addressed with a cordon. The cordon is for a larger area. In London it is not just the CBD. So the question is whether the city of Chicago will benefit from the cordon, and it may. But there's also all these expressways that come into the loop. The I-94 is one of the top 5 most congested roads in the country, the I-290 is not too far back. These roads will all be influenced by a cordon, so the question is how do you implement the cordon in such a way that it has some impact on the expressway also. It is more or less a continuous peak through the day, there are no valleys. It starts somewhere in the morning at seven and goes on through the day. So I think a cordon will be effective but it just may not be feasible.

Hypothesis 2

In Chicago, congestion pricing will cause more new developments closer to the city center which will result in a more densely built city.

I doubt it, because it's almost an irreversible process. Chicago is almost as sprawled as possible. And one thing that's happening in Chicago, that there are a lot of neighborhoods that start to gentrify. So more and more richer people start to move to the city, but a couple of days ago I saw

a news article about how seniors are moving back to the city, because they find it a lot more manageable in terms of their mobility needs and various other aspects. So there is an influx, but it is not going to result in people making different choices regarding their housing. So when you move away from the city the home prices go down, but transportation costs will rise. So that's essentially what's going to happen. So whether you pay less for your home and pay more for transportation. So for a family that lives in the city it will stay attractive to live in the suburbs. So, initially there will not be a big change. Maybe in the long term, with more policy initiatives that are aimed at altering land-use, then you can start to talk about making some changes. But from an equity perspective, you still have the majority of the poor living in the city, so they have a fantastic transportation system, to take advantage of, but the jobs are all in the far suburbs, so the transportation system doesn't provide the accessibility that is needed. So they are still dependent on the cars. And one thing that is happening, that more and more poor people are migrating to the suburbs, because they are going where the jobs are.

Hypothesis 3

A dynamic pricing scheme has to be implemented in Chicago in order to maintain free-flow traffic on the express lane.

I agree. It has to be dynamic, it has to vary. That will be the true spirit of congestion pricing. They do that in the Western part of the country, there are some examples of dynamic congestion pricing. Otherwise it just becomes tolling. So if the intent is to manage congestion, it has to be dynamic.

Hypothesis 4

When congestion pricing is implemented on added lanes to have more capacity and no other measures are being taken, this will only reduce congestion temporarily.

There are two things there. One is that you say that congestion pricing is implemented and the second is that the lane will be added. So there is a lane added to the free-flow capacity. The demand for the road is always going to catch up. Adding a lane is never the solution for reducing congestion, all of the studies have shown that. And so no matter how much capacity you keep providing there is going to be an equal demand, and so from that perspective I would always look very carefully and closely to adding a lane. And it may benefit in the short term, definitely, but it is only a very short term.

You have to be careful. What you want is enough movement. Is primary the motivation to make the express lanes very appealing, or do you want overall mobility to be improved? These are two different goals, and in my opinion it should be the latter. So you set the price at such a point where there will be enough movement on the express lane, but at the same time it has an effect on the free lanes, so overall mobility will be improved, that should be the goal. You want to adjust the toll, so that the demand is kept under control. That should be the spirit of congestion pricing, that you improve the overall mobility. And also what mechanism you use towards making the pricing dynamic, and at the same time make sure everyone benefits. If you do it only for the people on the express lanes then the equity issue starts to rise.

Hypothesis 5

The current proposal for congestion pricing in Chicago has a good chance to succeed, because of the visible benefits and low costs.

I think there is some validity to it. Because they have improved the shoulders for the bus to use it. If you're using the same right of way for tolled traffic then it makes it easier to get political support. That's important because there is always going to be questions about the feasibility. I'm sure they can simulate it so that it is going to work out. And if they didn't have the Pace buses on the shoulders, what would have happened? Would they have been able to pass this? Probably yes. And then it may not have been an issue on part of the planners or decision makers, it would have been an issue on the part of the public. Now the public is seeing the buses on the shoulder, so there's been enough learning curve, so it will be easier for the public to accept and adapt to that behaviour.

Hypothesis 6

Despite a lack of support for different toll prices for different highways because of income segregation, it is likely to be the outcome due to more demand for express lanes in richer neighborhoods.

I don't know. That's very difficult for me to visualize because when poor people live on the south side this doesn't mean people from the north side don't drive through the south side. One can even say that the toll on the north side should be lower or the toll on the south side should be higher, depending on who heads where. So unless someone does a very focused survey, with respect to willingness to pay, it will be very difficult to answer. When I think about it right now, I would dismiss it, it doesn't hold water. I would like to see papers about this, before I believe it. It's so farfetched in my mind. I don't think I know any toll system that is geographical separated like that, it will be very difficult.

Hypothesis 7

Investments in public transit on top of congestion pricing are crucial to create a more effective, sustainable and equitable system and gain more support.

It's not just public transportation, there are overall improvements that need to happen. Make sure you provide feasible alternatives for those that cannot use the priced lanes. So you should not be disadvantaged because someone else is benefiting. That's the whole spirit of environmental justice. So if you make an investment to improve a facility, that improvement should not come at the cost of someone else having a disadvantage. So to your point about improving public transportation. That's just one aspect of it. You have to improve the entire system. You have to look at the overall goal of implementing congestion pricing. Certain initiatives are taken upon because they seem to be the most appealing thing to do, while it's a good thing to make new technologies and implement new ideas. The fundamental principle of what you're trying to achieve should not be forgotten. And the fundamental thing to do is to improve the mobility for the whole region. So public transportation is just of one these solutions. It is about providing easier alternatives for those that cannot use the managed lanes. On the free lanes it is also important to keep a high mobility, but it is very complicated to have a same speed as the managed lanes, it is still going to be congested. But what's going to happen, you have to improve the arterial system as well. So if you take the interstate toll road, they have the parallels that are untolled, so you can make the connection from New York to Los Angeles, you can take the freeways or the toll roads. There is an alternative that has to be provided. Similar with the express lanes, that becomes part of the toll system. It is the responsibility that the arterials, which are the

next level down, are being improved. That would include traffic signal priority scheme, dedicated truck routes separating truck traffic from the regular traffic, speed management. So there's a lot of initiatives that need to happen with investments and enforcements at that level to help people who are priced out from the express lanes to prevent them by providing some alternatives.

Additional remarks

Congestion pricing can succeed, only with very strong political support and there should be an overall vision. There are a lot of red light cameras where if you violate the red light, if you drive without stopping at the intersection you get a 100 dollar fine. When it was implemented it was seen by the public as an instrument to reduce accidents. But all of the data since then has been showing it is not very conclusive, that the accident risk would reduce. Some locations have seen increasing accident rates and some have seen no difference. So it is only a system to gain revenues. So that's the fear, selling something that it is not. If you all sell the product, if you say we put on congestion pricing on I-55, so it has an average speed of 50mph, then you set yourself a fore failure. So you need to have a very clear idea of what you're trying to achieve by implementing congestion pricing. That's the key aspect of any public policy in my opinion.

Joe Schwieterman
De Paul University
12/04/2016

Introduction

Joe Schwieterman is a Professor in the School for Public Service. His main research focus is in the fields of urban planning and transportation. He has written several books on this topic. Also he has advised a lot of planning organizations in his career and he is frequently seen on television or heard on the Chicago radio to talk about transportation issues. For this interview we have agreed on a telephone interview on the 12th of April.

Hypothesis 1.

The characteristics of Chicago show that the best form to implement congestion pricing is a facility-based scheme.

With zonal pricing anybody travelling within a zone pays a fee, with a cordon you only pay a fee when you cross into a fee. I'm a sceptic of doing zonal or cordon pricing in the city of Chicago. I think a facility-based scheme is a better idea. This is because the worst congestion in Chicago is not happening in the downtown area, it is on expressways on choke points around the city. Cordon pricing is a set of policies aimed at reducing congestion in the downtown. In my view downtown traffic flows much better than the expressways, there are some exceptions. North of the river it is really crowded for example. My recommendations for the region would be to have congestion lanes on the expressways, to have a set of toll roads throughout the toll roads.

Hypothesis 2

In Chicago, congestion pricing will cause more new developments closer to the city center which will result in a more densely built city.

That's an interesting hypothesis. I know one effect and that is that congestion pricing will discourage people from coming to downtown, if it will cost you five dollars to get into the city. So people living in the suburbs will go less to the downtown. Because driving will become more expensive there will be more transit oriented development. So I would say on balance what you say is probably true. If you make driving more expensive by fees, people will more often use transit, resulting in a more densely build city.

Hypothesis 3

A dynamic pricing scheme has to be implemented in Chicago in order to maintain free-flow traffic on the express lane.

I think we have really long rush hours here, it's not just 5-7 pm, but 3.30 until 7.30. But there's no real need for congestion pricing at 9 pm or 5 am or during the weekends. But I agree with you, it has to be dynamic in order to be effective. When there is a cordon fee it is complicated to have a dynamic pricing scheme, this cannot be different for every other day. But when we talk about express lanes, it is very important to have a dynamic pricing scheme based on the demand. When traffic is unusually heavy one day the prices have to go up.

Hypothesis 4

When congestion pricing is implemented on added lanes to have more capacity and no other measures are being taken, this will only reduce congestion temporarily.

I would actually disagree with this hypothesis. I would say it would increase congestion elsewhere, because there will be highway traffic that doesn't want to pay a toll, and therefore uses other roads. But with added capacity you raise supply and you can manage the demand on the priced lanes, so this would have some effect. Even if you don't congestion price the added lanes the research shows that with 10% more capacity there will be 8% more traffic in the long run, it doesn't go 1 to 1. So I think there will be less congestion on the highway.

Hypothesis 5

The current proposal for congestion pricing in Chicago has a good chance to succeed, because of the visible benefits and low costs.

Well, I think it is a great proposal. CMAP is doing a great job, it is in the long range plans. But I'm not sure if it has a great chance to succeed. I don't think we have yet had a real public debate and I don't think suburbs are interested in it. They're still trying to determine if there is political will for it. There hasn't been talked about it as much as should be. We can still not say if the plan is likely to happen. I think the Stevenson is an excellent proposal, because the highway needs to be rebuilt anyway. I know CMAP has a proposal for express lanes on the Eisenhower expressway. The real missed opportunity is the tollway system. We don't have a toll structure that can deal with different rates during peak and off-peak times. I think it is a missed opportunity not to charge 75 cents or 1 dollar during the rush hour and 50 cents during the other times of the day to encourage people to shift to different times. It is a very easy thing to do from an administrative standpoint, it's a shame. The Tri-State is the most prominent tollway, but there is also the Northwest tollway. There is already a toll system and it could work without managed lanes, so with different rates at different times, discounts when there are more people in the car, some ways to change behaviour in a social beneficial way. They raised the rates two years ago, and they didn't even have a discussion about it. Maybe they should make the rates cheaper after 10 o'clock at night or have a carpool or something like that.

Hypothesis 6

Despite a lack of support for different toll prices for different highways because of income segregation, it is likely to be the outcome due to more demand for express lanes in richer neighborhoods.

Well, that's an interesting question. I think from an economic view you would need to have different fees. The goal is to change behaviour, and changing behaviour depends on income. So for wealthier people it takes a bigger price difference before encouraging people to shift. I guess what makes that argument difficult is the general belief that at the end of the day, you should just have enough revenues in order to maintain the road. And who gets the money when the north side gets charged more? Will this money go into the pockets of the other roads? By this pricing scheme a larger social goal is being tried to achieve, which may be beyond the scope of building a good highway. But I think you're right, it would have to be different. I think though the differences would have to be small between the north and the south since there is so much through traffic and traffic coming from the suburbs. Even on the Dan Ryan Expressway there are people from all over the US traveling on that road. Your point is well taken, a difference may be good.

Hypothesis 7

Investments in public transit on top of congestion pricing are crucial to create a more effective, sustainable and equitable system and gain more support.

I would say that is true in Chicago. I'm not sure if that is true when we're talking about the express lanes in Florida. In Chicago public transport is a major part of the total transport equation. I think it is true, but the trouble is though the idea that congestion pricing on the highway doesn't make sense unless there is a lot of money being invested in the public transit. If that's the premise, I don't think that is true. I think congestion pricing on highways all by itself is a really good thing. Now it would be better if it was more of a holistic plan of which public transit is a part, you don't want the transit plan to be independent to that. When congestion pricing discourages people to drive then the public transport system is better prepared for these people taking transit. I'm not sure if the public transit is ready for it at the moment, because the red line has reached its capacity, the Metra is pretty much full at rush hour. So it's not an easy question but I think the answer is yes. Now, whether or not the fees for congestion pricing should be used to pay for transit, that's a little bit more difficult question. I would say yes in some circumstances. Not all congestion pricing have a transit alternative, like in Florida with congestion pricing projects between Orlanda and Tampa.

Jorgen Harris
Cornell University
13/04/2016

Introduction

Jorgen Harris is currently a PhD student in Economics at the Cornell University in Ithaca, New York. When he was attending the University of Chicago he wrote the article *Value of time clustering and the efficiency of destination-based congestion pricing* (Harris & Shaikh, 2011). In this article he describes a method to research the demand for congestion pricing on different highways in Chicago. This article is useful for the quantitative data analysis which is executed in this thesis. For this interview we have agreed on a skype interview on the 13th of april.

Goal of the interview

The goal of this interview is to understand the background and methodology of the article *Value of time clustering and the efficiency of destination-based congestion pricing* (Harris & Shaikh, 2011), so this knowledge can be used in the data analysis for this thesis. Also this interview is used to test the hypotheses which have been presented in chapter 4.

The methodology for the article Value of time clustering and the efficiency of destination-based congestion pricing (Harris & Shaikh, 2011)

The approach that I'm using comes from a welfare economic standpoint. We wanted to calculate the externality cost of driving and the damage that it imposes on other drivers. And then say that the optimal tax is the tax that equals the externality, so you can internalize the externality. So value of time is therefore an important factor in a person's decision whether to drive or to take transit. It's also important that when you know everybody's value of time, you can calculate the consequences of driving for everybody else. Part of my idea was that, because Chicago is segregated by income, you think of wage rates as a reasonable proxy for value of time, since a lot of papers assume the value of time to be half the wage rate. People dislike commuting around half as much as they dislike working. So the idea was that I was able to get a distribution of the value of time in each neighbourhood, I was able to say what cost drivers impose on others. So I guess there are two things: One thing is what are things that you think are important? And the other is: What are the things that you can measure reasonably? So you know, getting at what's the length of commute for drivers vs. transit users? Using census data is relatively straightforward, because you can ask people what their commutes are. And for people coming from different neighborhoods, how much quicker are the car commuters than the transit commuters. And especially since they ask if you work in the central city of Chicago, and since the central city is quite small in Chicago, you can make some clear statements about this. So I also put in the utility preferences from driving, I wasn't super satisfied by using the utility function. You need to know the distribution of income for transit users and for drivers. Because my model was simple it just has money costs, which I think are the same for everybody, utility costs which are the same for everyone and then the value of time. It means once I know people's value of time I can put everyone on a line and say: If you're driving, then everyone richer than you must be driving. And then you can test who is the marginal person, if you drove the person below you might be taking transit. You keep on checking down until you find the marginal driver and then you solved the model for that particular tax rate, so that was another reason.

I was using the census microdata, which puts people in really big geographical blocks, which was less specific than zip codes. So the specificity was basically able to tell you the three different parts of Chicago, South side, West side and North side and then three other areas in the suburbs. So it was good enough that I was able to tell what highway people were closest to, but it wasn't good enough to say how long your specific commute was.

Critics about the paper

Not being able to see where the traffic on the expressways comes from, where they live etc. This is something I worried about. There are people who do cross city commutes. They live in the south side and move for their jobs to the north side and vice versa. I was a little bit concerned about this issue, but not terribly concerned. Because when you look at this travel patterns, especially during peak commute times, the outbound traffic from the city is pretty light. Even if all the outbound traffic in the city was people passing through rather than people doing a reverse commute it would still be a pretty distinct minority of drivers. The plan that Chicago had was charging people when they park their car in the central business district. It wouldn't impact people who passed through the city.

Hypothesis 1.

The characteristics of Chicago show that the best form to implement congestion pricing is a facility-based scheme.

So there are two things that happen with express lanes and HOV-lanes, especially express lanes. Part of what you're doing is you're separating the high value of time commuters from the lower value of time commuters. So you take one lane of the highway and say you have to pay if you want to use this lane. All people who are high income or are in a big hurry that day are going to use that lane. What's probably going to happen, and there are a couple of papers that look at this because they do this a lot in California, traffic may actually increase on the non-express lanes, because people get pushed out of the express lane. It is not clear if congestion pricing has a big effect on the welfare distribution, it depends on how big the income differences are. You might say, okay we are going to make the commute times for 70 percent of the people longer but we are going to have massive revenues from the 30 percent with the highest value of time. And with this money the schools can be funded or the CTA.

Also, in Chicago there are a lot of people who commute pretty long distances without getting on the highway. There are a lot of arterial service streets that can handle a lot of traffic. So even when you say we're going to put tolls on the highways, rather than doing a cordon, you still have this problem of segregating traffic by income. One thing that makes a cordon pricing scheme harder in Chicago is that there ain't really obvious geographical barriers. New York city was considering this for example. The cordon here is straightforward, just put it around Manhattan. You just have to charge people when they go over the bridge. Chicago doesn't really have that sort of thing. I think that there are trade-offs. I would really look at the distribution of income with this hypothesis, for drivers especially. So there are two questions here: One is identify people who will use the express lanes, the other thing is trying to estimate the effects on traffic speeds by reducing free traffic from three lanes to two lanes. There is probably enough variation in the amount of lanes on the Chicago highways, that you can make a good estimation with using data on this.

You can imagine having several different cordons and then charge people based on how deep in the city they are. And that might also be a way to address this. Then there is the question of where the congestion is occurring, who is causing this congestion and what are their destinations? So the choke points on the highways may be where there are major entrances. Popular entrances may not be close to the CBD, but if everyone is still trying to get to the CBD, a cordon around the CBD might still be effective. If you're seeing a lot of people making commutes across the city then a cordon around the CBD gets a lot trickier. And the way of how you implement the cordon, whether it is based on parking or on pass through is going to matter. And if you see a lot of people kind of never connects to the CBD at all, like commuting from the south to the west side then you're absolutely right that a cordon isn't going to be effective at all.

Hypothesis 2

In Chicago, congestion pricing will cause more new developments closer to the city center which will result in a more densely built city.

So there are two parts in this, there are absolute transportation costs, so an average effect and a marginal effect. If you imagine a cordon around the central London area, if you want to ask the question what it is going to do to the price of real estate or the level of density between inside the

cordon and right outside the cordon, it is pretty clear that it will increase density inside the cordon relative to just outside the cordon. And if you compare the area right outside the cordon to the suburbs than it gets a little bit complicated, because if people switch to public transit, public transit is often much better closer to the city center. But if people are still driving and paying that cost, the cost is not higher when you come from the far suburbs. So it might have variable and complicated effects. And an important question is: Are the costs high enough to let people switch to public transport. And who will switch to public transit. It could be that I'm a high income person and you introduce congestion pricing, you will make my transportation costs way lower. And in particular, my per mile transportation costs will get way lower. Because I can drive a lot faster, but I only have to pay a toll when I get into the city. So I can live in the countryside and my commute is not going to be so bad. Whereas if the cordon price is high enough to let me switch to public transport then I would have to move close to a train line. So I think with a cordon I think it gets complicated when you talk about the effects outside the city center. Whose transportation costs are actually increasing and whose costs are decreasing. And it is important to make a place by place comparison. Because one thing that you are doing is making the speed higher for cars, which actually makes it cheaper to live further away. There are two other things that I will say about this. One of them is the question if congestion pricing speeds up public transit? The reasons why I think it would are first of all when you are commuting by bus, the buses are directly affected by the traffic. And so reducing traffic is going to increase bus speeds. The other reason is that if you increase demand for public transit, it might be that there is an economies of scale instead of the bus coming every twenty minutes, it can now come every ten minutes. That's going to reduce my travel time in public transit. When there is a city with a lot of commuters, for example Chicago where half of the population uses public transit to commute this can make a big difference. When you choose between living a 20 minute walk from the bus stop or very close to the bus stop it will make living next to the bus stop more affordable and more attractive. And congestion pricing might help to make living next to the transit stops more attractive, since it makes sure the demand for transit increases, which means that there might be a better frequency for the transit.

Business might also rethink their location when congestion pricing is implemented, especially with a cordon it might become attractive to move out of the city center. On the other hand, the highest and lowest income people will see a reduce in transportation costs because high income people will save time on the road, because of reducing traffic and the lowest income people will shift to public transport, for which there will be an increase in demand. And together that makes the central city more attractive.

Hypothesis 3

A dynamic pricing scheme has to be implemented in Chicago in order to maintain free-flow traffic on the express lane.

I think particularly when you talk about express lanes, it probably makes sense to use dynamic pricing. So this IDOT data is really helpful for answering questions about how much variability there actually is in traffic conditions. So you do a better job in dampening demand on high traffic days and then the trade-off would be that more complicated price systems would scare people off. But people who use the express lanes are most of the times already more informed about the system, so I think the second concern is less serious. So particularly for express lanes I agree, with prices that are responsive with at the moment traffic. And certainly I agree with you that you definitely need to have peak and non-peak costs that differ.

Hypothesis 4

When congestion pricing is implemented on added lanes to have more capacity and no other measures are being taken, this will only reduce congestion temporarily.

Yes, I think that's right. There's a lot of anecdotal evidence to that. I don't think there is that much of a difference between adding a free lane and adding an express lane. I think express lanes in the short run at least, should increase the quality of the commute for people with a higher value of time and it would increase the quality less than if you would build a normal lane for people who don't choose to use the express lanes. The express lanes will probably always have less traffic than the normal lanes, cause otherwise people are not going to pay for it.

Hypothesis 5

The current proposal for congestion pricing in Chicago has a good chance to succeed, because of the visible benefits and low costs.

If the infrastructure is already there, and there is a restricted access lane, and when this lane will become a toll lane it will be a lot easier than when the whole infrastructure still has to be built. It is not clear to me that combining the express lane with a bus lane makes sense. I think there is the question right now, how much faster are the buses able to move than the cars. The problem is that the buses accelerate slower and generally move slower than cars. There is some kind of cap of how much express the express lanes can be. Probably still faster than peak traffic on the Stevenson Expressway otherwise. So I would say it's probably a lower cost than building a whole new infrastructure, but it probably also has a lower total benefit.

Hypothesis 6

Despite a lack of support for different toll prices for different highways because of income segregation, it is likely to be the outcome due to more demand for express lanes in richer neighborhoods.

Yes, I think that is almost certainly true. If you build express lanes on every highway in Chicago and you charge the same toll for every highway, there is no doubt in my mind that the lakeshore drive coming from the north and the 94 coming from the north will have a lot more demand than the Dan Ryan and the lakeshore drive south, there is just no question. That's actually a very good argument for dynamic pricing. There is no way that there would be political acceptance for different rates on highways in Chicago, but if you would say that there is a dynamic pricing scheme, that is based on the level of traffic on the expressways and on the non-expressways there will be a dynamically set optimal toll as a result of that. And then these express tolls just so happened to have profitability, so they will be high on the north side and low on the south side. So I think that's the way you can do that.

Hypothesis 7

Investments in public transit on top of congestion pricing are crucial to create a more effective, sustainable and equitable system and gain more support.

Yes, I totally agree. If you put congestion pricing in place along with public transit improvements you can decrease people's transportation costs and also increase revenues for the city and then everyone is happy and everyone wins. If you don't do that then you're charging people to drive on the express lane and you're not giving them an alternative. So I think this hypothesis is just 100 percent true.

Tom Murtha
Chicago Metropolitan Agency for Planning
26-04-2016

Introduction

Tom Murtha is a senior at the department of Policy & Programming at the Chicago Metropolitan Agency for Planning. As a policymaker his main interest lies in the field of congestion pricing. He has worked for years on this topic and has contributed to the highway congestion scans, which have been used for the data analysis of this thesis. This is the second interview with Tom Murtha, the first interview was aimed at understanding the congestion pricing projects in Chicago. In this interview the hypotheses which have been presented in chapter 4, will be discussed. For this interview we have agreed on an in person interview at the headquarters of the Chicago Metropolitan Agency for Planning in the Willis Tower.

Hypothesis 1.

The characteristics of Chicago show that the best form to implement congestion pricing is a facility-based scheme.

I think that's right on in my view. So we are focused on facility-based planning at this point and that's consistent with the project development progress. In the longer term we hope to be able to move toward the more network based approach, but that's not feasible because we have no facilities at this point. The facilities need to be developed and implemented and been shown to work before we can eventually do meaningful network planning. So a network would provide links between congestion priced facilities, and in Minneapolis this is shown. There they started off with single managed lanes facilities, and then implemented it on more highways to create a network of congestion priced facilities.

Hypothesis 2

In Chicago, congestion pricing will cause more new developments closer to the city center which will result in a more densely built city.

Actually, that's an interesting question. There's a couple of potential effects of congestion pricing. One of these effects is to raise the monetary costs. So there is the nominal costs, the out of pocket costs, and there is the total costs, which includes the costs of delay etc. And I don't know that I would necessarily agree that the overall costs would go up. In fact it may go down. So the impact may be to improve mobility rather than reduce mobility in my view. It's an interesting hypothesis, but I'm not sure if there is data supporting it. Because there are so many interactions for this hypothesis. We have had this view based on the fundamental diagram that with reduced congestion we will have a higher throughput and in fact higher speed, so again that moving towards that type of operation would not necessarily improve density. It would provide improved mobility for people in the center city, so increasingly refining industrial development, commercial operations and freight operations in the suburban areas, instead of the center of the city where this traditionally occurred in American cities. There is a suburbanization and an increasing percentage of people in the city itself. It very depends on neighborhoods, wealthy and impact neighbourhoods are doing good, impoverished neighborhoods are very much collapsing. There is a growing population in the city that commutes to the suburbs. Kind of having that reversed commute model and congestion pricing might actually help, so to the extent that a lot of development in the city is going to be residential, congestion pricing would improve the ability for people to move faster to suburban jobs.

Chicago like most American Cities is becoming multi nodal, with a lot of job centres in various locations. Within the downtown area, as well as places like O'Hare, the Oakbrook area, thousands and thousands of jobs require a reverse commute or suburb to suburb commute. Congestion pricing would improve the mobility or facilitate ease of travel to these nodes. To some extent we have to plan the transportation system for the region that we have and that is multi-nodal. So we require a transportation system that facilitates travel on that. And that may mean congestion priced express lanes, or buses on shoulder lanes, all sorts of basic manageable techniques of the express lane systems, that improves person throughput as well as mobility and accessibility for the people of the region. It is a balance of these things.

Hypothesis 3

A dynamic pricing scheme has to be implemented in Chicago in order to maintain free-flow traffic on the express lane.

I would agree with that. The alternative would be to have a schedule of rates by time of day. But then with managing lanes you can have choices being made on the fly for congestion pricing. If we were to manage all lanes on the expressway by price than it would be better to have a fixed price, so people know whether to go on the expressway or not. But as long as it is only one lane, then having that dynamic price will help to have free-flow conditions on the managed lane.

Hypothesis 4

When congestion pricing is implemented on added lanes to have more capacity and no other measures are being taken, this will only reduce congestion temporarily.

I actually disagree with that, because I think again people respond to price. That's the reason why we would implement congestion pricing, because by adding a lane this will reduce congestion temporarily. But by adding congestion pricing to that additional lane then you have the ability to maintain the benefits of that additional capacity much further into the future. Without congestion pricing demand will eventually fill in. With congestion pricing you can manage the additional demand, so you facilitate the free-flow speeds as long as you want into the future. I'm not sure for the case of the Stevenson, but the case of the Eisenhower, I-290, is that the travel speeds on all lanes will improve. So that's what the expectation is. That may be reduced over time, as the demand increases, but then it has to be reflected whether lane management has improved to maintain travel speed. Congestion pricing won't solve all of our problems. So we have other operations techniques to improve traffic flow. So better information to the public, better information to the managers of the system, to remove incidents, more quickly manage of traffic around the incidents, manage construction and special events. So another thing that's going to happen with I-290 is that the geometrical problems will improve. The bottlenecks are going to be eliminated. So congestion pricing is used to manage the lane, but we can also invest in other things to improve traffic flows as well. And going back to the bigger picture, by having that managed lane we also facilitate express transit, so by facilitating that express transit we are able to use that increased demand too. So because this bus will drive on the express lane, there will be less demand for the general road.

Hypothesis 5

The current proposal for congestion pricing in Chicago has a good chance to succeed, because of the visible benefits and low costs.

Yes, exactly, so it's an easy win. So, Illinois has some budget issues, we're in a budget crisis. But once that is resolved it is likely that this project will move ahead very rapidly. So it has the support of the governor, it is in our regional plan, there aren't any clearly identified losers in this project. Nobody's land is being taken. There is a lot of congestion out there, so the problem has to be solved. We want to have this added capacity on the Stevenson, when the Eisenhower is under full reconstruction. So the Stevenson project is going to be a little disruptive, not very disruptive. The Eisenhower is going to be very disruptive. So, having that extra capacity on the Stevenson is going to be very important. There is a very big chance that the project is going to implemented.

Hypothesis 6

Despite a lack of support for different toll prices for different highways because of income segregation, it is likely to be the outcome due to more demand for express lanes in richer neighborhoods.

I don't know that there is any data supporting that actually. I haven't seen this research, and haven't heard about. The socioeconomic status of both of the proposals we have now is probably similar. I'm not sure that for this first round there will be many differences in pricing between the Eisenhower and the Stevenson. And even further along, because the vast majority of Chicago is very moderate income. So we have some wealthy communities in the city, but the vast majority is kind of moderate income. And as you get further out into the suburbs with less and less dense development the need for congestion pricing in these areas is reduced anyway, because there is less congestion. I'm not sure how this is going to work out, but it is an interesting question. But another thing is that a lot of people on the north shore take transit, since it is so much faster than driving. It will be an interesting question once we deal more with suburb to suburb commutes on the Illinois tollway, when congestion pricing is ready to be implemented on this road. In general in our region the income is mixed somewhat but the southern part of the region tends to be lower income than the northern part of the region, so there may be some subtle changes between the south and the north part of the city. But this is only on the long term and it is very speculative. We haven't looked at that question, so I wouldn't be able to say if there is any support for this argument. I would tend to be a little doubtful.

Hypothesis 7

Investments in public transit on top of congestion pricing are crucial to create a more effective, sustainable and equitable system and gain more support.

Lane A versus Lane B there has to be an option for lower income to be able to take advantage of the reduced travel time. We have already seen the express bus lanes on the Stevenson. This has caused a dramatic increase in bus volumes, so they had to increase the bus service to be able to deal with the increased demand. We know there is a big demand for fast and frequent bus service in that corridor and maintaining with the express lanes is going to be crucial.

Bumsoo Lee
University of Illinois at Urbana-Champaign
27/04/2016

Introduction

Bumsoo Lee is an associate professor of urban and regional planning at the University of Illinois at Urbana-Champaign. His research is mainly focused on the spatial organization of urban areas and regional economies. In this context he tries to help communities to make informed decisions about sustainable infrastructure and development. For this interview we have agreed on an in person interview at the 27th of April.

Hypothesis 1.

The characteristics of Chicago show that the best form to implement congestion pricing is a facility-based scheme.

I agree, not only for Chicago. Most of US cities are best built for facility-based congestion pricing. It will be much more effective, since there are a lot of spread out areas in the USA. Doing cordon based congestion pricing like London, this may not have metro wide impact in most US cities. It could work in some particular areas, like Manhattan, which is perfect for cordon based congestion pricing or San Francisco downtown. The loop area in Chicago might also work, but the impact there will be minimized. And I agree that facility-based congestion pricing would work better in most US areas.

Hypothesis 2

In Chicago, congestion pricing will cause more new developments closer to the city center which will result in a more densely built city.

You have to look at new developments. And when you think about different developments there are different impacts. It might facilitate residential development in the downtown area, but it might decentralize other economic activities, like jobs. For example the office and retail sectors. It is more costly to travel to the downtown area, so jobs might decentralize. That is one possibility. I'm not sure if it is going to happen, but it is a possibility.

Hypothesis 3

A dynamic pricing scheme has to be implemented in Chicago in order to maintain free-flow traffic on the express lane.

Yes dynamic pricing with different prices on different times should always be more effective than the flat rates. Theoretically, you could think about real time price change, but you need to provide expectations to drivers. So you can't change the price all the time. You can change the price for different time intervals, like morning and afternoon peaks. You might adjust this price every two or three months so they can have an expectation. They need to decide to drive in the morning or not, when they leave their home. So you can't change the price every day.

Hypothesis 4

When congestion pricing is implemented on added lanes to have more capacity and no other measures are being taken, this will only reduce congestion temporarily.

Yes, possible. Basically if you add new lanes, it is adding new capacity to the highway facility. So it attracts more drivers. It is not a desirable policy in the long term. It is possible that when it attracts too many cars the congestion can go back to the congestion conditions before. It is all about demand. I always favor converting existing lanes into express lanes or HOT-lanes. Adding more highway capacity, will make more people drive. It has to be the transportation policy in the USA for a long time, now we are turning into a more sustainable and alternative way. It might be better to invest in different modes of transit.

Hypothesis 5

The current proposal for congestion pricing in Chicago has a good chance to succeed, because of the visible benefits and low costs.

I don't know the details about this current proposal, but if it is converted from a carpool lane to HOT-lanes or if it is to convert a general purpose lane into priced lanes. In this case only buses are allowed to drive on the lane, so that will improve the efficiency of that lane, it is now underutilized. So allowing passenger cars by paying toll I favor. I mean I will support that policy.

Hypothesis 6

Despite a lack of support for different toll prices for different highways because of income segregation, it is likely to be the outcome due to more demand for express lanes in richer neighborhoods.

This is a pretty complicated question. I don't know if this term, the demand for express lanes, is the right term. So support or acceptability of this pricing scheme would be better. Typically higher income people are more willing to pay the toll if they can drive faster. No one wants to pay, but in general it means faster driving speed. So high income people are more willing to pay the toll. I don't know if we can use that to apply different prices, it is a difficult question. But that policy might be more acceptable. Pricing the highway might be more acceptable in the north side where richer people live. There will be differences in political acceptability.

Hypothesis 7

Investments in public transit on top of congestion pricing are crucial to create a more effective, sustainable and equitable system and gain more support.

Yes, I mean all the research and experience supports this idea. If you provide alternative transportation that is good. Congestion pricing itself might have an inequitable impact. It is not progressive, it might benefit high income people more, especially in the US. In London even millionaires use public transportation. It may not cause too many problems. In the USA even really low income people drive, if you charge the highway that might constrain the mobility of low income people. So if you don't provide alternative transportation than that policy cannot be supported. So it is a serious equity issue. Definitely you can use the revenue toll to improve public transportation, especially on the south side that should be really important.