Review of Congestion Pricing Experiences

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Traffic congestion is a major problem in many urban areas. According to the Texas Transportation Institute (TTI, 2009), the average American driver lost 36 hours in 2007 sitting in congestion, wasting an average of 24 gallons of fuel. The average losses per driver in cities where the population exceeded one million were 25% higher. These costs were quantified into a national productivity loss of $87.2 billion, a four-fold increase (in 2007 dollars) from 1982. This figure does not take into account local air quality degradation due to the burning of the wasted fuel; though that externality is partly mitigated by the recent push towards electric and hybrid vehicles and the ongoing increases in fuel efficiency standards (Halsey, 2010). This push towards greater fuel efficiency comes with its own indirect cost, however, as the traditional way of funding road maintenance, gasoline taxes, is supplying less income per mile driven: for example, the proposed standard of 35.5 miles per gallon by 2016 would reduce federal gas tax income to just over $0.005/mile. With new freeway lane-miles costing $10 million or more in urban areas (FHWA, 2008), governments are less able to "merely" add capacity each year. This adds to the urgent need to examine increased utilization of existing capacity.

The problem of traffic congestion is spreading in the US. TTI (2009) predicts that if the annual growth rate exhibited from 1982 to 2007 were to continue, urban areas with populations between 500,000 and 1 million will be experiencing congestion problems within ten years that cities twice their size are experiencing today. The recent economic downturn has only delayed congestion growth. Once the economy recovers, congestion will once again be on the rise.

Congestion pricing is the term used for solutions that aim to shift traffic demand through the use of market forces. The theory is that by increasing the price of travel during peak periods, discretionary trips such as shopping will be moved to less congested (and less expensive) periods. Any profits generated by congestion tolls can be used to increase capacity of mass transit systems, increasing the density of existing systems with minimal increase in congestion, maintaining roadways in a state of good repair, or adding new highways where similar pricing measures may be applied.

The several domestic and international attempts to implement congestion pricing provide an excellent roadmap to the type of issues that are likely to arise when designing a new congestion pricing scheme. The objective of this review is to provide structure on our understanding of the worldwide experience, as a functional guide to the design of the field experiments in a wider research project. Our objective is not to provide an exhaustive or descriptive account of each of these experiences, but to juxtapose them in a way that allows us to draw inferences for our purposes. A more comprehensive list of projects attempted, along with locations of alternate treatments, is included in Appendix A.

It is convenient for us to structure the discussion according to the following broad topics:

- The use of traffic cordons in Europe;
- Various implementations of toll roads and toll lanes in the United States and abroad;
- Network pricing studies; and
- Lessons learned from failed projects.

Traffic cordons in Europe

A cordon in the context of this discussion is an area where vehicular access is restricted in some fashion, the boundary of that area being the actual cordon as well as the point of enforcement. There are two ways in which a cordon may be enforced. One method popular in developing countries is to restrict access by license plate number. While this method is effective in regions with low standards of living, residents of more developed cities, such as Athens, Greece, sometimes defeat this method with the purchase of a second car with a different license plate number (Phillips, 2009).

An alternative is to set a price for admission into the restricted area, which we will refer to as a "priced" cordon. The pricing of many cordons is fixed. That is, there is only a single rate for the same class of vehicle passing through a cordon boundary. This single period could be all-day or it could be timed to the peak period in each direction.

There are also some cordons where the admission charge varies by time. An example of a "shoulder" period being implemented with a cordon is the Area Licensing Scheme (ALS) in Singapore (Keong, 2002). Near the end of the life of the program, the period between rush hours was congested enough that the city decided to restrict access throughout the entire period from 0730 thru 1900 local time; previously, the cordon was not enforced during the inter-peak period of 1015-1630. This method involved daily permits: the literature is silent on whether there was a limit, or if one was even desirable. The variance in the permit pricing was based on the fact that there was less demand for area roads in the inter-peak period. The ALS was followed by the Electronic Road Pricing scheme, which uses electronic collection methods and is also in use along major expressways in the city.

Over the past decade, there have been many experiences with priced traffic cordons around urban centers in Europe. This section will explore the cordons implemented in Norway; Stockholm, Sweden; and Durham, England.

<u>Norway</u>

Norway has been using road tolling as a fundraising instrument for over 70 years. Proceeds from these tolls usually form 25% of the annual road construction budget. The deliberate design of a traffic cordon around an urban center, however, is a relatively recent mechanism (Ieromonachou, et. al. 2006).

The first such cordon was designed for the city of **Bergen** (Ieromonachou, et. al. 2006). Rather surprisingly, the intention was never to have much of an impact on traffic flows, and improvements in traffic efficiency did not figure significantly in the design and implementation of the program. Instead, the primary purpose for this cordon was fundraising; although the expected funds were scheduled for other projects designed to improve traffic efficiency. The plan was initially presented in 1983, given permission to proceed by the central government in June 1985, and implemented by January 1986. All vehicles entering the toll area between 0600 and 2200 on weekdays paid a fee. There were exceptions for public transport such as buses, and commercial trucks paid twice the amount for private vehicles. In 2004 an electronic toll collection system was implemented and discounts were provided for longer-term subscriptions. Collection costs in Bergen were generally high until the introduction of the electronic toll collection system.

It is not apparent that the cordon had much of an effect on traffic, largely because most of the revenues from the toll were directed towards the expansion of traffic infrastructure, so that it is hard to identify the net effect from the toll collection. There was a very slight drop in recorded traffic, less than 10 percent, at the initial implementation of the scheme (Ieromonachou, et. al. 2006).

Consistent with the original motivation of the scheme, to raise revenue for proposed infrastructure enhancements around the city, it was scheduled to cease functioning in 2001. However, by that time there were new programs for transportation and city infrastructure in place, and the toll scheme was retained until 2011. This extension of the life of the scheme was also tied in with a change in the apportionment of revenues, which are now split roughly equally between road infrastructure investment and city center environmental improvements. In the earlier stages of the scheme roughly 70% of the revenue went towards road construction costs, 20% towards operating costs, and a residual 10% was left for a politically contentious fund for miscellaneous projects.

Soon after the implementation of the scheme in Bergen, the city of **Oslo** implemented a toll ring scheme (Ieromonachou, et. al. 2006). Similarly, the original objective was to generate funds in order to pay for enhanced road capacity. In contrast to the rapid implementation experienced in Bergen, a much smaller city, there had been many years of debate in Oslo about the trade-off between revenue generation and traffic reduction. What is particularly interesting in the Oslo case is that there was an explicit debate about this trade-off, and indeed a clear winner: traffic tolls were deliberately set low, in order to fall below what was deemed to be a threshold level that would not be noticed by drivers. The thinking was that demand for driving was relatively price inelastic for very small changes in price, but would become more inelastic as price increased.

The scheme was implemented in 1990, and in 1991 the manual collection system became electronic. Around 85% of the traffic in peak hour uses the electronic tag system. The location of tolling booths was also designed explicitly to maximize revenue, exploiting what was perceived to be relatively inelastic demand for travel on certain routes. There is widespread recognition that this scheme could develop into a congestion pricing scheme designed to modify and reduce traffic levels, but there is a significant lobby group arguing against this evolution.

Just one year after the introduction of the scheme in Oslo, the city of **Trondheim** introduced an urban toll ring (Ieromonachou, et. al. 2006). This scheme had several innovations in terms of pricing and payment arrangements. From the outset it utilized electronic collection, it allowed for varying time of use tolls, and it even allowed for prepayment of tolls at a substantial discount. Another noteworthy feature was that it included different prices for different zones within the cordon. The scheme was, again, originally justified on the grounds of revenue generation, although in this case the infra-structure plans were not solely to expanding traffic by vehicles, but to increase and improve infrastructure for pedestrians and cyclists, as well as the public transportation network.

Figure 1: Cordon Locations in Scandinavia
SOURCE: Ieromonachou, et. al. 2006, Eliasson et. al., 2009

In contrast to the "life extension" that was given to the scheme in Bergen, the congestion pricing scheme in Trondheim was terminated in 2005, as originally planned. In part this was a deliberate attempt by the political authorities to keep faith with their original promise, and there was discussion at the time of the possible value of implementing a defined management version of the scheme in the future (Ieromonachou, et. al. 2006). Since then, there has been a traffic shift back to the first and last hours of the cordon period (Amdal, 2006).

Stockholm, Sweden

The congestion pricing scheme introduced in Stockholm, in 2006, was a deliberate attempt to reduce congestion in the center of the city. There was initially a trial period of seven months, at the beginning of 2006, and the scheme was made permanent after a referendum that September (Eliasson et. al., 2009). Like the Trondheim scheme, this scheme imposed a variable fee based on the time entering or leaving the cordoned area. The fee was highest for the two peak time periods, 0730-0800, and 1600-1730. A lower fee was charged during the day (See Note 18, Appendix A), and no fee was charged during evenings, weekends, and holidays. There were a large number of exemptions, such as for environmentally friendly vehicles, vehicles owned by disabled drivers, motorcycles, taxis, buses, and military and police vehicles. The evidence suggests that there was a significant reduction in traffic flows, particularly for the highest priced times in the day; around a 20% decline during each of the peak periods. However, there does not appear to have been a significant substitution effect towards vehicle traffic during the non-peak periods. This may be due to the extraordinarily wide public transport network available for Stockholm city, in particular the large and well used subway system. One particularly sensitive metric during the evaluation trial period was the impact on revenue for retailers inside the cordon, and there appears to have been no significant effect on those revenues (Daunfeldt et. al., 2009).

The September 2006 referendum gauged public opinion towards the pricing scheme (Eliasson et. al., 2009). Residents within the Stockholm area, and within the cordon area, were generally in favor of retaining the scheme (53% yes versus 47% no). On the other hand, neighboring municipalities, outside the cordon, were clearly opposed to the scheme (60% no versus 40% yes). In part this may be due to the scheme entailing no costs to those that used their vehicle within the cordon, or who only use their vehicle on weekends when there was no fee. This is relatively common in Stockholm, which is a city that has many residents downtown.

Durham, England

In 2002 congestion charges were introduced for the city of Durham. To be more precise, these charges were introduced for the historic district of Durham, which includes Durham Cathedral, Durham Castle, several buildings of the University of Durham including some old colleges, and a dense commercial area known as the Market Place (Harland, 2003). This part of Durham is characterized by very old buildings and very narrow cobblestone streets. The primary objective of the congestion charges was to reduce parking and traffic in this area, to make it more attractive for customers and users of the area to walk around. There is a fixed charge, and it is only payable between 1000 and 1600 Monday through Saturday. Hence it is not directed at peak hour traffic, so much as traffic during heavy commercial periods. There are exemptions for residents and businesses that already have parking lots, as well as public transportation, handicapped persons, and motorcycles (Ieromonachou, et. al. 2004).

One feature of the pricing scheme is that it charges a fee upon exit, rather than upon entry. This decision was made for several reasons, partly logistical, but also to prevent refusals or equipment failures from affecting traffic on the town's main thoroughfare (Ieromonachou, et. al. 2004).

The scheme appears to have brought about a dramatic reduction in traffic, by some measures over 85% compared to immediately before its introduction. There has been a considerable substitution effect by which delivery vehicles now make sure that they have completed their deliveries by early morning, or undertake them later in the evening (Harland, 2003).

Toll Roads and Lanes in the United States and Abroad

Toll roads are not a new development in the United States. From the Lancaster Turnpike of 1792, to its spiritual successor in the still-operational Pennsylvania Turnpike, to various water crossings such as the Holland Tunnel in New York and the Golden Gate Bridge, America has had

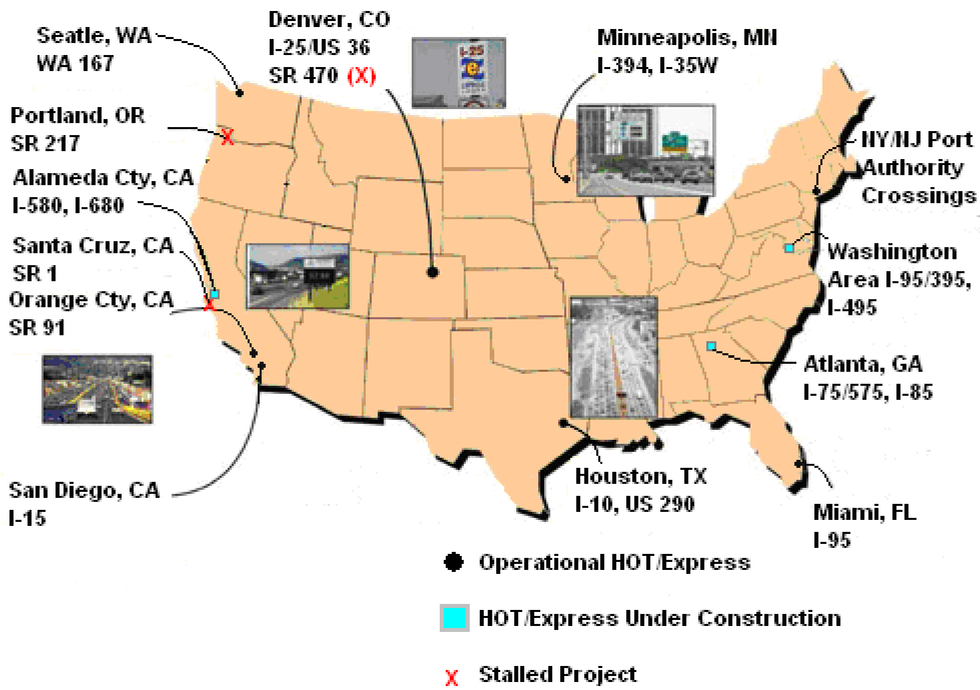

Figure 2: Location of Corridor Pricing Projects in the United States.
SOURCE: Value Pricing Program, Federal Highway Administration, Georgia Department of Transportation (I-85), http://www.680expresslane.org/Home.asp (I-580, 680)

its fair share of experiences with tolled roads. Varying the price to facilitate demand, however, is a recent development and a solution devised to meet the dual problems of congestion and maintenance costs. Because of the high costs of infrastructure maintenance and congestion, as well as a general ambivalence towards increased taxes, the Federal Government has authorized various programs to investigate the feasibility of tolling capacity additions of existing facilities (FHWA, 2010).

There is an extraordinary range of pricing schemes utilized throughout the United States for toll roads and lanes. We find it useful to differentiate these schemes according to the following criteria: (i) fixed pricing schemes, (ii) time of day pricing schemes, and (iii) "dynamic" pricing schemes. The above illustration shows the wide variety of express lanes that have opened up across the United States in recent years, as well as some proposed express lanes.

Fixed pricing schemes occur in many toll roads systems, where there is one price for a segment of the toll road that is fixed for all hours of the day. These prices often vary with the size of the vehicle, as given by the number of axles, but are otherwise fixed. Pricing schemes that vary by time of day are generally focused on peak period driving. The term "dynamic" pricing schemes refers to a situation where the toll varies with conditions on the road, usually to ensure that congestion never gets above some threshold level. Economists prefer to call these "responsive" pricing schemes, but the idea is the same, that prices will vary depending upon known rules and evolving conditions.

An excellent example of a **fixed price scheme** for our broader tolling study is the system in Orlando. In this case the regular user typically obtains a transponder that records usage for each segment, and it is connected to a credit card that is authorized to make payments to ensure a minimum balance is available (OOECA, 2008). The fee is fixed for each segment, and the number of segments varies depending on a number of factors (OOECA, 2010). This type of pricing scheme is found throughout the United States. In recent years it has been enhanced by technology that allows cars to be detected as they drive continuously passed a checkpoint, so that they no longer have to slow down significantly in order to be detected.

Even fixed price schemes can be used to reduce congestion. In 1996, the city of Seoul, South Korea started charging congestion tolls for single and two occupant vehicles traveling down either of two tunnels connecting the Central Business District with southern suburbs (Nasman #1 & #3 at approximately $1.50 per passage) (Son & Hwang, 2001). The toll is collected between 0700-1900 local on weekdays and 0700-1500 on Saturdays. Following an initial 25% reduction of vehicles in the first month of implementation, the traffic returned to 1996 levels in 2000; although at that point the traffic consisted primarily of trucks, busses, three person carpools, and other exempt vehicles. The number of bus passengers in the two tunnels increased 75% on average. There was also a significant traffic increase in the shoulder hours, especially 2100-2200. The speed of the tunnels also increased significantly by 16 km/hr during that time period. And despite traffic in the first two years on the adjacent corridors, travel speed along these corridors also increased by about 5 km/hr. The overall success of the policy has encouraged the city to extend the scheme to other arterials.

<u>The Variable-Priced Roadway: California 91</u>

An excellent example of a **pricing scheme that varies the price according to the time of day** is the SR91 scheme in California. This scheme consists of two express lanes in each direction on a roughly 10 mile stretch of highway on the Riverside Freeway in California, located close to Anaheim. The scheme employs variable tolls designed to reduce peak period delays. These express lanes opened late in 1995, and have been extensively studied since.

The scheme has had a dramatic effect on traffic use in the area, significantly reducing time delays. Prior to the introduction of the scheme average delays during peak hours were between 35 and 40 minutes. In the immediate aftermath of the introduction of the scheme, these delays dropped to around 10 minutes per trip for the express lanes, although it is important to note that they increased slightly to between 12 to 13 minutes after about a year of operation of the scheme. These differences are attributed to adjustments in traffic demand as well as an underlying growth in traffic volume during this period. Sullivan (1998) observed that the express lanes attracted about 13% of the weekday average daily traffic.

The tolls are not responsive to the immediate congestion conditions on the road, but vary across the time of day in a preset manner, adjusted every quarter (OCTA, 2010). There is a relatively higher demand for the express lanes in the afternoon peak period compared to the morning peak period, and this is reflected in differential pricing. There is also some variation in tolls across different days for the same hour. As of April 1, 2010, the eastbound weekday tolls for between 1600 and 1800 were above $5.00; Monday's average for the two hours is $5.45 while Thursday's average for that same period was $9.48. The highest toll rate, however, was Friday afternoon between 1500 and 1600 at $10.25; the other four weekdays at that hour were all below $6. Westbound charges were over $4 on Mondays thru Thursdays between 0600 and 0900, with Friday tolls for that same period being $0.10 or $0.15 less.

The vast majority of peak period travelers are engaged in travel between their home and their workplace. Sullivan (1998) puts this fraction at more than 80%. He also indicated that it is simply congestion avoidance that drives people to use the express lanes, rather than the need to be on time for a commitment. This finding is particularly important, if correct, because it suggests that it is the average time savings that motivates drivers to use the express lane rather than some expected reduction in the variance of travel time. Further, he reported that commuters tend to *overstate* the time savings from using the express lane, believing them to be in excess of 20 minutes per trip rather than the actual 12 to 13 minutes per trip. He also indicated, however, that a significant number of drivers avoid the express lane simply because they do not believe that the time savings are worth the price, and that relatively few of those that use the express lane did so on a daily basis.

Behavior in response to this scheme has been extensively studied, and there are rich databases available for review regarding aspects of behavior with respect to various demographics. The field experiments that we are considering should be viewed as complementary to surveys as ways of collecting data about the determinants of behavior.

Dynamic Volume Pricing

Dynamic pricing schemes have recently received a significant amount of attention in America, especially in terms of their ability to affect behavior in real time. One of the most significant examples, also in our field experimental study area, is the 95 Express in Florida. The northbound express lanes opened for revenue collection in December 2008 and the southbound lanes in January 2010. Additional extensions are proposed through 2012, if funding is available. The construction strategy here is to replace the existing High Occupancy Vehicle (HOV) lane with a High Occupancy Toll (HOT) lane, add an additional HOT lane, and implement variable pricing on the two HOT lanes. The reason for removing the HOV lane is that it was experiencing significant delays during peak periods. The overall objective of the pricing algorithm that is used to determine the tolls is to ensure unimpeded and safe operation at speeds of 50 mph or greater along the express lanes (FHWA, 2010).

Tolls vary between $0.25 and $3.75 for the operational segment (FHWA, 2010), although it is envisaged that prices could go as high as $7.25 under extreme conditions. There are also a number of exemptions, such as registered carpools. The toll rate applicable at the time is displayed on large electronic billboards prior to the entrance to the express lanes, allowing drivers the

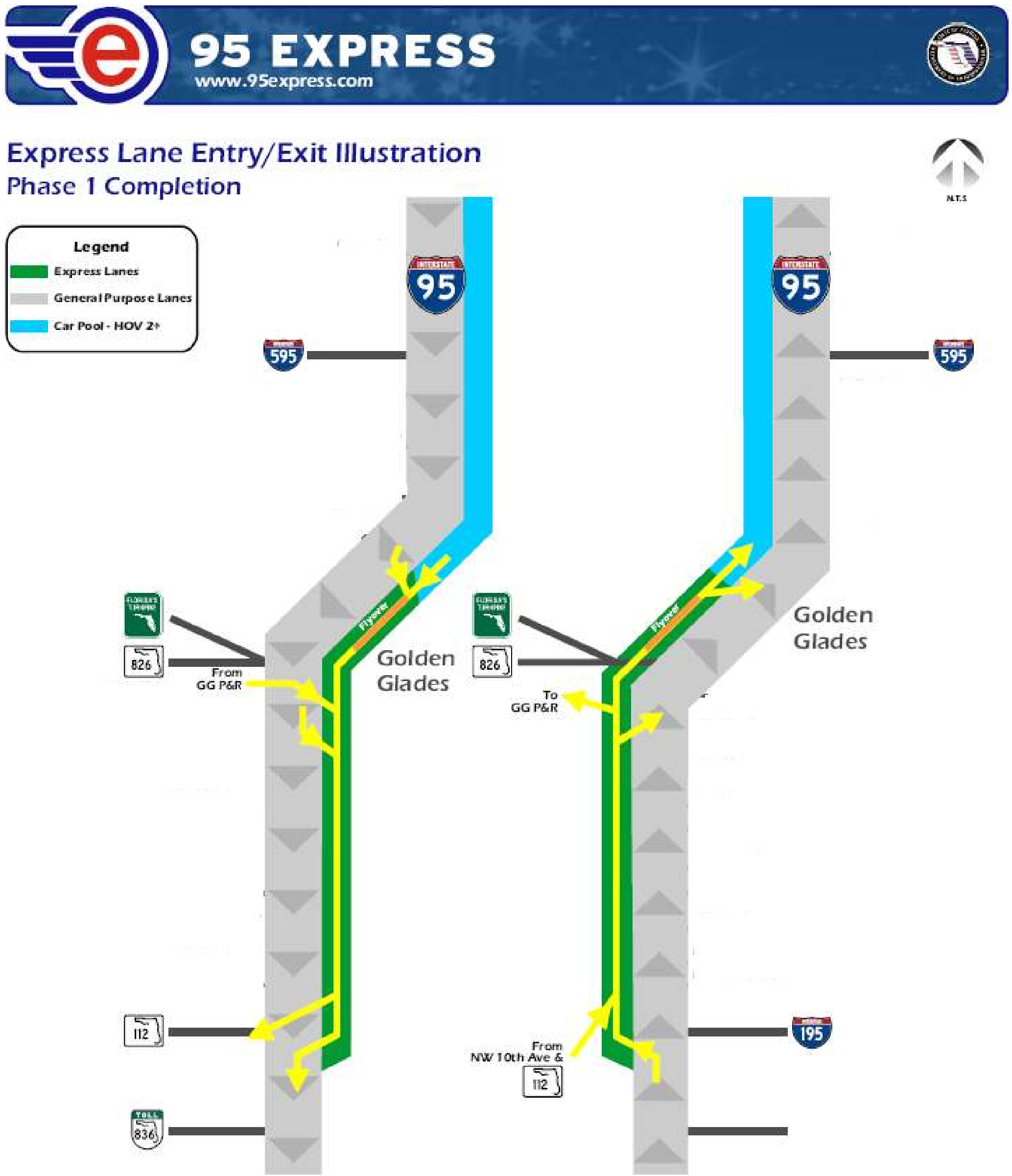

Figure 3: Express Lane Configuration on I-95 in Miami (Abridged to fit the report.)
SOURCE: Florida Department of Transportation (2010)

opportunity to decide if they want to use the express lanes at that time. The toll is determined by a predefined algorithm that is responsive to data that is being constantly accumulated and evaluated by computer (FDOT, 2010).

One of the earliest projects that used dynamic pricing is I-15 north of San Diego. The initial two in-median reversible express lanes serviced an 8-mile stretch of the interstate; these were southbound in the morning and northbound in the afternoon. This facility opened in 1988 as a HOV facility, then became a HOV facility plus monthly permits in 1996. In 1998 dynamic pricing for solo drivers was introduced. During this phase, the admission price to the facility varied, usually between $0.50 and $4.00, though sometimes higher, in order to maintain a Level of Service of "C"

(Supernak, 2001), where travel speed is still close to free flow speed, but freedom to move between lanes becomes restricted (TRB, 2005). A savings of 20 minutes during periods of heavy congestion were measured by the study analysts and stated by drivers as their estimate. The charging of a fee for single-driver use of the express lanes was seen as "fair" in the public eye. Supernak (2001) found that dynamic pricing more easily facilitated the redistribution of traffic to shoulder periods, whereas the permit system was more amenable to the development of carpools. This facility is being expanded, with 8 more miles presently operational, another 4 miles to go into operation in 2011, and the original 8 mile segment to be upgraded soon thereafter (FHWA, 2010).

Network Pricing Studies

Network pricing schemes refer to the pricing of an entire network rather than individual components of the network. There are few examples of actual implementations of network schemes because of the extensive informational requirements involved; these schemes charge based on either how much of the system a vehicle uses or how long it uses that system. A potential precursor could be the ticket system of tolling that is popular on freeways in the Northeastern United States. A paper ticket is issued to a vehicle entering a road, with the toll to be paid determined by where the vehicle left the road. This system was cumbersome due to the need for personnel to collect the tickets and the tolls, similar to the permit verification scheme in the Singapore ALS. However, electronic technologies, including Global Positioning Systems and license plate cameras, have made the enforcement process significantly less cumbersome, allowing such systems to potentially be applied across whole networks, as in Singapore's ERP and the Norwegian Cordons.

The State of Oregon conducted a trial in 2006 utilizing electronic tracking devices for mileage-based pricing, with the intent of gauging the feasibility of the method as a replacement for the gas tax (Rufolo & Kimpel, 2007). GPS-based devices were installed on test vehicles to collect in-State mileage. Electronic measurement was chosen because human recording was thought to be subject to significant errors and fraud. These measurements were collected by receivers located at gas stations. As designed, the system would charge only Oregonians and only when they drove in-State or on in-State portions of inter-State travel.

The same technology that allowed a distinction between Oregon and non-Oregon mileage also allowed for distinct regions to be defined. Therefore, two different mileage pricing schemes were tested in this study: a flat rate statewide (of $0.012/mi), and a "rush hour" rate of $0.10/mile during peak hours within the Portland Metropolitan Area along with a greatly reduced charge for other places and times. There were some issues of battery drain from the mounted devices (in the final concept, Oregon envisions the use of pre-installed hardware) and interference between receivers at close gas pumps. Apart from these type of concerns, many of which were classified as "pilot-specific," the concept as a whole was deemed "viable" with participants expressing satisfaction with most aspects of the program. Individual drivers also reported changes in driving habits due to the awareness inspired by the system, with the "rush hour" group recording a 22% decrease in peak-period driving (Rufolo & Kimpel, 2007).

A similar system utilizing only trucks is currently in operation in Germany. It replaced the Eurovignette system of annual fees based on emissions standards and number of axles. The system, launched in 2005, charges on average €0.125/km on an emissions-based sliding scale. The second iteration of the system, launched a year after initial implementation, uses dedicated short-range communication to track the vehicles to determine when they are tollable and where the trucks would go to try to avoid the toll. Doll and Schaffer (2007) concluded that the impacts on industry as a whole would be effectively neutral, though small operators would be disproportionately affected.

Lessons from Failed Projects

In 2008 the City of New York proposed a priced cordon scheme to control congestion in lower Manhattan. Passenger cars traveling south of 60^{th} St. would be assessed a once-a-day charge of $8; trucks would be assessed at a different rate. The charge would be assessed upon entering the cordon between 0600 and 1800 on weekdays while travel within the zone would be free. There were no free bypass corridors within the cordon. While it received approval from the city, the scheme failed to gain support in the New York State Assembly and was withdrawn without a vote. Alongside the pricing plan approved by the committee, a Minority Report was issued that called into question various aspects of the plan.

Over 20 years earlier, the colony of Hong Kong was planning on using an electronic-based area pricing scheme to reduce private car usage. This scheme was rejected due to public dissent. It is therefore useful to examine many of the causes listed by Hau (1990), as well as some objections raised in the New York Minority Report, in the context of various other schemes.

Education and awareness of how congestion pricing works is a critical aspect to the success or failure of a scheme. Hau (1990) bemoaned the lack of communication between the Hong Kong government and transportation and economic experts regarding the failed area scheme. A survey taken in Alameda County, California in 2005 discovered that HOT lanes were better sold as carpool lanes where solo drivers can piggyback for a fee as opposed to marketing them as a congestion management device or a method of fully utilizing lane capacity (ACCMA, 2005). The study attached to the survey concluded that the general population sees the physics of traffic flow in general as abstract and non-intuitive. However, as demonstrated by the previously mentioned projects, opposition to pricing schemes drops somewhat through education and exposure, particularly as drivers experience improvements to their particular situations. Former Mayor of Stockholm, Annika Billström, said that the city needed to have the cordon trial prior to its referendum so that they could "know what [they] vote about." The securing of a political spokesperson is a boon, as demonstrated in London (Isaksson, et. al., 2009), but is not a guarantee, as the New York scheme demonstrates (Shaw, 2008).

A key argument raised by opponents is that a flat fee system puts a larger burden on users with lower or fixed incomes. In the New York case, a single trip per day during the congestion period ($8), according to the Minority Report (2008), translates into approximately $2,000 per year. This translates to about 5% of the average income for commuters in the adjacent boroughs, but 2% or less in out-of-state suburbs. These equity concerns were aggravated by the contention that the $8 charge would be offset by existing toll crossing charges; hence, drivers from many of these latter suburbs would not pay the full charge. The Committee Recommendation (Shaw, 2008) notes that only 1 in 20 New York area residents drive to work within the area that would be affected by the charge. An analysis of the Stockholm cordon noted that it had relatively adverse impacts on both low-income and high-income earners, versus those in the middle ranges, but could not statistically prove any general regressivity or progressivity (Karlstrom & Franklin, 2009)

Concerns about equity are mainly leveled against cordons and networks, as alternative routes in those schemes are few, but can also be leveled against corridor plans. For these, the Congestion Primer (FHWA, 2008) cites studies that conclude that low income earners appreciate the option of uncongested priced lanes, and offers some scenarios where they may be used, such as picking up children from daycare.

A simulation using two future HOT corridors in Northern California was undertaken to test the feasibility of a credit system for frequent travel (ACCMA, 2005). It is notable that these two particular corridors do not have parallel alternate routes. The simulation found that limiting participation to low-income earners reduced the adverse impact on the facility's traffic flow, especially when the redemption rate was low. However, it cautions that drivers with such credits would likely "bank" them against times of high congestion, resulting in multiple users utilizing their credits simultaneously, compromising the facility. It also mentioned the possibility of a simple discount rate, but did not explore this option. A survey of frequent users in the same study cautions, however, that a focus on low-income earners could be seen as excluding "average" users. To this group, the thought of high-income earners being able to "buy their way out of traffic" was more discouraging than the thought of low-income earners not being able to utilize that escape. These "average" users concede that an anti-congestion option, such as an HOT lane, that not all drivers could employ could be acceptable if there was a general improvement in traffic conditions, though they were less likely to accept such concessions applied to themselves.

An aspect related to equity is the presence and reliability of alternate forms of transportation. Mass transit is usually exempt from scheme charges because it carries a much higher number of persons per square foot of lane space. It thus offers a low monetary cost alternative to car users, partly offsetting equity concerns. However, if service is not improved through more reliable schedules, or gets worse from overcrowding due to new customers, then drivers would stay in their cars and pay the charge. Indeed, one of the primary reasons for the success of the Stockholm cordon, as concluded by Kottenhoff & Brundell-Freij (2009), as well as the 2003 London cordon, as cited in the New York Minority Report (2008), was the increase of public transportation capacity prior to the implementation of the cordons. The Minority Report alleged that the New York plan would not make a pre-implementation transit investment. This may also be a contributing factor in Edinburgh's failed scheme, as the leaders of two political factions there claimed that improved public transit was a better remedy than a toll restriction (BBC, 2005).

One way to gain political support for congestion charges is to directly link proceeds of the charge to mass transit improvements (Kottenhoff & Brundell-Freij 2009) or road construction. Indeed, the Norwegian toll rings gained public support only after the roadway improvements funded by the charge were completed (Ieromonachou et. al., 2006), while the Northern California study (ACCMA, 2005) found that the HOT project had better public viability when it was directly tied to the local carpool lane system. The lack of such a direct connection was another critique of the New York scheme (New York, 2008). A survey conducted for the Minnesota Department of Transportation (Fichtner & Riggleman 2007) reports that while there was a general public conception of the gas tax being used for transportation, the public had little notion of how much tax was actually being collected, or how much was being used for transportation and on what projects. It also reported that a significant minority believed that transportation funds were being mismanaged, suggesting that any future funding schemes need to be linked directly to projects that the payers could recognize. A similar distrust was cited by Hau (1990) in the Hong Kong failure. In this case the public was not confident in the government's promise that the area charge would replace license fees. As a public official in Trondheim was quoted: "when the public sees where and how the money is used, this helps winning acceptance for a project" (Ieromonachou et. al., 2006).

Another political dimension that could derail a pricing project is privacy, especially where video and electronic collection methods are involved. An op-ed in the *New York Daily News,* submitted by the New York Civil Liberties Union (Dunn & Lieberman, 2007), cautioned that a camera-based collection and/or enforcement system has the potential for abuse by agents of the government and private investigators. Fichtner and Riggleman (2007) also addressed public skepticism that electronic transponders could be used as tracking devices, and that agencies needed to address this fear. A fear that was particularly strong in Hong Kong in 1985 when its area scheme was under consideration, as the United Kingdom had announced that it would soon return the city to China the year prior (Hau, 1990).

Conversely, inadequate enforcement can also present problems. The Minority Report (New York, 2008) criticized the lack of direct payment for non transponder holders, as well as the lack of distinction in the electronic collection system for certain potential exemptions. Another example is a plan to allow commercial vehicles on to the HOV lanes of I-880 in California. The Federal Highway Administration (2010) reported that the addition of a permit sticker would have been an added burden in the eyes of the law enforcement patrols already charged with determining whether a vehicle meets occupancy requirements.

Another concern is that businesses within the central business district would have reduced sales figures when that business district is placed in a cordon scheme. In their study of the Stockholm trial, Daunfeldt et. al. (2009) did not find a significant impact on retail sales. The primary reason they listed was that most shops within the cordon were open past the charge times, though they also cite the fact that a large number of Stockholm's shoppers use public transit and the ones that use automobiles would be higher-income earners that would absorb the charge. This is partially supported by a study showing that an outlet of a store that deals in bulk goods within the London cordon established in 2003 did have statistically lower sales compared to five outlets outside of the cordon (Quddus et. al., 2007). It should be noted, however, that this decline started with an incident on a public transit line that occurred one month prior to the launch of the scheme, and which was not mended until a few months after that launch. The study did not test for interaction between the two factors.

Finally, not all solutions can be applied to each problem. The city of Santa Cruz looked into incorporating a HOT treatment on State Route 1 through their city. Unfortunately, the number of access points within the project limits, combined with the access needs between the points within those limits, made barrier-separated treatments, and thus the HOT options, infeasible (Wilbur Smith Assoc., 2001). Attempted schemes can be used to help define a general policy by means of a process where limited cases are initially tested, then duplicated in other sites, often with modifications appropriate for those sites (Ieromonachou et. al., 2004). In the above example, the HOT policy was examined and determined not to be appropriate for the Santa Cruz context. This method may explain why different regions favor different solutions, as shown in Appendix A.

Timing is also a reason for the rejection of some plans. Hau (1990) also cites the 1980s recession and infrastructure improvements as other reasons why the Hong Kong area scheme was not accepted. Capacity expansions, where feasible, also help stem the congestion tide. However, economic cycles are cycles and, again, a downturn is only a temporary respite (TTI, 2009), as shown by Hau (1990). Average travel speed in Hong Kong increased from 20 km/hr in 1979 to 28 km/hr in 1984 when the scheme was being considered, and then came back down to 24 km/hr in 1988.

Conclusion

As the Hong Kong example demonstrates, economic cycles cannot be relied on to limit vehicular congestion in the middle-term or long-term. In several areas where congestion is a major problem, capacity expansion is cost-prohibitive, even when otherwise feasible. In these areas, the best solution becomes regulation of existing capacity. Congestion pricing allows everyone the option of paying to gain access, even those of lower incomes, if they believe that that is the less expensive option. Under other policies, groups of people are excluded either by their habits or just because it is "their day" to be excluded as determined by their license plate.

The chief difficulty in implementing anti-congestion schemes appears to be convincing the public, or the right group of civil servants, that putting an external price on congestion would cost less than the congestion itself. The public's understanding of traffic flow is severely limited and mainly anecdotal. Therefore, they often see only the immediate personal adverse effects at first, and not the beneficial effects generated as a result of these schemes. While the public bemoans the leisure time lost to traffic, charges have an upfront visible monetary price tag, especially when the public has no reason to expect time savings from unfamiliar schemes.

The ultimate solution to this problem is to let the successful projects prove themselves, and promoting those successes to the broader public. Individual successes can be duplicated in similar conditions or tailored to slightly different conditions. A direct correlation to related improvements is often necessary in the short-term, but a project's own merits will speak for themselves given enough time, as shown by the retained toll roads in California and cordons in Scandinavia, among others. And official studies even have some impact on their participants, as Portland and Minnesota demonstrate. To quote from the encapsulated recommendations from the Minnesota survey, any agency wanting to establish a mileage or congestion scheme for raising funds for road improvements "must be able to answer the question 'Why not just raise the gas tax?' with a clear and convincing response" (Fichtner & Riggleman 2007). The questions, "Why not just build more lanes/add more busses?" must also be answered to public understanding, if not public satisfaction. Only when their planners can do so can congestion pricing gain traction.

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