Value of Time Clustering and the Efficiency of Destination-Based Congestion Pricing

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In cities with a hub-and-spoke style transportation system, each individual's transit decision produces externalities contained within a particular transit spoke. When spokes vary in the typical number of drivers, in the capacity of the infrastructure, or in the average income of commuters, the efficient tax to charge drivers to minimize the externalities may vary across spokes. The size and importance of this variation are evaluated by comparing the potential welfare benefits of a congestion tax in Chicago, which is different rates for different highways to a tax that is a single rate. Using the 2000 United States Census Public Use Microdata to estimate wage distribution and data from the Illinois Department of Transportation on vehicle speed and road occupancy, this research provides estimates of optimal taxes for each neighborhood and for the city in aggregate. Results show that optimal tax rates vary substantially, from a low of $6.75 per vehicle per day to a high of $16.50, but that the overall welfare difference between charging a neighborhood-specific tax and charging a citywide tax is minor. This occurs because the number of drivers changes very slowly at high tax rates, meaning that a wide range of taxes can produce nearly optimal results in terms of welfare. An optimal congestion tax of $11.25 per day is estimated to result in 400,000 fewer downtown commutes per day, reducing pollution costs valued at $2.9 million per year.

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Since the first modern discussion of congestion pricing in Vickrey (1952), *congestion pricing* has become an important topic for scholarly research and in practice and policy. Several global cities, including London, Stockholm, and Singapore, have implemented congestion schemes, while other cities, including Paris, New York, and Chicago, have been considering congestion pricing policies of their own (Small, 1994).

Such policies have the potential to reduce environmental problems significantly in urban areas. At the most fundamental level, congestion taxes increase the cost of driving relative to the cost of public transit, encouraging a reduction in fossil fuel use. Local pollutants have high costs, especially in urban areas where estimates range from 2 to 7 cents per mile (Parry, 2008). Congestion pricing encourages less driving but may not be the most effective tool in addressing global pollutants, since the systems are designed to affect trips made to particular destinations and at particular times of day and do not specifically target overall miles driven or fuel consumed. However, because congestion pricing discourages driving at times and places where the density of other drivers and pedestrians is greatest, local pollutant emissions will be reduced when and where the public health impact is greatest. Fuel taxes are a more direct way to counteract pollution, but because rates are set too low to fully cover externalities and road maintenance (Parry, 2008), congestion pricing is a useful supplement to fuel taxes in addressing pollution and are vital to traffic reduction. Congestion taxes, if implemented in United States (US) cities could serve as an effective tool for traffic management, as well as for reducing polluting emissions associated with private-car use.

As the policy environment has grown more favorable, academic discussion of congestion pricing has evolved into a mature field, considering complex models of traffic flow with bottlenecks and speed differences between drivers (Holguín-Veras and Cetin, 2009; Li, 2002), value of time

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differences across drivers (De Palma and Lindsey, 2004; Eliasson and Mattson, 2006, Holguín-Veras and Cetin, 2009; Parry, 2000; Schweitzer and Taylor, 2008), and the design of an optimal and efficient tax, as well as the varying degrees of efficiency between various types of taxes (Holguín-Veras and Cetin, 2009; Parry, 2000). Researchers have undertaken rigorous applications alongside these theoretical contributions, often replicating real road and transit systems with drivers coming from and going to multiple origins and destinations (De Palma, Kilani, and Lindsey, 2005, De Palma and Lindsey, 2002, 2006).

This research examines the effect of the clustering of individuals with similar values of time on the efficiency of destination-based congestion taxes. People are segregated by income in most cities, both between city and suburb and between different sides of the city. One consequence of this segregation is that low-income drivers tend to drive to work on roads with lower-than-average incomes of drivers, whereas high-income drivers tend to drive to work on roads with higher-than-average incomes of drivers. Because the external cost of driving depends on the average value of time of other drivers, drivers from low-income areas of a city tend to impose lower external time costs (but similar pollution costs) than do drivers from high-income areas of the city, even if traffic density and congestion delays are the same. As a result, a tax based only on trip destination overcharges drivers from poor neighborhoods and undercharges drivers from richer neighborhoods, leading to inefficient outcomes for both sets of drivers. This research explores the importance of this sort of inefficiency by using a congestion pricing scheme considered for the city of Chicago as a case study. Chicago, where congestion costs an estimated $7.3 billion annually, is an ideal testing ground for such inefficiencies (Metropolitan Planning Council, 2008; Schrank and Lomack, 2007), and with a large disparity in income between the city's relatively poor South and West Sides and relatively rich North Side.

This report evaluates the effects of applying a congestion tax to the city of Chicago by using a model developed by Harris and Shaikh (2010).[1] The model considers geographic income clusters when determining optimal congestion taxes, which are used to compare the welfare gains from a uniform tax and a neighborhood-specific tax. This research compares expected efficiency gains in Chicago from an optimal tax and a destination-based cordon tax by using income data available through the 2000 US Census and the 2009 American Community Survey, and road data available through the Illinois Department of Transportation (IDOT). The remainder of this article begins with a brief description of the congestion model and its application to Chicago. A discussion of the data follows and includes the estimation results of the speed-volume relationship, which were used to parameterize the model. The optimal taxes for each neighborhood are then calculated and compared to second-best taxes by using welfare analysis. A discussion of the economic efficiency of the results is followed by attention to equity, environmental impact, tax revenues, and political feasibility as additional criteria for the adoption of congestion taxes. The report concludes with a summary and suggestions for further research.

Model and Assumptions

Chicago has considered the imposition of a daily tax on all vehicles parking within the central business district in Chicago (Chicago Metropolitan Agency for Planning, 2007a,b). Similar to the congestion tax in London, the plan did not take into account the origin of cars parked downtown or the route by which they arrived into the city. This report considers this tax design, first finding an optimal level if the tax level does not depend on the neighborhood of origin and then an optimal tax for each neighborhood of origin. In addition, this research outlines the practical outcomes of the optimal tax, including equity, political feasibility, and environmental impacts. For the purposes of this report, which is focused on tax efficiency and income distribution, important questions like the distance traveled, the route chosen, and the time of day will not be addressed.

Individuals in this model choose the mode of transportation that minimizes their own cost of commuting. This cost is comprised of three categories—monetary cost, time cost, and utility cost—with each expressed in dollar value and summed together into total commuting cost. *Monetary cost* is the sum of all expenses required to drive, *time cost* is equal to the monetary value of time spent commuting, and *utility cost* is the amount that the commuter would be willing to pay for the comfort and status of driving as opposed to taking public transit.

The city's transportation system is modeled as a single-destination hub (downtown, which is also known as the *Loop*) connected to the rest of the city through transit spokes. Each transit spoke, which will be referred to as a *neighborhood*, has a public transportation option and a driving option. Because Chicago's train lines follow the routes of expressways, and because Chicago mostly lacks intersections between highways outside of the Loop, it fits the hub-and-spokes model well. Even so, some residents can and do choose between routes to the city center, particularly when living in areas between expressways and train lines, or when expressways are close together. Arterial roads in between expressways may also be used by individuals in distinct neighborhoods.

Drivers in this model impose external costs on transit users, as well as other drivers. This feature breaks with much of the current congestion literature but is consistent with the method used by Small and Yan (2001) and Small (2004), which take transit times to be affected by transit decisions. This decision represents Chicago well because higher car traffic slows buses, which make up a majority of Chicago's transit ridership, whereas lower transit ridership can lead to reductions in the number of routes and the frequency of buses and trains that can be supported (De Palma and Lindsey, 2001). As a result, the transit system should move each commuter more rapidly if the fraction of commuters using transit rather than private cars increases. As will be shown later, this has profound consequences for the level of tax chosen, the equity effects of congestion taxation, and the efficiency difference between a general tax and regional taxes.

The monetary cost of driving is set to be higher than the monetary plus utility cost of using public transit. As a consequence, if any commuters choose to drive, driving speed must be greater than the speed of public transit, meaning that when commuters choose to drive, they are reducing time cost and increasing money cost. Because commuters here vary only by their value of time, commuters with a higher value of time will drive at higher money costs and lower time differences than will commuters with lower values of time. As a result, the *marginal driver* (the driver who is indifferent between driving and using public transportation) must have a higher value of time than all public transit users, and a lower value of time than all other drivers. Treating each driver as the marginal driver, the number of drivers and transit users can be found, which in turn gives the difference between the commuting cost of driving versus transit for the marginal driver (and thus the highest tax the driver is willing to pay). It also gives the external cost of each driver, which is found by taking the sum of the external cost on each driver and the sum of the external cost on each transit user. The driver for whom the external cost is equal to the highest allowable tax is the marginal driver under an optimal tax.

To find the best tax across neighborhoods, the marginal driver, and associated aggregate commute cost, are found for each neighborhood across a range of taxes. The tax rate with the lowest aggregate commute cost, summed across neighborhoods, is the optimal cross-neighborhood tax.

Applying the Model to the City of Chicago

Dividing the City into Neighborhoods

The city is divided into neighborhoods that have relatively self-contained transportation systems, as shown by the expressways and highways in Figure 1, and that have data on individual wages. Because they are the smallest geographies for which individual-level data exist, neighborhoods are defined using the US Census Public Use Microdata Area (PUMA) definitions, with each neighborhood consisting of the PUMA areas surrounding a highway. Since each highway is treated as the representative unit of an independent transit system, this definition means that most PUMA areas are defined as being part of more than one neighborhood. In this case, the income distribution of the PUMA as a whole is used to approximate the distribution near the highway. While necessary for the purposes of application, this simplification does result in some lost information: each of our transit defined neighborhoods contains areas of greatly different income, which conservatively treats the disparities in optimal tax rates by region.

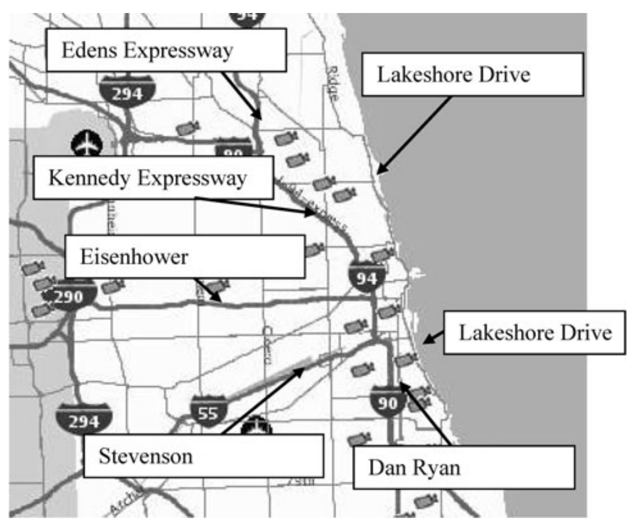

Figure 1. Chicago expressways and highways. Adapted from the Illinois Department of Transportation (Travel MidWest, http://www.travelmidWest.com/lmiga/map.jsp?mapname=chicagoArea).

Choice of Parameters and Fit with Actual Data

To calculate the optimal taxes,[2] five values are estimated and discussed in the sections that follow: the money cost of driving and transit for the typical commuter, the distribution of value of time in each neighborhood, the speed of travel without congestion, the speed-volume relationship for each Chicago highway, and the willingness of the typical Chicago commuter to pay to drive rather than use transit.

Money Cost of Driving and Transit

The money cost of driving is made up of the cost of parking plus the per-mile cost of gasoline, car maintenance, depreciation, and accident risk. Adjusting the Santa Cruz (California) Regional Transportation Commission's cost-of-driving estimate of $0.58 per mile (not counting travel time, parking, and finance costs; Commute Solutions, n.d.) to the Chicago Region's $3.24/gallon average price (May 25, 2010, from chicagogasprices.com) resulted in no significant change so that the per-mile cost of $0.58 is maintained throughout this research. According to a survey of Chicago parking by the *Chicago Tribune*, surface lots in the Central Business District charge an average of $239/month, or $11.95 per day for regular commuters ("Cost of Parking," 2008). Thus, total monetary cost of travel for a commuter living 10 miles from the city is $17.75. For transit users, monetary cost is set to $2.50, which is the price of a trip involving one transfer.

Uncongested Speed of Travel

Driving speed in the absence of congestion is set at 45 miles per hour (mph), which is the average speed of highway traffic as detected by the IDOT during periods of zero congestion. For North Side and South Side neighborhoods, transit speed in the absence of congestion is set to 20 mph. Chicago estimates system-wide average bus speed to be 10 mph, and average train speeds to be 25 mph (City of Chicago and CTA, 2007). When including wait times and transfers, current average travel speed likely falls between 10 and 15 mph. With zero drivers, the system could increase speed by significantly reducing wait times at stations and increasing bus speed. Because the West Side has fewer bus routes than North Side and South Side, and because the Blue Line, Orange Line and Western Green Line have a higher-than-average percentage of areas on which train speeds cannot exceed 15 mph (Chicago Transit Authority, 2010), uncongested transit speed in West Side neighborhoods is set at 16 mph.

Value of Time Estimation

Each commuter's value of time is estimated using individual-level data from the US Census 2000 on earned income, hours worked per week, and weeks worked per year. Earned income is then converted using working hours in a year to obtain an estimate of hourly wage. A proportion of these estimates was either very high, with values over $500/hour, or very low, with values under $5/hour. Further examination of these values revealed that 95% of individuals with estimated wage rates above $200/hour work fewer than 1,200 hours per year. Such cases were removed from the usable data set, as well as cases where wages fell below $5/hour. In total, 15% of observations were dropped.

This approach gave estimates of average hourly wage of $24.43 for the South Side PUMAs, $34.47 for the North Side PUMAs, and $23.63 for the West Side PUMAs. Median wages were $20.03 for the North Side, $16.82 for the South Side, and $15.20 for the West Side. While all three regions had high wage earners, the North Side had far more upper-middle-income commuters. Figure 2 shows wage by income percentile in each region.

Calculating the Speed-Volume Relationship

The optimal congestion tax is expected to differ by neighborhood because of differences in the distribution of value of time but also because of differences in the sensitivity of traffic speed to traffic volume. Estimating the magnitude of the differences in optimal taxes therefore relies on accurate estimation of the speed-volume relationship.

The best available data for this purpose is a data set (IDOT, 2010) taken from detectors placed at mile intervals across the Gary-Chicago-Milwaukee transportation network. The

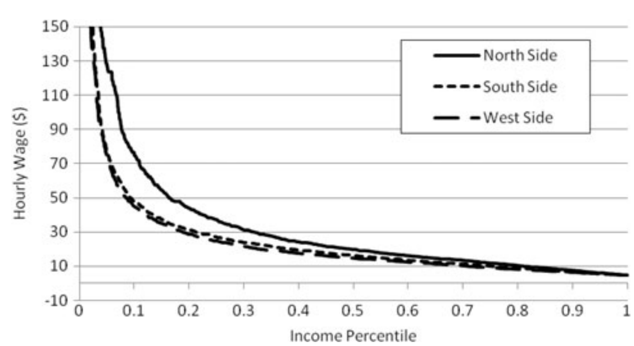

Figure 2. Hourly wage by income percentile for Chicago regions (2008 $). Adapted from US Census (2000).

Table 1. Estimated elasticities and R^2 of increased occupancy on speed by highway

Highway	Highway location	β In	β Out	R^2	Observations
Eden's	North	−.0368	−.0289	0.824	98,006
Lakeshore Drive North	North	−.0306	−.0313	0.774	54,849
Kennedy	West/North	−.0433	−.0432	0.902	128,077
Eisenhower	West	−.0296	−.0245	0.882	102,316
Stevenson	South/West	−.0374	−.0393	0.852	121,049
Dan Ryan	South	−.0222	−.0261	0.619	15,270
Lakeshore Drive South	South	−.0296	−.0294	0.833	36,623

detectors record an observation in 2-minute intervals of the number of cars that have passed, and the percent of the interval in which a car was passing the detector. IDOT imputes average traffic speed from the volume and occupancy calculations. Because the computation of occupancy gives the concentration of cars on the road rather than the flow of cars over a period of time, occupancy was used to indicate the number of drivers in each period.

A regression of the log of speed on occupancy and a set of dummy variables representing each detector was used to determine the speed-occupancy relationship on each highway. The log of speed was the best fit for the data; log-linear regressions produced high R^2 values for all highways. Because the relationship between speed and occupancy is mechanistic, there is no need to control for factors influencing occupancy, such as time of day. These regressions estimated the effect of occupancy on speed to an extremely high degree of accuracy, with standard errors less than one thousandth of the coefficient. The high R^2 values and low standard errors in these regressions indicated that the log-linear model was appropriate for this relationship. Table 1 lists the elasticity estimates resulting from the speed-occupancy regressions by highway.

Highways varied greatly by speed-occupancy relationship. The Kennedy Expressway, which separates the North and West Sides, decreases the most in speed with increased occupancy: An increase in occupancy of 1% on the inbound Kennedy is expected to decrease speed by 4.33%. On the inbound Dan Ryan, a 1% increase in occupancy decreases speeds by only 2.22%.

Resolving Observable Utility

The final variable, the utility cost of public transportation, was chosen to adjust the estimates of the fraction of commuters driving to be consistent with the reported fractions from the 2000 Census data. Two constraints restrict the effect of this value: (1) utility is taken to be equal across neighborhoods, and (2) utility is assumed to be independent of income. We chose a value for utility of $10 per day.

Results

Calculating the optimal tax by the method described above yielded a surprising result. Although optimal tax levels varied greatly between neighborhoods, results show virtually no efficiency gain from charging different tax rates to each neighborhood. This occurs because a broad range of tax levels will produce very similar welfare gains, with virtually all optimal taxes by roadway falling within that broad range (Table 2).

An optimal congestion tax, in which residents are charged based on their neighborhood of origin, would decrease average cost of commuting by 17.2% when compared with no tax, with large decreases in travel time for drivers and a smaller decrease for public transit users. A uniform tax realizes virtually all of those gains. Virtually all of the gains from a congestion tax are realized for taxes of over $9/day, and virtually all of the gains remain for taxes of less than $25/day. Even fairly low taxes, in the range of $5/day, are predicted to decrease travel cost by 8.9%.

As shown in Figure 3, the first $7 of tax is largely beneficial both because it causes a large number of drivers to switch to public transit and because each driver greatly reduces travel times. As the tax increases, fewer drivers switch to transit per dollar, and each switching driver has a smaller impact on travel times.

Figure 4 demonstrates the reductions in the percentage of commuters driving and associated travel times at the varying tax rates. While gains from tax increases after the first

Table 2. Calculated optimal taxes by highway (2008 $)

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

$7 are low, the losses from these tax increases are also fairly minor. The small number of drivers who switch to transit are hurt by higher taxes, but ever larger numbers of public transit riders gain. Losses from overtaxation increase at high taxes because the drivers who switch have higher wage rates but are never high for any particular dollar increase.

Discussion of Optimal Tax Levels and Conclusions

Because a wide range of taxes have similar effects on transit efficiency, city planners can select a tax level based on other criteria. The most likely such criteria are equity, environmental impact, tax revenue, and political feasibility.

Equity

Many economists consider congestion taxes regressive because the benefit of decreased travel time has the highest value for the richest commuters and the lowest for the poorest drivers (Eliasson and Mattson, 2006; Parry, 2008). Recognizing the gains to transit users complicates this argument: nearly half of Chicagoans, most of whom are poorer than average, use public transportation to get to work; all of these commuters receive free benefits from a congestion tax. Congestion taxes create two groups of winners and one possible group of losers, with transit users and low-income drivers (who prefer improved transit to driving before the tax) gaining, high-income drivers gaining, and middle-income drivers, who either switch to public transit at a time cost or continue to drive at a financial cost, either losing from the tax or gaining less than others.

Changing the level of a second-best congestion tax within the range from $7–$20 has a serious impact on distribution of benefits among these groups. Because higher taxes provide gains without costs to transit users, all transit users at

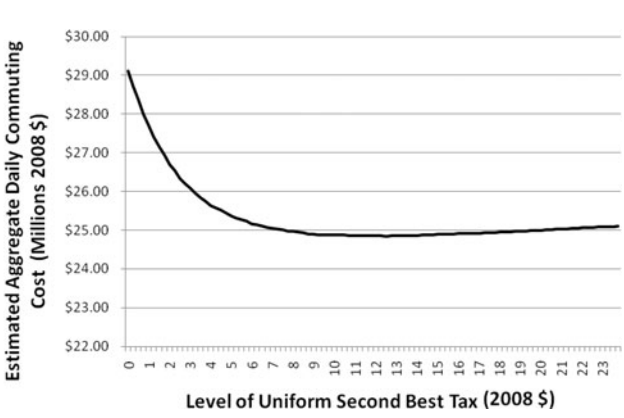

Figure 3. Aggregate commuting cost by level of second best tax.

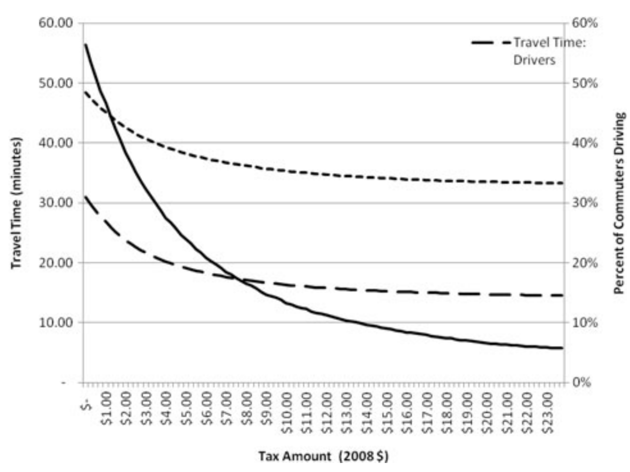

Figure 4. Average total travel time for drivers and commuters, and percent driving, as a function of tax level.

a particular tax rate benefit from a rate increase. Higher-quality transit may also benefit drivers near the margin, who prefer transit under a higher tax to driving with a lower tax. Tax increases hurt most drivers who chose to continue driving after the tax increase, but benefit the highest value of time drivers. Figure 5 illustrates gains in the Eden's Expressway neighborhood from three levels of congestion tax based on income percentile.

Table 3 shows that as the tax rises, lower- and middle-income commuters gain, upper-income commuters lose, and very high-income commuters gain. More commuters switch to transit, and most drivers who do not switch are made worse off.

Comparing a $7.50 tax, an $11.25 tax, and a $20.00 tax, Figure 6 shows that higher optimal tax neighborhoods benefit most from high taxes, whereas low optimal tax neighborhoods benefit the most from low taxes. No neighborhoods were made worse off by even the $20 tax, but the low-tax South neighborhoods lost most of their gains under a $20 tax.

This model has important limits in analyzing equity. Because the model takes the transit trade-off between money and time as identical across commuters, lower-value-of-time commuters are always the commuters most willing to use public transportation. In reality, although many low-income commuters live in dense neighborhoods with good transit access, many others do not. Lower-income Chicagoans living far out in the South and West Sides may drive because of poor access to transit, while richer Chicagoans on the near North Side may use transit because it is plentiful. Low-income drivers who lack access to transit would be hurt by a congestion tax. Furthermore, value of time may not track with overall wealth or income. This model considers only commutes to work; drivers on shopping trips and restaurant outings may have a low value of time for the hours on the road despite high incomes. Meanwhile, if poorer commuters are more likely to hold jobs with inflexible hours and penalties for lateness, they may have high values of time for the hours of commute. Such commuters would be in a higher percentile for value of time than they are for income.

Finally, the gains to transit users depend on increased ridership and new sources of funding improving the quality and availability of transit. If a city does not invest in new transit, or invests only in affluent areas, a congestion tax would not have equity benefits. Because low-income commuters are the least likely to switch from public transit, cities may find it in their interests to distort spending away from low-income areas.

Table 3. Distribution of gains by tax level

Tax level	Fraction (%) of gains to transit users	Fraction (%) of gains to drivers	Fraction (%) of gains to revenue	% Driving
$7.50	41	44	15	14
$11.25	48	38	14	10
$20.00	50	31	19	7

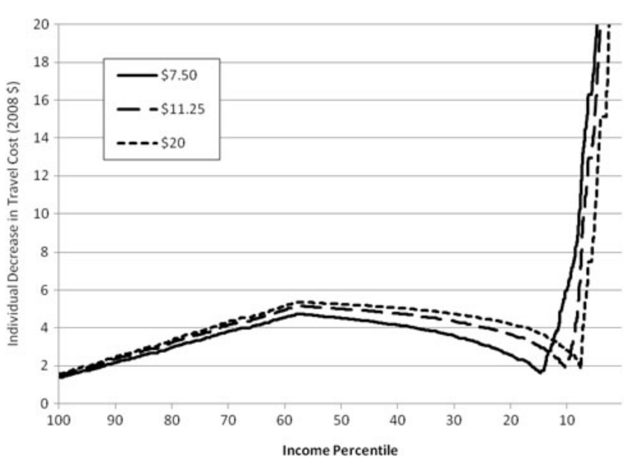

Figure 5. Change in individual travel cost as a function of income percentile.

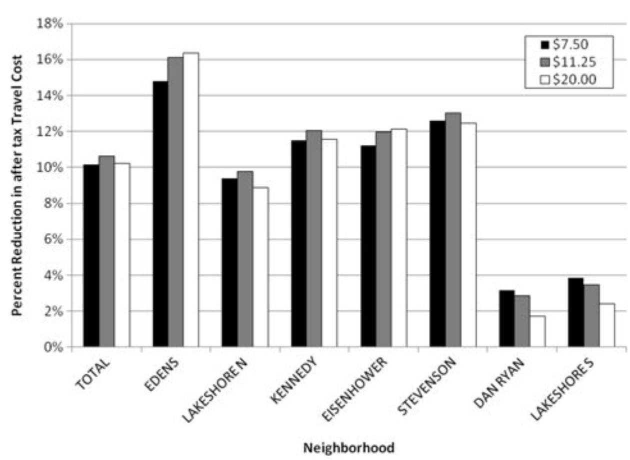

Figure 6. Percent reduction in after tax travel cost by neighborhood and tax level.

Environmental Impact

Higher tax levels are almost certain to reduce pollution associated with the daily Chicago commute. Because the external cost of driving due to pollution is more similar across neighborhoods than is the external cost of congestion, a uniform tax is also preferable for the goal of pollution reduction. However, the changes in the number of drivers, and thus the change in emissions, due to an increase in tax fall as the tax increases. For instance, while 6% of commuters switch from driving to public transportation when the uniform congestion tax is raised from $5 to $7, only 0.81% of commuters make this switch when tax increases from $18 to $20. Table 4 shows the effect of the taxes on the number of daily commutes and associated pollution externalities.

Overall, $7.50, $11.25, and $20.00 taxes, respectively, would reduce the number of daily car commutes by 1.3 million, 1.5 million, and 1.68 million, respectively. Using our estimate of 10 miles per trip, and Parry's (2008) conservative estimate of 2 cents per mile of pollution externalities, these tax levels would reduce annual pollution externalities by $191.23 million, $219 million, and $245 million, respectively.

Tax Revenue

Because virtually all sources of government revenue collection induce deadweight losses, a dollar of government revenue is more expensive than a dollar of private revenue. If the level of government spending reflects the deadweight costs of taxation, a tax level that brings in more revenue without reducing transit efficiency is preferable whether the government retains the increased revenue or cuts other taxes. However, Figure 7 shows that taxes higher than $7.50 are all expected to yield roughly equal revenues because higher revenues per person are offset by declines in the number of drivers.

Table 4. Effect of taxes on number of driver and associated pollution cost savings

Tax amount	Number of forgone daily commutes (millions)	Pollution cost savings (2008 million $)
$7.50	1.3	$191.23
$11.25	1.5	$219
$20.00	1.68	$245

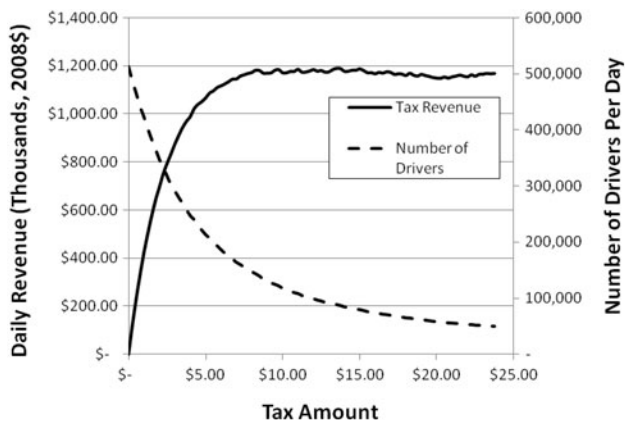

Figure 7. Daily tax revenue by second best tax level.

Political Feasibility

Because the benefits of any high congestion tax are similar, the best rate may be the one most likely to be enacted. A charge of $11.25 per day is not unprecedented: the London congestion charge is 8 pounds ($12.25) per day, and Electronic Road Pricing in Singapore charges a maximum $15 per day fee (Leape, 2006; Li, 2002). However, a tax is probably more likely to pass into law if the amount is low and the transition to the tax is gradual. The results of this study suggest that such considerations can play a large role in the implementation of a congestion tax so long as the final level is at or above $7.50/day.

Conclusion and Further Research

At the end of the day, should practitioners consider differences in the average value of time across regions of the city in setting a congestion tax? On the one hand, in Chicago, a city with large average wage differences across regions, the tax that minimizes commute cost along the South Side's Dan Ryan Expressway is $9.75 lower than along the North Side Eden's Expressway. The optimal compromise tax, of $11.25 per day, is more than $5 too low for the highest tax region and $4.50 too high for the lowest tax region. This result is achieved despite estimates for average wage that likely underestimate differences in average value of time across neighborhoods. Regional differences within a city may be worth considering in congestion tax policy, even if such considerations carry a political and implementation cost.

On the other hand, the estimates of the welfare differences between a neighborhood specific, first-best tax scheme, and a general, second-best tax scheme indicate that the actual costs of charging nonoptimal tax rates are insignificant compared to the 17% reduction in commute cost from a single rate tax. At tax levels higher than $7 per day, changes in tax level have small effects on efficiency. Complicating the tax jeopardizes the gains from a simple congestion tax in order to achieve a tiny increase in benefits.

The right choice for a city must depend on the city's characteristics. Cities with substantial income segregation that rely on trains more than on buses (reducing benefits to transit riders) and that have political support for a congestion tax may choose to reduce rates for drivers from lower-income areas. Cities with mixed-income neighborhoods, greater reliance on buses, and tenuous political support for a congestion tax may avoid politically and practically difficult complications to a proposed tax. Taxes can also be revised after the fact, particularly if a disproportionate share of trip abatement occurs in lower-income regions of the city.

Because traffic patterns, and thus the external costs of a particular individual, are complicated and variable, any feasible congestion tax will overcharge some drivers and undercharge others. To set effective congestion taxes, it is important to know how variable individual external costs actually are and how valuable accuracy and specificity are in setting a congestion tax. This report addresses both of these questions, showing that optimal tax rates vary substantially by neighborhood but also indicating that congestion taxes may be inexact in their rates and still be effective.

Acknowledgments

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Notes

1. While this article does not include the full derivation of the model, it includes a brief summary of the model and some discussion of its appropriateness to Chicago. A full exposition and development of the congestion model and its results can be found in Harris and Shaikh (2010).

2. See Harris and Shaikh (2010) for the derivation of the optimal tax function resulting from the congestion model.

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