

CIGARETTE TAX AVOIDANCE IN THE CHICAGO AREA: A CONTRIBUTION TO THE LITTERATURE¹

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Abstract

The large tax differentials between Chicago and neighboring jurisdictions provide an incentive for smokers to buy cigarettes outside Chicago. By examining a random sample of discarded cigarette packs, I can see whether Chicago taxes have been paid on the cigarettes consumed in Chicago. I find a startling amount of tax avoidance: three-quarters of the packs found on the streets of Chicago did not display a Chicago tax stamp. Demonstrating that the cost of tax avoidance influences behavior in the predicted direction, the percentage of packs without a Chicago tax stamp fell as distance to lower-tax borders increased.

KEYWORDS: Cigarette taxes, tax avoidance, littering, Commodity taxation
JEL CLASSIFICATION: H73, H26, H71, R23

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CIGARETTE TAX AVOIDANCE IN THE CHICAGO AREA: A CONTRIBUTION TO THE LITERATURE

Reporter: Tell me what you do for a living basically.

Seller: Basically, I sell boot-leg cigarettes...

Reporter: How many packs do you tend to buy in Indiana and sell in Illinois?

Seller: ... Probably right now, 30 packs...like three cartons...we [used to] sell them for \$5, now we have to go up to \$6, people don't want to go up the dollar. Even though the cigarettes are still \$7 to \$8 in Chicago....

Reporter: How long have you been selling cigarettes?

Seller: I have been selling cigarettes for something like two years. Last year I had a great year man, we calculated up 55-60 thousand dollars...This year its way down from there...I was buying... 17..18..30 cartons...¹

I. Introduction

Sin taxes are designed to discourage certain behaviors. The public health argument for discouraging smoking is especially powerful because, according to the Surgeon General of the United States (2004), “[s]moking is the single greatest cause of avoidable morbidity and mortality in the United States”. It is widely believed that the most effective tool to reduce cigarette consumption is increases in cigarette prices: “Numerous studies ...confirm a fundamental principle of economics: increased tobacco prices will reduce tobacco use [and the] .. most important policy related determinants of prices...are taxes on tobacco products” (U.S. Department of Health and Human Services, 2000). Since January 2002 at least 36 states and the District of Columbia have increased their cigarette tax rates (Goolsbee, Lovenheim and Slemrod 2007).

The tax increases have sometimes created large price disparities in neighboring communities. For example, portions of the City of Chicago, which has a combined state-local tax of \$3.66 per pack, border on Indiana, which until July of 2007 had a state tax of only 55.5 cents per pack and has no local cigarette excise taxes. The tiny state of Rhode Island has a tax of \$2.46 per pack while its neighboring states of Massachusetts and

Connecticut have taxes of only \$1.51 per pack. Maine charges a tax of \$2.00 per pack but neighboring New Hampshire charges only 80 cents. Oklahoma's tax of \$1.03 per pack is 86 cents higher than its border state Missouri and Montana's tax of \$1.70 is \$1.26 higher than adjacent North Dakota. The discrepancies in tax rates may encourage some smokers to cross jurisdictional borders to buy cigarettes.

The relatively high share of the purchase price attributable to taxes, the easy access to low-tax, or no tax, sources of cigarettes in nearby jurisdictions, on Indian reservations, and on the internet, and the authorities' lack of overt effort to discourage tax avoidance make cigarette tax avoidance an unusual laboratory for the study of consumer behavior. The literature on tax compliance (see Andreoni, Erard and Feinstein, 1998, and Slemrod, 2007a for reviews) most often has focused on avoidance or evasion of federal taxes. Slemrod (2007a) calculates an aggregate tax gap, defined as the tax that is not collected on this income equal to about 14 percent of the revenue collected from federal taxes. However, Slemrod notes that the amount of under-reporting varies widely by source of income—almost all wage and salary income is reported but more than half of non-farm proprietor income is not. In this literature, it is difficult to tell how much of the difference in propensity to comply is due to differences in income and characteristics of the taxpayer (e.g., wage earners may be systematically more risk averse than sole proprietors) and how much is due to differences in the probability of detection. There have been few studies of the effects of the cost of avoidance on tax avoidance behavior. The geography of cigarette taxes provides an exogenous source of variation in the cost of tax avoidance, allowing for a clean estimate of the relationship between tax avoidance and its cost.

A substantial decline in tax-paid sales associated with recent tax increases has been documented (Chernick 2007), but whether consumption of cigarettes falls or whether buyers simply switch their place of purchase from high-tax to low-tax areas is unclear. Because cigarette tax avoidance consists in part of individual consumers engaging in unorganized cross-border shopping and because it is sometimes covert, it is difficult to measure. While economists and others have conducted many studies and developed sophisticated econometric techniques to assess cigarette tax avoidance (see appendix 1 for a brief review of the literature), none of the widely used approaches is fully satisfactory because they require researchers to infer tax avoidance based on discrepancies in observed data (e.g., the difference between tax revenues collected and the amount of smoking reported in surveys).

This paper reports on a simple but novel technique that has the potential to shed light on the extent of cigarette tax avoidance. In brief, this technique involves inspection of littered cigarette packs to determine whether legally required taxes have been paid. In all states except North and South Carolina, wholesalers must affix state tax stamps to the cigarette packs before distributing them to retailers to indicate that taxes have been paid². Working in the “unobtrusive measures” tradition of Webb et. al. (1966), I organized research teams of students to collect littered cigarette packs in a representative random sample of areas in the City of Chicago and some neighboring jurisdictions. A separate survey of appropriately disposed of cigarette packs from some of the same areas also was conducted. We carefully examined the tax stamps from the collected packs to determine the extent of cigarette tax avoidance. I find a startling degree of tax avoidance—three quarters of the Chicago packs found did not display the Chicago tax stamp and thus

avoided Chicago taxes. I find that tax avoidance declines with distance to low-tax borders.

The paper proceeds as follows. In section II I, provide background about recent changes in cigarette taxes and sales in Chicago. In section III, I describe the advantages of using littered cigarette packs as a source of data to study tax avoidance behavior. I then describe in section IV the novel sampling, data collection, and data coding procedures employed in this study. Section V contains the main results, and I discuss the representativeness of our findings and some ancillary issues in section VI. I conclude in section VII.

II. Background on cigarette sales and taxes in the Chicago area

In the City of Chicago there are four overlapping governments that impose an excise tax on cigarette sales: the federal government, the state government, the Cook County government and the City of Chicago. Wholesalers that provide cigarettes to retail outlets in Chicago are required to affix an Illinois state stamp and a joint city-county stamp to each cigarette pack, including those offered for sale in cartons.

Cigarette sales: Figure 1 displays monthly data on the sale of joint city-county (i.e. Chicago) tax stamps from 2001 to late 2007. During this period there were five tax increases by the state, county and city governments that raised the cigarette tax by a cumulative total of \$2.64 cents per pack. Average monthly sales of Chicago cigarette tax stamps fell from about ten million in 2001 to less than five million by mid 2006. Note that the data show a spike in sales in the month before each tax increase—evidence suggestive of hoarding of stamps or cigarettes in anticipation of higher taxes³. Unfortunately, we cannot be certain how much cigarette consumption changed over this

period. Lower sales of tax stamps may have been partially or completely offset by increased cross-border purchases of cigarettes or other tax avoidance techniques.

[insert figure 1 about here]

Cigarette taxes: Figure 2 is a map of total state and local excise taxes on cigarettes in the Chicago area during the summer of 2007, when the data for this study were collected. The map shows all of Cook County, portions of the Illinois counties of Lake, DuPage and Will, a small portion of Lake County, Indiana, which borders on Cook County, and the borders of several municipalities located within Cook County and next to the City of Chicago. As previously noted, beginning in March of 2006 Cook County had a \$2 per pack cigarette tax so that the total tax (combining federal, state and county excise taxes) in all municipalities in Cook County was at least \$3.37 per pack. In Lake, DuPage, and Will counties, only the combined state (98 cents) and federal (39 cents) taxes were applicable so the total tax per pack was \$2 less than the minimum in Cook County. In Indiana, state taxes were 55.5 cents per pack and there were no local cigarette excise taxes so the tax was even less than in other surrounding areas. Within Cook County, the municipalities of Berwyn, Cicero, Chicago, Evanston, and Rosemont levied additional taxes on top of the federal, state and county taxes. Chicago's taxes were the highest and resulted in a total tax of \$4.05 per pack, which was \$3.10 per pack higher than in Indiana and \$2.68 per pack higher than in Lake, DuPage and Will counties⁴. For a pack a day smoker, purchasing cigarettes in Indiana rather than Chicago would result in savings of more than \$1,100 per year⁵.

[insert Figure 2 Map of Total (Federal+State+Local) about here]

III. Why study littered cigarette packs?

The study of tax evasion and tax avoidance presents special challenges for economists because such behavior is generally sensitive and hidden (Slemrod 2007a). A major advantage to using littered cigarette packs as a source of data is that littered cigarette packs are easily available in Chicago (as our findings will demonstrate) and they are likely dropped with little thought as to the legality of the cigarette pack because it is impossible to trace the pack to its owner. One concern about this source of data, however, is that those who litter may be systematically different with regard to tax avoidance behavior from those who do not litter. In partial response to this concern, I note that the limited evidence available suggests that littering is not confined to any particular socio-demographic group. Australian research teams observed almost nine thousand people disposing of rubbish in public places such as parks and outdoor shopping malls and found that 23 percent littered. The researchers observed that people of all ages and backgrounds littered, men and women were equally likely to litter and a lack of bins was not a major factor in littering as most littering occurred within five meters of a bin (Williams, Curnow, Streker 1997 p.7). I provide some additional direct evidence about bias in the Chicago litter sample in section VI, but note here that, even if we cannot definitively dismiss this objection, studies of litter should provide a useful upper bound on tax avoidance and can be informative about how tax avoidance varies across space.

A possible alternative approach to gathering littered packs would be to ask people who pass by in the street to see their cigarette packs and to record the origin of the stamp on the pack⁶. This is a potentially promising cross-validation technique, however the implementation of this method faces several significant practical barriers. First, it would

likely be quite time consuming and expensive to generate as large a sample as we obtained by collecting litter. A 2005 (Dell et. al) survey of six diverse Chicago neighborhoods found smoking prevalence to vary from 18 percent in the wealthiest neighborhood to 39 percent in the poorest neighborhood. Thus, we would expect that only two to four out of every ten people passing in the street would be smokers. If one of two smokers was too busy, suspicious, or private to allow the surveyor to look at their pack it would be necessary to approach about 92 people in the wealthiest neighborhoods to obtain a sample as large as in our litter survey (8.3 packs per neighborhood). It seems likely that in some areas it could take many hours, perhaps days, while our litter collections generally required less than one-half hour of walking.

There are additional practical problems as well. In a large city such as Chicago, many people do not speak English and tax avoidance behavior and willingness to comply with surveyors' requests could vary with ethnic and language background. Underage youth also would be unlikely to comply with a request to see their packs. Even in anonymous telephone surveys it is well-known that smokers vastly under-report smoking behavior, so it seems highly likely that many people would disguise this behavior in face-to-face meetings with unknown surveyors⁷.

Even when subjects agreed to comply with the request to show their packs, this data gathering methodology might face substantial barriers. In order to gain compliance, surveyors would have to do a rather quick examination of the pack and the tax stamp. There are numerous possible stamps that might appear on the pack. Even well-trained surveyors might make mistakes and, unlike with littered packs, there would be no way to check the coding of the stamps.

What do littered cigarette packs tell us about tax avoidance? Observations on littered cigarette packs at a single point in time cannot provide a definitive measure of tax avoidance since we do not observe the mix of litter in the absence of tax differences. However, we can compare the observed distribution of stamps on littered cigarette packs with the distribution we would expect to find if there were no cross-border differences in cigarette taxes. In Appendix 2 I present a simple model to predict the mixing of Chicago and non-Chicago cigarette tax stamps in the litter in Chicago in a world with uniform prices and I present simulations of the model using available data. The simulations suggest that less (perhaps much less) than 15 percent of the littered packs in Chicago would bear non-Chicago stamps. Even fewer packs would be expected to bear non-Cook County stamps and less than one percent of littered packs would be expected to bear non-Illinois stamps.

IV. Data collection methods

Sample: The data collection strategy was designed to produce a sample that was representative of cigarettes smoked within the legal boundaries of the City of Chicago. For transportation planning and other purposes the city is divided into 930 relatively homogenous geographic areas known as transportation analysis zones (TAZs). In the Chicago region, TAZs usually coincide with a geographic subdivision known as a “quarter-section,” which is a one-half-mile by one-half-mile (hence one quarter square mile) area. In some cases, TAZs have an area that is larger or smaller than a quarter section because of geographic idiosyncrasies or high population or employment densities. Census data were matched to each TAZ and used to estimate population and employment. We drew a weighted random sample of 100 City of Chicago TAZs. In the

sampling process, TAZs were weighted based on their estimated population (100% weight) and employment (49% weight)⁸. One TAZ, located very near O'Hare airport, is within the City of Chicago but in DuPage County and was selected in the random sample. In addition to the sample of TAZs located within the City of Chicago, we collected data from all five TAZs outside of Cook County that border Chicago: three located in DuPage County and two located in Indiana⁹. We also drew a weighted random sample of 30 out of the 160 TAZs that are in Cook County and border the City of Chicago, but are not within the legal boundaries of the city. A summary of the universe and sample is given in Table 1 below.

[insert Table 1 about here]

A street map was overlaid on a satellite photo for each of the 135 TAZs from which data were to be collected. We then designated a route of approximately one mile along which littered cigarette packs were to be gathered. Routes were selected based on our judgment about whether areas were (1) safe places to walk and (2) a good place to find littered cigarette packs. A typical collection route required data collectors to walk one-half mile on the north side of the street along a commercial strip at which point they crossed to the south side of the street and walked one-half mile back to the starting point.

Data collection procedures: Teams of data collectors consisting of at least two people were sent to each designated route. The teams were told to walk precisely along designated routes. Since tax stamps are affixed to the cellophane, only littered packs with cellophane can be used to determine whether taxes have been paid. However, in order to simplify data collection and avoid arbitrary judgments in the field, data collectors were told to pick up every littered cigarette pack they spotted on the route. They were

told to deposit each littered cigarette pack in a plastic bag labeled “without cellophane” or “with cellophane” as appropriate. The plastic bags were labeled with the location (TAZ number), date, time, and names of those on the collection team and tied shut. The collected samples were returned to the research office.

Data coding procedures: Each pack was labeled with a serial number that indicated the TAZ in which it was found. Teams of research assistants were then trained to identify tax stamps from Illinois, Cook County, Chicago, Indiana, and Wisconsin. Research assistants completed a computerized questionnaire with approximately 10 questions about the location (denoted by serial number), brand, and, most importantly, the tax stamps on the pack. The entire data set was coded twice and a computer program was written to identify cases in which the first coding of tax stamps did not match the second coding. Research assistants located all of the packs where discrepancies were found and determined the correct coding.

V. Main Results

During primary¹⁰ data collection we found a total 2,396 littered cigarette packs, 1,146 (47.4 percent) of these packs had cellophane attached so that we could identify tax stamps if present. Figure 3 provides information about where we found packs with cellophane attached.

[insert figure 3 Map of Sample TAZs about here]

These raw data were used to construct estimates of the prevalence of tax compliance in each of five groups of TAZs defined by the city, county and state boundaries as enumerated in Table 1. Our estimates assume each littered pack is a random draw from an identically distributed and independent binomial distribution with a

probability of compliance that is constant within a TAZ, but that varies across TAZs.

The total observed number of packs that comply with a given tax within a TAZ thus has a Bernoulli distribution. Because we drew a weighted random sample of TAZs in each group it can be shown that the un-weighted average of the observed TAZ-specific probabilities of compliance is an unbiased estimator of the true group-wide probability of compliance under the assumptions of our model (see appendix 3 for a more formal proof).

[insert Table 2 about here]

As shown in Table 2 the data provide evidence of an astounding degree of tax avoidance in Chicago, and to a lesser extent in the surrounding suburbs. Based on our sample, only one-quarter (25 percent) of littered packs in Chicago have a Chicago tax stamp while slightly more than one-third (36 percent) contained evidence that the hefty \$2 per pack Cook County tax had been paid. Fifty-nine percent had Illinois stamps and 29 percent had Indiana stamps. In fact, in Chicago littered packs are slightly more likely to have an Indiana stamp than a Chicago stamp. Five percent have stamps from some other state and seven percent have no state tax stamp at all, which could indicate that they were purchased from remote locations via the internet or from vendors on Indian reservations.

Although we have only small samples from DuPage county and from Indiana, avoidance of state taxes appears to be much smaller in these locations. In the three DuPage county TAZs that border Chicago we estimate that 83 percent of littered packs have an Illinois stamp. In the two Indiana locations that border Chicago, 97 percent of the packs have an Indiana stamp.

Our random sample of 30 TAZs that are in Cook County but not in Chicago is designed to be representative of all 160 such TAZs that border the City. We estimate that more than three-quarters (76 percent) of the packs in border TAZs have an Illinois tax stamp and 51 percent have paid Cook County taxes.

Figure 4 contains three maps showing the share of packs with Illinois, Cook County and Chicago stamps. We have suppressed the data in TAZs where less than five packs were found because the high variance of the results in those TAZs may yield a misleading picture. Figure 4A clearly shows that we found many fewer Illinois stamps in south-side TAZs near the border with Indiana. Figures 4B and 4C show that, although Chicago and Cook County stamps were relatively rare everywhere, they were most plentiful in the downtown “Loop” area and on the northeast side of the city, two regions relatively far from low-tax jurisdictions. These maps are thus consistent with the hypothesis that avoidance of the Illinois tax is most prevalent close to Indiana and avoidance of the Chicago and Cook County taxes is most common among smokers close to Indiana and close to the city and county border.

[insert Figure 4 Maps showing locations of Illinois, Cook Count and Chicago Tax Stamp percentages] about here

A more formal test of the hypothesis that proximity to lower tax sources of cigarettes increases the probability of avoidance is shown in Table 3 where we report probit regression estimates of a “tax avoidance” gradient. We include three categories of independent variables: geographical variables—measuring the distance to various tax borders—land use variables—indicating the type of land uses in the TAZ—and economic and demographic variables describing residents of the TAZ. The most interesting

variables are the geographic variables which measure the distance to the Chicago border, the additional distance (if any) from the Chicago to the Cook county border and the additional distance (if any) from the county to the state border. The land use variables control for the fact that commercial districts may have more out-of-town visitors than other types of land uses and the demographic variables control for the fact that certain types of populations (particular low income and black populations) typically live closer than others to some tax borders.

[insert Table 3 about here]

In column 1 we estimate the share of packs with an Indiana stamp but omit the share of households that are black from list of demographic variables. In column 2 we have the same dependent variable but include share of households that are black. Columns 3 through 6 report analogous regressions where the dependent variable is the probability of an Illinois, Cook County or Chicago stamp. The Illinois and Indiana regressions (columns 1 through 4) unequivocally confirm that distance matters. The further the TAZ from a tax border the less likely we are to find avoidance (an Indiana stamp) and the more likely we are to find compliance (an Illinois stamp). We find slightly less compelling evidence that distance matters in regressions on Cook County and Chicago stamps. In columns 6 and 8 the five of six distance coefficients are statistically significant with the expected sign but when we include the share of households in the TAZ that are black none of the distance coefficients are statistically significant although all retain the expected sign. In all cases the estimated coefficient indicates significantly less compliance as the share of black households increases. Thus, in this data set we do not have sufficient statistical power to determine whether we see more avoidance of

Chicago and Cook county taxes close to borders because proximity facilitates avoidance or because areas close to the border happen to house more of the types of people that avoid cigarette taxes.

In Table 4 we report on similar analyses for Indiana, Illinois and Cook County stamps in Cook County TAZs that border Chicago. In these regressions distance to the Cook county and state borders are again significant and have the expected sign—tax avoidance declines with distance to the border—when we omit share of households that are black. In columns 2 and 4 when we include the share of households that are black, the distance variables become insignificant. However in column 6, when the dependent variable is the presence of a Cook County stamp, the share of black households is insignificant and the distance variables retain their statistical significance.

We use the coefficients from the regressions reported in columns 2,4,6 and 8 of Table 3 to plot the predicted probability of finding each type of tax stamp—conditional on observed distances to the Chicago and Cook border and mean value of other independent variables—against distance to the Indiana border as displayed in figure 5.

[insert figure 5 about here]

Very close to Indiana about 80 percent of packs contain an Indiana tax stamp but this declines quickly with distance and 30 miles from the Indiana border almost no packs have Indiana stamps. The graph of the predicted probability of finding an Illinois stamp is practically the inverse of the graph of probability of an Indiana stamp. Thirty miles from the Indiana border 80 percent of all packs have an Illinois stamp. The probability of Chicago and Cook county stamps also grows with distance to the Indiana border. The probability of finding a Chicago stamp hits a maximum of 30 percent 30 miles from the

border, while the probability of a Cook county stamp reaches a maximum of about 43 percent at that distance.

We generate an analogous plot using the coefficients from Table 4 as displayed in figure 6. In border areas, where the Chicago tax is not levied, we find much less evidence of avoidance. About 24 percent of all packs have an Indiana stamp five miles from the Indiana border and nearly 59 percent have an Illinois stamp. Only about 10 percent have a Cook county stamp at those locations but the share of Illinois and Cook stamps rise with distance to the Indiana border. Thirty-five miles from the border (the maximum distance in our data set) 84 percent of packs have Illinois stamps and 43 to 73 percent (depending on distance to other tax borders) have paid the two dollar per pack Cook county tax. Only about nine percent have an Indiana stamp about 35 miles from the Indiana border.

[Insert figure 6 about here]

VI. Ancillary analysis

Because the data collection strategy employed in this research is relatively novel we conducted a number of ancillary analyses in an attempt to learn about the representativeness of our sample.

a. Resampling

One might ask how long a typical pack in our sample of littered cigarettes packs has been on the ground. Tax policies have changed over time and tax avoidance behavior also may have changed. If the littered packs we collected are not recent it may be difficult to use the data to estimate behavioral changes in response to changes in tax policy. We sent teams of data collectors back to 14 routes to resample the areas. The

areas for resample were selected using the following algorithm. Once the initial data collection was completed we ranked the 135 routes from lowest to highest based on the total number of packs found. We then designated every 10th ranked route starting with the 5th route for resample. We therefore resampled the 14 routes ranked 5, 15, 25...135¹¹. Resampling was done during the period June 22 to July 16, 2007. In each case precisely the same route was resampled 32 to 38 days after the original sampling.

A basic tabulation of our results is shown in Table 5. Since data collectors were instructed to pick up every littered pack they spotted when they did the original

[Insert Table 5 about here]

data collection, we know that all of the littered packs found during the resample were littered in the 32 to 38 day period between our original sampling and the resample. We find no evidence that there was any diminution in the amount of littered packs found. In seven of the 14 TAZs we found more littered packs during the resample than in the original sample. In the original sample we found a total of 282 packs, 136 of which (48 percent) had cellophane on these routes. In the resample we found 302 littered packs, 154 (51 percent) of which had cellophane.

We use data from these 14 TAZs to estimate the ratio of the number of littered packs in the original to the number of littered packs in the resample. Our results are displayed in Table 6.

[Insert Table 6 about here]

Whether we consider all packs or just packs with cellophane our estimated ratios are slightly less than one and a 95 percent confidence interval contains the value one. Using our finding for all packs the highest level of confidence at which we can reject the

hypothesis that the ratio is equal to 1 is 57 percent. Using packs with cellophane the highest level of confidence at which we can reject the hypothesis the ratio is equal to one is 59 percent. This evidence is consistent with the (maintained) hypothesis that littered packs we discovered in our original sample were of recent origin and reflect behavior that was influenced by current tax policy.

b. Sample from Receptacles

A prominent threat to the internal validity of this study is the potential non-representativeness of a sample based on littered cigarette packs. Even though evidence, discussed above, shows that littering is a very widespread behavior that is engaged in by people of all socio-economic classes, it is possible that smokers that litter have a greater propensity to avoid taxes than smokers who do not litter. Smokers who litter are necessarily those who have flaunted a (minor) law. It is reasonable to ask whether smokers who litter also are unusually likely to circumvent other laws such as the requirement that cigarette taxes are paid.

This is a difficult hypothesis to investigate but we attempted to get some relevant information by comparing tax avoidance in littered cigarette packs to tax avoidance in appropriately disposed of cigarette packs in a few areas. With the cooperation of the Chicago Department of Streets and Sanitation (Streets and San) the research team was given access to public trash receptacles in three areas of the city. These public receptacles are placed along many city streets. In most areas Streets and San empties the receptacles on a daily basis during summer months. In three areas of the city, we rode with Streets and San on one occasion and took the trash from each receptacle in a large plastic bag. We brought the plastic bags to a suitable area and sorted through them

extracting every cigarette pack we found. The extracted packs were labeled based on where they were found and information about them was coded into a data base. In total we examined the trash from 40 trash receptacles and found one or more packs in 31 receptacles. In these 31 receptacles we found a total of 82 packs with cellophane.

In each of the three areas where we gathered data from receptacles we walked exactly the same streets within 24 hours looking for littered packs. In two of the areas we found no littered packs. In all three areas we compared the receptacle sample to the sample of litter obtained from the closest TAZ. Table 6 information from nine samples. Samples 1, 2 and 3 were collected along an approximately 1.5 mile long stretch of road in the

[Insert Table 7 about here]

north-east section of the city. Along that stretch we obtained data from three sources: a TAZ (#414513) that we surveyed as part of our representative sample, trash receptacles, and littered packs collected on the same day along the same street that data was gathered from the trash receptacles. In this area we found 18 packs with cellophane in the trash receptacles (sample 2). Six of the packs had Chicago tax stamps and 12 did not. In the parallel search for litter (sample 3) we found nine cigarette packs six of which did not have a Chicago tax stamp. In TAZ #414513 (sample 1) we found seven packs with cellophane, four of which had a Chicago tax stamp. In row 4 of the table the first number in square brackets gives the probability, conditional on our sample, that there is less compliance with Chicago taxes among littered packs than among properly disposed of packs in the area. In that row we also present the probability that there is less compliance with Illinois taxes. In the rest of the table we present data about and test analogous hypotheses for two other areas.

While the number of areas sampled is small, the data in Table 7 provides little evidence that smokers who litter disproportionately avoid applicable taxes. In two of the three cases we found higher compliance with both Illinois and Chicago taxes among littered cigarette packs than among nearby receptacles. In the third case, we found nearly equal compliance with Illinois taxes among the two samples but higher compliance with Chicago taxes in the receptacle sample.

Even if compliance was disproportionately low in the littered sample we might obtain valuable information by studying how tax avoidance in the littered sample varied with other variables such as distance to a low-priced border. In any case, our evidence provides little reason to believe the littered sample results in biased estimates of tax avoidance.

c. Brand distribution

Another way to check the representativeness of our littered sample is to compare the distribution of cigarette brands in our Chicago tax paid litter sample with the distribution of cigarette brands reported by Chicago vendors of tax paid sales. Table 8 compares the brand distribution in data collected from the scanners of vendors located in Chicago in the second quarter of 2002 to the weighted sample of tax paid littered packs we found during the summer of 2007.

[Insert Table 8 about here]

In both distributions Marlboro is, by far the leading brand and Camel, Kool and Parliament have small shares. The greatest differences between the two distributions are that the littered sample shows a much higher market share for Newport (29% versus 12%) and a much lower share for “Other” brands (9% versus 25%). One possible

explanation for this discrepancy is that Newport gained market share during the period 2002 to 2007 at the expense of brands in the “Other” category. Another possibility is that because stores that use scanners tend to be large, they stock a greater variety of brands than the average. In this case, the scanner data might over-represent relatively obscure brands (collected in the “Other” category). Of course, it is also possible that the littered sample over-represents Newports and under-represents “Other” brands but we have no clear reason to explain why this should be so¹².

d. Counterfeits

In order to determine whether applicable taxes had been paid on littered cigarette packs we trained coders to recognize tax stamps from Chicago, Illinois, and several other jurisdictions. However, without professional assistance coders were not able to recognize counterfeit tax stamps. Representatives of the City of Chicago Department of Business Affairs and Licensing assisted us in checking a random sample of 100 littered packs of cigarettes with Chicago tax stamps for counterfeits. A specially developed light that is shined on the stamp to identify counterfeits was used in our investigation. Fifteen of the packs we presented did not have enough information to determine whether the stamp was valid. Of the remaining 85 stamps one was counterfeit. If those 85 packs were a random sample of cigarette packs with Chicago stamps we can be 95 percent confident that in the population as a whole between .02 percent and 6.4 percent of stamps are counterfeit.

Representatives of the State of Illinois Liquor Commission assisted us in checking a random sample of 100 littered packs of cigarettes with Illinois tax stamps for counterfeits using a similar technology. Five of the packs we presented did not have enough information to determine whether the stamp was valid. Of the remaining 95

stamps none was counterfeit. If those 95 packs were a random sample of the population of packs with Illinois stamps we can be 95 percent confident that in the population as a whole less than 3.8 percent of stamps are counterfeit.

VII. Implications and conclusions

In this section we explore three questions: First, what do these findings suggest about cigarette tax avoidance in other US metropolitan areas? Second, in light of the high degree of tax avoidance in Chicago what is the effect of the cigarette tax on consumption? Third, how much would Chicago's cigarette tax revenue increase if cross-border shopping was eliminated?

A. What do these findings suggest about cigarette tax avoidance in other US metropolitan areas?

To answer the first question we note that Chicago is not typical of metropolitan areas in the US. In the summer of 2007 Chicago had the highest state and local cigarette tax in the country at \$3.66 cents. Of the 26 metropolitan areas with a population over two million in 2000 only New York had a tax of \$3 or above and only three others (Detroit, Phoenix and Seattle) had a state-local tax of \$2 or more. Metropolitan areas with a border tax differential of more than ten cents and a population of more than two million are shown in Table 9 along with the average distance to the lower priced border. Clearly, Chicago, is in a class by itself. Its border tax differential of \$3.11 is nearly \$2 more than the second ranked tax differential—\$1.09 in Phoenix-Mesa—and the average Chicago resident is only 24 miles from the lower priced border while the average Phoenix-Mesa resident is 171 miles from the border. Clearly, citizens of no other major metropolitan area have such a high incentive to avoid cigarette taxes and such a short

distance to go to do so. Without further empirical research it is not possible to say precisely how much tax avoidance we would find in other metropolitan areas but clearly, we should not expect Chicago to be typical—the incentives and opportunities for tax avoidance far exceed those in other areas.

[Insert Table 9 about here]

B. In light of the high degree of tax avoidance of in Chicago what is the effect of the cigarette tax on consumption?

Somewhat counter-intuitively, if tax avoidance requires effort, particularly increasing marginal effort, a cigarette tax can effectively deter smoking even if a large share of the population avoids the tax. The essence of this argument is illustrated in Figure 7.

[Insert Figure 7 about here]

Imagine, as shown in the figure, that the tax free price of cigarettes is four dollars per pack and that the tax is three dollars per pack. The demand curve is downward sloping as shown in the figure. In the absence of tax avoidance consumers will purchase Q units at the after-tax price of \$7. Suppose however, that it is possible for smokers to avoid the tax but avoidance requires increasing marginal effort¹³. The true marginal cost of a pack of tax free cigarettes is the tax free price (P) plus the cost of avoiding the tax. In the figure the tax avoidance cost is assumed to be a linear function (h) of the quantity purchased (q). Given the value of h assumed in the figure the consumer will purchase CBS packs of tax free cigarettes and $Q-CBS$ packs of tax-paid cigarettes. Total consumption is unchanged by tax avoidance. In this model the amount that a tax increase reduces consumption is independent of the ease of cross-border shopping¹⁴.

- C. How much would Chicago's cigarette tax revenue increase if cross-border shopping were eliminated?

If we take the invariance argument presented above literally, consumption of cigarettes in Chicago would not be changed if tax avoidance could be eliminated. According to table 2 tax is paid on only one in four packs of cigarettes smoked in the City of Chicago. This suggests that Chicago's cigarette tax revenue would quadruple if tax avoidance could be eliminated.

Taking the invariance argument literally may be too strong. Instead, suppose that cross-border shoppers would cut consumption if tax avoidance were eliminated. Suppose, consistent with empirical evidence, that cross-border shoppers have a price elasticity of demand for cigarettes of $-.40$ and suppose, consistent with Chicago's observed tax rates, that eliminating cross-border shopping would cause the price cross-border shoppers face to increase by 73 percent¹⁵. The quantity purchased by cross border shoppers would then fall by $-.40 \times 73 \text{ percent} = 29 \text{ percent}$. Thus, Chicago would garner revenue from 71 (100-29) percent of the 75 percent of cigarettes purchased by cross-border shoppers. This would result in an approximately three-fold increase in Chicago's cigarette tax receipts.

The techniques described in this paper should be viewed as a supplement to, rather than a replacement for, econometric studies. The strength of the techniques described here is that they provide relatively precise, direct and easily understandable measures of tax avoidance. However, compared to econometric techniques that make use of existing data these methods may require time consuming and relatively expensive data

gathering. The techniques are best used in combination, with each method being used to cross-validate the other.

Higher taxes on cigarettes are intended to discourage use and increase tax revenue but tax avoidance may mute the impact of tax cuts. Previous research on this topic has generally inferred tax avoidance based on econometric analysis. In this paper we have shown that more direct investigation about this topic is possible. We obtained physical evidence of tax avoidance by collecting littered cigarette packs from a sample of areas in the City of Chicago. Ancillary analysis suggests that this sample is representative of very recent purchases.

Our empirical results show very high levels of tax avoidance consistent with the survey findings of Hyland et al. (2004). Our results are not directly comparable to econometric studies since those studies usually report tax avoidance only at the national or state level while our results apply only to the City of Chicago and border areas¹⁶. Despite the high level of tax avoidance found in Chicago are results do not necessarily imply that tax avoidance is high elsewhere—Chicago is certainly an extreme and special case. Furthermore, although our results show that Chicago is losing significant tax revenue to tax avoidance, the policy of high cigarette taxes may well be having its intended effect of reducing smoking since tax avoidance is a apparently a significant obstacle for consumer and diminishes rapidly with proximity to low-tax borders.

Appendix 1
Brief review of the literature on cigarette tax avoidance

Previous research on cigarette tax avoidance can be grouped into three areas: econometric studies on tax paid sales, survey research and previous litter studies.

Econometric studies on tax paid sales: Literature to this point has largely treated cigarette tax avoidance as a nuisance that makes it more difficult to get accurate estimates of the price elasticity of demand for smoking. Usually cigarette tax avoidance has been measured indirectly by correlating residuals from cigarette demand equations with variables that are plausibly connected to smuggling or cross-border sales. These findings are often unsatisfying since it is difficult to definitively reject the hypothesis that some unobserved variable other than tax avoidance is responsible for the correlation with the residual.

Extensive reviews of the literature on the demand for cigarettes are contained in U.S. Department of Health and Human Services (HHS) (2000) and Chaloupka and Warner (2000). As noted in the HHS study (p.326)

The use of state cross-sectional data over time can...create various estimation problems. In general, such studies ... employed data on state taxes paid for cigarette sales; these data may not accurately reflect average cigarette smoking within the states, because cigarettes may have been smuggled from low-tax states into high-tax states. If this smuggling is not controlled for, estimates of the price elasticity of demand from these data are likely to overstate the impact of price on cigarette smoking. However, many of the most recent studies ...made careful efforts to control for both casual and organized smuggling of cigarettes...

The authors in this literature generally do not highlight their findings with respect to smuggling and tax avoidance because it is a secondary issue in these studies.

However, Merriman, Yurekli and Chaloupka (2000) review the literature based on US and Canadian studies and summarized the implied estimates of tax avoidance. The authors conduct several additional quantitative exercises and find that worldwide cigarette smuggling and tax evasion may account for 6 to 8.5 percent of consumption with smuggling somewhat lower among Western European countries.

Goolsbee, Loveheim and Slemrod (2007) present evidence that internet purchases of cigarettes without payment of state taxes may do even more to undermine cigarette tax increases than smuggling or cross-border sales. They demonstrate that cigarettes easily can be purchased on the internet at something close to the tax free price. They use pooled time-series cross-section data to regress tax paid sales by state on a number of independent variables including a state and time specific measure of internet access. They find that “there has been a substantial increase in the sensitivity of taxable cigarette sales that is correlated with the rise of Internet usage within states...[so that] cigarette smuggling over the Internet has lessened the revenue generating potential of recent cigarette tax increases substantially.”

Surveys: Andrew Hyland and his coauthors (Hyland et. al. 2004) conducted telephone interviews with more than 900 randomly selected smokers in upstate New York counties that are close to Indian Reservations. Respondents were asked about their usual sources of cigarettes and about two-thirds responded that they purchased them from Indian reservations where state and local taxes may be evaded.

There is also a significant literature on cigarette tax evasion in the United Kingdom where tax evasion is thought to be a significant problem. Tax increases in the UK resulted in a 25 percent price increase between 1997 and 2000. In a March 2000

report (HM Treasury 2000) the British government concluded that efforts to reduce smoking were being undermined by smuggled cigarettes. Cigarette smuggling was estimated by the difference between (adjusted) cigarette consumption as reported in a general survey of the population and official data on customs clearance of cigarettes. Using this new method, the government estimated that the market share of smuggled cigarettes had reached nearly 20 percent by 2000 and would rise to more than 35 percent by 2003 if no action were taken. Revenue losses from smuggled cigarettes were estimated to be £2500 million in 1999.

In a recent study, Stehr (2005) uses a methodology that is similar but more sophisticated than that used to study the UK. Stehr uses regression analysis to compare cigarette consumption data—from a telephone sample of respondents—to tax paid cigarette sales. He finds that reported consumption is much lower than reported sales but that reported consumption does not drop as much sales when taxes increase. After carefully controlled statistical analyses, he concludes that tax avoidance accounted for up to 9.6 percent of sales between 1985 and 2001.

Recently Lovenheim (2008) has developed a different methodology to make use of reported consumption data. Using data aggregated to the metropolitan area level, Lovenheim regresses cigarette consumption as reported in several waves of the Current Population Survey against measures of price and the distance of an average consumer to a low-priced border and a variable that interacts average distance with the difference in price as well as other control variables. The interacted variable is designed to measure the net benefit from tax avoidance. Lovenheim finds that this interacted variable is statistically significant and of such a large magnitude that “demand elasticities with

respect to home state price are indistinguishable from zero on average.” In other words, Lovenheim claims that, on average, increases in state cigarette prices do nothing to discourage consumption because of cross-border tax avoidance. However, Lovenheim finds that a national tax increase (which would not raise the incentive to cross state borders in order to avoid taxes) would significantly decrease smoking. Lovenheim estimates average cigarette tax avoidance rates of between 13 and 22 percent.

Studies using litter: No published studies use littered cigarette packs to estimate cigarette tax avoidance. However, tobacco company executives presented evidence from a study of cigarette packs littered around pubs, clubs, football stadiums in the UK in testimony to a UK House of Commons Treasury Committee panel studying Excise Fraud in 2005. They reported that about 18 percent of the packs they examined were smuggled. However, in that same document the researchers acknowledge that, to date, such studies have been non-representative.

UK Tobacco Manufacturers Association collected littered cigarette packs on various occasions outside the matches of the Liverpool football club from 2000 to 2006 and near the Newcastle horse race course in 2005 and 2006 and shared this data with UK customs officials. In both cases they found between about 25 and 40 percent of packs had avoided UK taxes².

Recently Lakhdar (2008) has reported on a study of tobacco tax avoidance in France using various methodologies. One methodology was to extract cigarette packs from a waste collection plant in Paris suburb of Nanterre in November 2005 and December 2006. About 19 percent of the packs were of foreign (usually lower priced)

² This information was supplied in a private communication from Judith Kelly of the UK Excise Office with the permission of the UK Tobacco Manufacturers Association.

origin in 2005 and about 16 percent were of foreign origin in 2006. This level of tax avoidance was generally consistent with the estimates found using other methods.

Overall evaluation: Most econometric studies have estimated cigarette demand functions and correlated residuals with measures of the availability of low priced alternatives. Other studies have correlated the residual obtained when sales and consumption are compared with measures of the potential for tax avoidance. Inherent methodological weaknesses of both approaches include: (1) the need to estimate unknown functional forms for demand functions (2) a small and relatively arbitrary set of variables is used to measure the ease of tax avoidance (3) the necessity of aggregating data across space (e.g. several states) and/or over time when various factors other than changes in cigarette taxes might influence consumption and tax avoidance.

Studies that use self-reported consumption data, such as telephone surveys, also are hampered by the fact that respondents apparently routinely under-report consumption. For example, Stehr (2005) writes that in his data “reported consumption as a percentage of tax paid sales average 57.1% from 1985 to 2001.” Statistical analyses of these data must assume that under-reporting is random with respect to included variables but it is inherently impossible to test this assumption.

Appendix 2

Expected share “Foreign” tax stamps in cigarette litter

Even if no one crossed borders in order to avoid taxes we expect that some littered cigarette packs in Chicago would have non-Chicago (foreign) tax stamps simply because people routinely commute across borders for employment and other purposes. Such people make some of their cigarette purchases in non-Chicago locales and might litter some non-Chicago packs in Chicago. Three types of people litter cigarette packs in Chicago: workers, resident non-workers, and tourists and other visitors.

A. Workers

Workers who regularly commute across Chicago borders might be the most frequent obvious source of “foreign” tax stamps in Chicago litter. We illustrate how this might work with a simple model that combines cigarette purchases, commuting and littering. Consider an area in which all residents are workers and there are just two jurisdictions labeled “A” and “B”. Cigarette consumption (in packs) in area A (C_A) is:

$$(1) C_A = \lambda_{AB}c_R + \lambda_{AA} + \lambda_{BA}c_W$$

where λ_{ij} = number of packs smoked by those that live in area i and work in area j

c_R = share of cigarettes consumed in residential jurisdiction

c_W = share of cigarettes consumed in work jurisdiction

$$c_W + c_R = 1$$

Let litter in area A be a fixed share (ϕ) of consumption. Then the number of littered packs with a stamp from area A found in area A is:

$$(2) L_A^A = \phi(\lambda_{AB}c_R p_R + \lambda_{AA} + \lambda_{BA}c_W p_W)$$

where p_R = share of packs purchased in residential jurisdiction

p_W = share of packs purchased in work jurisdiction

$$p_W + p_R = 1$$

and the number of littered packs with a stamp from area B found in area A is

$$(3) L_A^B = \phi(\lambda_{AB}c_R p_W + \lambda_{BA}c_W p_R)$$

So, the ratio of “foreign” stamps to the total in area A is:

$$(4) \frac{L_A^B}{L_A^A + L_A^B} = \frac{\lambda_{AB}c_R p_W + \lambda_{BA}c_W p_R}{\lambda_{AB}c_R + \lambda_{AA} + \lambda_{BA}c_W}$$

In order to estimate this ratio in Chicago we require estimates of the various parameters of equation (4). The “journey to work” tabulations of the 2000 Census provide estimates of λ_{ij} and these are displayed in table A1.

Table A1*
Commuting patterns of Chicago workers and residents

		Residence			
		Chicago	Not Chicago	Not Cook	Not Illinois
Workplace	Chicago	842,375	494,287	187,022	42,771
	Not Chicago	349,638			
	Not Cook	89,155			
	Not Illinois	10,789			

Source: Census tabulations of Place of Residence by Place of Work in 2000 US Census available at

http://www.transtats.bts.gov/DL_SelectFields.asp?Table_ID=1348&DB_Short_Name=C_TPP%202000 (accessed November 21, 2007).

*Chicago/Not Chicago categories include all workers who live or work in Chicago. Not Chicago category includes all those in Not Cook or Not Illinois categories and Not Cook includes those in Not Illinois category.

We do not have an empirical estimate of the other parameters in equation (4) but provide some illustrative calculations using assumed values. Since an eight hour workday implies that commuters spend about two-thirds of their time in their home jurisdiction in a typical day we assume that, in the absence of purposeful tax avoidance, two-thirds of cigarettes

would be consumed and purchased in the residence jurisdiction ($c_R = p_R = 2/3$) and one-third would be consumed and purchased in the workplace jurisdiction ($c_W = p_W = 1/3$). Combining these assumptions with data from Table A1 and equation (4) leads to the following prediction for “foreign” tax stamps in cigarette litter when there is no purposeful tax avoidance.

Table A2 Predicted Share of Foreign Stamps in Chicago Litter from Workers*	
Predicted share of	
Non-Chicago stamps	0.15
Non-Cook County stamps	0.06
Non-Illinois Stamps	0.01

*Author's calculation using equation (4), data in Table A1 and assumptions given in the text.

These calculations show that, in the simple case given here we would expect to find very few non-Illinois and non-Cook county stamps in the litter of workers. The share of non-Chicago stamps would be somewhat higher because of the large degree of cross-commuting in this major city.

The results in Table A2 do not change much even if we assume that a considerably higher (or lower) share of cigarettes are bought and consumed in the work jurisdiction. For example if 50 percent are purchased and consumed in the work jurisdiction 17 percent of Chicago’s litter would have non-Chicago stamps. If ninety-percent of cigarettes are purchased and consumed in the home jurisdiction only six percent of Chicago’s litter would have non-Chicago stamps

B. Resident non-workers

According to the 2000 Census of the Population there were about 2.1 million residents of Chicago over 18 years of age but only about 1.3 million resident commuters

were measured in the journey-to-work portion of the Census. The other 0.9 million residents of Chicago over 18 includes househusbands, and housewives, retirees, students, disabled and unemployed individuals. It seems likely that these individuals would have less reason to commute outside of city boundaries than workers and thus, in the absence of purposeful tax avoidance would have a lower level of foreign tax stamps in their litter than would workers.

C. Tourists and business visitors

According to the Chicago Office of Tourism (2007) in 2000 Chicago had about 37 million business and leisure visitors. If these visitors stayed two days on average—we do not have solid data on the actual average length-of-stay—they would account for about seven percent of the person nights in Chicago. In the absence of tax avoidance such visitors would probably have a higher level of foreign tax stamps in their litter than would resident workers and non-workers but the exact ratio is difficult to determine. Certainly, some of these visitors would be expected to purchase cigarettes in Chicago during their stay and the longer the stay, the more likely Chicago purchases would become.

In any case, it is extremely unlikely that packs littered by tourists and business visitors have an important influence on the results reported here. In Chicago, most tourists probably spend the majority of their time in the central downtown area that houses most of the major corporate headquarters, museums, cultural attractions (theater, symphony, opera) and shopping attractions. We recomputed the figures in Table 2 omitted the ten TAZ in this central area and obtained figures nearly identical to those reported in the text. In particular, with this sample only 25 percent of the packs found in

Chicago had a Chicago stamp and 30 percent of the packs found in Chicago had an Indiana stamp.

D. Conclusions

The calculations presented in this section are illustrative rather than precise predictions. We do not have precise estimates for the parameters of equation 4 and have very limited data about resident non-workers and visitors. Still, the estimates in Table A2 probably give a rough order of magnitude of what we would expect to find in the data in the absence of purposeful tax avoidance. In that case we would expect the vast majority of littered packs in Chicago to carry Chicago, Cook County and Illinois tax stamps.

Appendix 3
Statistical theory on unbiasedness of estimate of mean tax compliance

Define μ_Y as the share of littered packs on which taxes have been paid. By definition

$$\mu_Y \equiv \frac{\sum_{n=1}^N Y_n}{\sum_{n=1}^N i_n} = \frac{\sum_{n=1}^N Y_n}{I} \text{ where } I = \sum_{n=1}^N i_n$$

Where $(n=1 \dots N)$ is the set of all N TAZs in the city, (i_n) is the number of littered packs smoked in TAZ n , Y_n is the number of tax-paid littered packs in TAZ n .

Let $\lambda_n = \frac{Y_n}{i_n}$ be the probability that a pack smoked in TAZ n has a legal tax stamp.

Let the share of packs smoked in TAZ n be $s_n \equiv \frac{i_n}{I}$. Then $\mu_Y = \sum_{n=1}^N s_n \lambda_n$.

Let Y_n^{\square} be the number of tax-paid packs found by data collectors that collected a total of i_n^{\square} littered packs from TAZ n ($i_n^{\square} < i_n$).

If the probability that each littered pack found within TAZ n has a tax stamp is identical and independent of the probability that other packs found within TAZ n have a tax stamp, Y_n^{\square} has a binominal distribution with mean $i_n^{\square} \lambda_n$ and variance $i_n^{\square} \lambda_n (1 - \lambda_n)$.

Define $\lambda_n^{\square} = \frac{Y_n^{\square}}{i_n^{\square}}$ then $E(\lambda_n^{\square}) = E\left(\frac{Y_n^{\square}}{i_n^{\square}}\right) = \left(\frac{i_n^{\square}}{i_n^{\square}}\right) \lambda_n = \lambda_n$ and

$$V(\lambda_n^{\square}) = \left(\frac{1}{(i_n^{\square})^2}\right) V(Y_n^{\square}) = \left(\frac{1}{(i_n^{\square})}\right) (\lambda_n (1 - \lambda_n))$$

Define $\mu_Y^{\square} = \frac{\sum_{n=1}^N d_n \lambda_n^{\square}}{\sum_{n=1}^N d_n} = \frac{\sum_{n=1}^N d_n \lambda_n^{\square}}{K}$

Where $d_n=1$ if TAZ n is included in the sample and zero otherwise. By construction

$K = \sum_{n=1}^N d_n = 100$ is the predetermined number of TAZs in which data are collected.

$$E(\mu_Y^{\square}) = E\left(\frac{\sum_{n=1}^N d_n \lambda_n^{\square}}{K}\right) = \left(\frac{1}{K}\right) E\left(\sum_{n=1}^N d_n \lambda_n^{\square}\right)$$

Note that d_n is equal to either 1 or zero so we can use the law of iterated expectations to write:

$$E(d_n \lambda_n) = E\left(E(d_n \lambda_n | \lambda_n)\right) = E\left[\left(1 * \Pr(d_n = 1 | \lambda_n)\right) \lambda_n\right]$$

Since sample selection is independent of tax compliance probability

$$\Pr(d_n = 1 | \lambda_n) = \Pr(d_n = 1) = p_n$$

By construction $p_n = K s_n$ Therefore;

$$\begin{aligned} E\left(\sum_{n=1}^N d_n \lambda_n\right) &= \sum_{n=1}^N p_n E(\lambda_n) = \sum_{n=1}^N p_n \lambda_n \\ &= \sum_{n=1}^N K s_n \lambda_n = K \sum_{n=1}^N s_n \lambda_n = K \mu_y \Rightarrow E(\hat{\mu}_y) = \mu_y \end{aligned}$$

Thus, $\hat{\mu}_y$ (the simple mathematical average of the probabilities from each of the n TAZs) is an unbiased estimator of the true city-wide mean probability of compliance (μ_y).

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¹ Tafoya, Bernie (reporter) aired June 29, 2007. "Indiana Cig Tax Hike Pinches Bootlegger" WBBM newsradio 780 in Chicago. (Author's transcription of selected portions of interview). Complete audio for interview available at <http://www.wbbm780.com/pages/629549.php?contentType=4&contentId=649846> (accessed December 19, 2007).

² Slemrod 2007b provides an enlightening examination of the effect of a 1998 change in Michigan policy requiring the use of cigarette tax stamps.

³ In most cases wholesalers and retailers will not benefit substantially by hoarding stamps before a tax increase. Generally when governments' enact a excise tax increase they simultaneously enact a "floor tax". Wholesalers' and retailers' floor tax liability is the difference between the cost of the new stamp and the cost of the old stamp times the number of old stamps the business holds in inventory. Apparently, the legislators that drafted Chicago's January 2005 tax increase failed to enact a floor tax resulting in an extreme spike in sales in the month prior to the tax increase.

⁴ These cigarette excise tax differences understate the total difference in taxes on a pack of cigarettes because the city of Chicago had a sales tax of nine percent which applied to the excise tax-inclusive price of cigarettes while Indiana's sales tax was six percent. Other areas in Illinois have a sales tax rate between 6.5 and nine percent.

⁵ On July 1, 2007 Indiana raised its state tax to 99.5 cents. This change occurred after the data employed in this study were collected.

⁶ Several readers of this manuscript have suggested such an approach to us.

⁷ Stehr 2005 reports that in a nationally representative survey self-reported consumption as a percentage of tax paid sales averaged about 57 percent from 1985 to 2001.

⁸ This weighting scheme would be sensible if we believed that about one-third of cigarettes are smoked at a place of business and two-thirds are smoked at home. This weighting scheme was influenced by technical constraints. Because employment is much more concentrated than population the highest weight that can be assigned to employment when selecting a population and employment weighted random sample of 100 TAZs from the universe of 930 Chicago TAZs without replacement is 49 percent.

⁹ In each case this is the universe of TAZs that fall in these categories. That is there are only five TAZs that border Chicago and are not in Cook county. Three of the TAZs are in DuPage county and two are in Indiana.

¹⁰ We conducted several subsidiary data collections. These are discussed in more detail below.

¹¹ We ranked the routes based on the initial count after the first coding. In some cases the counts were adjusted slightly after we conducted a second coding and rechecked the data. Tables comparing the original and resample routes presented below use the cleaned data after the second coding.

¹² Our tabulations are based on scanner data from 3.3 million packs sold during the second quarter of 2002. According to data presented in Figure 1 there were almost 30 million Chicago tax stamps sold during that period. Thus, the scanner data may represent only a small fraction of total Chicago cigarette sales.

¹³ To understand why tax avoidance might require increasing marginal effort we can imagine that in the normal course of events smokers visit tax free areas once every six months and can purchase cigarettes there with little extra effort. For some reason—perhaps because having cigarettes around will encourage them to smoke more—smokers do not purchase an entire six months supply when they visit tax free areas. When they run out of tax free cigarettes smokers might make an extra and inconvenient trip to a tax free area or they might impose on a friend or relative going that way to purchase cigarettes for them. In either case, we can imagine effort increasing with the level of tax avoidance. Indeed, if the level of effort did not increase with the amount of tax avoidance each individual would purchase only tax free or only taxable cigarettes.

The evidence, contained in figures 5 and 6 that tax avoidance declines with proximity to the Indiana border is consistent with the hypothesis that tax avoidance has a significant cost.

¹⁴ For a more complete discussion of this issue see Merriman (2002). See Lovenheim (2008) for some empirical evidence on this question.

¹⁵ Based on Chaloupka and Warner's 2000 review a price elasticity of demand of $-.40$ is a rough consensus of the literature. As a result of the tax paid price of cigarettes in Chicago was roughly 73 percent higher than identical cigarettes bought in Indiana in June of 2007.

¹⁶ One exception is Lovenheim (2008) who estimates that 63.48 percent of Washington, D.C. smokers smuggle.

Table 1
Summary of TAZ universe and Sample

Location	Number of TAZs in universe	Number of TAZs in sample
In City of Chicago and Cook County	929	99
In City of Chicago and DuPage county	1	1
Not in City of Chicago borders on City of Chicago but in Cook County	160	30
Not in City of Chicago borders on City of Chicago but in DuPage County	3	3
Not in City of Chicago borders on City of Chicago but in Indiana	2	2
Total	1,095	135

Table 2 Number of packs and TAZ and estimated share of packs with various types of tax stamp by location (Estimates of shares and standard errors adjusted for survey weights)*								
Location of TAZ	Number of packs with cellophane	Number of TAZ	Share of packs with no tax stamp	Estimated share of packs with stamps from				
				Indiana	Illinois	Other state	Cook County**	Chicago
in Chicago & Cook county	823	99***	0.07 (0.01)	0.29 (0.02)	0.59 (0.02)	0.05 (0.01)	0.36 (0.02)	0.25 (0.02)
in Chicago & DuPage county	5	1	0.00 (0.00)	0.20 (0.18)	0.80 (0.18)	0.00 (0.00)	0.40 (0.22)	0.00 (0.00)
borders Chicago in Cook county	218	30	0.04 (0.01)	0.16 (0.03)	0.76 (0.03)	0.05 (0.02)	0.51 (0.05)	0.15 (0.03)
borders Chicago and is in DuPage county	83	3	0.07 (0.03)	0.01 (0.01)	0.83 (0.05)	0.09 (0.04)	0.19 (0.05)	0.10 (0.04)
borders Chicago and is in Indiana	17	2	0.00 (0.00)	0.97 (0.03)	0.03 (0.03)	0.00 (0.00)	0.03 (0.03)	0.03 (0.03)
*Estimates weight each TAZ equally regardless of the number of packs found in the TAZ. See text for explanation.								
**Since purchase of a Chicago tax stamp requires payment of Cook County taxes, packs with Chicago stamp were treated as having a Cook County stamp.								
***In three of 99 surveyed Chicago TAZs we found no packs with cellophane.								

Table 3
 Estimates of marginal change in probability of each stamp from a small change in each independent variable
 (823 littered packs from 96 Chicago TAZ included in all regressions)

	Jurisdiction issuing stamp							
	Indiana		Illinois		Cook County		Chicago	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dist to Chicago border (miles)	-0.05*** (-3.16)	-0.04** (-2.44)	0.05*** (3.21)	0.04** (2.47)	0.02 (1.05)	0.00 (0.05)	0.02* (1.85)	0.01 (0.86)
Add. Dist. to County border (miles)	-0.03*** (-3.39)	-0.02*** (-2.99)	0.03*** (3.27)	0.03*** (2.88)	0.02* (1.71)	0.01 (1.16)	0.01* (1.71)	0.01 (1.15)
Add. Dist. to State border (miles)	-0.03*** (-5.31)	-0.02*** (-4.16)	0.03*** (5.34)	0.02*** (4.03)	0.01*** (2.73)	0.01 (1.16)	0.01*** (2.67)	0.01 (1.24)
Share land for Single Fam. Housing	-0.00** (-2.36)	-0.00** (-2.48)	0.00*** (2.92)	0.00*** (2.99)	0.00 (1.14)	0.00 (1.04)	0.00** (1.98)	0.00* (1.85)
Share land for commercial use	-0.00 (-1.06)	-0.00 (-0.78)	0.00** (2.13)	0.00* (1.89)	0.00** (2.43)	0.00** (2.10)	0.00 (1.34)	0.00 (1.16)
Median HH income (000s dollars)	-0.01*** (-4.01)	-0.01*** (-3.70)	0.01*** (5.57)	0.01*** (5.25)	0.01*** (2.75)	0.01** (2.50)	0.00 (1.09)	0.00 (0.92)
Share HH in poverty	-0.57** (-2.10)	-0.82*** (-3.00)	0.89*** (3.32)	1.13*** (4.04)	0.38 (1.42)	0.69** (2.48)	0.33 (1.48)	0.55** (2.35)
Share hispanic HH	0.05 (0.57)	0.32*** (2.60)	-0.01 (-0.14)	-0.23* (-1.80)	0.02 (0.19)	-0.22* (-1.67)	0.04 (0.52)	-0.13 (-1.19)
Share Asian HH	-0.12 (-0.41)	0.26 (0.89)	-0.15 (-0.48)	-0.44 (-1.32)	-0.08 (-0.25)	-0.37 (-1.12)	0.35 (1.41)	0.14 (0.51)
Share Black HH		0.29*** (2.66)		-0.24** (-2.19)		-0.27** (-2.33)		-0.20** (-2.06)
Pseudo r-squared	0.16	0.17	0.13	0.14	0.06	0.07	0.03	0.04
t statistics in parentheses								
* p<0.10 ** p<0.05 *** p<0.01								

Table 4						
Estimates of marginal change in probability of each stamp from a small change in each independent variable						
(218 littered packs from 30 TAZ in Cook county but not Chicago included in all regressions)						
	Jurisdiction issuing stamp					
	Indiana		Illinois		Cook County	
	(1)	(2)	(3)	(4)	(5)	(6)
Dist to Cook county border (miles)	-0.03***	-0.01	0.03*	0.01	0.05**	0.06**
	(-3.12)	(-0.52)	(1.91)	(0.43)	(2.24)	(2.03)
Add. Dist. to State border (miles)	-0.01***	-0.00	0.01***	0.01	0.02***	0.02**
	(-3.66)	(-0.98)	(2.93)	(1.32)	(2.58)	(2.30)
Share land for Single Fam. Housing	-0.00	-0.00	0.00	0.00	0.00**	0.00**
	(-0.68)	(-0.02)	(1.54)	(1.02)	(2.11)	(2.08)
Share land for commercial use	-0.00	-0.00	0.00	0.00	-0.00	-0.00
	(-0.02)	(-0.19)	(0.31)	(0.48)	(-0.48)	(-0.49)
Median HH income (000s dollars)	-0.01**	-0.01***	0.01**	0.01**	0.01***	0.01***
	(-2.35)	(-3.55)	(2.10)	(2.26)	(3.00)	(2.91)
Share HH in poverty	-2.12***	-2.44***	3.00***	3.53***	4.48***	4.34***
	(-3.09)	(-3.97)	(2.95)	(3.34)	(2.85)	(2.80)
Share hispanic HH	0.22	0.35***	-0.24	-0.44*	-0.63*	-0.58
	(1.37)	(2.82)	(-0.97)	(-1.84)	(-1.73)	(-1.54)
Share Asian HH	0.28	0.51	-1.22	-1.56	-0.46	-0.42
	(0.27)	(0.54)	(-0.86)	(-1.08)	(-0.25)	(-0.22)
Share Black HH		0.32***		-0.38**		0.09
		(3.01)		(-2.22)		(0.39)
Pseudo r-squared	0.18	0.23	0.11	0.13	0.14	0.15
t statistics in parentheses						
* p<0.10 ** p<0.05 *** p<0.01						

Table 5 Comparison of collections from original and resample of 14 TAZ						
			Original		Resample	
	Rank in original tabulation	TAZ number	total	number with cellophane	total	number with cellophane
1	5	284411	2	1	1	1
2	15	293495	4	2	10	3
3	25	293130	5	4	1	0
4	35	284464	9	5	6	3
5	45	284493	10	5	18	11
6	55	283435	14	10	19	5
7	65	403486	14	9	7	4
8	75	412225	18	4	35	35
9	85	293118	19	5	12	2
10	95	273113	20	10	20	10
11	105	273188	23	11	28	18
12	115	284514	29	9	22	9
13	125	284507	33	6	17	5
14	135	401150	82	55	106	48
Sum			282	136	302	154

Table 6*
 Estimate of ratio of number of packs in original
 sample to number of packs in resample for the
 population

			Bounds of a 95% confidence interval	
	Ratio	Std. Err.	Lower bound	Upper bound
All packs	0.93	0.11	0.69	1.18
Packs with cellophane	0.88	0.22	0.42	1.35
* Point estimates and standard deviations for shares are adjusted for survey weights and clustering strategy.				

Table 7 Comparison of tax avoidance in appropriately disposed of and littered cigarette packs*								
Sample	Chicago tax paid	Chicago tax not paid	Share on which Chicago tax was paid	Illinois tax paid	Illinois tax not paid	Share on which Illinois tax was paid	Source of Packs	Location
1	4	3	0.57	4	3	0.57	Nearby Litter	TAZ 414513 is a subset of the receptacle route
2	6	12	0.33	9	9	0.50	Receptacles	6138 to 7400 N. Sheridan
3	3	6	0.33	6	3	0.67	Parallel Litter	6138 to 7400 N. Sheridan
			[0.14]			[0.38]		
4	2	5	0.29	6	1	0.86	Nearby Litter	TAZ 404501 Southern edge of litter route is one half mile from eastern edge of receptacle route
5	18	13	0.58	28	3	0.90	Receptacles	1600 to 2018 W. North
6	0	0		0	0		Parallel Litter	1600 to 2018 W. North
			[0.92]			[0.64]		
7	5	3	0.63	6	2	0.75	Nearby Litter	TAZ 294412. Eastern edge of litter route is one-half mile from western edge of receptacle route
8	19	14	0.58	24	9	0.73	Receptacles	1925 to 2122 W. Division
9	0	0		0	0		Parallel Litter	1925 to 2122 W. Division
			[0.40]			[0.45]		
* Numbers in square brackets [] give the probability that there is less tax compliance in the littered data than in the nearby receptacle data, conditional on our sample.								
When comparing samples 2 and 3 the probability that there is less tax compliance in the parallel litter data is 0.50 for Chicago taxes, and 0.20 for Illinois taxes.								

Table 8: Comparison of brand shares in scanner data and Chicago tax paid sales litter data*

Brand	Scanner data from Q2, 2002	Tax paid littered sample
Marlboro	40%	38%
Unidentified Cigarettes	-	@
Newport	12%	31%
Camel	3%	6%
Virginia Slims	7%	@
Kool	6%	11%
Parliament	4%	6%
Benson & Hedges	4%	@
Basic	#	1%
Other	25%	8%
Chicago Cig Total	100.0%	100%

* Scanner data based on tabulations of Nielsen data graciously provided by Professor John Tauras of the University of Illinois at Chicago.
 # subsumed into "Other" category.
 @ subsumed into "Other" category

Table 9
 State and Local Cigarette taxes, distance to lower price border and tax differential for
 metropolitan areas with a population exceeding two million
 and state border price differential greater than ten cents

Metro area name	July 1, 2006 population estimate	City plus state tax in metro area*	Border state**	State tax in border state Oct. 2007	Distance to lower price border** (miles)	tax differential
New York	18,818,536	3.00	CT	2.000	22	1.00
Chicago	9,505,748	3.66	IN	0.555	24	3.11
Dallas	6,003,967	1.41	OK	1.030	65	0.38
Philadelphia	5,826,742	1.35	DE	1.150	9	0.20
Houston	5,539,949	1.41	LA	0.360	91	1.05
Washington, DC	5,290,400	1.00	VA	0.300	3	0.70
Detroit	4,468,966	2.00	OH	1.250	53	0.75
Boston	4,455,217	1.51	NH	1.080	29	0.43
Phoenix-Mesa	4,039,182	2.00	NM	0.910	171	1.09
Seattle-Bellevue- Everett	3,263,497	2.03	OR	1.180	139	0.85
Denver1	2,408,750	0.85	WY	0.600	89	0.25
Pittsburgh	2,370,776	1.35	WV	0.550	29	0.80
Portland-Vancouver	2,137,565	1.18	ID	0.570	286	0.61
Cleveland-Lorain-Elyria	2,114,155	1.25	WV	0.550	83	0.70
Cincinnati	2,104,218	1.25	KY	0.300	10	0.95

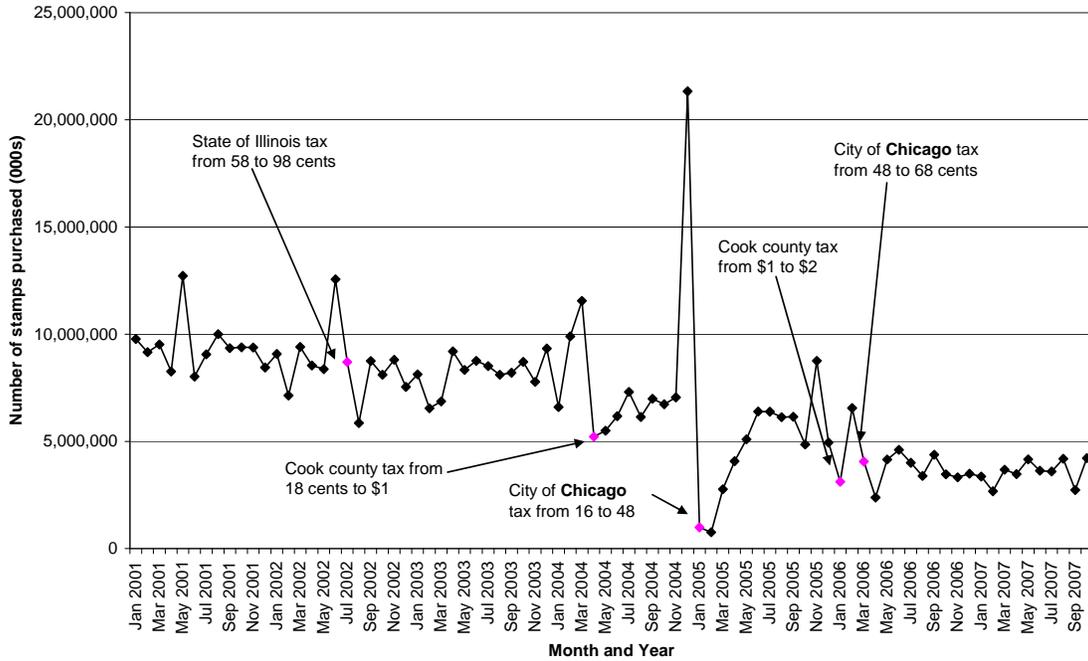
**Source of tax data is Campaign for Tobacco-Free Kids (February 2006 and October 2007)
 with adjustments.

* *Lovenheim 2007 is source of these data.

1. local tax of one cent per pack according to <http://www.theberkshiregroup.com/colorado-tax-guide.html>

Figure 1

Tobacco taxes and monthly purchases of Chicago tobacco tax stamps
2001 to 2007

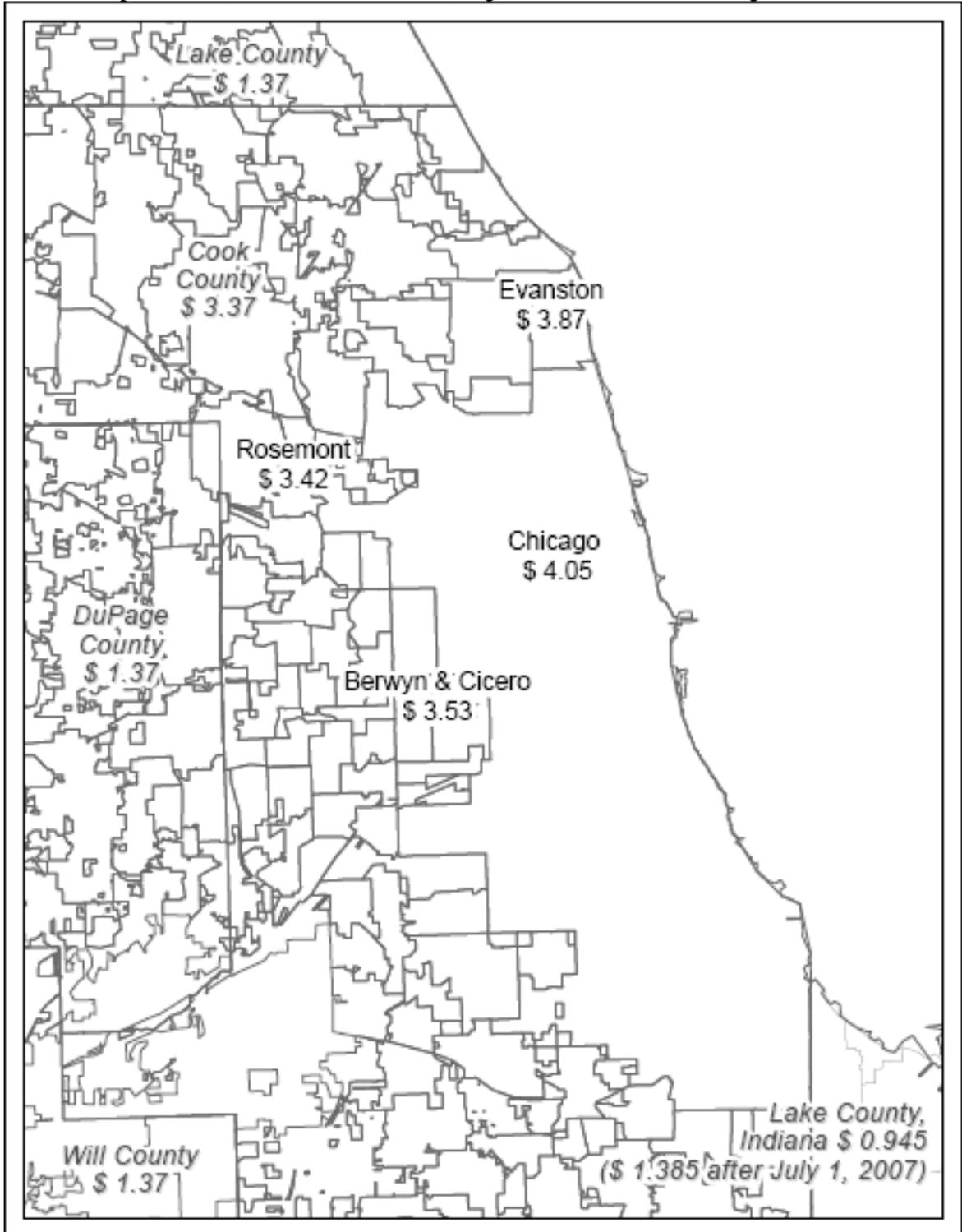


History of recent rate increases:

- 1) State of Illinois July 1, 2002- 58 cents to 98 cents.
- 2) Cook County April 1, 2004- 18 cents to \$1.00
- 3) city of Chicago January 1, 2005- 16 cents to 48 cents
- 4) city of Chicago- January 10, 2006- 48 cents to 68 cents
- 5) Cook County March 1, 2006- \$1.00-\$2.00

Source of data in figure 1: Private communication with Mr. Bill Cerney, Deputy Director- Tax Division, Chicago Department of Revenue, Nov. 21, 2007.

Figure 2
Map of total (Federal+State+Local) cigarette taxes in the Chicago area



North-south distance is approximately 42 miles
East-west distance is approximately 32 miles.

Figure 3
Map of sample TAZs

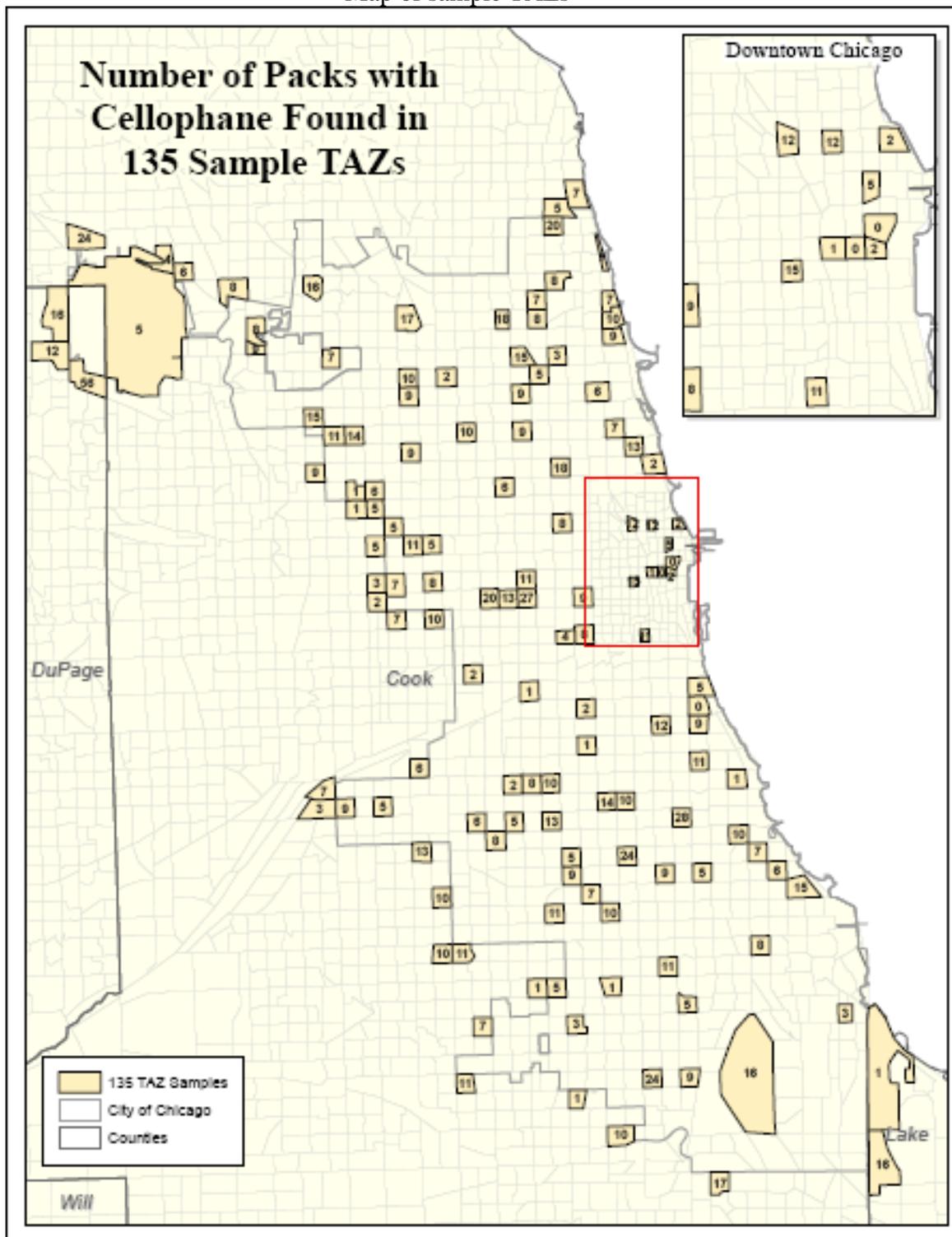
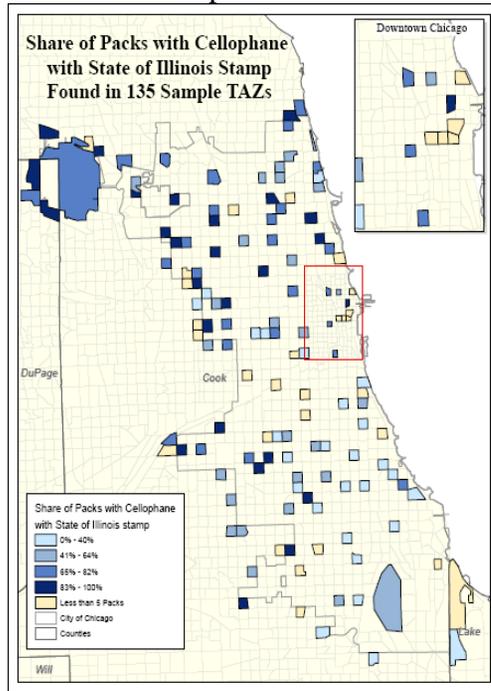
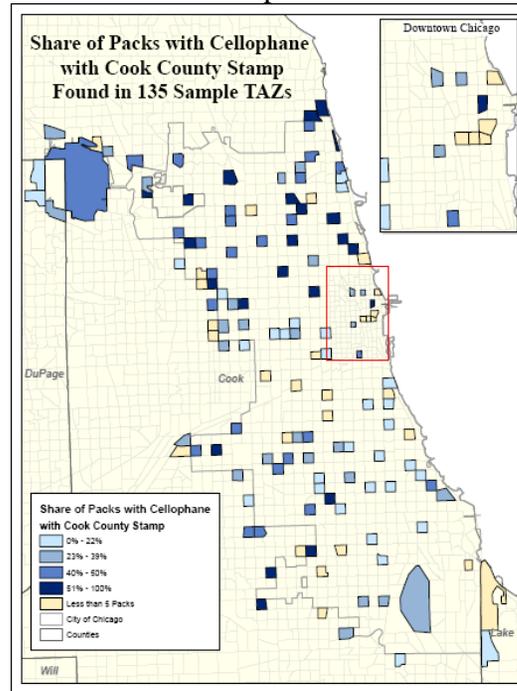


Figure 4
 Maps showing locations of Illinois, Cook County and Chicago tax stamp percentages

Map 4A



Map 4B



Map 4C

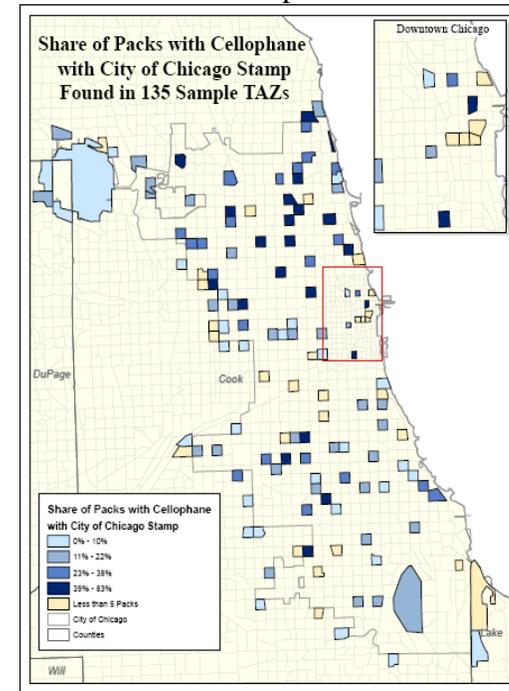


Figure 5

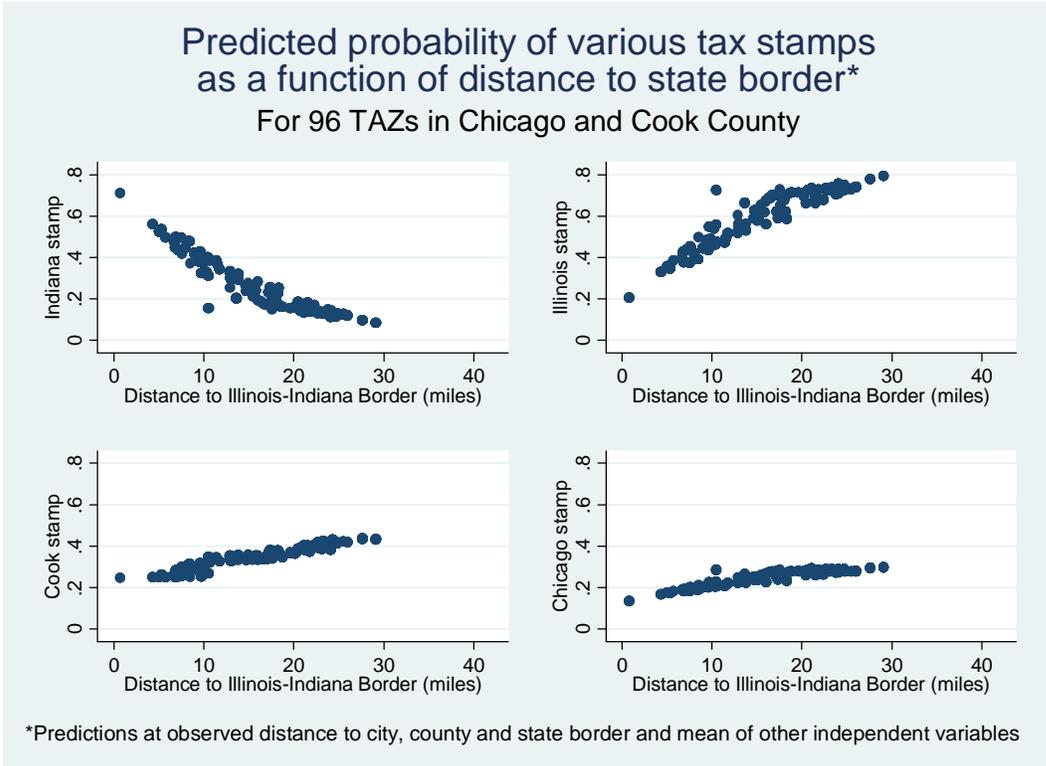


Figure 6

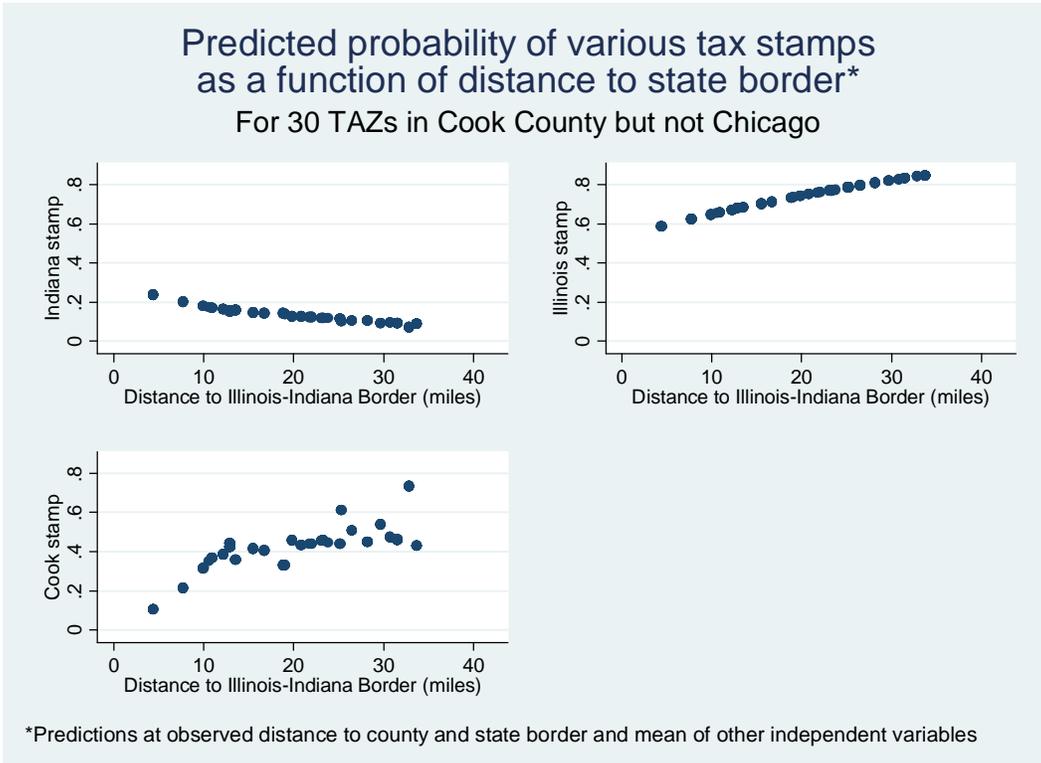


Figure 7
When marginal cost of avoidance is increasing
total consumption is invariant to ease of cross-border shopping

