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Empty Discarded Pack Data and the Prevalence of Illicit Trade in Cigarettes

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Abstract

Illicit trade in tobacco products (ITTP) is big business in the United States and creates many harms including reduced tax revenues; damages to the economic interests of legitimate actors; funding for organized-crime and terrorist groups; negative effects of participation in illicit markets, such as violence and incarceration; and reduced effectiveness of smoking-reduction policies, leading to increased damage to health. To improve data availability for study in this area, we describe and make available a large, novel set of data from *empty discarded pack* (EDP) studies. In EDP studies, teams of researchers collect all cigarette packs discarded (either in trash receptacles or as litter) in the public spaces of selected neighborhoods. Packs are examined for the absence of local tax stamps, signs of non-authentic packaging or stamps, and other indications of potential tax evasion or counterfeit product. We describe the data and analyze the prevalence of ITTP. Data from 23 collections in 10 U.S. cities from 2010 to 2014 are available, yielding 106,500 observations (by far the largest dataset of its kind available for academic study). Each observation includes dozens of variables covering the brand, location to the ZIP code level, tax status, counterfeit status, and other information about the pack. There is significant evidence of tax avoidance (up to 74% of packs in New York City). In some markets there is also a significant amount of illicit trade (up to over half the market in New York City), which includes bootlegging, counterfeits, cigarettes produced for illicit-market sales, and cigarettes without any tax stamps. These data will be highly useful for research in illicit markets and organized crime.

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C83 (Survey Methods; Sampling Methods); K42 (Illegal Behavior and the Enforcement of Law); C81 (Methodology for Collecting, Estimating, and Organizing Microeconomic Data; Data Access)

Keywords

Black markets, contraband, counterfeit cigarettes, excise taxes, garbology, interstate smuggling, ITTP, smoking, state and local taxation, tobacco

I. Introduction

The tobacco market is highly regulated because of harms to health due to smoking. High taxes and limits on the sale of tobacco products, intended to reduce tobacco consumption, are adopted worldwide (WHO, 2015). As is often the case, however, regulation may influence behavior in ways not in accord with the intentions of policymakers (Benham, 2008). Tobacco taxes and regulation may induce or promote the growth of illicit markets for tobacco products (Prieger and Kulick, 2016). In the case of cigarettes, large differences among state excise taxes exacerbate the problem by making it highly profitable for smugglers to acquire cigarettes in low-tax states and resell them illicitly in higher-tax states (Pelfrey, 2015). In turn, illicit trade in tobacco products (hereafter "ITTP") creates its own detrimental impacts on public welfare, including reduced tax revenues; damage to the economic interests of legitimate actors; funding for organized-crime and terrorist groups; negative effects of participation in black markets, such as violence and incarceration; and reduced effectiveness of smoking-reduction policies, leading to increased harms to health from smoking (Joossens et al., 2000; State Department, 2015; Kulick, Prieger, and Kleiman, 2016).

Policymakers need to learn about the current state of illicit trade both to evaluate the impacts of existing policies and to analyze prospectively the outcomes that would result from proposed policy changes. This requires data that on the scale, geographic distribution, and composition of ITTP. However, despite the manifold criminal, social, and economic consequences of illicit trade, reliable data from illicit markets generally and ITTP specifically are scarce (Calderoni, 2014). Consequently, tobacco-policy researchers, health economists, criminologists, and others interested in illicit markets and the underground economy more generally find themselves with limited data for analysis, for hypothesis testing, and for offering policy recommendations (Allen, 2014).

We have assembled for public usage a large, novel set of data from empty discarded pack (EDP) surveys. The data are provided by an industry source, Altria Client Services LLC (ALCS).[1] ALCS has conducted EDP surveys since 2010 in select U.S. markets to estimate the percentage of untaxed and illicit cigarettes consumed in those markets. Market Survey Intelligence (MSI), a third-party private

[1] ALCS is a subsidiary of Altria Group, Inc., which also holds the major tobacco company Philip Morris USA Inc. (PM USA). The most popular brand of cigarettes produced by PM USA is Marlboro; other Altria brands (listed in order of prevalence in the data) include Parliament, L&M, Benson & Hedges, Virginia Slims, Basic, and Merit. Outside the U.S., these brands are also produced by Philip Morris International (PMI); Altria Group spun PMI off in 2008, retaining no ownership.

company that specializes in market research and EDP surveys, executed the collection on behalf of ALCS and analyzed the discarded packs jointly with ALCS. The purposes of this paper are to describe the data to interested researchers and analyze the prevalence of ITTP in the surveyed markets. Academic researchers wishing to access the data can do so from IllicitTobaccoTrade.com. Given the interest in ITTP in economics, criminology, and tobacco control, we expect that these new data will be of great interest for purposes of research.

EDP studies have at least two advantages over other methods of studying ITTP. EDP analysis attempts to measure the prevalence of illicit activity based directly on actual consumption rather than relying on reports from individuals on their own illegal behavior. Moreover, since the study area can be tightly defined, ITTP prevalence can be associated with local neighborhood characteristics (Merriman, 2010; Davis et al., 2014). This allows the exploration of how economic and social factors affect the supply and demand of illicit product. EDP studies are also subject to some limitations, most notably the difficulty of determining the licit or illicit status of some discarded packs.

We use EDP to estimate the level of tax avoidance and a minimum verified level of ITTP, which does not include inter-jurisdictional bootlegging of taxed cigarettes, product intended for foreign markets, or brands suspected of being manufactured for illicit sale (i.e., cheap whites) if no other evidence of illegality is found. This approach provides the most conservative estimates of ITTP. Then, by adapting the methodology developed by Davis et al. (2014), which relies on more liberal assumptions on the flows of illicit cigarettes within the United States, we provide broader and upper-bound estimates of ITTP in the various U.S. markets in the data. We find significant evidence of tax evasion and avoidance in some of the markets analyzed, most notably New York City, Buffalo, and Chicago. Verified ITTP is highest in Buffalo (31% of packs analyzed) and New York City (14%). Under broader yet still conservative assumptions, the prevalence of ITTP rises to 37% in Buffalo and 39% in New York City. Under more aggressive assumptions, we estimate ITTP to be 58% in New York City, 40% in Buffalo, 39% in Chicago, and 13% in Boston. ITTP, however measured, is much lower in Dallas, Houston, Los Angeles, Miami, Minneapolis, and Oklahoma City.

This paper consists of five sections. The first introduces the concept of ITTP and explains how its study can inform smoking-reduction policies. The second section discusses the main methods researchers have adopted to study ITTP; it briefly reviews previous studies that have exploited EDP analysis and discusses strengths and weaknesses of this method. The third section describes the methodology behind the data collection. The fourth section presents estimates of the level of tax

avoidance and ITTP in ten U.S. metropolitan areas, with insights about the prevalence and the composition of ITTP in the different cities. The final section discusses the results of the EDP analysis and options for further studies.

II. The Illicit Trade in Tobacco Products

In 2009, Congress enacted the Family Smoking Prevention and Tobacco Control Act, which grants the U.S. Food and Drug Administration (FDA) the authority to regulate tobacco products to reduce their use. Such regulation includes restrictions on the manufacturing, marketing, sale, and distribution of tobacco products (Reuter and Majmundar, 2015); for example, flavored cigarettes other than menthol are banned (Jo, Williams, and Ribisl, 2015). Tobacco taxation, passed on to consumers in the form of higher cigarette prices,[2] is recognized as one of the most effective strategies to deter smoking and, together with market regulations, is a key component of the smoking-reduction policies of most governments worldwide (WHO, 2008; Chaloupka, Straif, and Leon, 2010; Bader, Boisclair, and Ferrence, 2011). Taxes are also intended to raise revenue, both to fund public-health measures that mitigate the harms from tobacco consumption and other expenditures (Prieger and Kulick, 2016). Consequently, cigarettes are among the commodities with the highest tax value by weight (Joossens and Raw 1998; Calderoni, 2014). Taxes, on average, account for about 44% of cigarette retail price in the United States and exceed 75% of retail in most European countries (von Lampe, 2011; WHO, 2013; Orzechowski and Walker, 2014).

These restrictions generate criminal opportunities as one of their unintended consequences (Reuter and Majmundar, 2015). The market for tobacco products is a "dual market," in which legal and illegal transactions coexist and interact (Calderoni, Savona, and Solmi, 2012). In such markets, restricting access to a product through regulation is often met by evasion of the law by consumers, reducing the efficacy of the regulations and giving birth to other harms (Benham, 2008). In the case of tobacco, product bans, high taxes, and large differentials among the tax rates of the U.S. states[3] spur illicit markets for banned products and tax evasion (Baltagi and Levin, 1986; Becker, Grossman, and Murphy,

[2] Tobacco tax pass-through to consumers has been measured at slightly more than dollar for dollar (Keeler et al., 1996; Sullivan and Dutkowsky, 2012; Prieger and Kulick, 2016).

[3] State excise taxes range from $4.35 per pack in New York to $0.17 per pack in Missouri. Local taxes can increase the differential between nearby areas; state and local taxes are $6.16 in Chicago and $5.85 in New York City, but only $0.995 and $1.60 in nearby Indiana and Pennsylvania, respectively. The federal excise tax is $1.01 in all locations.

1994; Stehr, 2005; DeCicca, Kenkel, and Liu, 2013; Kleiman, Prieger, and Kulick, 2015; Kulick, Prieger, and Kleiman, 2016).

ITTP reduces the effectiveness of taxation toward protecting health by making available cheaper cigarettes (Joossens et al., 2000; Stehr, 2005). In some cases involving counterfeit cigarettes, concentrations of toxins are higher than in licitly produced cigarettes (Stephens, Calder, and Newton, 2005). ITTP also creates significant losses in tax revenue: estimates on the order of $40 billion globally, and between $3.0 and $6.9 billion in the United States are widely accepted (Joossens and Raw, 2008; 2012; Reuter and Majmundar, 2015). Because ITTP tends to be a low-risk, high-reward criminal activity, traffickers can make large profits, with less risk of detection or harsh punishments than for other illicit activities with similar revenue potential (GAO, 2011; Allen, 2014; Pelfrey, 2015). Consequently, organized crime groups may exploit ITTP for revenues to fund other illicit activities (Joossens et al., 2000; Joossens and Raw, 2008; 2012; OECD, 2015; State Department, 2015). ITTP also damages the economic interests of legitimate actors in the tobacco industry, distorting the incentives to hire labor and invest in capital, and reducing state and federal taxes on profits. Like any illicit traffic, it can generate disorder and violence, enforcement expenditures, and the public costs and private suffering associated with arrest, prosecution, and incarceration (Joossens et al., 2000; Kleiman, 2010; Green, 2015; Kulick, Prieger, and Kleiman, 2015). ITTP may also damage the tobacco-control effort indirectly by discouraging decision-makers from raising taxes and tightening regulations.

ITTP products, *modi operandi*, and actors vary significantly, depending on criminal opportunities (Transcrime, 2015). Still, it is possible to identify three main schemes: 1) cigarettes legally manufactured and sold but then smuggled from lower-tax jurisdictions to higher-tax jurisdictions, whether by large-scale operators or by casual bootlegging;[4] 2) *cheap whites*, also known as *illicit whites*, which are brands

[4] Large-scale smuggling occurs when cigarettes are sold without the payment of any taxes or duties, even in the jurisdiction of their origin; large-scale smuggling refers to the *modus operandi* by which it occurs and not the actual scale of the evasion activity (Joossens et al., 2000; Reuter and Majmundar, 2015). In large-scale smuggling schemes, cigarettes are usually obtained directly from the manufacturer at factory price (Reuter and Majmundar 2015). Bootlegging indicates the legal purchase of tobacco products in a low-tax jurisdiction and their illegal retail sale in a high-tax jurisdiction. Therefore, while in large-scale smuggling, no taxes or fees are paid, bootleggers take advantage of tax differentials. Bootlegging usually concerns individuals or small groups who smuggle smaller quantities of cigarettes but it may also entail operations trading truckloads of cigarettes (Hornsby and Hobbs, 2007; Allen, 2014; KPMG, 2014; Reuter and Majmundar, 2015).

produced primarily for illicit markets;[5] and 3) illegal production, in the form of counterfeit products and illegal manufacturing[6] (Joossens et al., 2000; Reuter and Majmundar, 2015; Transcrime, 2015).

In the United States, ITTP mostly consists of bootlegging from low-tax states (and Indian reservations) to high-tax states. The dominance of bootlegging has been explained by a relatively effective external border and customs control, significant interstate tax differentials, and the preferences of U.S. consumers for domestic brands (DeCicca, Kenkel, and Liu, 2013; Reuter and Majmundar, 2015). Another factor is the ease of the practice; the organization required to bootleg tends to be low (Antonopoulos, 2007; Joossens et al., 2009; Calderoni et al., 2014).

The volume of cigarettes smuggled from lower-tax to higher-tax jurisdictions in the United States is impressive. Recent studies estimate that ITTP accounts for between 8.5% and 21.0% of national consumption, or between 1.24 and 2.91 billion packs of cigarettes per year (Reuter and Majmundar, 2015). A large empirical literature indicates that price differentials are fundamental in predicting tobacco smuggling flows in the United States (Baltagi and Levin 1986; Becker, Grossman, and Murphy 1994; Saba et al., 1995; Galbraith and Kaiserman 1997; Thursby and Thursby, 2000; Stehr, 2005; Chiou and Muehlegger, 2008; Lovenheim, 2008; DeCicca, Kenkel, and Liu, 2013). Indeed, in high-tax states such as New York, Arizona, Washington, and New Mexico, ITTP is estimated to have market share as much as double the national average (Drenkard and Henchman, 2015). Data limitations create substantial uncertainties about the scale of illicit trade in the United States and elsewhere (Khetrapal Singh, 2015).

III. Approaches to Estimating ITTP

Several approaches to estimating ITTP are in common use (Kleiman, Prieger, and Kulick, 2015). *Population surveys* are conceptually straightforward, but run into difficulties: market participants try to hide, may not be available for interview, and have reasons not to be frank in responding to questions.

[5] Cheap whites are cigarettes legally manufactured in one country, but normally intended for smuggling into countries where the manufacturer does not hold the permission to sell them. Exportation from manufacturing countries may occur legally, and taxes in production countries are normally paid. Import into destination countries, instead, takes the form of smuggling (Joossens and Raw 2012; Transcrime 2015). The exact definition of cheap whites can differ in the literature and by law- or tax-enforcement agency (Ross et al. 2015;2016). Later in the paper we distinguish between cheap whites and illicit whites, since not all of the former are illicit.

[6] Illegal manufacturing indicates the unlicensed or underreported production of tobacco products, while counterfeiting indicates the production of branded cigarettes without the permission of the trademark owner (Allen, 2014; Reuter and Majmundar, 2015).

Indeed, even in anonymous surveys, consumers may be unwilling to disclose their illegal behavior and interview subjects tend to underreport even their legal purchases of cigarettes and alcohol, especially when they are socially undesirable.[7] Moreover, in some cases smokers might not be sure if all applicable taxes were paid on the cigarettes they bought at legal retail (Merriman, 2002).[8] Finally, even a survey that provides a representative sample of people may not provide a representative sample of cigarettes consumed (the appropriate target population to determine the market share of ITTP).

Gap analysis examines discrepancies between consumption (as reported from surveys) and licit sales; gaps between the two are attributed to illicit-market sales (see HM Customs & Excise and HM Treasury, 2000). While this method can be comprehensive, providing estimates for any jurisdiction for which survey and sales data are available, in the end the estimate reduces to calculating a residual and ascribing it to the illicit market. In fact, of course, the computed discrepancies between stated consumption and licit sales reflect not only illicit trade but also survey errors (including sampling error and reporting error), accounting inaccuracies, and any mistakes in the statistical modeling.

The *pack observation/swap survey* approach interviews smokers regarding their smoking habits, but at the end of the interview, the smokers are asked to show their pack of cigarettes or to exchange it for another. By doing this, researchers are able to collect information on both the smokers and their actually consumed cigarettes (Reuter and Majmundar, 2015). Some researchers favor this method (GfK Group, 2006; Gallus et al., 2012; Fix, 2013; Stoklosa and Ross, 2013; Joossens et al., 2014), despite the difficulty they face in engaging large and representative samples of smokers (Reuter and Majmundar, 2015).

Other approaches include econometric modeling (Becker, Grossman, and Murphy 1994; Merriman, Yürekli, and Chaloupka, 2000; Yürekli and Sayginsoy, 2010); analysis of data on product seizures (Calderoni et al., 2013); estimation of trade gaps (Bhagwati, 1974; Joossens 1998); and expert opinion (see Joossens et al., 2010). All these methods lead to different estimates of the size of the illicit tobacco market, at least in part because they capture different combinations of tax avoidance and evasion (Reuter and Majmundar, 2015).[9] The International Agency for Research on Cancer (2008) and Reuter and Majmundar (2015) have analyzed these methods.

[7] This phenomenon is an example of social-desirability bias in survey responses (Krumpal, 2013).
[8] This may be due to inattention or counterfeit tax stamps on the product.
[9] Tax avoidance involves legal methods of circumventing tobacco taxes, while tax evasion relates to illegal methods. Tax avoidance is mostly due to individual tobacco users and includes some cross-border, tourist, and

There is a growing interest in sewage epidemiology, which is the analysis of wastewater to determine the consumption of drugs at the community level (Banta-Green and Field, 2011; van Nuijs et al., 2011; Prichard et al., 2014; Kilmer, Reuter, and Giommoni, 2015). Researchers measure substance and metabolite concentrations, and deduce the quantities consumed by the population served by the sewage-treatment plants (Castiglioni et al., 2006; Zuccato and Castiglioni, 2012; Castiglioni et al., 2014). Sewage tests might become a powerful instrument to collect epidemiologic information also in the field of tobacco studies, but we are aware of no applications to tobacco consumption yet.

These methods are complementary, but all have shortcomings, some of which can be addressed via EDP methods, which yield a geographically broad and yet granular view of illicit cigarette consumption. In EDP studies, teams of researchers are sent out to find all discarded cigarette packs in a defined geographic area in order to assess the market shares of manufacturers and brands and to measure the prevalence of ITTP (both non-locally taxed genuine products and counterfeit products). Some studies limit collection to littered packs for the sake of convenience, while others (including the present study) are more comprehensive. Once collected, the packs are analyzed to determine which tax stamps are present and whether the packs bear other potential indicators of contraband status (e.g., absence of tax stamp, absence of obligatory health warnings, or cheap-white brands). See Figure 1 for examples of various state and local cigarette tax stamps. Counterfeit product can be determined by examining packaging or with sophisticated laboratory analyses. The data described below are from a large set of EDP surveys in the United States.

A. Brief review of EDP studies

EDP studies have gained broad currency in the last decade in the United States and Europe since the seminal study of Lakhdar (2008). Most studies have focused on limited areas with short time frames. Merriman (2010) analyzed littered packs collected in Chicago and found evidence that proximity to lower-tax jurisdictions is an important determinant of the share of packs that are missing their required tax stamps. Collectors gathered cigarette packs from each identified area on a single occasion between

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duty-free shopping. For example, in New York state up to 400 cigarettes can be legally brought into the state for personal consumption without use tax being required in lieu of the excise tax on cigarettes (refer to tobaccopolicycenter.org/tobacco-control/new-york-state-law/new-york-state-tax-laws-related-to-tobacco-products). Internet sales to avoid excise taxes are not legal anywhere in the United States. Tax evasion is the purchase of smuggled and illicitly manufactured tobacco products, in both small and large quantities, and is more likely to involve criminal offenders (IARC, 2011).

mid-May and mid-June 2007. Almost 2,400 packs were collected, 47.7% of which had cellophane attached so that tax stamps could be identified if present.[10]

Merriman and Chernick (2011) estimated the prevalence in New York City of packs lacking a NY State tax stamp before and after the 2009 federal excise-tax increase. They found that packs without the tax stamp rose from 15% to 24%. Two additional waves of data collection in subsequent months suggested that the tax-avoidance rate stabilized. In total, four collection waves gathered 1,662 packs (61.1% with cellophane). Kurti, von Lampe, and Thompkins (2012) focused on the illicit market for cigarette in the Bronx. Their study constitutes one of the first attempts to conduct EDP analysis at a local level in an area generally known to be rife with ITTP. The study is based on a sample of 497 packs of cigarettes collected in 30 randomly selected census tracts.[11] Davis and colleagues (2014) employed a broader geographical approach and collected 1,439 discarded packs from a random sample of census tracts in five northeastern U.S. cities. They found that 58.7% of packs did not have the proper tax stamps, and that 30.5%–42.1% were ascribable to ITTP, reflecting as much as $700 million annually in lost tax revenues.

Kurti, von Lampe, and Johnson (2015) conducted a study in the South Bronx to investigate the impact of a change in New York tax law on the numbers of untaxed cigarettes bootlegged from Indian reservations. The study collected 1,737 packs over three waves, 1,111 of which still had their cellophane wrapping. Researchers found that the tax amendment introduced in June 2010 in New York State to limit the sale of untaxed cigarettes by wholesalers to Indian reservations, which was intended to reduce illicit supply from reservations, affected the distribution of contraband types.[12] After its introduction,

[10] In the United States, tax stamps are applied on the cellophane wrapper, so that if a pack has no cellophane it is generally impossible to determine if state or local excise taxes have been paid (Kurti, von Lampe, and Johnson 2015). In the case of counterfeit cigarettes, it is reasonable to assume taxes most likely have not been paid, regardless of the cellophane (although we find a small number of counterfeit packs with apparently genuine stamps, as discussed below).

[11] U.S. census tracts typically contain 1,200–8,000 people.

[12] The state tax law as amended requires state-licensed stamping agents (i.e., wholesalers) to prepay the cigarette excise tax and affix tax stamps on all cigarette packs, including those intended for resale to tax-exempt Native Americans. To account for tribal tax immunity, taxable and tax-free cigarettes sold to tribes or reservation retailers are distinguished. The tax applies to all cigarettes sold on a reservation to non-members of the Native Americans nation or tribe. Thus, when purchasing inventory of taxable cigarettes, tribes or reservation retailers must prepay the tax to wholesalers. Because the tax does not apply to cigarettes sold to Native Americans for their own use tribes or reservation retailers may purchase a limited quantity of cigarettes without prepaying the tax to wholesalers. To prevent tax evasion, the quantity of untaxed cigarettes wholesalers in such manner is limted to the tribe's "probable demand" [paraphrased from the decision in *Oneida Nation of New York v. Cuomo*, 645 F.3d 154 (2011)].

packs originating from reservations almost disappeared from the sample, while the prevalence of packs without any tax stamps rose from 18.3% to 66.3%.

Consroe et al., (2016) studied a college campus in New York City after spring break, during which many students were presumed to have traveled out of state (in particular, to warm southern states, most of which have far lower excise taxes than New York). They refer to their EDP collection method as "garbology, an archaeological method that reconstructs patterns of human behavior from discarded materials." They found that 72.4% of the cigarette packs collected in 2012 and 2013 on the campus lacked either the state or local tax stamp.

KPMG (2011; 2012; 2013; 2014; 2015) analyzed EDPs collected by the tobacco industry to estimate national-level ITTP in the European Union. Researchers used ad hoc surveys, border crossings, and sales data to disentangle tax avoidance and tax evasion. These results are widely cited but remain controversial; Gilmore et al. (2013) reviewed these estimates and, by comparing them with data coming from independent sources, concluded that KPMG's analysis inflated the estimates of ITTP. Calderoni (2014) and Transcrime (2015) used KPMG EU data to estimate ITTP at the subnational level.

In Canada, research has focused on discarded butts (unlike in the United States, individual cigarettes in Canada have distinctive markings that can indicate licit status). The Canadian Convenience Stores Association (2007; 2008) gathered 11,267 butts near high schools in 2007 and 26,210 in 2008. Butts were classified as illegal if the butt had no brand, a foreign brand, or an untaxed/native brand; legal if the brand was considered to be legitimate in the Canadian market; unknown if the butt had no identifiable marking. According to these studies, ITTP accounts for about the 30% of the consumption of young Canadians. In 2009, another butt analysis was conducted in Canada to assess young adults' use of First Nations (native Canadian reservations, with tax-exempt status similar to Indian reservations in the United States) tobacco. Discarded cigarette butts were collected from smoking locations at 12 universities and 13 colleges. Of 36,355 butts collected, 14% were from First Nations (Barkans and Lawrance, 2013).

B. Strengths and weaknesses of EDP analysis

Unlike other approaches, EDPs allow direct measure of the prevalence of illicit activity (Merriman, 2010) and thus avoid the underreporting of illegal behavior in surveys (Davis et al., 2014). In addition, since the study area typically is tightly defined, prevalence of ITTP can be linked to local demographic, social, and cultural characteristics. This allows exploration of how such factors are related to the supply

and demand of illicit tobacco products, thus permitting the design of more focused and effective counter-ITTP policies (Transcrime, 2015). EDP studies can also identify the location of the last licit transaction in the sales chain from the tax stamps or other features of the pack, such as the language of health-warning labels or industry production codes printed on the pack (Merriman, 2010).

EDP surveys also allow for identifying different kinds of untaxed and illicit products, such as foreign and duty-free cigarettes, counterfeits, and cheap whites. This permits researchers to differentiate organized ITTP from simple tax avoidance by consumers. Although all types of tax avoidance and evasion affect revenues and tobacco control, they affect these to different extents and through different channels. To know the absolute and relative importance of different illicit products, it is crucial to design better policies and to allocate resources in the most effective way (Stehr, 2005; Transcrime, 2015). EDP approaches also yield replicable figures based on a constant methodology, allowing direct comparison across location and time (Calderoni et al., 2014).

EDP studies are not, however, without limitations (Merriman and Chernick 2011). Some biases might emerge from the fact that, because of feasibility and cost constraints, the surveys focus on manufactured cigarettes and exclude other products such as roll-your-own (RYO) tobacco products or cigars (Calderoni, 2014). Actual biases may emerge depending on which aspect of the market is being estimated. If the focus of inquiry is illicit retail trade in cigarettes, then illicit activity in the markets for these other products is of no concern. However, often a broader subset of ITTP is of interest, for example cigarettes of any kind and close substitutes such as cigarillos and little cigars. If so, then whenever the incidence of ITTP among manufactured cigarettes and the other products differ, estimates of the prevalence of overall ITTP from a discarded pack study will suffer from bias. For example, Joossens et al. (2014) found that, especially in the United Kingdom, the share of illicit products is higher for RYO tobacco than it is for manufactured cigarettes. In this case, EDP analysis would lead to underestimation of the level of the ITTP.

For the present data, such biases are likely to be minor. In the United States, RYO tobacco has a minuscule market share—less than 1% in 2014 and projected to fall further in the next few years (see Figure 2).[13] Thus, it may appear that any biases caused by lack of information on ITTP in this market

[13] Statistics on sales of RYO and pipe tobacco are from Euromonitor's Passport database, accessed February 10, 2016. Market share is out of the market for RYO and pipe tobacco and manufactured cigarettes, measured by sticks or stick equivalents. For loose tobacco, a stick equivalent is taken to be 1 gram. These calculations include only legal, fully taxed product.

segment would necessarily be minimal. However, due to higher taxes on RYO tobacco than pipe tobacco in some states, consumption of product sold as pipe tobacco may be replacing product explicitly designated RYO tobacco.[14] Therefore the worst-case scenario, from the standpoint of an EDP study intending to reflect the market for all cigarettes, would be to consider all RYO and pipe tobacco as ending up in RYO cigarettes. Figure 2 shows that the combined market share of RYO and pipe tobacco, if considered to be in the same market as cigarettes, is 5.5%.

Two factors may provide opportunities for the smuggling of non-cigarette tobacco products in the United States. First, Figure 3 shows that the consumption of loose tobacco and cigars was increasing from 2000 through at least 2013 (see also Centers for Disease Control and Prevention, 2012; Agaku and Alpert, 2015); second, state taxes on these products vary widely from state to state (O'Connor 2012; Boonn, 2015). However, only six states explicitly require excise tax stamps on products other than cigarettes, thus making difficult to measure the size of their illicit markets (Chriqui et al., 2015; Reuter and Majmundar, 2015).

EDP analysis also misses consumption in private residences by concentrating on packs discarded outside the home. A related issue afflicts studies (unlike the present data[15]) that examine littered packs only, because the behavior of litterers with regard to ITTP may systematically differ from that of non-litterers. However, Merriman (2010) argues that no evidence suggests that littering is limited to any specific sociodemographic groups. An Australian study found that almost a quarter of the population littered, with little correlation with gender, age, background or access to trash bins (Williams, Curnow, and Streker, 1997). Schultz et al. (2013) state that, although the widely accepted conclusions from observational studies are that littering is more common among men, young people, and in rural communities, the associations are "far from conclusive." In their own observational study of general littering in 130 locations in the United States, however, Schultz et al. (2013) found statistically significant evidence that younger people littered more than older people and that men littered more than

[14] Some of the substitution may be purely on the part of consumers, but some producers facilitated such substitution. When the federal excise tax increased from $1.10 per pound to $24.78 per pound on RYO (fine cut) tobacco in 2009, some tobacco companies relabeled their RYO product as "pipe tobacco." The companies marketed such "dual-use" tobacco blends as a replacement for the much more expensive RYO tobacco (Euromonitor, 2012).

[15] As discussed below, in the EDP surveys conducted by MSI, attempt was made to collect all discarded packs, whether in trash containers or on the ground.

women.[16] The association between gender or age and the propensity to litter, even if confirmed, may not introduce biases into studies of ITTP since these have been shown to be insignificant predictors of purchasing illicit cigarettes (at least in Europe; Joossens et al., 2014).

In his study, Merriman (2010) compared his main sample of littered packs with a smaller sample collected from trash bins and found no evidence of systematic discrepancies. He did, however, find that packs from Newport brand cigarettes (a menthol cigarette disproportionately consumed by African Americans) are littered out of proportion to their local market share as ascertained from point-of-sale scanner data. One less-examined sociodemographic determinant of littering is income. If lower-income individuals are both more likely to litter and more likely to engage in ITTP, then the prevalence of ITTP as calculated from simple proportions in the EDP samples would be overestimated. However, these correlations have been neither confirmed nor rejected, mainly due to lack of information on the income of individuals in observational studies of littering and because of the paucity of individual-level studies of engaging in ITTP.

Because collection occurs at the local level, the extrapolation of estimates based on EDPs to the aggregate level is more difficult and may lead to biases (Fix et al., 2013). In particular, EDP analysis may lead to inflated estimates whenever packs collected in urban areas are used to estimate the level of ITTP for a larger jurisdiction, which include both urban and rural parts. This is because the concentration of illicit packs is likely to be higher in larger cities (Gilmore et al., 2013). In the present study, random, representative sampling from the target geographic area (an MSA or a city) helps avoid this potential bias. See Appendix B for a careful discussion of the sampling technique and the resulting representativeness of the samples.

The factors mentioned above that might bias estimates of the prevalence of ITTP would not necessarily bias the estimates of regression coefficients in structural or analytic studies examining the determinants of ITTP. With a proper set of control variables and appropriate specification of the regression function (for example, modeling the scale of ITTP in logs instead of levels, so that the impacts are in percentage terms), the estimated marginal effects of the regressors on the conditional mean of

[16] Bator, Bryan, and Schultz (2011) also found that younger individuals and men littered more than older people and women, respectively, in an observational study of littering in 14 locations in eight states.

the dependent variable could be unbiased even when the scale of ITTP is mismeasured or the demographic characteristics of the sample do not coincide with those of the population.[17]

A more difficult challenge for EDP and some other studies—one that the present data cannot avoid—is to distinguish tax avoidance from tax evasion (Merriman, 2010; Reuter and Majmundar, 2015). Examination of EDPs reveals the prevalence of products lacking state or city tax stamps, which inevitably include cigarettes legitimately purchased by commuters, foreign tourists, or nationals traveling abroad. For this reason, the share of products lacking the mandatory stamp should not be considered as a direct estimate of ITTP, especially in states with high cigarette prices and in regions bordering lower-price jurisdictions (Gilmore et al., 2013; Calderoni, 2014). Moreover, in some locations EDP analysis cannot identify "gray-market" contraband consisting of genuine cigarettes diverted from the legitimate supply chain and resold within the same jurisdiction (Calderoni, 2014). In this case, smuggled packs may appear similar to legitimate ones and not be ascribed to ITTP.[18]

The largest disadvantage of the method is its cost. EDP studies are highly time- and labor-intensive, both to collect the samples and then to conduct careful analysis of the specimens in a lab. This disadvantage of such studies in general becomes an advantage of the present data set, however: the costly collection and analysis has already been performed.

Most large-scale EDP surveys, including the present one, are subject to the criticism that cigarette manufacturers funded the collection of the packs and analysis of the data.[19] This criticism arises in the tobacco-control literature, for example, concerning the Project Star and Project Sun reports (KPMG

[17] Further discussion of these issues regarding survey data, sampling, weighting, structural versus descriptive modeling, and the bias and consistency of weighted versus unweighted regression is beyond the scope of the present work (apart from discussion of some of these matters in Appendix B). Interested readers are referred to Pfeffermann (1993), section 17.8 of Wooldridge (2002), section 24.4 of Cameron and Trivedi (2005), and section 7.2 of Heeringa, West, and Berglund (2010).

[18] Note that this shortcoming is a greater concern in Europe than in the United States, where any legitimate product manufactured for export and exempt from excise taxes is required to have a notice on the package (typically, "U.S. Tax-exempt. For use outside the U.S."). See ttb.gov/tobacco/tobacco-faqs.shtml. In the present data, the production codes on the packs have also been examined to determine the intended retail markets for the product.

[19] We note that the distinction between industry-funded data collection and analysis and that performed by tobacco-control researchers (inside or outside academia) is not always that of an interested party versus dispassionate, disinterested investigators. Given the goals of tobacco control, some researchers have an interest in minimizing the importance of ITTP and particularly its relationship to tobacco taxes (Prieger and Kulick, 2016). Pecuniary conflicts of interest may also be found on both sides of tobacco control policy. A U.S. court found that three anti-tobacco members of an advisory committee to the FDA had financial conflicts of interest (Lorillard Inc. et al. v. United States Food and Drug Administration, No. 11-440, July 21, 2014 [later vacated on appeal for an unrelated reason]).

2011–2015) performed in Europe (Stoklosa and Ross, 2013). Gilmore et al. (2013) assert that the tobacco industry has an interest in inflating the relevance of the ITTP—counterfeiting, in particular[20]—to argue against tobacco-control measures such as high taxation and plain packaging. Such criticisms, however, commingle distrust of the sampling methodology (which is often not well described) with suspicion about the subsequent analysis of the data (which is typically complex and often draws on other data sources and expert opinion). Unlike those reports, however, as part of the present project we thoroughly describe the sampling plan, discuss its strengths and weaknesses, make available the raw data, and carefully describe our methodology for arriving at our estimates of the incidence of tax avoidance and ITTP. By making the data available to researchers, we therefore allow those who wish to use alternative methods of data analysis to arrive at their own estimates of ITTP to do so.

When data collection is funded by industry, external validation would be desirable but rarely is possible (Gilmore et al., 2013). Independent EDP collections may be more transparent, but they usually rely on smaller samples (Calderoni, 2014), limiting the precision of the estimates. Moreover, the participation of manufacturers is crucial in the analysis of counterfeit packs, especially in the identification of the proprietary, hidden security features in the packs (Transcrime, 2015).

However, analysis of EDPs does not suffer from many of the disadvantages of other methods. Nonresponse or underreporting by subjects is not an issue, as it is with surveys of individuals. Unlike gap analysis, no demand modeling is required. In contrast to expert opinion, objective and replicable procedures are employed. Identification of the location of consumption and the category of illicit product are straightforward. EDP analyses have thus proven to be a fruitful method to study ITTP at the local level and across different areas (Merriman, 2010; Davis et al., 2014). In the absence of large-scale, independent data collections, there is limited alternative to the use of industry-sponsored EDP studies (Transcrime, 2015).

IV. The Empty Discarded Pack Surveys

Altria Client Services has conducted EDP surveys since 2010 in select markets for its own purposes of assessing brand integrity and the incidence of ITTP. ALCS has shared results from its own analysis of these data with law enforcement officials and other stakeholders for many years and now desires to

[20] It is worth noting here in passing that the incidence of counterfeit cigarettes in the data examined here, as will be shown in section V, is relatively low.

make the data available widely to academic researchers for external analysis of ITTP. ALCS arranged under a consulting agreement with the present authors for them to examine and analyze the data and to prepare the data to enable access by other researchers.[21] ALCS's EDP surveys are executed by a third party, Market Survey Intelligence (MSI), which specializes in market research and the execution of EDP surveys.[22] Table 1 provides a list of EDP surveys commissioned by ALCS since 2010. All surveys rely on a sampling plan intended to collect a representative sample of empty discarded cigarette packs from the target area and timeframe. The data are available to interested academic researchers online at IllicitTobaccoTrade.com, where users will also find more detailed information about the variables in the dataset.

In brief, all packs from public spaces and trash receptacles within the surveyed areas are collected. Packs are analyzed to determine which tax stamps are present,[23] whether the package or tax stamps are counterfeit, where the packs were intended for sale, and whether the packs bear other potential indicators of contraband status (e.g., foreign or cheap white cigarettes). The EDPs are also analyzed to determine whether applicable state tax was paid, when possible; we supplemented the analysis by also examining whether local excise taxes were paid. Details on the sampling, collection, pack categorization, and analysis follow in the remainder of this section.

A. Sampling of neighborhoods

ALCS selects markets for EDP surveys based on a number of factors, including historical or recent contraband activity, upcoming or recent changes in law, and exploratory purposes. Since markets are not randomly selected, there is no claim to representativeness at anything larger than the market area. In particular, these data cannot be used to estimate the national incidence of tax avoidance or ITTP in the United States.[24] Markets correspond either to the largest city in a Metropolitan Statistical Area (MSA) or several such cities within an MSA.[25] The set of markets used for this study includes Boston,

[21] The source of the data naturally raises questions regarding bias. These issues are discussed in Appendix C.
[22] MSI, a private company headquartered in Geneva, Switzerland, has executed over 850 EDP surveys in over 70 countries using survey methods developed by its research and development team. See msintelligence.com.
[23] 47 U.S. states require tax stamps on cigarettes; in North Carolina, South Carolina, and North Dakota wholesalers are not required to attach the local tax stamps to cigarette packs before distributing them to retailers to indicate that taxes have been paid. Similarly, local governments with high cigarette excise taxes, including Chicago and Cook County, Illinois, and New York City require tax stamps (Reuter and Majmundar 2015; Boonn 2016a).
[24] At least, that is, without model-based extrapolation to non-surveyed markets, which we do not attempt here.
[25] An MSA is a collection of counties composing a metropolitan area with a high population density at its core and close economic ties throughout the area. Some MSAs contain a single large city that wields substantial influence

Buffalo, Chicago, Dallas, Houston, Los Angeles, Miami, Minneapolis, New York City, and Oklahoma City; the 23 EDP surveys have been conducted in each market from one to five times over the period 2010–2014 (see Table 1). For each selected market, MSI develops a sampling and collection plan that, while not a true probability sample,[26] is intended to result in samples that are representative of the cities composing the market area. The neighborhoods from which discarded packs are collected are selected at random, with a probability of selection proportional to the population, and mirror the socioeconomic features of the market to be sampled.

Depending on the MSA, MSI selects the largest city or a collection of the largest cities, as noted in Table 1. Each city is divided into five mutually exclusive and collectively exhaustive sectors.[27] Except for New York City, where the sectors are the five city boroughs, the sectors are arbitrarily defined but designed to have approximately equal population. Sectors may be missing due to irregular borders or topographical features of the city.[28] As many non-overlapping circular areas of radius 250 meters as possible are defined within each sector; these are termed neighborhoods. Neighborhoods are the ultimate sampling cluster and are sampled to create the set of areas to which to send the collection teams. The number of neighborhoods sampled within each sector depends on its population. One neighborhood is selected for every 100,000 people in the sector population.[29] MSI classifies each neighborhood as residential, industrial, or commercial; this will be referred to below as the neighborhood's *type*. If the initial random selection of neighborhoods does not reflect the proportion of neighborhood types in the sector, resampling is performed to bring the final set of neighborhoods more in line with the sector proportions.[30] The sampling of neighborhoods is completed once during the

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over the region (e.g., New York City), while others contain more than one large city with no single municipality holding a substantially dominant position (e.g., the Dallas–Fort Worth metroplex). MSAs are defined by the Office of Management and Budget (OMB) for statistical purposes.

[26] As discussed in Appendix B, probability sampling (i.e., a sampling plan resulting in a known inclusion probability for each observation in the sample) is impossible for EDPs, since there is no frame (i.e., a list of population units from which to sample) available.

[27] Except for New York City, all the cities are subdivided into MSI-defined sectors labeled North, East, South, West, and Center. New York City is, instead, subdivided into its five boroughs (i.e., Manhattan, Brooklyn, Queens, the Bronx, and Staten Island).

[28] Waukegan in the Chicago MSA has only four sectors.

[29] Thus if the sector's population is less than 100,000, collection takes place in one neighborhood, if the sector's population is 100,000–200,000, collection takes place in two, and so on. Neither the population counts used by MSI in these calculations nor the precise boundaries of the neighborhoods are available in the data (although the ZIP code into which the neighborhood falls is recorded).

[30] For example, if one third of the neighborhoods are in commercial areas in the sector but none happen to be chosen in the initial random sample, then some randomly chosen residential and industrial neighborhoods in the

market's initial assessment; once selected, the same neighborhoods are used for all subsequent collections.

The total number of EDPs to be collected and analyzed in market *i* at time *t*, N_{it}, is determined by budgetary constraints and the desire to have no fewer than about thirty observations per neighborhood (while respecting the approximate guideline of one neighborhood per 100,000 people).[31] The total number of EDPs collected in each neighborhood is determined by first apportioning N_{it} to the cities in the MSA in proportion to population (when the market contains multiple cities). Then the apportioned number of EDPs for the city is divided proportional to the population of the sector. Finally, the sector's allotment of packs is divided by the number of neighborhoods in the sector. An additional small number of "buffer" packs are also collected to replace packs that do not meet the quality criteria for data analysis.[32] Given the sampling scheme, the various areas of the market are represented in approximate proportion to their population and type of neighborhood. In the statistics presented below, therefore, the data are not weighted.

Not every pack within a neighborhood is collected. MSI precisely defines two random routes the collectors are to take and prepares detailed collection instructions for each sampled neighborhood. Within each neighborhood, the routes correspond to two circuits; the first one covers the center of the area (roughly the inner, centered circle of diameter 250 meters), while the second traverses a peripheral route through the remainder of the neighborhood.[33] The second, outer route may not be used if enough packs are collected from the inner route (as explained in the next subsection). For some example routes, see Figure 4. While the details of the creation of the "random walks" are proprietary, our examination of the neighborhood route maps revealed that in most cases there are only a few alternative routes at most in any event, given the tight boundaries of the inner and outer parts of the neighborhoods.

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initial sample will be discarded and replaced with an equal number of randomly selected commercial neighborhoods.

[31] The actual number of packs analyzed per neighborhood falls below 30 in about 3% of the neighborhoods, but is never less than 25 and has a median of about 50.

[32] A pack must be free of mold, legible, and intact. If a pack does not satisfy these three conditions it is replaced with a pack from the buffer. Wherever possible, replacements are made using a random selection from among buffer packs with the same brand. If the same brand is not available, a replacement is made from among buffer packs within the same brand family. If there are no buffer packs in the same brand family, a replacement is made from among buffer packs from the same manufacturer. If there are no buffer packs from the same manufacturer, then a randomly chosen buffer pack is used.

[33] I.e., through the annulus with inner diameter 250 meters and outer diameter 500 meters.

Geographic coverage within the neighborhood is therefore typically fairly comprehensive and randomly determined.

Finally, the specific neighborhoods, dates, and times of collections are checked to ensure that people visiting the area do not unduly distort the distribution of packs. In particular, collection locations do not include airports, sporting venues, or major tourist attractions; neighborhoods that include such extraordinary features are replaced with neighborhoods of the same type during the sampling process. If the survey schedule would coincide with an extraordinary event in the neighborhood (e.g., parades, street fairs, or planned demonstrations), the collection is postponed until after the event.

B. Collection of packs

At least two collectors are assigned to each neighborhood.[34] Collectors are instructed to complete their entire route and to pick up all discarded cigarette packs observed on streets and readily accessible public trash receptacles on the route, irrespective of the brand, country of origin or whether the cellophane is intact. Collection takes place any time of day, including weekends, and in all weather conditions. Collectors move along the predefined routes, beginning with the inner route in the neighborhood. If at the end of the first route the supervisors determine that the collectors have not gathered the minimum number of packs desired from that neighborhood, the collectors walk through the outer route. The collectors do not know the objective of the collection nor the quotas; only the supervisors know this information. Collectors always pick up all packs along an entire route.[35] In the (rare) event that they have not gathered enough packs after completing the second circuit, they restart with the first circuit on another day.

Collectors place packs within a labeled bag for the neighborhood. After collection from a route is complete, the neighborhood bag is turned in to the supervisors. The supervisors randomly pull packs from the bag, until the quota and buffer-pack requirements for the neighborhood are met with the specified number of adequate-quality packs. Pack quality is deemed inadequate if the pack is severely damaged (e.g., large portions of the pack are missing), illegible, or excessively dirty, wet, or moldy. If the

[34] MSI extensively trains the collectors and sends the same teams to the various markets. Before each collection survey, a pilot is performed with the collectors during which the supervisor demonstrates all of the steps in the collection process and ensures that the collectors understand the protocol.

[35] This avoids the potential problem of collectors "cherry-picking" packs that are easy to find because they know they only need to collect a few more packs to make quota for the neighborhood. Such selective collection may introduce unknown biases into the sample since littered packs would be easier to spot than packs discarded in trash receptacles (refer to the discussion of the behavior of litterers in section III.B above).

quota is not met, the collectors return to walk the next route in the neighborhood as described above. Once the quota is met, the supervisor places the complete set of EDPs in the neighborhood bag, discarding any surplus packs except those in the buffer, and seals and labels the bag. The neighborhood bags from each market are then delivered for cleaning and analysis.

Each pack is cleaned,[36] flattened, and placed into a zipper bag (a "pack bag"). A sticker is placed on each pack bag with a barcode that links the sample to the date, city, sector and neighborhood of collection. Buffer packs collected during the survey are maintained separately as replacements for packs that fail to meet the acceptance criteria during the cleaning, data entry, and final pack screening processes.[37]

C. Analysis of packs

The physical analysis of the packs is performed by MSI, with supplemental analysis by ALCS as described below. The manufacturer, brand, and presence of the cellophane wrapper on collected packs are recorded. Packs with cellophane are then examined for the current or former presence and jurisdiction of tax stamps. Stamps from most states have a chemical marker in them that allows researchers to determine if there was previously a stamp on the pack even when it is physically missing. If analysis of the cellophane detected the chemical marker from a stamp, the status is recorded as if a stamp were present.[38]

The next phase of analysis involves counterfeit tax stamps and cigarette packs. Screening is performed on all tax stamps. MSI performs an initial analysis, based on training provided by ALCS, using confidential and non-confidential authentication techniques to determine if the stamp is counterfeit.[39] A few states (California, Massachusetts, and Michigan) have "high-tech" counterfeit-resistant tax stamps

[36] The cleaning process involves first removing the cellophane wrapper (to which any tax stamp is affixed) and removing any dirt or mold on the pack. Doing so prevents the pack from deteriorating while in storage or transit prior to categorization or analysis. Because moisture can degrade quality, any wet packs that are collected are dried as part of the cleaning process. The cellophane wrapper is placed back on the pack after cleaning.

[37] A pack could fail in the final screening for counterfeit packs and stamps if, for example, moisture created mildew on the pack while it was stored awaiting analysis.

[38] The chemical marker typically does not identify which state a stamp was from. When the state cannot be identified, the state is recorded with code 99 in variable tax_stamp_state. Per staff at ALCS, often times there is enough residual stamp remaining once the presence of the chemical marker has been found to allow identification of the state from which the stamp originated, and in such cases the actual state is recorded.

[39] As with many efforts to combat counterfeiting and fraud more generally, some methods of detection remain confidential to law enforcement and industry actors so that counterfeiters do not make their products harder to detect.

with features such as holographic or encrypted images, color-shifting dyes, tamper-evident surface cuts, and unique serial numbers (CDC, 2016).[40] Other evidence of counterfeit stamps includes stamps with inconsistent coloring, poor imaging, crooked placement on the pack, or that were affixed with adhesive tape (NJ OCI, 2014).

Unlike the screening of tax stamps, inspection to detect counterfeit manufacture is performed only on packs that are Altria or Philip Morris International (PMI)[41] brands (whether or not the wrapper is present). [42] Per ALCS, genuine packs contain multiple features used to detect counterfeits.[43] Some of the testing procedures are available only for Altria brands.[44] Methods known from the literature to be used by industry to identify counterfeits include visual assessment, ultraviolet irradiation of the pack, and chemical analysis of the packaging (Kurti, He, von Lampe, and Li, 2015).[45] In the 2010 New York City survey, no packs were inspected for counterfeiting. MSI recorded its preliminary determination of counterfeit status and submitted its data and all collected packs to ALCS, which performs its own laboratory analyses to verify the authenticity of the packs.

Other data elements for each pack are also recorded and linked to the pack by scanning the barcode label on the bag containing the pack. Data entered include: market, sector, ZIP code, neighborhood location, date of collection, UPC code, pack production code, tax-stamp serial number, fluorescence status, and original-design market (although not all of these are necessarily available for any given pack).

[40] A fourth state, New Jersey, had passed legislation requiring high-tech stamps but had not yet implemented them by the start of the sample period (Chriqui et al., 2015).
[41] See footnote 1.
[42] There are a few exceptions in cases where the counterfeiting was obvious. In 2011, four packs of Newport brand cigarettes, which are not manufactured by PM USA, were marked as counterfeit by MSI and ALCS because the print style on the packaging was obviously incorrect. In 2014, two packs of duty-free Newports from the Boston market were marked as counterfeit, for reasons unknown to us. In the 2012 Los Angeles market, two packs of brand Parliament purportedly produced for a non-domestic market by PMI (marked for sale in duty-free zones in Korea) were marked as counterfeit, for reasons unknown to us.
[43] The comment in footnote 39 applies here as well.
[44] This means that ALCS does not test Marlboro (or other branded) packs produced by PMI as thoroughly as Marlboro packs produced by PM USA. In particular, the test for the presence of a chemical taggant in genuine packaging (mentioned below) is performed only on packs purportedly produced by PM USA.
[45] Visual inspection looks for low-quality printing on the pack, generally due to the use of offset printing instead of the more expensive and higher-quality gravure printing. The quality differences may be difficult to detect with the naked eye but show up readily under a microscope. Fluorescence under UV radiation signals counterfeit status because counterfeit packaging often contains optical brightening agents (OBAs) to conceal the use of low-quality paper; legitimate packages manufactured by PM USA and some (but not all) other manufacturers have no OBAs. OBAs fluoresce a blue light. Industry sources inform us that the lack of OBAs has become a less reliable indicator of genuine product over the years, since OBAs are now sometimes absent from higher-quality counterfeit packages. In addition, incorrect production codes (or codes known by industry to be copied by counterfeiters) printed on packs signal counterfeit manufacture (Kurti, He, von Lampe, and Li, 2015).

Table A-1 (see Appendix A) provides a list of the variables MSI and ALCS entered for each pack; see also the codebook available online at IllicitTobaccoTrade.com.

D. Categorization of packs

Based on the analysis of the packs, the status of each pack can be categorized regarding taxes not paid, counterfeit product, and contraband. MSI and ALCS categorized packs in various ways in the different waves of the survey. In this section we describe their schema; our own categorization and analysis is presented in section V. Their main grouping, recorded in the variable CF_GROUP,[46] has the following categories: 1) no cellophane (so that the tax status cannot be determined from the presence or absence of tax stamps); 2) correct state tax stamp (local tax status is ignored);[47] 3) incorrect state tax stamp;[48] 4) counterfeit tax stamp; 5) cellophane intact but no tax stamp;[49] 6) counterfeit pack; and 7) product intended for a non-domestic market. These categories and their names change slightly over the sample, as noted in Table 2.

The absence of an applicable state tax stamp (categories 3 and 5) does not necessarily indicate illicit trade, because the presence of a discarded pack in a location does not mean it was sold in that jurisdiction, nor does it indicate how it was transported into the collection area (Ross, 2015).[50] The tax-paid status of packs without cellophane cannot be determined,[51] although if the pack were intended for a foreign market it can be assumed federal, state, and local taxes were not paid even if the film is missing from the pack.

Since the measures used to protect the brand integrity of PM USA products are a trade secret,[52] ALCS does not make available the exact relationships between certain indicators of counterfeits found in the data and the placement into category 6 (*counterfeit pack*) of CF_GROUP. However, the relationships can

[46] Variable names refer to variables in the Excel and Stata files containing the EDP data.
[47] In Texas, a tax stamp from the Alabama Coushatta Texas Tribe is exempt from the state tax requirement and MSI marked the six packs with such stamps in the Texas markets as state-tax paid, even though the state earns no tax revenue from it. The same is true for a "Native American MN" stamp in the Minneapolis market (found on 19 packs). See DeLong et al. (2016) for details on the state-tribal compacts and intergovernmental agreements regarding tobacco excise taxes.
[48] Packs with tribal or Native American stamps other than those mentioned in the previous footnote fall into this category.
[49] North Carolina, North Dakota, and South Carolina are the only U.S. states that do not require a tax stamp. None of the surveys are in these states.
[50] MSI makes no determination regarding whether brands are certified for sale in the states of collection pursuant to the Master Settlement Agreement (in effect in 46 states) and associated state laws.
[51] But see footnote 10.
[52] See footnote 39.

be examined from the data presented for domestic-market Marlboro packs in Table 3. The data show that whenever a chemical taggant incorporated into genuine PM USA product packaging was detected, the pack was deemed genuine regardless of the other indicators.[53] Whenever a Marlboro pack fluoresces under UV radiation,[54] it was deemed to be counterfeit. In the remaining cases (i.e., the pack did not fluoresce and the taggant either was not detected or the test results are not available) the counterfeit status was completely determined by whether the PM USA production code printed on the pack is one known by ALCS to be copied by counterfeiters.[55] While these results give some insight into how counterfeit packs may be detected, we emphasize that these apparent "rules" are merely inferred from the data, and that in any event ALCS informed us that it may conduct additional tests for brand integrity that are not captured by any of the indicators.

Special care must be taken by any researchers using these data to investigate the prevalence of counterfeiting in the U.S. tobacco market. Because analysis to detect counterfeits is conducted only on PM USA and PMI brands, the simple prevalence of counterfeits out of the entire sample is a downward-biased estimate of the share of all counterfeit product in the cigarette market. Conversely, the counterfeiting rate for PM USA or PMI brands cannot be simply extrapolated to other brands. Marlboro brands, which are produced by PM USA and PMI, are the world's most counterfeited (WCO, 2014). In 2014, Marlboro alone accounted for the 45% of the counterfeit cigarettes seized worldwide (WCO, 2015), while accounting for only 7.2% of world market share (Euromonitor, 2016). Seizures made worldwide testify to the counterfeiting of other legitimate brands and even of cheap whites (WCO, 2013). In the absence of further information to adjust the estimates for the United States, calculating the incidence of counterfeits for the inspected manufacturer would likely lead to overestimating the incidence of counterfeit packs in the market as a whole.

[53] In two cases not included in Table 3 (because some of the indicators of counterfeit status were missing), field TAGGANT_STATUS has value "failed" but ALCS changed MSI's categorization from "counterfeit domestic" to "correct tax stamp" in variable CF_GROUP, from "contraband" to "applicable tax paid" in variable CATEGORY, and from "counterfeit" to "genuine" in variable PACK_STATUS. In such cases, additional testing by ALCS verified that these two packs were genuine and that the taggant field reflected a false negative. Detection of the taggant on the packaging can be impaired if the pack is wet, mutilated, etc.

[54] See footnote 45.

[55] There are several cases where a positive taggant presence trumps a production code on the counterfeit list, leading to a designation as not counterfeit.

Packs of cheap whites are identified by MSI only in the 2011 EDP samples.[56] We supplemented the data with an expanded list of brands of cheap whites from Ross et al. (2015b). The Appendix contains the complete list of cheap white brands (Table A-2). Although cheap whites are produced mainly for purposes of illicit sale, in some cases in the sample a cheap white pack has a valid tax stamp. We therefore distinguish between *cheap whites* and *illicit whites* hereafter, with the former depending only on the brand. In our determination, two conditions have to hold simultaneously to label a pack of cigarettes as illicit whites: 1) the brand is identified with cheap whites and 2) the wrapper is intact but there are no tax stamps. Given the contentious nature of the definition of cheap white brands in the literature (Ross et al., 2015,2016),[57] we separate cheap whites based on whether the brand was determined as such by multiple sources or by industry sources alone.[58]

MSI and ALCS created a summary field with their final determination of contraband status. The field CATEGORY takes values 1) applicable tax paid, 2) applicable tax not paid (ignoring local taxes, if any are applicable), 3) contraband (counterfeit product or counterfeit tax stamp), 4) non-domestic, and 5) undetermined due to lack of cellophane.[59] The correspondence between the categorical variables CF_GROUP and CATEGORY is shown in Table 4.

In summary, the categorization of packs by MSI and ALCS with fields CF_GROUP and CATEGORY provide a useful starting point for statistical analysis. There are a few possible shortcomings with the categorizations. First, the dimensions of tax status and counterfeiting are collapsed to a single dimension in these variables, at the cost of some potentially useful information. There are a few cases in which the pack is counterfeit but bears a valid tax stamp appropriate to the jurisdiction.[60] Second, there are unexplained discrepancies in the categorizations as noted above, in table notes, and in footnotes, although such discrepancies are very rare. Most importantly, however, the category *contraband* undoubtedly misses a huge amount of activity involving large-scale bootlegging of genuine product,

[56] The brands identified as cheap whites by MSI are Chunghwa, Double Happiness, Esse, and Hatamen. We identified several other brands based on other sources, as described below.

[57] Ross et al. (2016) suggest that the traditional tobacco companies have incentive to label cheap white brands as illicit even when they are not since they create lower-price competition for traditional brands. Ross et al. (2016) find that the illicit status of cheap white brands is variable, sometimes even within the same country of sale, although the preponderance of brands examined had neither the appropriate tax stamp nor the required health warnings in at least one country of sale.

[58] The relevant variables in the dataset are CHEAP_WHITE (MSI's determination), A_CHEAP_WHITE_BRAND (our determination based on the list of brands in Table A-2), and A_CHEAP_WHITE_SOURCE (the source of the designation of the brand as a cheap white, as in Table A-2).

[59] See footnote 10.

[60] It may be that counterfeiters reuse valid tax stamps from previously sold packs (which would be illegal).

which should be considered contraband as well.[61] The next section contains statistical analysis of the data based on our own categorizations of the packs. Future researchers can use these data to explore alternative categorizations as desired.

V. Analysis

A strength of this new database is that it allows for a rigorous and geographically broad study of ITTP. Packs have been collected between one and five times each in ten different metropolitan areas, using a constant methodology. Overall, the database includes 106,500 discarded packs—usually 5,000 per wave, with an average of 4,630—of which 72.2% have cellophane.

The analysis presented here is based on study of the EDPs. First, we estimate the combined prevalence of tax avoidance and tax evasion, where the latter is defined as packs lacking genuine tax stamps. Then, we examine ITTP by enumerating packs whose provenance is nearly certainly illicit (counterfeits, illicit whites, and U.S. packs without any tax stamps[62]) and those of questionable legality (U.S. packs with the wrong state or local tax stamp and foreign packs).

While counterfeits, illicit whites, and U.S. packs without any tax stamp are nearly certainly part of ITTP, it is not possible to confirm the illicit origin of other packs lacking tax stamps without further information or assumptions. Our first estimate of ITTP in this study does not include packs with the wrong U.S. tax stamp or foreign packs. Consequently, it is a conservative, lower-bound estimate.

To account for bootlegging and other forms of ITTP, we also relax the previous assumptions to provide broader estimates. In addition to counterfeits, illicit whites, and packs with no stamp, some packs from nonadjacent states are included in these estimates (as proposed by Davis et al. (2014)), as well as some foreign packs, intrastate bootlegging to evade local taxes (e.g. packs with an Illinois stamp but lacking the Cook County/Chicago stamp), and cheap whites.

[61] In addition, we cannot rule out the possibility of false-negative results: counterfeit packs that pass scrutiny and are classified as genuine.

[62] Packs with no stamp may originate from the three U.S. states that do not use tax stamps (i.e., North Carolina, North Dakota, and South Carolina), Internet sales (illegal since 2010 in the U.S.) or Indian reservations (Davis et al., 2014). We follow the convention in the literature of ascribing any U.S. pack without a tax stamp to ITTP (e.g., Davis et al., 2013; Wang et al., 2016), despite the fact that packs coming from North Carolina, South Carolina, and North Dakota do not have stamps even if licitly purchased.

All averages in this section are at the market level. We do not calculate averages across the entire sample because the sample does not reflect any well defined target population. In particular, averages across the entire sample would not yield unbiased estimates of ITTP for the nation as a whole.

A. The prevalence of tax avoidance and tax evasion

The database supports estimation of the proportion of cigarettes consumed in each area that are missing the required tax stamps. For packs with cellophane, we deem that the state excise tax appropriate for the jurisdiction of consumption was not paid if any of the following are true: 1) there is no stamp, 2) there is a counterfeit stamp, or 3) the stamp is for the wrong state.[63] Additionally, packs lacking the cellophane wrapper but satisfying one of the following conditions are also deemed tax unpaid: 4) the intended market is non-domestic,[64] or 5) the pack is counterfeit.[65] Our determination is recorded in variable A_STATE_TAX_PAID, and all statistics in this section regarding state tax compliance are for the subsample of packs for which it can be determined whether the state tax was paid. In this subsection we make no distinction between avoidance and evasion of taxes.

Overall, the data confirm that the proportion of cigarettes for which appropriate state excise taxes were not paid varies greatly across markets (Table 5) and years (Table 6). New York, which has the highest state taxes ($4.35 per pack compared to a national average of $1.48 in 2013),[66] has the highest prevalence of non-state-taxed cigarettes in the panel. In New York City, 62.6% of packs lack a valid state tax stamp; the same holds for 50.7% of the packs collected in Buffalo.[67] The prevalence of non-state-taxed cigarettes in New York City is not only the highest (by far) over the entire period (Table 5) but also in each individual year (Table 6).

The difference in the prevalence of tax avoidance and evasion between the New York markets (New York City and Buffalo) and the other cities and MSAs is stark. In Boston, the market with the third-highest prevalence, non-state-taxed cigarettes account for only 17.5% of the sample; the rate in Chicago

[63] We follow MSI's convention regarding the tribal stamps discussed in footnote 47. We treat other tribal stamps as if they were stamps from an incorrect state.

[64] We limit this condition to packs without cellophane because in a few (25) cases packs intended for non-domestic markets have a genuine, appropriate tax stamp. These may be gray-market packs that were reimported to avoid federal excise taxes. Non-domestic packs with cellophane otherwise fall under condition 1.

[65] We limit this condition to packs without cellophane because in a few (5) cases counterfeit packs had genuine, appropriate tax stamps. Counterfeit packs with cellophane otherwise fall under conditions 1 or 2.

[66] See Drenkard and Henchman (2015). Refer also to footnote 3.

[67] The share of packs on which state tax has been paid is calculated by dividing their number by the number of packs for which it was possible to determine if taxes were paid. The set of years over which the averages here are calculated differs by market; refer to Table 1 for the years each market was surveyed.

is similar (15.9%). The other six markets have shares ranging from 8.6% in Miami to 4.4% in Minneapolis (see Table 5). Minnesota has the third-highest average price per pack of cigarettes ($8.40) after New York State ($10.45) and Massachusetts ($9.10); however, it is among the states with the smallest *increase* in taxes in recent years (+1.0% between 2006 and 2013) (Drenkard and Henchman, 2015; Boonn, 2016b).

Where do untaxed out-of-state cigarettes in the New York markets come from? Figure 5 shows the source locations for packs that are not properly state taxed (based on the tax stamp). Of the untaxed packs collected in New York City, 31% come from Virginia (where the excise tax is only 30 cents) while 28% come from abroad. New Jersey (tax = $2.70) supplied 9% of the untaxed packs collected in New York City and Georgia (tax = 37 cents) and Pennsylvania (tax = $1.60) each contribute about 3-4%. Virginia and Georgia are both tobacco-producing states and their cigarette taxes and prices are among the lowest in the country (Drenkard and Henchman, 2015; Boonn, 2016b). Davis et al. (2014) and Reuter and Majmundar (2015) have observed that bootleggers legally purchase cigarettes in Virginia and other low-taxation states to resell them in large quantities in high-tax jurisdictions, and so it is no surprise to see such a large share of the untaxed packs originating from Virginia. Almost one-fifth of untaxed packs were intended for domestic markets but lack a genuine stamp and so are of unknown origin.[68] The remaining 8% come from other states or tribal areas.

The picture is quite different in Buffalo, also shown in Figure 5. One-half of untaxed packs are Native American brands without a tax stamp and about another one-sixth have a Native American tax stamp (i.e., a Seneca Nation of Indians stamp, which does not count toward the required New York state excise tax). Given the prevalence of Native American tobacco sales in the Buffalo market, the many media reports about New Yorkers buying cigarettes on reservations to avoid state excise taxes (e.g., Weaver, 2015), and the fact that mainstream brands are also offered for sale on reservations, it may be that many of the 12% of packs of unknown origin are also from reservations (although there is no way to test this hypothesis). Virginia product is much less prevalent in Buffalo than in New York City, (5%), as is product intended for foreign markets (7%). Kentucky, another tobacco-producing state with low taxes (60 cents a pack), is the only state that supplies at least one percent of the Buffalo market but less than one percent of the New York City market.

[68] See footnote 62 regarding unstamped packs.

New York City, in addition to state taxes, also has high city taxes ($1.50 per pack), thus the minimum price for a fully taxed pack of premium-brand cigarettes is $10.45 and the most common price is around $12.50 (Campbell, 2015; Boonn, 2016b). In contrast, the average cost of a pack nationwide is $5.96. It follows that a New York City resident who smokes a pack a day would spend about $375 per month buying only fully-tax-paid cigarettes. By purchasing out-of-state cigarettes at around $7–8 per pack, that smoker could save about $120 per month (Campbell, 2015). Genuine smuggled cigarettes sell in the Bronx at about the same price as could be obtained by buying out of state. (Kurti, von Lampe, and Johnson, 2015). Chicago has even higher combined state and local excise taxes than New York City.[69] Once local taxes are considered in addition to state taxes (also in Table 5 and Table 6), only 26.0% of packs consumed in New York City were fully tax-paid. In the Chicago area, only 30.5% of packs were fully tax-paid. Note that the smaller the area of the tax jurisdiction, the easier it is to avoid taxes by purchasing in an adjacent, lower-tax jurisdiction, which is one reason why so few packs in Chicago and New York City are fully tax-paid.[70]

New York City and Boston are among the cities where Davis and colleagues (2014) performed their EDP analysis, which allows comparison of our results with theirs. For December 2011, they estimated the incidence of packs with correct state and local tax stamps as 39.3% in New York City and 51.8% in Boston. Our estimate of the incidence of packs with the proper combined state and local tax stamp in New York City is 19.5% for 2011 (see Table 6). Estimates for Boston also differ, but in the opposite direction; we find 83.2% of packs were fully tax paid in 2012. The only obvious differences between the surveys are the slightly different collection periods, the relatively small sample sizes of Davis et al.,[71] and the fact that they appear to have collected littered packs only.[72] Another, less direct comparison can be

[69] See footnote 3. The Chicago market in the surveys includes three distinct tax jurisdictions: the city of Chicago, where state, county, and city excise taxes must be paid; the parts of the city of Elgin that are in Cook County, where state and county taxes are due; and the rest of Elgin and the other surveyed cities (Aurora, Joliet, and Waukegan, all outside Cook County), where only state taxes are due. The figures in Table 5 and Table 6 are calculated with reference to the local taxes due in the specific neighborhoods in the Chicago sample.

[70] The distance from the consumer's home to a lower-tax jurisdiction has been shown to be an important driver of tax avoidance (Chiou and Muehlegger, 2008; Lovenheim, 2008).

[71] Davis et al. (2014) collected an average of only 287 packs per city from 30 Census tracts within each city, for an average of 9.6 packs per tract. In the present study there are well over a hundred packs from each neighborhood sampled in Boston and New York City, and 5,000 packs collected from each city. The present data also have greater coverage within a city, with over 40 neighborhoods sampled in Boston and over a hundred in New York City.

[72] Recall that our data include packs properly disposed in trash bins. Thus, if littering and tax avoidance/evasion are positively correlated in Boston, Davis et al.'s (2014) methodology would yield lower estimates of fully tax-paid packs. If so, however, the question arises of why the same direction of the difference does not appear with the New York City estimates.

made to Merriman's (2010) finding that three-quarters of packs in Chicago did not have a local tax stamp in 2007; the present data from Chicago in 2013 and 2014 show that tax compliance to be five to six percentage points higher than that (see Table 6 – Tax paid status of collected samples by market and year).

In six markets, the MSI EDP surveys have been conducted in multiple years, thus allowing for assessment of changes in the consumption of non-taxed cigarettes. Chicago, Miami, and New York City (local tax) register fluctuations of less than 10% in their shares of untaxed cigarettes over time, with no clear trends (see Figure 6). In Boston, consumption of untaxed cigarettes rose 12.3% between 2012 and 2014. When considering only state excise taxes, New York City saw its proportion of untaxed cigarettes increase by 33.6% from 2010 to 2014, with the share rising each year. In Los Angeles, where tax compliance was already relatively high in the first survey, the non-state-taxed proportion decreased by 28.1% from 2011 to 2014, although not monotonically. Houston experienced the largest percentage increase in the prevalence of non-state-taxed cigarettes (+71.1%), and the increase was rapid (from 2012 to 2013).

B. The prevalence of cheap whites

Our data show that cheap whites are relatively rare in the United States, as opposed to in Europe where they are more prevalent (Joossens and Raw, 2012; Ross et al., 2016). Table 7 shows that only a tiny fraction of packs are cheap whites. Only in New York and Dallas do cheap whites compose more than one-half of one percent of the sample. Houston, Los Angeles, and Miami are the only other cities with shares for cheap whites of more than one-tenth of one percent. Such small numbers of cheap whites, and their non-negligible presence only in cities close to international borders (Houston, Dallas) and the top three cities visited by foreigners (Los Angeles, Miami, and New York),[73] suggest that most cheap whites may be carried into the country as the personal property of travelers from abroad. Such small-scale importation of cheap whites from abroad is not necessarily illicit, since travelers can bring up to 200 cigarettes (10 packs) into the United States. duty free if they are properly declared to customs officials and are intended for personal use.[74]

[73] Thirty percent of all visitors to the United States list New York as their destination city, while Miami and Los Angeles have about a 12% share each (NTTO, 2015).

[74] Refer to the U.S. Customs and Border Protection information available at help.cbp.gov/app/answers/detail/a_id/53/~/traveler-bringing-tobacco-products-(cigarettes,-cigars,-bidis)-to-the-u.s.-for.

The fractions of cheap white brands identified only from industry varies greatly between the cities (see columns three and four of Table 7). Given the minuscule presence of cheap whites in the sample, the distinction does not appear to be important in the United States (at least in the cities represented in the sample).[75]

C. The prevalence of illicit tobacco products

Understanding the consumption of non-taxed cigarettes provides information to improve tobacco-control policies and estimates of revenue losses due to cross-border purchases. A broader understanding of ITTP dynamics involves law-enforcement costs, violence related to illicit markets, funding of criminal and terrorist organizations, etc. (Joossens et al., 2000; Stehr, 2005; Shelley and Melzer, 2008; Perri and Brody, 2011; FATF 2012; Prieger and Kulick, 2014).

Given the indeterminacy of the licit status of some of the packs, we present a range of estimates of the incidence of ITTP. Our most conservative estimate of ITTP, which we refer to as *verified ITTP*, includes counterfeits and domestically produced cigarettes lacking a genuine tax stamp. This estimate also includes all cheap whites without a genuine tax stamp (i.e., illicit whites) as ITTP, regardless of where they were produced or their intended market.[76] This methodology does not, however, include in ITTP any pack with genuine tax stamps differing from the jurisdiction where the pack has been collected or foreign cigarettes (apart from illicit whites). While verified ITTP is a very conservative estimate of ITTP and probably greatly undercounts the scale of illicit activity (as will be shown below), the measure is not necessarily a lower bound on ITTP.[77] The results of this definition are stored in variable A_ITTP1 in the database.

[75] In some cases the proportions are driven by a single brand. For example, in Dallas all 31 cheap white packs are of the Classic brand, which are produced in India. Similarly, 39 of the 43 cheap white packs in Houston are Classic brand. Since Ross et al. (2015b) found multiple sources apart from industry that identify Classic as a cheap white brand, the proportion of cheap whites that are identified as such from multiple sources is 100% in Dallas and 91% in Houston.

[76] Thus illicit whites are the only foreign-market packs included in verified ITTP.

[77] In particular, stamps may have been removed from or fallen off the wrapper and a pack designated as illicit whites may have been purchased legally in a foreign location for personal use and either properly declared to U.S. Border and Customs Control or included under the 200-cigarette personal-use exemption. The former appears to be a rare occurrence; in 2014 MSI added an indicator for the presence of a remnant of a tax stamp, and less than one-half of one percent of packs fell into that category. Regarding illicit whites, the small number of cheap whites in the sample implies that the method of dividing cheap whites into licit and illicit categories affects the statistics on ITTP very little. Finally, see also footnote 62 on unstamped packs.

The first columns of Table 8 (for cities) and Table 9 (for survey waves) show the proportion of verified ITTP out of determinable packs. The same information as in Table 8 is also depicted graphically in Figure 7. Comparison of the verified ITTP shares confirms the distinctiveness of New York State within the panel. ITTP accounts for at least 31.4% of the market in Buffalo and at least 13.7% in New York City (see Table 8). Miami, the next highest, has a verified ITTP share of 2.5%. Verified ITTP is lowest in Chicago. Among these cities, Buffalo stands out as the only market in which the number of packs of verified illicit origin are greater—and by far—than those with a tax stamp from another state. The collection of so many packs without any tax stamp[78] suggests the prominence of large-scale smuggling.

The definition of verified ITTP necessarily misses much smuggling of genuine product. Much contraband product will bear a valid stamp from a lower-tax state. Tax evasion composes an unknown fraction of the figures in the next three columns of Table 8 and Table 9: interstate cross-border purchases and bootlegging, intrastate cross-local-border purchases and bootlegging, and product intended for foreign markets. These three categories mix tax evasion and tax avoidance, the latter of which breaks no laws. The final column in these tables show the fraction of fully tax-paid product intended for the domestic market, which is the only column certain *not* to contain any ITTP. After accounting for verified ITTP, tax avoidance, and tax evasion, only 30.5% of packs in Chicago, 34.3% of packs in New York City, and 49.3% of packs in Buffalo are fully tax-paid genuine product.[79]

New York City is notable for its low share of fully tax-paid domestic packs and its great variety of verified and potentially illicit products. Genuine cigarettes originating from low-tax states (an indicator of bootlegging) compose the most widespread potentially illicit category in Table 8, and foreign-market cigarettes make up roughly one-sixth of the market in New York City. The situation is different in Buffalo, where cigarettes of verified illicit origin (434 packs in 2011) are almost double those with a tax stamp other than New York State (221 packs in 2011). The collection of packs without any tax stamp suggests the prominence of large-scale smuggling, while packs with a tax stamp different from New York State are indicators of bootlegging. Of the other areas, Miami has the highest incidence of verified illicit cigarettes: counterfeits and cigarettes without tax stamps have an average of 2.5% of the market across all years but compose 7.6% of the market in 2014.

[78] Looking ahead to Table 12, we see that *all* verified ITTP in Buffalo takes the form of unstamped packs.

[79] But recall that brands other than PM USA's brands destined for domestic markets are not checked for counterfeiting. Thus, there may be some counterfeit packs of other brands in the *fully tax paid domestic* category in the table.

We now explore broader—and more realistic—definitions of ITTP, with results shown in Table 10, Figure 8, and Table 11. The first column shows the prevalence of verified ITTP as in the previous tables. The second column of results in the tables contains the more conservative of the two broader measures of ITTP. Under the conservative assumptions, all verified ITTP, one-quarter of packs coming from bordering states,[80] three-quarters of packs coming from nonadjacent states, and one-quarter of foreign-market packs are treated as illicit.[81] Intrastate purchases without a valid local stamp are treated as licit (as if, for example, all such packs were purchases by people living in other parts of the state who happened to travel to New York City or Chicago).[82] With these conservative assumptions, ITTP is measured at 37% in Buffalo and 39% in New York City (after 2010) and is lower than 7% elsewhere (see column two of Table 10). The greatest amount of ITTP under this definition (39.3%) is in New York City in 2013 and the least (2.3%) is in Los Angeles in 2014 (see Table 11).

Under more aggressive assumptions the definition of ITTP can be further broadened. In the third column of results in Table 10 and Table 11, it is assumed that all verified ITTP, three-quarters of packs coming from bordering states,[83] all packs coming from nonadjacent states, half of packs coming from within the state but not locally taxed, one-half of foreign-market cigarettes, and all cheap whites are illicit. The impact of broadening the definition of ITTP is seen most starkly in the New York City market, where ITTP rises to 52-59%, and Chicago, where ITTP is measured at 39%. The greatest amount of ITTP under this definition is 61.1% in New York City in 2011 (see Table 11). Even with these aggressive—yet still plausible—assumptions, ITTP is measured to be below 5% in at least some years in Los Angeles, Miami, Minneapolis, and Oklahoma City.

[80] This assumption is the low-range assumption adopted by Davis et al. (2014).

[81] A recent (unscientific) survey found that 22% of Americans try to sneak goods through customs (Agence France-Presse, 2015). A recent (unscientific but weighted to be demographically representative) poll of UK travelers found that about half (46%) of those who bootlegged brought cigarettes into the country (Gocompare.com, 2014; we could not find any comparable poll for the U.S. market). Multiplying these two figures yields an estimate of approximately 10% of people bootlegging cigarettes through customs, which would imply that roughly half of smokers bootleg (surveys from Eurobarometer and the Centers for Disease Control, respectively, indicate that the prevalence of smoking was about 22% in the UK and 17% in the US in 2014). If bootleggers bring in more foreign cigarettes on average than those who declare them at customs, then the share of illicit foreign-market cigarettes would be even higher than one-half. On the other hand, some smuggled cigarettes may just as well have been declared (since they were under the personal-use importation limit), and while technically illicit no duty would have been imposed on them anyway.

[82] Here we depart from the methodology of Davis et al. (2014), who treated packs in New York City bearing only a New York State tax stamp the same as if the tax stamp were from another state (we verified this with those authors via personal communication; their published article does not contain this information).

[83] This assumption is the high-range assumption adopted by Davis et al. (2014).

The final column in Table 10 and Table 11 shows the upper bound for ITTP. We calculate the upper bound as including all verified ITTP and all other packs except for those bearing genuine state and local stamps.[84] The upper bound, so calculated, is unrealistically high as an estimate of ITTP since it assumes that no out-of-state, out-of-city (for Chicago and New York City), or foreign-market packs are licit. I.e., the upper bound assumes there is no licit tax avoidance but only illicit tax evasion. The upper bound on ITTP averages over all years below 10% in Dallas, Houston, Los Angeles, Miami, Minneapolis, and Oklahoma City (see Table 10). In Buffalo it is 51%, in Chicago 70%, and in New York City 66–74%. The single market and year with the highest upper bound on ITTP is New York City in 2011, at 81%.

D. The composition of ITTP

In this section, ITTP is split into its constituent components to see which forms of illicit behavior are most prevalent in the markets for cigarettes. Table 12 shows the composition of verified ITTP. With the exception of Los Angeles, Houston, and New York City, the majority of verified ITTP takes the form of packs lacking any tax stamp. In Buffalo and Minneapolis, this is the only form of verified ITTP found. Illicit whites compose no more than 8% of verified ITTP anywhere except in the Texas markets and Los Angeles, where they make up roughly one-third to one-half of illicit packs.

Counterfeit product makes up no more than 6% of verified ITTP in any market except Los Angeles, where it composes about a third of verified ITTP. Counterfeit tax stamps placed on otherwise genuine product make up the highest proportion of verified ITTP in Chicago (21%) and New York City (59%). Counterfeiting tax stamps has a dual purpose; it reduces the risk of being identified by law-enforcement agencies and it may allow smugglers to resell their products at a higher price since they appear to be legitimate (at least to the casual observer). In some cases, packs with counterfeit stamps are sold at the regular price in retail shops to unaware consumers who do not get the benefit of an "illicit discount" (Campbell, 2015; Silver et al., 2016).

The elements of the broader measures of ITTP are presented in Table 13. Interstate bootlegging generally makes up the majority, and often the great majority, of the broader measures of ITTP. The three exceptions are Buffalo and Miami, where packs lacking a stamp are most prevalent, and Los Angeles, where foreign-market packs are most common. Overall, the rough order of importance of the

[84] Despite our term for this category, it is not a true upper bound for ITTP since the base for the proportions is packs with intact wrappers. If packs lacking wrappers are more likely to be illicit, the share of illicit packs could be even higher than the figures in our "upper bound."

various methods of ITTP across the markets (under the aggressive assumptions) is interstate bootlegging (in first place by a large margin), packs without a stamp (which is mostly likely another form of interstate bootlegging), foreign-market illicit packs, illicit and cheap whites, counterfeit stamps, and counterfeit product. Intrastate bootlegging is highly important in Chicago but much less so in New York City.

Los Angeles has the most diverse illicit market for cigarettes, as measured with the Shannon diversity index.[85] Compared to other markets, counterfeit product, cheap whites, and foreign illicit are more prevalent in Los Angeles. Together with the long distance from the eastern states with the cheapest cigarettes, trade and travel between Los Angeles and China might explain the concentration of these products.[86] Indeed, more than 80% of illicit whites collected in Los Angeles are manufactured in China. Relative proximity to China might be part of the explanation for the greater prevalence of counterfeits. China is the largest source country of counterfeit cigarettes and in the United States counterfeit cigarettes have been traced back, in particular, to China, North Korea, and Paraguay (Shen, Antonopoulos, and von Lampe, 2010; WCO, 2013). Even so, Los Angeles has a low overall level of ITTP, even when potentially bootlegged cigarettes are included in the calculations.

E. Estimates at the submarket level

As seen, EDPs allow for estimating the prevalence, development, and composition of ITTP. EDPs also allow for less aggregated analyses. Four of the markets are subdivided into cities (boroughs, in the case of New York City), and all of the areas are subdivided into sectors and ZIP codes. By subdividing the areas into smaller units, we see that consumption of non-state-taxed cigarettes is homogeneous within some cities and extremely varied in others.

In New York City, for example, the consumption of untaxed cigarettes is widespread in all boroughs. Over all years, the prevalence of packs lacking evidence of state tax payment[87] is highest in Brooklyn at 70%, but is also high in the Bronx (64%), Queens (60%), Manhattan (58%) and Staten Island (55%). Buffalo, on the other hand, has a narrower range (from 46% in the east sector to 54% in the center sector) in the prevalence of untaxed packs across the city.

[85] The Shannon index of diversity (or entropy) is calculated as $-\sum s_i ln(s_i)$, where s_i is the market share of an individual component of ITTP.

[86] Despite the fact that the Los Angeles MSA covers only about 4% of the nation's population, almost 12% of U.S. residents traveling to China in 2012 by air were from Los Angeles (OTTI, 2013).

[87] Results not shown in a table. The statistics in this section are for the category *State Tax, Share of determinable packs, Applicable tax not paid, %* as defined for column 4 in Table 5.

The Chicago, Houston, Los Angeles, Miami, and Oklahoma City markets display a high degree of internal heterogeneity. The Chicago MSA has a fairly homogeneous distribution in 2013, the first available year, but in 2014 the prevalence of untaxed packs grows in Chicago but drops in all other cities of the MSA. In Joliet, in particular, non-state-taxed cigarettes accounted for the 16.9% of the consumptions in 2013 and for only 1.6% in 2014. In Oklahoma City, the western sector has 11.1% non-state-taxed cigarettes while the eastern sector has only 5.5% prevalence. In the Miami MSA, Fort Lauderdale has the lowest prevalence of non-state-taxed cigarettes in 2012 and the second lowest in 2013, but in 2014 it jumped to more than double the overall Miami rate. It is beyond the scope of this paper to explore why ITTP can differ so greatly within the same tax jurisdiction. In future work we intend to explore how local area ITTP is associated with demographic, socioeconomic, and other factors.

VI. Discussion and Conclusions

This study describes the methodology of EDP surveys and illustrates their potential by presenting a series of estimates of the level of tax avoidance and ITTP in ten metropolitan areas of the United States. The review of the literature suggests that EDP surveys have several advantages over alternative data sources and methods, which generally do not allow for equally broad estimates, geographically and temporally, and have other shortcomings (e.g., confounding factors complicate gap analysis, underreporting makes consumer surveys suspect, etc.) The present set of EDP surveys has the tremendous advantage of a much larger sample size than any other EDP survey analyzed in the literature. Given the broad interest in illicit markets in general and illicit markets for tobacco in particular, and the ability to explore many hypotheses regarding ITTP due the broad coverage and large sample size, we expect that these new data will be heavily used by other researchers.

Our analyses confirm that the incidence of cigarette-tax avoidance and ITTP varies substantially within the United States. The prevalence of non-state-taxed cigarettes in New York City and Buffalo, for example, is almost five times larger than the rest of the sample. By contrast, Los Angeles has an especially low prevalence of illicit cigarettes, but a high share of illicit whites within its illicit market. High tobacco taxes in New York State are likely to contribute (Davis et al., 2014; Reuter and Majmundar, 2015), but the composition of ITTP is heterogeneous within New York State, and Illinois and Minnesota also have high taxes but state-tax avoidance is less common. These differences merit further investigation of these data, in future work by the present authors and others making use of these freely available data.

In contrast to tax avoidance and smuggling of unstamped packs, our analysis indicates that counterfeit cigarettes account for a small part of ITTP in the U.S. markets studied here, with the exception of Los Angeles. Illicit whites compose a considerable share of ITTP in Los Angeles and the Texas markets, but little elsewhere. Counterfeit tax stamps are particularly prevalent in New York City.

Future research will include econometric analysis of how ITTP relates to tobacco-control policies, such as the elasticity of illicit consumption with respect to taxation rates. Moreover, the geographic detail that EDP data offer allows for better spatial analysis of illicit tobacco markets.

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Table 1 – Collected samples by market and year

Market/MSA	Cities Included	Year	Collection Date	Packs Collected
Boston	Boston	2012	Q4	5,000
Boston	Boston	2014	Q2	3,500
Buffalo	Buffalo	2011	Q4	2,000
Chicago	Aurora, Chicago, Elgin, Joliet, and Waukegan	2013	Q1	5,000
Chicago	(same as above)	2014	Q2	4,000
Dallas	Dallas	2013	Q1	5,000
Houston	Houston	2012	Q3	5,000
Houston	Houston	2013	Q1	5,000
Los Angeles	Anaheim, Long Beach, Los Angeles, Riverside, and Santa Ana	2011	Q4	5,000
Los Angeles	(same as above)	2012	Q3	5,000
Los Angeles	(same as above)	2013	Q1	5,000
Los Angeles	(same as above)	2014	Q1	5,000
Miami	Cooper City, Doral, Fort Lauderdale, Hialeah, Hollywood, Miami, Miami Gardens, and Pembroke Pines	2011	Q4	5,000
Miami	(same as above)	2012	Q3	5,000
Miami	(same as above)	2013	Q1	5,000
Miami	(same as above)	2014	Q1	5,000
Minneapolis	Minneapolis	2012	Q3	5,000
New York City	All boroughs	2010	Q3	5,000
New York City	All boroughs	2011	Q3	5,000
New York City	All boroughs	2012	Q3	5,000
New York City	All boroughs	2013	Q1	5,000
New York City	All boroughs	2014	Q1	5,000
Oklahoma City	Oklahoma City	2011	Q4	2,000
Total				106,500

Notes: Actual collection dates were typically three or four weeks long; the exact dates are recorded in the data.

Table 2 – MSI/ALCS categories for tax and counterfeit status (field CF_GROUP)

2010	**2011-2013***	**2014**
None. Field is blank.	No cello	No cello
	Correct tax stamp	Correct tax stamp
	Wrong tax stamp	Wrong tax stamp
	Counterfeit tax stamp	Counterfeit tax stamp
	No tax stamp	No tax stamp
	Counterfeit domestic	Counterfeit
	Counterfeit non-domestic	
	Non-domestic	Non-domestic

Table 3 –Relationships among counterfeit indicators and final determination of counterfeit status for domestic-market Marlboro packs

	Pack code is on the counterfeit list		**Pack code is not on the counterfeit list**	
Taggant detected	*Pack fluoresces*	*Pack does not fluoresce*	*Pack fluoresces*	*Pack does not fluoresce*
No	**14 counterfeit**	**39 counterfeit**	-	277 genuine
Yes	-	10 genuine	-	19,852 genuine
N/A	-	**2 counterfeit**	**1 counterfeit**	1,694 genuine

Notes: The subsample analyzed here are the 21,889 Marlboro brand packs intended for the domestic market from survey waves in which all three indicators (TAGGANT_STATUS, PACK_FLUORESCES, and COUNTERFEIT_LIST) were recorded. Data for *Taggant detected* are from variable A_TAGGANT_DETECTED (a recoding of TAGGANT_STATUS). A value of N/A refers to packs not tested for taggant. Refer to the codebook for details on the recoding.

Table 4 – Correspondence between the MSI/ALCS fields CF_GROUP and CATEGORY

CF_GROUP	CATEGORY	Number of cases
No cello	Undetermined	26,762
Correct tax stamp	Applicable tax paid	58,576
Wrong tax stamp	Applicable tax not paid	8,148
Counterfeit tax stamp	Contraband	1,135
No tax stamp	Applicable tax not paid	1,511
Counterfeit	Contraband	21
Counterfeit domestic	Contraband	129
Counterfeit non-domestic	Contraband (but see note)	3
Non-domestic	Non-domestic	5,207
(blank)	(blank)	5,000
	Total:	106,500

Notes: There are an additional 7 discrepant cases with CF_GROUP = “correct tax stamp” and CATEGORY = “applicable tax not paid”. Of the four cases with CF_GROUP = “counterfeit non-domestic”, three have CATEGORY = “contraband” (as shown in the table) and one (not shown) is “non-domestic”. These variables are missing for 2010.

Table 5 – Tax paid status of collected samples by market

		State Tax			Local and State Tax		
		Share of all packs	Share of determinable packs		Share of all packs	Share of determinable packs	
Market	Wrapper intact, %	Tax status determined, %	Applicable tax paid, %	Applicable tax not paid, %	Tax status determined, %	Applicable tax paid, %	Applicable tax not paid, %
Boston	69.28	69.78	82.48	17.52	69.78	82.48	17.52
Buffalo	68.30	69.15	49.31	50.69	69.15	49.31	50.69
Chicago	75.48	75.66	84.08	15.92	75.66	30.47	69.53
Dallas	67.74	65.10	92.63	7.37	65.10	92.63	7.37
Houston	79.21	78.12	92.08	7.92	78.12	92.08	7.92
Los Angeles	71.37	73.67	91.88	8.12	73.67	91.88	8.12
Miami	73.28	74.16	91.36	8.64	74.16	91.36	8.64
Minneapolis	76.88	76.76	95.60	4.40	76.76	95.60	4.40
New York City	68.86	70.90	37.42	62.58	70.95*	26.01*	73.99*
Oklahoma City	76.95	77.05	92.21	7.79	77.05	92.21	7.79

*Excludes 2010, for which local tax stamp information is unavailable.

Note: *Tax status determined* refers to the proportion of all packs that have intact cellophane, are intended for non-domestic markets, or are counterfeit and lacking cellophane.

Table 6 – Tax paid status of collected samples by market and year

			State Tax			Local and State Tax		
			Share of all packs	Share of determinable packs		Share of all packs	Share of determinable packs	
Market	**Year**	Wrapper intact, %	Tax status determined, %	Applicable tax paid, %	Applicable tax not paid, %	Tax status determined, %	Applicable tax paid, %	Applicable tax not paid, %
Boston	2012	74.90	75.16	83.24	16.76	75.16	83.24	16.76
Boston	2014	61.26	62.09	81.18	18.82	62.09	81.18	18.82
Buffalo	2011	68.30	69.15	49.31	50.69	69.15	49.31	50.69
Chicago	2013	77.60	77.50	83.82	16.18	77.50	29.96	70.04
Chicago	2014	72.82	73.35	84.42	15.58	73.35	31.15	68.85
Dallas	2013	67.74	65.10	92.63	7.37	65.10	92.63	7.37
Houston	2012	76.98	76.38	94.19	5.81	76.38	94.19	5.81
Houston	2013	81.44	79.86	90.06	9.94	79.86	90.06	9.94
Los Angeles	2011	71.32	74.32	90.85	9.15	74.32	90.85	9.15
Los Angeles	2012	62.00	63.72	92.03	7.97	63.72	92.03	7.97
Los Angeles	2013	77.76	80.32	91.26	8.74	80.32	91.26	8.74
Los Angeles	2014	74.38	76.30	93.42	6.58	76.30	93.42	6.58
Miami	2011	68.92	69.96	89.82	10.18	69.96	89.82	10.18
Miami	2012	76.22	77.28	91.41	8.59	77.28	91.41	8.59
Miami	2013	82.48	83.52	93.65	6.35	83.52	93.65	6.35
Miami	2014	65.48	65.88	90.01	9.99	65.88	90.01	9.99
Minneapolis	2012	76.88	76.76	95.60	4.40	76.76	95.60	4.40
New York City	2010	69.42	70.68	48.42	51.58	0.00		
New York City	2011	67.84	69.46	37.92	62.08	69.46	19.49	80.51
New York City	2012	66.64	68.96	35.44	64.56	68.96	27.90	72.10
New York City	2013	66.52	69.04	34.62	65.38	69.04	29.98	70.02
New York City	2014	73.88	76.36	31.09	68.91	76.36	26.64	73.36
Oklahoma City	2011	76.95	77.05	92.21	7.79	77.05	92.21	7.79

Note: Only some of the Chicago market (the areas in Cook County) and all of the New York City market have local excise taxes on cigarettes. See also notes to previous table. Figures include domestic and foreign product.

Table 7 – Cheap whites in the sample by market

	Out of all packs		Share of packs with brands identified as cheap whites	
Market	Cheap white brands, number of packs	Cheap white brand, %	Brand identified only from an industry source, %	Brand identified from multiple sources, %
Boston	5	0.06	60	40
Buffalo	0	0		
Chicago	2	0.02	100	0
Dallas	31	0.62	0	100
Houston	43	0.43	9.30	90.7
Los Angeles	57	0.28	91.23	8.77
Miami	34	0.17	58.82	41.18
Minneapolis	2	0.04	100	0
New York City	159	0.64	86.79	13.21
Oklahoma City	0	0		

Note: see Ross et al. (2015b) for brand list and source. The brands mentioned in footnote 56 are added to the list of brands identified by industry. The base for the calculations is all packs, with or without cellophane.

Table 8 – ITTP status of collected samples by market, as percentage of determinable packs

	Verified ITTP	Packs other than verified ITTP				Total
Market		Interstate tax avoidance and evasion	Intrastate tax avoidance and evasion	Foreign	Fully tax paid domestic	
Boston	0.84	11.85	0.00	4.82	82.48	100.00
Buffalo	31.38	15.91	0.00	3.40	49.31	100.00
Chicago	0.28	13.06	53.61	2.58	30.47	100.00
Dallas	2.24	5.53	0.00	0.43	91.80	100.00
Houston	0.87	6.04	0.00	1.41	91.68	100.00
Los Angeles	0.63	0.59	0.00	7.02	91.76	100.00
Miami	2.54	0.49	0.00	5.91	91.07	100.00
Minneapolis	0.63	3.05	0.00	0.73	95.60	100.00
New York City	13.71*	27.71	6.93**	17.35	34.29	100.00
Oklahoma City	1.43	5.97	0.00	0.39	92.21	100.00

* MSI did not analyze packs from New York City in 2010 to determine if they are counterfeit. Therefore, the estimate of ITTP for New York City 2010 does not take counterfeits into consideration.

** Local tax stamp information is unavailable for 2010 and this figure assumes full tax compliance for that year. If 2010 data are excluded for this cell of the table, the figure rises to 8.66 percent.

Notes: The base for the percentages is the number of packs with determinable tax status: those with intact wrappers, intended for foreign markets, or counterfeit. *Verified ITTP* includes counterfeits and domestically produced cigarettes lacking a genuine tax stamp. *Interstate tax avoidance and evasion* includes interstate licit cross-border purchases and (illicit) bootlegging, which cannot be distinguished from each other in the data; the same comment applies to the category for *Intrastate tax avoidance and evasion*. Figures in the *Fully tax paid domestic* column may be lower than the figures for applicable state tax paid in Table 5 because the latter does not exclude ITTP and a small number of counterfeits have apparently valid tax stamps. Figures may not sum to 100 due to rounding.

Table 9 – ITTP status of collected samples by market and year, as percentage of determinable packs

		Verified ITTP	Packs other than verified ITTP				Total
Market	**Year**		Interstate tax avoidance and evasion	Intrastate tax avoidance and evasion	Foreign	Fully tax paid domestic	
Boston	2012	0.77	11.55	0.00	4.44	83.24	100.00
Boston	2014	0.97	12.38	0.00	5.48	81.18	100.00
Buffalo	2011	31.38	15.91	0.00	3.40	49.31	100.00
Chicago	2013	0.08	13.26	53.86	2.84	29.96	100.00
Chicago	2014	0.55	12.78	53.27	2.25	31.15	100.00
Dallas	2013	2.24	5.53	0.00	0.43	91.80	100.00
Houston	2012	0.86	3.74	0.00	1.70	93.69	100.00
Houston	2013	0.88	8.24	0.00	1.13	89.76	100.00
Los Angeles	2011	0.57	0.43	0.00	8.29	90.72	100.00
Los Angeles	2012	0.56	0.35	0.00	7.06	92.03	100.00
Los Angeles	2013	0.95	0.72	0.00	7.25	91.09	100.00
Los Angeles	2014	0.42	0.81	0.00	5.50	93.26	100.00
Miami	2011	1.66	0.60	0.00	8.35	89.39	100.00
Miami	2012	0.67	1.04	0.00	7.07	91.23	100.00
Miami	2013	0.98	0.17	0.00	5.60	93.25	100.00
Miami	2014	7.62	0.12	0.00	2.37	89.89	100.00
Minneapolis	2012	0.63	3.05	0.00	0.73	95.60	100.00
New York City	2010	16.41*	not determinable	not determinable	15.90	not determinable	
New York City	2011	18.43	27.93	18.43	15.75	19.46	100.00
New York City	2012	12.76	34.95	7.51	16.91	27.87	100.00
New York City	2013	11.85	37.05	4.63	16.51	29.95	100.00
New York City	2014	9.46	38.19	4.45	21.32	26.58	100.00
Oklahoma City	2011	1.43	5.97	0.00	0.39	92.21	100.00

*MSI did not analyze packs from New York City in 2010 to determine if they are counterfeit. Therefore, the estimate of ITTP for New York City 2010 does not take counterfeits into consideration.

Notes: See notes to previous table on the definition of determinable packs (the base for the statistics) and the tax avoidance and evasion categories. Local tax stamp information is unavailable for New York City in 2010. Figures in the *Fully tax paid domestic* column may be lower than the figures for applicable state tax paid in Table 6 because the latter does not exclude ITTP and a small number of counterfeits have apparently valid tax stamps. Figures may not sum to 100 due to rounding.

Table 10 – ITTP status of collected samples (with broader assumptions) by market, as percentage of determinable packs

	Verified ITTP	Broader Measures of ITTP		Upper Bound for ITTP
Market		Conservative Assumptions	Aggressive Assumptions	Verified ITTP + all other packs except for fully tax paid
Boston	0.84	6.35	12.81	17.52
Buffalo	31.38	36.55	39.80	50.69
Chicago	0.28	5.90	39.00	69.53
Dallas	2.24	5.35	7.41	8.20
Houston	0.87	4.68	7.05	8.32
Los Angeles	0.63	2.68	4.73	8.24
Miami	2.54	4.34	5.96	8.93
Minneapolis	0.63	2.48	3.68	4.40
New York City (all years)	13.71*	35.30**	51.77**	65.71**
New York City (excluding 2010)	13.04	39.01	58.57	74.03
Oklahoma City	1.43	2.89	4.41	7.79

*MSI did not analyze packs from New York City in 2010 to determine if they are counterfeit. Therefore, the estimate of verified ITTP for New York City 2010 does not take counterfeits into consideration.

**Local tax stamp information is unavailable for 2010 and for that year this figure assumes full tax compliance if a state stamp is present.

Notes: In the final column, *fully tax paid* includes any local taxes. The *Conservative Assumptions* are that 100% of verified ITTP packs, 25% of packs from bordering states, 75% of packs from non-bordering states and other domestic locations (e.g. packs bearing a tribal stamp), 25% of foreign-market packs, and 0% of intrastate cross-border purchases are contraband. The *Aggressive Assumptions* are that 100% of verified ITTP packs, 75% of packs from bordering states, 100% of packs from non-bordering states and other domestic locations (e.g. packs bearing a tribal stamp), 50% of foreign-market packs, and 50% of intrastate cross-border purchases are contraband. The base for the percentages is the number of packs with intact wrappers.

Table 11 – ITTP status of collected samples (with broader assumptions) by market and year, as percentage of determinable packs

		Verified ITTP	Broader Measures of ITTP		Upper Bound for ITTP
Market	**Year**		Conservative Assumptions	Aggressive Assumptions	Verified ITTP + all other packs except for fully tax paid
Boston	2012	0.77	5.95	12.23	16.76
Boston	2014	0.97	7.04	13.82	18.82
Buffalo	2011	31.38	36.55	39.80	50.69
Chicago	2013	0.08	6.26	39.41	70.04
Chicago	2014	0.55	5.43	38.47	68.85
Dallas	2013	2.24	5.35	7.41	8.20
Houston	2012	0.86	3.31	5.01	6.31
Houston	2013	0.88	5.99	9.00	10.24
Los Angeles	2011	0.57	2.80	5.17	9.28
Los Angeles	2012	0.56	2.51	4.51	7.97
Los Angeles	2013	0.95	3.08	5.22	8.91
Los Angeles	2014	0.42	2.27	3.98	6.74
Miami	2011	1.66	4.14	6.42	10.61
Miami	2012	0.67	3.16	5.21	8.77
Miami	2013	0.98	2.48	3.94	6.75
Miami	2014	7.62	8.29	8.92	10.11
Minneapolis	2012	0.63	2.48	3.68	4.40
New York City	2010	16.41*	20.39**	24.46**	32.31**
New York City	2011	18.43	39.19	61.12	80.54
New York City	2012	12.76	38.78	57.70	72.13
New York City	2013	11.85	39.27	57.20	70.05
New York City	2014	9.46	38.83	58.28	73.42
Oklahoma City	2011	1.43	2.89	4.41	7.79

Note: See notes to previous table for the meaning of asterisks and other information.

Table 12 –Composition of verified ITTP by market, as percentage of ITTP

Market	Counterfeit packs	No tax stamp	Counterfeit tax stamp	Illicit whites	Verified ITTP
Boston	4.00	78.00	10.00	8.00	100.00
Buffalo	0.00	100.00	0.00	0.00	100.00
Chicago	0.00	73.68	21.05	5.26	100.00
Dallas	0.00	63.01	0.00	36.99	100.00
Houston	0.00	47.06	5.88	47.06	100.00
Los Angeles	31.18	38.71	0.00	30.11	100.00
Miami	4.24	85.68	2.65	7.43	100.00
Minneapolis	0.00	100.00	0.00	0.00	100.00
New York City*	5.78	29.16	58.91	6.16	100.00
Oklahoma City	0.00	100.00	0.00	0.00	100.00

*Excludes 2010 survey.

Notes: If a pack is counterfeit and also bears a counterfeit tax stamp, it is placed in the *Counterfeit pack* category. If a pack has no stamp or a counterfeit stamp and is a cheap white brand, it is placed in the *Illicit whites* category. Figures may not sum to 100 due to rounding.

Table 13 –Composition of broader measures of ITTP by market, as percentage of ITTP

	Verified ITTP				Other components of ITTP				Total ITTP
Market and assumptions	Counterfeit packs	No tax stamp	Counterfeit tax stamp	Illicit whites	Interstate bootlegging	Intrastate bootlegging	Foreign illicit	Cheap whites	
Conservative assumptions									100.0
Boston	0.5	10.4	1.3	1.1	67.7	0.0	19.0	0.0	100.0
Buffalo	0.0	85.9	0.0	0.0	11.8	0.0	2.3	0.0	100.0
Chicago	0.0	3.5	1.0	0.2	84.3	0.0	11.0	0.0	100.0
Dallas	0.0	26.4	0.0	15.5	56.0	0.0	2.0	0.0	100.0
Houston	0.0	8.8	1.1	8.8	73.9	0.0	7.5	0.0	100.0
Los Angeles	7.4	9.1	0.0	7.1	10.8	0.0	65.6	0.0	100.0
Miami	2.5	50.1	1.5	4.3	7.5	0.0	34.0	0.0	100.0
Minneapolis	0.0	25.3	0.0	0.0	67.4	0.0	7.4	0.0	100.0
New York*	1.9	9.8	19.7	2.1	55.2	0.0	11.4	0.0	100.0
Oklahoma City	0.0	49.4	0.0	0.0	47.2	0.0	3.4	0.0	100.0
Aggressive assumptions									
Boston	0.3	5.1	0.7	0.5	74.5	0.0	18.8	0.1	100.0
Buffalo	0.0	78.8	0.0	0.0	16.9	0.0	4.3	0.0	100.0
Chicago	0.0	0.5	0.2	0.0	27.2	68.7	3.3	0.0	100.0
Dallas	0.0	18.8	0.0	11.0	65.8	0.0	2.9	1.6	100.0
Houston	0.0	5.7	0.7	5.7	76.2	0.0	9.7	2.0	100.0
Los Angeles	4.1	5.1	0.0	4.0	10.8	0.0	71.9	4.1	100.0
Miami	1.8	36.3	1.1	3.1	7.8	0.0	49.2	0.7	100.0
Minneapolis	0.0	16.8	0.0	0.0	72.1	0.0	9.8	1.4	100.0
New York*	1.3	6.5	13.1	1.4	55.1	7.4	15.0	0.2	100.0
Oklahoma City	0.0	32.4	0.0	0.0	63.2	0.0	4.4	0.0	100.0

*Excludes 2010 survey.

Notes: Figures may not sum to 100 due to rounding. See notes to Table 10 for definition of the assumptions. See also notes to Table 12.

Figure 1 – State and local cigarette excise tax stamps.

(1)
New York
(state)

(2)
New York
(city and state)

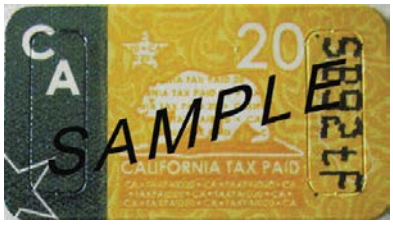
(3)
Virginia
(state)

(4)
Virginia (state and Northern VA Cigarette Tax Board)

(5)
Illinois (state)

(6)
Cook County, IL

(7)
Chicago, IL



(8)
California

Figure 2 – Market share of loose tobacco out of the market for RYO and pipe tobacco and cigarettes.

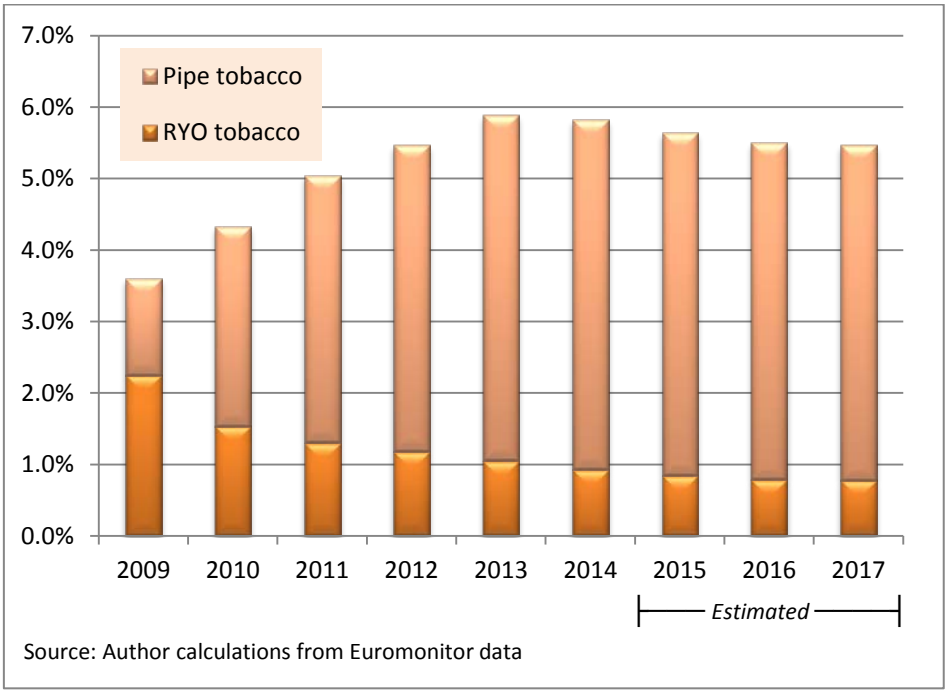


Figure 3 – Sales of cigarettes, cigars, and smoking tobacco in the United States.

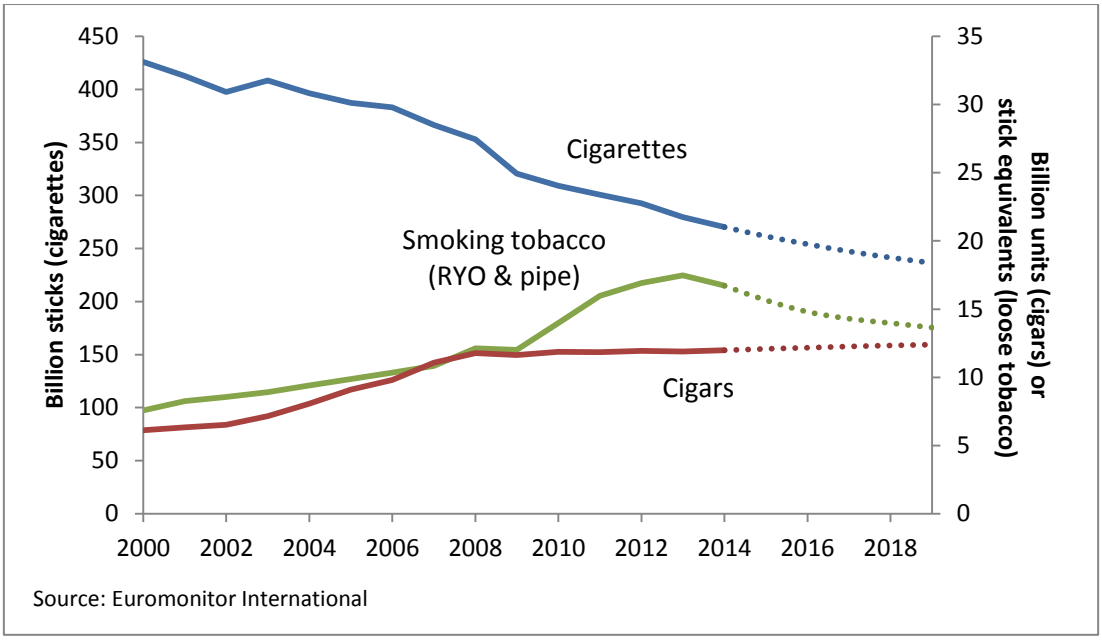
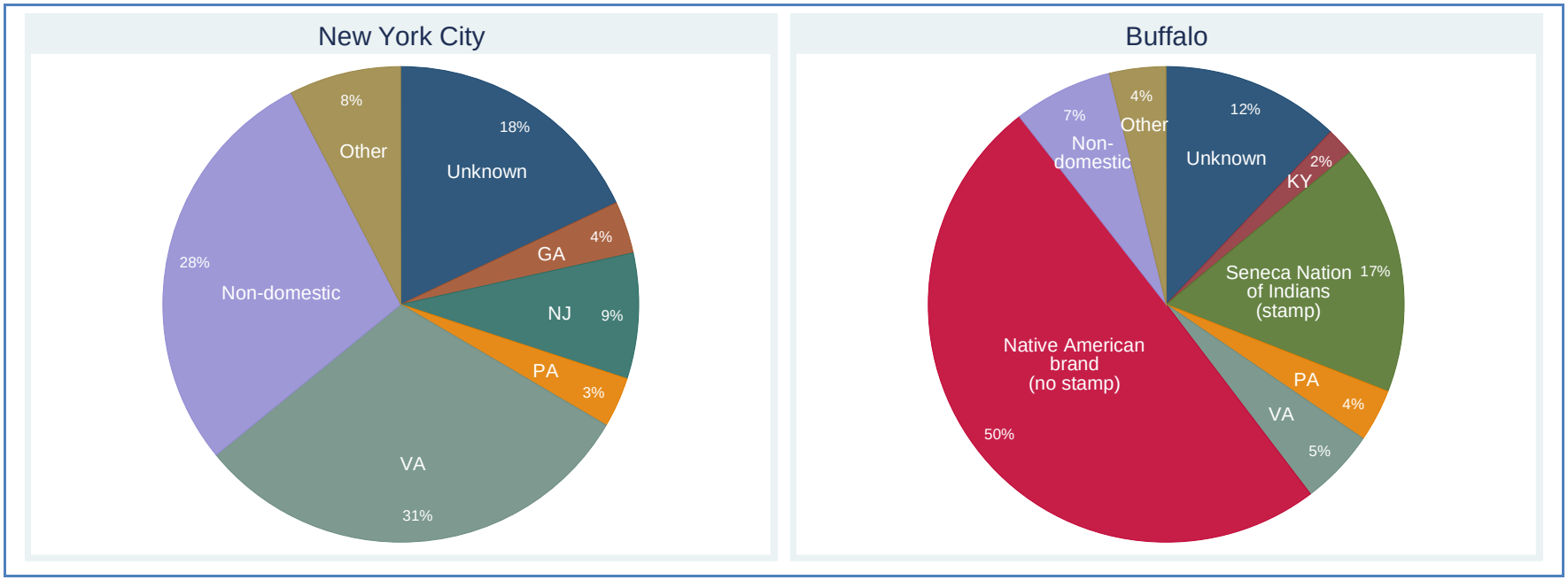


Figure 4 – Examples of collection routes.

Figure 5 – Sources of state-untaxed packs in New York markets



Notes: Percentages are out of all packs for which state taxes have not been paid. Category *Unknown* includes packs without a stamp and packs with counterfeit stamps. Category *Other* refers to states not otherwise categorized and (for New York City) Native American brands, none of which have more than one percent share.

Figure 6– Tax-not-paid percent by market and year, with changes over time

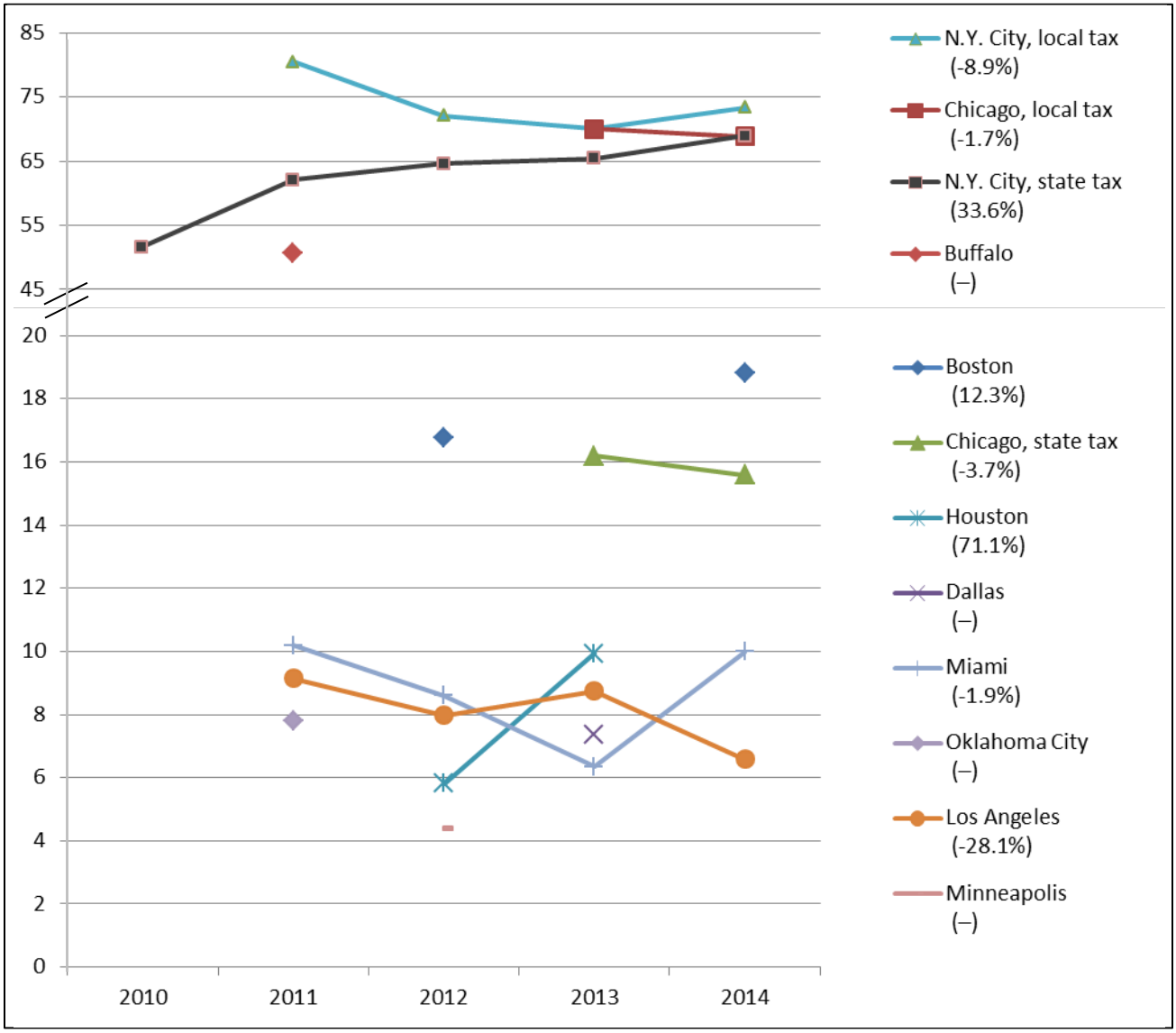
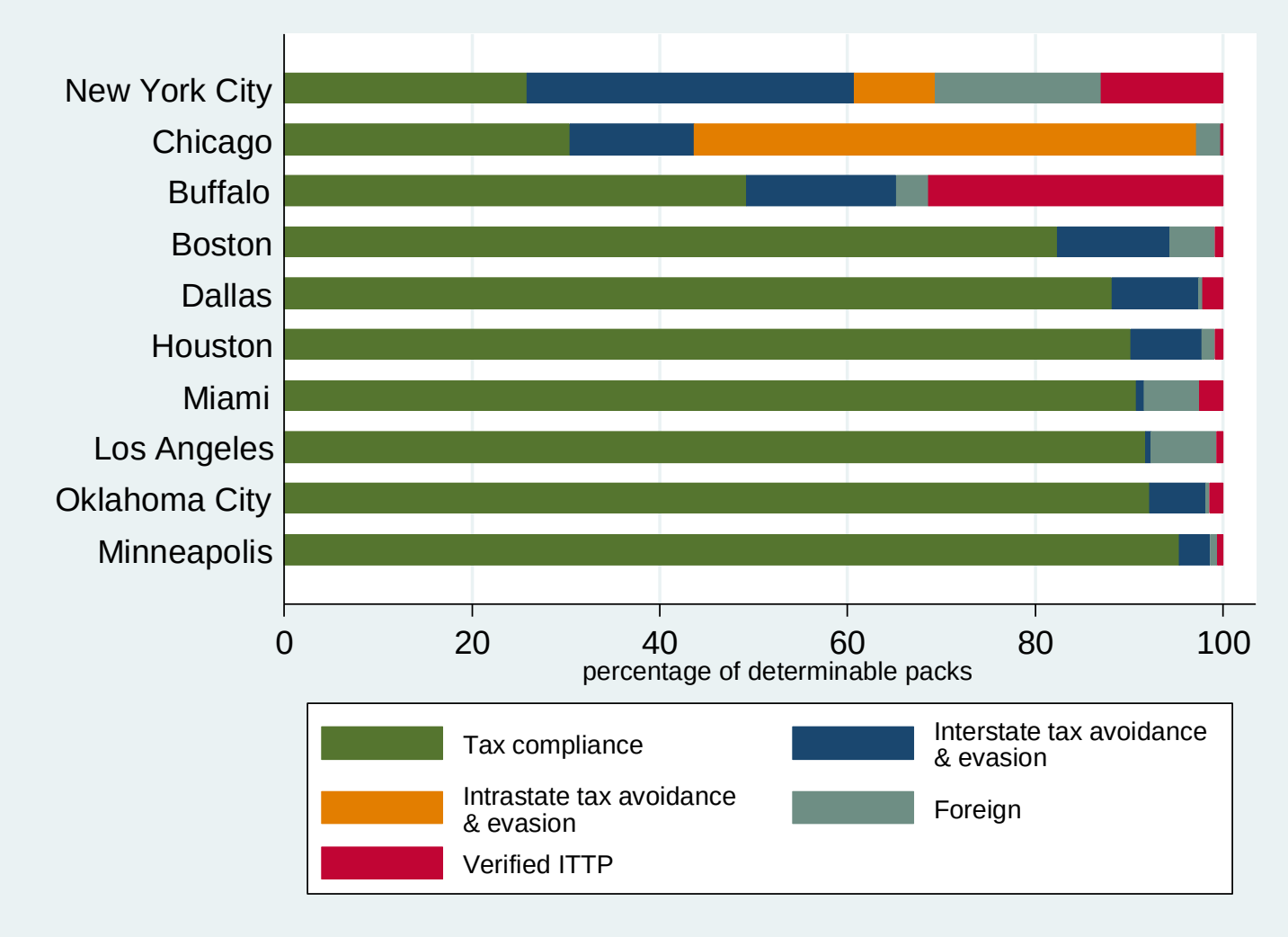


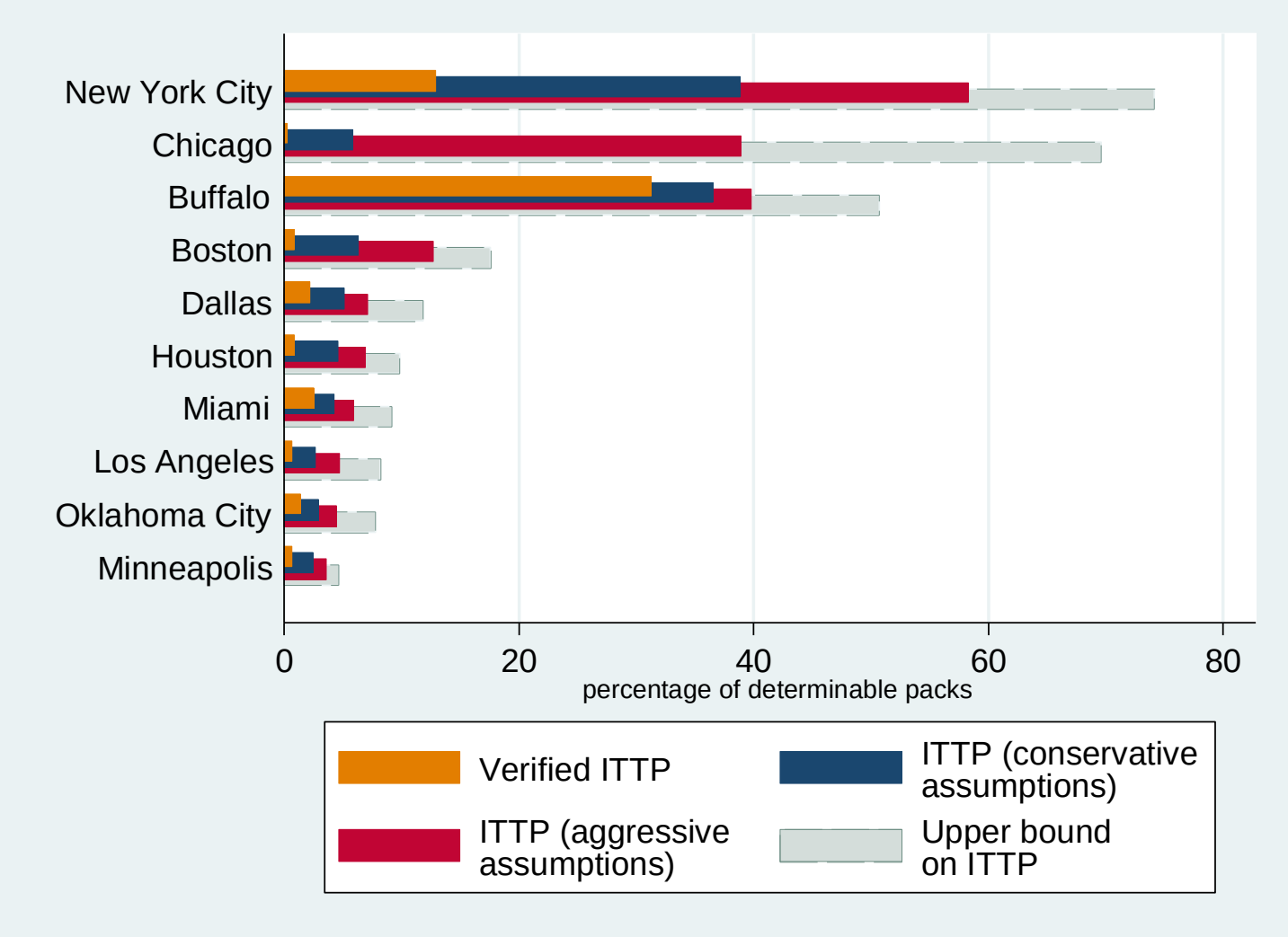
Figure note: Vertical axis level and scale changes at the hashes (to show detail in lower section). Figures in the legend indicate the percentage change from the first to the last available observations.

Figure 7– ITTP status of collected samples by market and year, as percentage of determinable packs



Notes: Figures for New York City are 2011-2014. See also notes to Table 8, which contains the same figures.

Figure 8– ITTP status of collected samples (with broader assumptions) by market, as percentage of determinable packs



Notes: Figures for New York City are 2011-2014. See also notes to Table 10, which contains the same figures.

Appendix A: Variables in the EDP Database

Table A-1 – Information reported in the EDP database from the original data.

#	Variable	Definition	Notes
1	Date of Collection	Date range of collection period.	
2	Wave City	MSA in which collection occurred.	
3	Bag Number	Identifies the bag in which cartons are put after the analyses.	Bag numbers are assigned after the screening and categorization process. Bags most commonly include packs from a single manufacturer and category of CF group.
4	Pack Number	Pack sequence number within a collection (neighborhood) bag.	
5	Carton Number	Identifies the carton in which bags containing collected packs are collected.	It allows associating the carton to all the bags and the packs it contains.
6	Manufacturer	Name of cigarette manufacturer.	
7	City	City in which pack was collected.	In some cases this is the main city in the MSA only, in others it is one of several cities within the MSA.
8	Sector	Sector within the city in which the EDP was collected.	In New York City, these are the boroughs. Elsewhere, they are arbitrarily defined.
9	Neighborhood	Sub-section of the sector in which the EDP was collected.	This is the lowest-level (ultimate) sampling unit from which packs are collected.
10	ZIP Code	ZIP code in which pack was collected.	This is the ZIP code associated with the neighborhood. Packs are not collected from all parts of the ZIP code.
11	Pick-up Source	Source from which the pack was picked up.	
12	UPC	Value of barcode on pack.	Retailers use Universal Product Codes (UPCs) to identify products by scanning.
13	Brand Description	Detailed brand and package description.	Example: “Marlboro Gold Pack 100'S Box”
14	Brand Family	Broad brand designation (e.g., “Marlboro”).	This variable was not collected before 2013. ALCS populated pre-2013 values based on the value of the Brand Description field
15	Film Intact	Indicates whether the pack's cellophane wrapper was intact.	ALCS modified the value recorded by MSI in 1 observation.
16	Tax Stamp Present	Indicates whether a tax stamp was present.	ALCS modified the values recorded by MSI in 4 observations after further analysis. Three values were changed to “yes” and one to “no.”

#	Variable	Definition	Notes
17	Special Tax Jurisdiction	Indicates if packs sold in the location of the collection should bear a local tax stamp in addition to the state tax stamp.	In the markets covered in this set of surveys, only the Chicago market required two distinct stamps. The second stamp is either a Cook County stamp or a combined Chicago and Cook County stamp.
18	Tax Stamp State	Indicates the U.S. state in which the tax stamp present on the pack was issued.	
19	Domestic Indicator	Indicates whether the pack was intended for the domestic market.	US duty free markets are marked as non-domestic.
20	Pack Production Code	Reports a code printed on the pack by the manufacturer.	The codes contain information for the manufacturer such as date of manufacture. If a character is illegible it is denoted with "*" in the data. *Note: this variable has been censored in the publicly available data, because 1) in conjunction with variable 38, it could alert counterfeiters to which production codes are known to be counterfeited, and 2) it conveys no useful information to parties other than the manufacturer (e.g., although the manufacturer can back out the production date from the codes, we cannot).*
21	Tax Stamp Serial Number	Indicates the serial number that appears on the state tax stamp.	This variable is recorded only for counterfeit tax stamps.
22	Genuine Stamp Remnant	Indicates whether there was a genuine tax stamp remnant present on the pack.	Most states use stamps that have a chemical taggant. This variable indicates packs for which a stamp is no longer present but that either display visual evidence of a stamp formerly having been affixed or present chemical evidence of the taggant.
23	Pack Fluoresces	Indicates whether the pack fluoresces under ultraviolet irradiation.	Used as a means of detecting counterfeit packs. ALCS modified values recorded by MSI in 22 cases, where additional testing found that the pack fluoresced.
24	Native American Y/N	Indicates whether the brand is produced on an Indian Reservation.	Collected on a trial basis only in the early survey waves.
25	Original Design Market	Designates the market in which the pack was intended to be sold.	ALCS modified values provided by MSI in a number of observations, using information not available to MSI regarding the specific country of the duty free market for which the pack was intended.
26	Original Design Region	Indicates the region in which the pack was intended to be sold.	
27	Category	Designates the tax status of the pack. See middle column of Table 4 for possible values.	ALCS populated this variable in 2011 using information unavailable to MSI.
28	Remarks	Comments about the pack from the analysts at MSI. ALCS also uses this field to make additional comments, including the tax stamp state for any remnant detected.	This variable was generally useful only for the pack analysts.

#	Variable	Definition	Notes
29	Number of Packs	Indicates the statistical weight of the packs in the database.	MSI included this variable but did not use it to adjust for any oversampling or undersampling (it is always equal to 1 if not missing).
30	Collection Type	Type of collection - EDP/Pack	Always the same value: EDP. No longer in use.
31	Sampling Plan Type	Indicates whether the EDP was collected in the main sample (sample proportional to the city population) or in a focus sample (not-proportional to the city population).	Always the same value in these surveys: BASE (i.e., the main, proportional sample).
32	Region	Country of collection - Always the same data. No longer in use.	All surveys were performed in the U.S.
33	Cheap White	Indicator variable.	Collected on a trial basis only in the early survey waves.
34	Tax Stamp Assessment	Indicates the result of MSI's preliminary assessment of counterfeit packs and stamps.	In 2011, ALCS examined the Empty Discarded Packs in order to fill in these data.
35	CF Group	Indicates the result of ALCS's laboratory analysis of counterfeit packs and stamps.	
36	Taggant Status	Indicates the results of a test for the presence of a chemical marker ("taggant") that identifies genuine, non-counterfeit packs. Applies to Philip Morris USA brands only.	If the pack is missing cellophane, wet, or smudged, the absence of the chemical marker may be environmental and lead to a false positive for counterfeit status.
37	Pack Status	Indicator variable - genuine or counterfeit pack.	ALCS modified the value recorded by MSI for 46 packs, all of which proved to be false positives for counterfeits.
38	Counterfeit List	Indicates whether the pack production code is a known counterfeit code.	ALCS cross references pack production codes with a database of known counterfeit pack production codes. ALCS corrected the values recorded by MSI for a number of observations.

Notes: not all variables are available in all survey waves. We have created additional variables useful for analysis; see the separately available codebook (available at IllicitTobaccoTrade.com) for details.

Table A-2 – List of cheap white brands

Brand	Source
821	multiple
American Legend	industry
Austin	industry
Bayron	industry
Bon	industry
Bon International	industry
Bredal	industry
Broadway	industry
Business Club	multiple
Business Man	industry
Capital	multiple
Chunghwa	MSI
CK	industry
Classic	multiple
Compliment	industry
Corsair	industry
Derby	industry
Double Happiness	MSI
Ducal	industry
EB	industry
Elixyr	industry
em@il	multiple
Esse	MSI
Fest	industry
Fu-qi	multiple
GB	industry
George Karelias and Sons	multiple
Goal	industry
Gold Classic	multiple
Gold Mount	industry
Golden Bridge	multiple
Golden Seagiies	industry
Good Fortune	multiple
GR	industry
Half Time 5	multiple
Hatamen	multiple
Hd	industry
Hero	multiple
Jet	multiple
Jim	multiple
Jin Ling	multiple
June Slims	multiple
Karelia	industry
Kiss	industry
Lifa	industry
Luffman	multiple
Magnat	industry
Manchester	multiple
Marble	industry
Master	multiple
MG	industry
Minsk	industry
Modeng	industry
Mond	multiple
Mond International	multiple
More	industry
Mo-shen	multiple
My Way	industry
Napoli	industry
Nelson	industry
NZ	multiple
Palace	multiple
Paladium	industry
Penang	industry
Portman	industry
Premier	industry
President	industry
Queen	industry
Raquel	multiple
Red	industry
Red Golden Dragon	industry
Regal	multiple
RGD	industry
RGD (Red Golden Dragon)	industry
Richman	multiple
Rodeo	industry
Ronhill	industry
Shan	multiple
Super Sunday	industry
Top Mountain	multiple
Toro	industry
Vigor	multiple
VIP	industry
VP international	industry
Walton	industry
Yes	industry
Yesmoke	multiple
Yun Yan	industry

Note: Brands with source *industry* or *multiple* are from Ross et al. (2015b); brands with source *MSI* are from our data. Refer to text for discussion.

Appendix B: The Survey Sample Design and Issues Regarding Inference

This appendix contains a brief discussion of some of the issues involved with the complex sample design of the EDP surveys presented in the paper. Conceptually speaking, a survey is a method used to gather data to infer information about a population when a census (i.e., gathering data on the entire population) is unavailable. Whether, and how accurately, a survey sample allows estimation and inference about the target population depends on many factors, including the sample size and the methods employed to collect the data.

Broadly speaking, there are two approaches to surveying. Academic researchers typically use *probability sampling* methods when possible, which involve choosing items for study from a *sampling frame* (a list of known population elements).[88] Probability sampling results in samples for which there is a known, nonzero probability of selection for each element. These sampling probabilities play a crucial role in weighting the data to reflect population averages and totals and in computing standard errors for the estimates. As opposed to the academic approach to surveying, marketers and others in the corporate world typically use *non-probabilistic sampling*. There are many variants of non-probabilistic sampling, ranging from methods highly prone to sample selection bias to best-effort procedures adopted of necessity when probabilistic sampling is impossible.

A study of ITTP has the set of all cigarettes (and perhaps other tobacco products) consumed in a particular place during a particular period as its target population (unless the questions revolve specifically around individuals involved in ITTP). True probability sampling of EDPs appears to be impossible, since there is no way to build a sampling frame.[89] Unlike for housing units in the U.S., students at a university, or taxpayers in a state, no list of cigarette packs consumed within a given geography and period is available. Even if there were, the final location of the consumption of a pack would still be unknown.[90]

As a market research company, MSI adopted a complex non-probabilistic sampling plan for its EDP surveys. The target population for a survey is the set of cigarette packs consumed and discarded in the market city (MSA) during the sampling period, and the sampled population (i.e., units potentially able to make it into the final sample) is further limited to packs discarded in public locations. The details of the many stages of sampling are described in sections IV.A and IV.B of the main text. The methodology employs randomization in the selection of neighborhoods and packs to avoid the bias inherent in

[88] The classic reference on probability sampling is Leslie Kish, *Survey Sampling*, New York: John Wiley & Sons, 1965. Much of the discussion here is drawn from this source.

[89] This issue has been ignored in some of the literature employing EDP surveys. Most studies weight the data by population, if at all.

[90] Thus, in a conceptual sense, studying ITTP from EDPs is somewhat akin to studying an animal population in the wild of unknown size and range of habitat.

judgment sampling. [91] Nevertheless, because there was no sampling frame and the probability of any given pack making it into the final sample is unknown, standard errors for estimates cannot be calculated using the typical survey methods used for finite populations. Proper probabilistic sampling and weighting requires *measures of size* (MOS) for the sampling units at the various stages of sampling. MOS are not available in the data for sectors or neighborhoods because MSI defined ad hoc geographical areas and their population counts are not available in the data (even if population were the correct MOS). It is therefore not possible to compute sampling weights for the neighborhoods (the cluster). Within a neighborhood, pack sampling weights cannot be computed because the overall number of packs collected is not recorded (just the number analyzed to meet the quota, which is not proportional to neighborhood population or any other characteristic).[92] For these reasons we have computed no standard errors and performed no inference in this paper.

What are the options available to researchers wishing to compute standard errors for estimates? This is an open area of research for the present authors, but we share the following thoughts for others who may wish to use these data.

1. The issue could be ignored and the data could be treated as if they came from a simple random sample from an infinite population. This is typically the default assumed by statistical software when calculating standard error of estimates, and also appears to have been tacitly adopted in some previous EDP studies. We do not recommend this approach when calculating means, although a slightly modified version (accounting for clustering at the neighborhood level) may be appropriate for regression analysis (see point 5 below).
2. The safest approach, albeit an unsatisfying one, is to make no claims concerning how representative of the target market the samples are. If the sample is analyzed as if it were a census—i.e., as if the target population of the survey were the exact set of packs that were collected—then there is no need to calculate standard errors at all (since they are all zero).[93] While by definition all statements about means, etc., will be correct for target, the question will remain as to how typical of the whole market is that target (or, similarly, how interesting is that target in isolation from the larger market).

[91] Researchers may consult T.M.F. Smith (1983), "On the validity of inferences from non-random samples," *Journal of the Royal Statistical Society, A*, 146(4):394-403 for a formal set of conditions under which the selection mechanisms used in non-probabilistic sampling are ignorable.

[92] However, despite the uses of quotas in the determination of the final set of packs to be analyzed in each neighborhood, MSI does *not* employ "quota sampling" per se (at least as it is commonly denigrated). Kish (1965, op. cit.) defines quota sample as "a form of purposive sampling widely used in opinion, market, and similar surveys. The enumerators are instructed to obtain specified quotas from which to build a sample roughly proportional to the population, on a few demographic variables. Within the quotas, the enumerators are supposed to obtain representative individuals." As explained in the text, all packs are gathered from the target areas and the quota is met by random selection (not selection of "typical" or "promising" specimens) from the set of collected packs.

[93] That is, the census population quantities (see point 5 below) can be calculated exactly.

3. While there are no MOS available for the neighborhoods, it is known in which ZIP code each neighborhood falls. Population density, information on commuting patterns, or other data specific to the ZIP code could be used to develop approximate MOS.[94] Such approximate MOS could then potentially be used to develop survey weights for packs within neighborhoods. The neighborhood weight would still be unknown, but given the survey design each should have approximately the same weight (in terms of the general population, at least, but not necessarily in terms of the smoking population).

4. ZIP code characteristics on demographics, commuting patterns, amount of commercial activity, etc., could be used to *rake* the sample ex post to develop weights to make the sample match the overall demographics of the market.[95] Raking could alleviate concerns about whether certain demographic groups are over- or underrepresented in the survey. Raking could even be employed to force the demographics of the weighted survey sample to match marginal distributions of the U.S. as a whole, in an attempt to extrapolate the individual market results to the nation. Given the importance of the widely differing tax rates among states and localities, however, such a procedure is not likely to produce accurate national estimates of ITTP; clearly ITTP depends on more than mere demographics. With any raking of the present data, however, one must remember that the unit of observation is a pack, not a person. If anything, then, it is the demographics and commuting patterns of *smokers* that are relevant.

5. The finite population survey approach to estimation and inference could be abandoned altogether in favor of the infinite population (i.e., superpopulation) approach familiar to econometricians.[96] While the former attempts to estimate *census population quantities* (CPQs), the latter focuses on parameters of the data generating process (or *superpopulation model*). To put it another way, the former approach attempts to measure the population, while the latter attempts to find internally consistent relationships among the measured variables as if they were generated by an experiment. The issues involved in the distinctions between the two approaches are complex, and we do not go into them here.[97] However, roughly speaking, if the data are being used for descriptive purposes (e.g., what is the mean level of ITTP in a particular city or other CPQs) then inference should be based on finite population methods; if the data are being used for multivariate, analytic purposes (e.g., what is the marginal effect on ITTP of a one

[94] ZIP code population, however, is not an appropriate MOS for a neighborhood since the latter is only a subset of the former. Since the neighborhoods all have the same area, population density is a better datum to use to construct a MOS.

[95] Raking is variously known as iterative proportional fitting, sample-balancing, or raking ratio estimation. Raking is an iterative maximum-likelihood procedure that ensures that the rows and columns of a contingency table add up to known marginals. See C. T. Ireland and S. Kullback, "Contingency Tables with Given Marginals," *Biometrika* 55(1):179-188, 1968.

[96] Although it is not always familiar to econometricians by that name, since in much of traditional econometric pedagogy the infinite population approach to estimation and inference is the *only* approach discussed (and therefore did not require a name in the classroom or the textbook).

[97] Refer to Steven G. Heeringa, Brady T. West, and Patricia A. Berglund, *Applied Survey Data Analysis*, Boca Raton, FL: Chapman Hall/CRC Press, 2010 (particularly sections 3.2 and 7.2) or any econometrics textbook discussing why (and when) weights need to be used in estimation. See also the sources noted in footnote 17 in the main text.

percentage point increase in the presence of demographic group *x* in a neighborhood), then superpopulation methods can be used. For an example of the latter approach, if a pack characteristic is the dependent variable in regressions, the estimated slope coefficients from a regression (but not the intercept) are unbiased estimates of the parameters of the data generating process (if the postulated model is correct). When adopting the infinite population approach, the neighborhood or ZIP code can be taken to be the cluster for purposes of calculating standard errors, and sandwich-type robust estimators of the coefficient variance-covariance matrix can be employed.

Appendix C: Issues Regarding the Provenance of the Data

To allow interested third-party researchers to assess the research methods leading to the findings regarding tax evasion and ITTP presented here, the authors have made available the original data and Stata code used to produce the "clean" version of the dataset and the results in the paper (see IllicitTobaccoTrade.com). It is important to note, however, that the original data—and most importantly the results of testing of the packs and tax stamps for authenticity—were created by (in the case of ALCS) or funded by (in the case of work performed by MSI) an interested party, Altria Client Services. As discussed in the paper, given that some of the telltales of counterfeit packaging are proprietary, it would be impossible for outside researchers to assess whether a pack is counterfeit as accurately as the manufacturer or an affiliated company. So even in principle the data are unverifiable by outsiders.

Given these inescapable features of the data, it is useful to consider 1) what the tendency of the data source may be and 2) how estimates of ITTP compare with external estimates from other sources. Begin with the first consideration: in source criticism (used by historians to evaluate the quality of a source of information), the *tendency* refers to the source provider's motivation toward bias. Given that Altria profits from selling cigarettes, it would appear that one tendency behind the original data would be to overstate the prevalence of counterfeiting. Counterfeiting directly cuts into the profits of legitimate manufacturers. If the manufacturer convinces the authorities to crack down on production and sales of counterfeit product, sales of legitimate product would increase (ceteris paribus) and the manufacturer would benefit. The research paper shows that these data, in fact, exhibit quite low levels of counterfeiting in the market. When a source provides evidence contrary to its tendency, it may be judged more likely to be accurate.

The tendency of the source regarding the prevalence of tax evasion and avoidance involves more factors. Tobacco companies often cite ITTP as an argument against raising taxes. Some tobacco-control advocates argue that the tobacco industry overstates ITTP to pressure policymakers to lower tobacco excise taxes (typically in overseas contexts).[98] Anti-smoking advocates want higher tobacco taxes to reduce smoking; tobacco manufacturers want lower taxes to be able to sell more product. Given that ITTP is a possible consequence of high taxes, it is therefore in the interests of tobacco companies to

[98] See, for example, A. Rowell et al., "Tobacco industry manipulation of data on and press coverage of the illicit tobacco trade in the UK," *Tobacco Control* 2014;23:e35–e43.

overstate ITTP.[99] Historically, some tobacco companies have been complicit in ITTP.[100] It might logically be in the interests of those companies to understate tax noncompliance to avoid enforcement, though as far as we know that charge has not been made in print.

Given these factors regarding the tendency concerning tax avoidance/evasion, two observations are important. First, while the MSAs from which to collect packs were not randomly chosen, neither were certain obvious choices made that would have biased the findings on tax compliance. For example, the data from Minneapolis show almost no ITTP of any form, notwithstanding that Minnesota has one of the highest tax rates for tobacco. ALCS could have omitted that survey wave from the data provided to the BOTEC researchers and we would not have known; they did not. For another example, some academic studies of ITTP examine only urban cores or known problem spots, such as the South Bronx in New York City, where they are virtually guaranteed to find the highest incidence of ITTP.[101] The survey methodology employed to gather the present data, on the other hand, is designed so that all areas and types of neighborhoods in a chosen city are sampled roughly in proportion to their population (see the research paper for details). Including areas outside the urban core most likely reduces the incidence of ITTP in the sample.

Second, the results for tax avoidance/evasion are not greatly out of line with the very few external academic estimates available. These findings are discussed in the research paper; in some cases (Boston, Chicago) the tax compliance rate looks higher than other estimates, in other cases lower (New York City).

[99] As Joossens et al. (2010, p.1644) state, "…tobacco industry experts may have an incentive to exaggerate the extent of smuggling in order to lobby for reduced tax, while public health advocates may have an incentive to understate the size of the smuggling problem to argue for tax increases."

[100] See, for example, J. Collin et al., "Complicity in contraband: British American Tobacco and cigarette smuggling in Asia," *Tobacco Control* 2004;13:ii104–ii111. To our knowledge, there are no allegations regarding interstate cigarette smuggling within the U.S. involving U.S. manufacturers.

[101] We do not claim that authors of such studies misrepresent their sampling plans or fail to note the potentially non-representative nature of their survey designs.