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Cigarette Taxes and Illicit Trade in Europe

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Abstract

Cigarettes are highly taxed in Europe to discourage tobacco use and to fund public-health measures to mitigate the harms from tobacco consumption. At higher prices some consumers substitute more toward illicit cigarettes. Illicit retail trade in cigarettes (IRTC) includes counterfeiting and smuggling—either of legally purchased products, from lower-tax to higher-tax jurisdictions, or of entirely non-tax-paid cigarettes. Some existing literature includes claims that taxes are not an important factor determining the scale of IRTC. We investigate these claims with data from the European Union. We find that while the simple correlation between licit cigarette prices and the market share of illicit cigarettes in consumption is negative, raising prices in any one country would lead to substantial increases in the expected illicit market share and volume in that country. A one euro increase in tax per pack in a country is expected to increase illicit market share by 5 to 12 percentage points and increase illicit cigarette sales by 29% to 95% of the average consumption. The results are robust to a host of alternative specifications and sources of data.

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I. Introduction[1]

Trade in tobacco products is subject to an array of taxes worldwide. The World Health Organization's 2003 Framework Convention on Tobacco Control (FCTC), a treaty to which 180 countries are party, embraces taxation as a central part of its demand reduction strategy. The European Union, whose countries are signatories to the FCTC, mandates minimum rates of excise taxes on tobacco for member states. Although tobacco usage has fallen in recent decades, prevalence in European countries still ranges from about a quarter to a half of adults.[2] The taxes are intended to discourage tobacco consumption and to raise revenue to fund public-health measures aimed at tobacco control or mitigating the harmful effects of tobacco use. However, not all taxes imposed are fully paid, since in many locations consumers can readily turn to the black market as a substitute for licit tobacco products. In this study we investigate the determinants of illicit retail trade in cigarettes (IRTC) in the EU, and find that raising the excise tax has large marginal effects on illicit market shares and quantities.

IRTC in Europe takes several forms, listed in order of prevalence: contraband genuine cigarettes smuggled in from lower price jurisdictions, whether by large-scale operators or by casual bootlegging by consumers; "cheap whites," brands produced mainly for black market sales,[3] and counterfeit product (Transcrime, 2015). Our investigation focuses on large-scale organized smuggling, cheap whites, and counterfeits, since casual bootlegging is not included in our data. Since much of the literature focuses on casual bootlegging,[4] our exploration of organized smuggling is a near novelty. Estimates of the scope of the global illicit trade in tobacco products vary widely, but an estimate on the order of $40 billion in annual lost tax revenue globally is generally cited (Joossens & Raw, 2012). IRTC is approximately ten percent of the global retail market (see Figure 1), with a strong upward trend in Western Europe since at least 1999 and in Eastern Europe more recently. These shares differ greatly by country, varying from near zero to over one-half of all consumption in the data we introduce below.

The influence on IRTC of taxes and tax differentials between jurisdictions is hotly disputed. How taxation affects IRTC is of more than academic interest; if policymakers increase cigarette tax rates in order to reduce consumption, the estimated impacts must account for consumption shifted to illicit cigarettes and the resulting lost tax revenue.

Some analysts find that prices weigh heavily on the incidence of smuggling. According to Goel (2008, p. 591), in the United States "price inducements remain the main force behind

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[2] Data for the EU from the European Monitoring Centre for Drugs and Drug Addiction, 2008 to 2013, show country-level rates for last-month prevalence of tobacco usage ranging from 24% to 47% among people 15-64 years of age. Cigarettes are by far the most popular form of tobacco. See emcdda.europa.eu/data/stats2015.

[3] "Cheap whites" are cigarettes produced for the purpose of untaxed sales. As opposed to counterfeit product, cheap whites are sold under their own brands, independent of the traditional tobacco manufacturers (Ross et al., 2015).

[4] See, for example, the studies cited from the large empirical literature based on data from North America (referenced in section II.

smuggling" and nonprice influences (own or border corruption) are statistically insignificant. Others contend that prices matter little in determining the incidence of cigarette smuggling and that other factors such as corruption are more important, particularly outside the United States (Merriman, Yurekli, and Chaloupka, 2000). Joossens and his coauthors, in numerous articles and other outlets, have made the most vigorous claims that prices only minimally affect IRTC and that other factors are more important (e.g., Joossens et al. 2009, 2014). Joossens is one of the most highly visible commentators on tobacco taxes in the policy arena, and these arguments are widely cited by health policy organizations and researchers working in the fields of health policy and tobacco control.[5] The following statements from a recent handbook article in the field of tobacco control summarize well the intended lessons for policymakers offered by this literature: "Price and tax differences have been shown not to be the main cause of smuggling…. [l]ittle relationship has been shown between the extent of smuggling of tobacco and its price or tax" (Townsend, 2015, p.128). Similarly, a standard reference on the economics of tobacco control for public health researchers states: "In contrast to the hypothesis that higher cigarette taxes and prices will lead to increased illicit trade, the data suggest the opposite, with illicit market share generally falling as cigarette prices rise" (US NCI, 2016, p.521).

These assertions, however, are counterintuitive; economic theory suggests that increasing taxes in one jurisdiction, which—all else equal—increases the potential profit from evading those taxes, should yield an increase in such evasion. Given the importance of the public-policy issue and the frequent repetition of these assertions minimizing the role of taxes in stimulating IRTC, these claims warrant careful consideration. We find that they are typically based on methods such as cross-sectional OLS regressions that are unlikely to identify the causal effects of taxes on smuggling. In this paper we instead use panel data to estimate the relative contributions of prices and other factors to the incidence of IRTC in countries of the European Union in recent years. Our estimation methods include pooled OLS regressions, fixed effects estimations, and IV regression.

We find that although IRTC is generally lower in European countries with lower prices, the econometric evidence soundly rejects the assertion that prices and taxes are not a main cause of smuggling. We show that market forces work exactly as predicted by microeconomic theory, after holding other things equal: fraud and tax evasion occurs because greater price differentials between licit and illicit cigarettes cause some consumers to substitute toward the cheaper product. Our conclusion persists after controlling for corruption, and applies equally to illicit market shares and illicit volumes. The estimated marginal effects of prices on IRTC are substantial. Raising taxes within a single country by one euro per pack, and holding other factors equal, is estimated to increase illicit market share by no less than one-third and perhaps more than 100%. That means increasing the quantities of illicit cigarettes consumed by 29%–95%. The main findings are corroborated by a host of alternative econometric specifications and data on illicit trade.

[5] Joossens has authored or co-authored at least 32 publications since 1991 on tobacco and illicit trade, and these have over 1,600 citations per Google Scholar (as of yearend 2015).

Our econometric study is novel as the only one using panel data and performed directly on IRTC (i.e., with IRTC as the dependent variable) in Europe. Merriman et al. (2000), the only other econometric study of European IRTC, use cross-sectional data, which we show is an important limitation that can lead to misleading results, and in any event examined data from well before the FCTC.[6] Apart from that study, we are the only study to examine directly IRTC anywhere in the world.[7]

II. Policy setting and literature review

In addition to the direct loss of tax revenue, other negative consequences such as violence and funding for terrorism may be associated with IRTC (Prieger & Kulick, 2014, 2015; Levi et al., 2015; OECD, 2015; U.S. Department of State, 2015). In the EU, the illicit cigarette market was estimated to produce €10.5 billion in illicit revenue for criminals in 2012, which is comparable to the cocaine or heroin markets (Transcrime, 2015). Effective policymaking regarding tobacco therefore requires understanding how efforts at control may be undermined by illicit trade, which has its own negative social consequences.

The principal claim in the literature that we test is that raising cigarette prices or taxes does not tend to increase IRTC. For example, Joossens et al. (2014) state that "our data show that illicit trade is not directly related to tobacco prices." This claim typically appears in the tobacco-control literature regarding countries other than the United States, for example Europe (Joossens et al., 2014), Iran (Abdolahinia et al., 2013), and New Zealand (Ajmal and U, 2015). The studies that reach such conclusions are often cross-sectional, may otherwise have inadequate controls for confounding factors, or are based solely on visual inspection of the data. In many cases in the tobacco-control literature, the claimed insensitivity of illicit trade to prices is argued to follow directly from the fact that high-income countries in Europe (which tend to have higher taxes and so more expensive cigarettes) tend to have lower levels of smuggling than lower-income countries.[8]

A recent report by the National Research Council on IRTC acknowledges the relationship between relative cigarette prices and illicit market share, stating that tax and price differences among countries are "major drivers of bootlegging" in Europe (Reuter and Majmundar, 2015). However, the report also cites Joossens et al. (2014) as finding that there are "no significant associations" between cigarette prices and the prevalence of IRTC.

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[6] Merriman et al. (2000) also indirectly explore ITTP with a few regressors related to bootlegging in panel data regressions of licit sales, and conclude that "[w]e can be quite confident that a policy that raises incentives for bootlegging (such as a tax increase) will significantly reduce domestic sales" (p. 379).

[7] Stehr (2005) indirectly studies IRTC in the U.S., since he takes the log of the licit sales to total consumption ratio as his dependent variable, which is the complement of our illicit market share variable. In the many other relevant studies cited in the next section, ITTP-related variables appear as regressors in regressions of licit sales or total consumption.

[8] For example, Joossens and Raw (1998, p.67) state that "If it [i.e., that smuggling is caused by large cigarette price differences among countries] were true, however, countries with highly priced cigarettes would experience high levels of smuggling into them, whereas countries where cigarettes are cheap would not. In fact almost the opposite is true." They then show that are cigarettes were highly expensive in several European countries (such as Norway, Sweden, Denmark, and the United Kingdom) with low smuggling rates.

In contrast to the tobacco-control literature, studies by economists generally find the expected positive relationship between taxes and illicit trade. However, almost all such work uses data from North America. The theoretical link between taxation and smuggling was set forth by Norton (1988), who shows that the aggregate volume smuggled into a country is an increasing function of the tax rate. When the tax rate rises, existing smugglers substitute supply away from licit trade, and new smugglers located farther away from the border (and therefore with higher transport cost) find it profitable to enter the market. A large empirical literature based on data from North America finds that tobacco smuggling responds to prices as predicted (Baltagi & Levin, 1986; Becker, Grossman, & Murphy, 1994; Coats, 1995; Saba et al., 1995; Galbraith & Kaiserman, 1997; Thursby & Thursby, 2000; Stehr, 2005; Chiou & Muehlegger, 2008; Goel, 2008; Lovenheim, 2008).[9] In contrast, there is far less econometric work examining the European or worldwide markets, and much of the work is cross-sectional (Merriman et al., 2000; Yurekli & Sayginsoy, 2010). Recent reviews of the state of research regarding IRTC cites the econometric literature regarding North America but names Merriman et al. (2000) as the only econometric study of Europe.[10] The present research helps fill this void in the literature, a task of importance for policymakers since the EU is a leader in raising tobacco taxes and the European experience is the main base for the claims that taxes do not much affect illicit trade.

III. Data on the cigarette industry and smuggling

In this section we describe the data and provide summary statistics for illicit trade, prices, taxes, and other market characteristics.

A. Sources and construction of the data

All countries in the European Union are included in the study except Cyprus, Luxembourg, and Malta, for which market data are unavailable. The data cover 1999 to 2014. For countries joining the EU since 1999, only the years of membership are included (see Table A.1). Industry statistics, including estimates of IRTC, come mainly from Euromonitor International's Passport database, vintage June 2015. These data have been widely used in reports for the European Commission and for academic studies. The advantages and weaknesses of these data are discussed in section IV.C. However, we show below that the Euromonitor estimates of IRTC are highly correlated with data from an alternative source, and explore several robustness tests with alternative data.

Key variables from Euromonitor include the number of cigarettes traded in the retail market within each country. Licit trade includes retail sales of duty-paid cigarettes, including legitimate sales for consumption in other countries. Illicit trade includes all cigarettes for which duty

[9] In closely related work, Harding et al (2010) and DeCicca, Kenkel, & Liu (2013) show that the availability of lower-tax cigarettes across borders creates significant differences in how consumer prices are affected by excise taxes (because of casual bootlegging).

[10] WHO (2010) states that "[regard to econometric studies, there is no existing work on cigarette large-scale smuggling in Europe and only one of bootlegging (Merriman et al., 2000) [posed to large-scale smuggling]" (pp. 70-71).

has not been paid, and thus includes smuggled, gray-market,[11] and counterfeit cigarettes and any produced domestically for black-market sales.[12] Legitimate cross-border sales (casual smuggling), which can be a form of legal tax avoidance, are excluded. From these two variables, our main dependent variable is the market share for the illicit trade share.[13] The average licit cigarette price per stick is calculated as the total industry retail value of licit trade in cigarettes divided by total licit retail-trade volume. All monetary variables in the dataset are deflated to reflect the real prices in 2010 euros.[14]

Data on cigarette excise taxes are from the European Commission[15] and include the specific excise tax per stick and the ad valorem excise tax as a percentage of the retail sales price.[16] Every country in the EU has both specific and ad valorem cigarette taxes. The tax components are used to construct the total excise tax per stick, based on the average pre-tax price in each country and year.[17] The total excise tax (both actual and the hypothetical tax used as an instrument) varies widely across countries and years. Additional information about these taxes is provided in the online appendix.[18] How these variables are used as instruments is described in section IV.B.1 below.

Other variables are used to control for potentially confounding factors related to illicit trade and consumption. Control of corruption is measured with an index from the World Bank.[19] The measure "reflects perceptions of the extent to which public power is exercised for private gain… as well as 'capture' of the state by elites and private interests" (Kaufmann, Kraay, & Mastruzzi, 2011, p. 223); higher values of this variable indicate less corruption in a country. The income level of a country is measured with real Gross National Income from the World Bank.[20] The

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[11] Gray-market tobacco products are produced by a legitimate manufacturer for consumption in one jurisdiction, but somewhere along the supply chain (often in free-trade zones) are diverted to another jurisdiction, sometimes without the knowledge of the manufacturer.

[12] Cheap whites (see footnote 3) may be consumed in the country of production, in which case taxes for local consumption are normally paid and the sales do not count toward the quantity of illicit trade for that country. Cheap whites are often smuggled abroad, in which case they are part of the smuggled product counting toward illicit trade in the receiving country (Joossens & Raw, 2012).

[13] To the extent that illicit market share is mismeasured due to inaccurate estimates of the scale of the illicit market, there will be additional variance in the econometric errors terms in the regressions and therefore larger standard errors for the estimated coefficients. However, as long as the measurement error is uncorrelated with the regressors, error in a dependent variable does not bias coefficient estimates.

[14] The figures are originally denominated in current euros (using current exchange rates where needed), which are then deflated using the relevant country's CPI from the World Bank.

[15] See Part III (Manufactured Tobacco) of the excise duty tables of the yearly Excise duties and transport, environment and energy taxes reports published by the European Commission Directorate General for the Taxation and Customs Union.

[16] A *specific* excise tax is levied as a fixed monetary amount per unit, while an *ad valorem* tax comes from a tax rate applied to the pre-tax price of the good.

[17] See section B in the Appendix for details.

[18] The online appendix, Prieger and Kulick (2017), is available at https://digitalcommons.pepperdine.edu/sppworkingpapers/71/.

[19] Data are from The Worldwide Governance Indicators, 2016 Update, available from govindicators.org.; see Kaufmann, Kraay, and Mastruzzi (2011) for details. Data for 1999 and 2000 are linearly interpolated.

[20] GNI data from the World Bank (calculated using the Atlas method) are in current US dollars. The figures are deflated using the relevant country's CPI (base year 2010, data also from the World Bank) and then converted to euros at that year's average exchange rate (data from Euromonitor). Units are €1,000.

definition and sources of these and other variables to be introduced below are presented in Table A.2.

B. Summary of the market and descriptive evidence

Summary statistics for the data are shown in Table 1. IRTC, prices, and taxes all display large variation in the data. The illicit market share of cigarettes averages about 10% and ranges from virtually nil (0.4%, Italy in 2003) to over half the market (53.8%, Latvia in 2010). Prices range from €0.056 in Latvia upon first joining the EU[21] to €0.476 in Ireland; prices are nearly as high in the UK. Excise taxes average about 11 euro cents. Corruption and income range widely across the EU but do not move in lockstep: Greece has middling income but high levels of corruption, while Lithuania and Poland have low income but middling levels of corruption.

There is no tight correlation between IRTC and taxes. Some countries have high prices and taxes and little illicit trade. Prices and illicit market shares for EU countries in 2013 are plotted in Figure 2 (the same figure with all the years is in Figure A.2). Denmark and Sweden have relatively high prices and the lowest rates of IRTC. On the other hand, Estonia, Latvia, and Lithuania have the highest levels of illicit market share, while having among the lowest prices in the EU. The relation between prices and IRTC is mildly negative in the pooled data (see Figure A.2).

Of course, correlation in the pooled data does not answer the key question for policymakers: If a country were to raise cigarette prices by increasing the taxes, what would happen to illicit trade? There are many confounding factors across countries; consider what the data look like when the country-specific time-averages of prices and the illicit market share are removed. The positive correlation is obvious in Figure 3 for the within-transformed variables. While Figure 2 shows that the *levels* of prices and IRTC have little obvious relationship, Figure 3 indicates clearly that *increases* in cigarette prices are associated with increases in IRTC. While the main story is evident in Figure 3, additional regressions will be explored to control for possibly confounding factors that change over time as well as across countries, such as corruption, income, and factors making prices potentially endogenous.

IV. Estimation

This section presents the results of the estimations. In section A, regressions using the pooled panel data are explored to show that the apparent negative correlation between prices and IRTC is due to bias from omitting corruption and national income. Prices in other countries are also found to be important determinants of IRTC. In section B, fixed-effects regressions using panel data are employed to control for unobserved differences among countries that may affect both prices and illicit activity. Results from a variety of regression specifications and methods, including instrumental variables regression, show that raising prices indeed leads to more illicit trade. In sections C and D, the robustness of the conclusions is verified by exploring alternative specifications and measures of IRTC, prices, and taxes.

[21] While EU regulations dictate a heavy minimum taxation of cigarettes, newly joining countries typically have a few years to phase in the higher taxes.

Identification of the price effects on illicit market shares varies according to the type of estimation. In the OLS regressions, identification requires 1) that all potentially confounding factors—factors that are correlated with illicit market share and the price variables of interest—be included as regressors, 2) that the price variables be exogenous. Identification of the price effects in the OLS regressions rests heavily on variation in prices and IRTC across countries. Since one or both of the identification requirements is likely to fail, we also estimate fixed effects and IV regressions. The fixed effects regressions remove the first potential problem, to the extent that it is caused by country-specific unobserved factors. Identification in these models rests on within-country changes in prices and IRTC. The fixed effect IV regressions additionally remove the second potential problem, as long as the instruments are valid. Instrument validity is discussed below. Linear IV estimates can be interpreted as a weighted average of local average treatment effects. Country/years where cigarette prices are the most responsive to changes in the instruments (which are based on excise taxes) will have the largest effects on the magnitudes of the IV estimates. To the extent that places where prices are highly responsive to taxes are also places where consumers' desire for alternative sources of cigarettes is highly responsive to prices, the LATE interpretation of IV helps explain why our IV estimates of the marginal effect of prices on IRTC are larger than the fixed effects estimations.

Proper inference requires accounting for the clustering of observations within a country. Since there are only 25 countries, standard asymptotic formulas for variance estimation with clustering may result in biased inference. Accordingly, we base our inference on the wild cluster bootstrap-*T*, which provides an asymptotic refinement over tests using critical values from the normal distribution and can substantially reduce the bias of *t*-tests (Cameron, Gelbach, and Miller, 2008).[22]

A. Pooled regressions

1. Impact of licit price on illicit share

We begin the econometric investigation of the link between cigarette taxes and IRTC with pooled OLS estimators. By pooling the data, unobserved differences among countries are ignored. Instead of examining taxes directly, the key regressor is the log of real cigarette prices, under the assumption that consumers care about the total price of the product, not the composition of the price. In any event, taxes are the main driver of variation in prices; 93.4% of the variation in real cigarette prices is explained by variation in taxes (see Figure A.3).

A simple regression of illicit share on the log of real cigarette prices, the results of which are labeled OLS 2.1 in Table 2, finds the line of best fit (shown in Figure A.2) through the scatterplot of the bivariate data. The estimated price coefficient is negative but small (–0.05) and insignificant. However, the identification of the impact of prices on IRTC is not convincing in this specification; given the heavy reliance of cross-sectional variation and the lack of controls, it tacitly assumes that raising prices turns Latvia into Sweden.

[22] Bootstrapping was performed using the `boottest` add-on command (Roodman, 2015) in Stata 15.

Given the likely omitted variables bias in this regression, we first add control of corruption as an additional regressor in estimation OLS 2.2 (Table 2). Since countries with less corruption such as the Scandinavian countries have lower IRTC than more corrupt countries such as some in Eastern Europe, some authors argue that corruption is a more important determinant of IRTC than are cigarette prices, (Merriman et al., 2000; Joossens et al., 2000, 2009). The coefficient on control of corruption is indeed negative and statistically significant while the price variable remains insignificant.

However, corruption is correlated with characteristics of the country that are omitted from the regression. In particular, control of corruption is positively correlated with the country's income level (r = 85%), and income likely affects the IRTC share. Income in levels and squares is added in estimation OLS 2.3. The impact of income on IRTC share is negative, as to be expected if illicit product is an inferior good.[23] With income in the regression, the corruption variable loses significance and the impact of price on IRTC turns positive (though still not significant).[24] Regression OLS 2.3 suggests that controlling corruption by itself is no guarantee that illicit trade will fall, and the fixed effects estimations in the next section show that the evidence for the link between prices and illicit trade is much stronger. Despite the insignificance of the corruption coefficient corruption it is included in the regressions to follow given the importance ascribed to it in the literature as a proposed alternative driver of IRTC.

2. Impact of IRTC-relevant factors in other countries

Cigarette prices in other countries are also expected to be correlated with IRTC in the home country. IRTC is an economic activity that depends not only on prices in the home country but also on other factors that affect the incentive for smugglers to import illicit cigarettes (Norton, 1988; Thursby, Jensen, and Thursby, 1991). Some such factors are the difference in prices of cigarettes between the home and other countries and the distance to countries with lower prices. If raising the price in the home country did not in fact have anything to do with increasing domestic IRTC, then after controlling for the domestic price, prices in and distances to other countries should have no effect on the IRTC share. For example, as noted by Baltagi and Levin (1986), if taxes do not lead to bootlegging, then tax rates and prices in other places should not affect consumption.

Many IRTC-relevant variables reflecting conditions outside the home country have been proposed in the literature (Baltagi & Levin, 1986; Becker, Grossman, & Murphy, 1994; Saba et al., 1995; Stehr, 2005; Thursby & Thursby, 2000; Merriman et al., 2000; Chiou & Muehlegger, 2008; Goel, 2008; Lovenheim, 2008). We computed many alternatives to show that the regression results are generally similar regardless of which measures are included (see the section on robustness checks); for illustrative purposes the maximum real price difference per km between the home country and any other European country in the dataset (whether or not the other

[23] The marginal effect of income is U-shaped overall but is negative across the range of income found in the sample.
[24] One may worry about collinearity between corruption and income. The variance inflation factor (VIF) for control of corruption in regression OLS 2.3 is 3.6; the most common rule of thumb suggests that VIFs above 10 indicate cause for concern about near multicollinearity.

country is in the EU)[25] is included as a regressor in place of the home price in estimation OLS 2.4. Since this variable is larger the greater the relative price in the home country, we expect the coefficient to be positive if price differentials with other locations lead to smuggling. The regression results show that the coefficient has the expected sign and is statistically significant. The implied elasticity of illicit market share with respect to these price differences is 0.88.

B. Fixed-effect panel regressions

Fixed-effect panel regressions allow us to control for unobserved country-specific factors that may bias the OLS price coefficients. There are many country-specific unobserved factors that might be correlated with illicit market shares and cigarette prices. Attitudes about illegal behavior, enforcement against smuggling and illicit trade, and travel distances to major sources of illicit supply are all examples. While these factors may change over time, much of the variation is likely to be between countries and not within a single country. In such cases, fixed-effects regression removes the impact of differing within-country averages on IRTC that would bias estimates from a cross-sectional or pooled regression.

1. Illicit market share and cigarette prices

Table 3 contains several fixed-effects regressions of the IRTC share on cigarette prices. The first estimation, labeled FE 3.1, is otherwise identical to the specification of pooled estimation OLS 2.3. Correcting for omitted factors increases the magnitude of the price coefficient, which is significant at the 1% level. The coefficient of 0.170 in this linear-log regression means that a 10% increase in the real cigarette price is associated with an increased illicit market share of approximately 1.7 percentage points. The implied average price elasticity of illicit market share is 3.4.[26] As before, there is no statistical significance of corruption.

There may be trends across all countries that lead to spurious correlation between prices and IRTC even after controlling for unobserved country factors. For example, prices generally rose across the EU after 2004, as shown in Figure 4,[27] and the overall trend for IRTC share is upward during the entire period. To remove any association between prices and IRTC that stems merely from spurious correlation of trending variables, year fixed effects are added to estimation FE 3.2 in Table 3. The size of the price coefficient increases slightly and is significant at the 5% level. The implied average price elasticity of illicit market share in the sample is 3.5— a sizeable effect. Trends specific to each country may also induce spurious correlation between prices and IRTC. In estimation FE 3.3, the addition of controls for country-specific linear time trends lowers the price coefficient, reducing the elasticity to a still-large 2.5, while retaining significance.

Even after controlling for time- and country-specific omitted factors, the coefficient on the cigarette price might not reflect a causal impact on IRTC. In particular, there are three reasons

[25] The Euromonitor data cover 37 countries in Europe (including Russia and Turkey). We also included Algeria since it has the lowest prices and is estimated to have the highest outflow of illicit cigarettes of the North African countries (KPMG, 2017).

[26] The elasticity is calculated as the sample average of β_{price}/Y_i.

[27] Average price in the EU fell in 2004 due to the admittance of several Eastern European countries that had lower cigarette prices. See footnote 21.

why the price coefficient in the previous regressions is potentially downward biased. First, given that price is measured as average revenue, there is measurement error in this regressor. While using average revenue for price is standard in demand studies with aggregated data, it necessarily means that the actual price in any single transaction may differ from the average. Measurement error in a regressor leads to attenuation bias in its coefficient. Second, there may be remaining unobserved factors that bias the price coefficient due to endogeneity. Because licit and illicit cigarettes are substitutes, a positive demand shock for smuggled cigarettes may lower the equilibrium price of licit product. This would create a downward bias on the licit price coefficient. Third, it is possible that there is reverse causality between illicit trade and tax rates if the tobacco industry used rising IRTC to successfully lobby for lower taxes. This would create spurious negative correlation between IRTC and prices and therefore downward bias in a positive price coefficient. However, two pieces of evidence (explored in the appendix, section A) make it appear unlikely that reverse causality could materially affect the results. First, taxes generally rose or stayed level in each country in our sample. Second, regressions similar to the main panel estimations but with the excise tax instrument (described below) regressed on lagged illicit market share show no evidence of the negative coefficient implied by such reverse causality. Since some of these regressions include country-specific trends, they also cover the case where tax officials may have responded to high IRTC by raising taxes but by less than they otherwise would have.

To correct for endogeneity, we estimated a fixed-effects instrumental variables (IV) regression using cigarette-specific tax instruments. It is common to instrument cigarette prices with excise taxes (e.g., Gruber, Sen, & Stabile, 2003; Stehr, 2005; Nonnemaker et al., 2009). The cigarette-specific tax instrument we construct is the hypothetical total excise tax (in real euros) that would be levied on a cigarette with pre-tax price equal to the average in the sample. Excise taxes on cigarettes in the EU consist of a fixed amount per pack (the "specific" tax) and an ad valorem component. Details of the calculation of the hypothetical total excise tax are in the appendix (section B), as is strong evidence that the relationship between the instrument and prices is monotonic (see Figure A.5). The log hypothetical excise tax is highly relevant instrument: its correlation with log real cigarette prices is 0.86. The hypothetical tax is calculated based on a constant pre-tax price for all observations to avoid endogeneity from using the actual, potentially endogenous prices in the formula. The hypothetical excise tax can be viewed as a particular nonlinear combination of the specific and ad valorem tax rates; using these variables as separate instruments instead yields similar results.

Results are presented from two-stage least squares estimation, although alternative IV estimators yield substantially similar results.[28] In first-stage regressions of log prices on the instruments and the exogenous regressors, the coefficients for the instruments are all positive as expected (see Table A.4). The instruments appear to be strong and exogenous.[29]

[28] The alternative estimation methods include two-step efficient GMM estimation, LIML, and Fuller's LIML. The price coefficients varied among methods by no more than a few thousandths.

[29] The *F* statistic on the excluded instruments is 66.6 when the hypothetical total excise tax is used and 35.1 when the specific tax, the ad valorem tax rate, and their cross product are used as instruments. The Sargan-Hansen statistic has a *p*-value of 0.81 in the latter, and so the test fails to find any evidence that the instruments are invalid due to

The IV results are in Table 3, labeled IV 3.1 (when the instruments is the log hypothetical excise tax) and IV 3.2 (when the tax rate components are the instruments). As expected, when the downward bias from endogeneity is removed, the price coefficient rises compared to the fixed effects regressions. The price coefficients of 0.395 and 0.423 imply that a 10% increase in cigarette prices causes illicit market share to rise by about 4.0 to 4.2 percentage points. At the mean illicit share, that would be an increase from 10.0% of the market to 14.0–14.2%. Stated another way, the 10% increase in cigarette prices would lead to about a 40% increase in illicit market share. The implied elasticity of illicit market share with respect to real cigarette prices is 7.9 to 8.4. These appear to be large effects.

2. Impact of licit price on illicit quantities

The preceding sections have established that raising prices or taxes on cigarettes increases the market share of illicit cigarettes by an appreciable amount. However, illicit market share can increase even as the actual number of illicit cigarettes smoked decreases. Thus an increase in taxes could, in theory, lead to both a higher illicit market share *and* a lower illicit level of consumption (Stoklosa, 2015). To investigate, we repeat the estimations from Table 3 with the new dependent variable of illicit quantities instead of shares. In particular, the dependent variable is the log of the quantity of illicit cigarettes. Note that differences in the population of countries are largely absorbed into the country fixed effects, and in any event the log-log specification implies that impacts are in percentage terms.[30]

The results, shown in Table 4, demonstrate that the results above are not merely an artifact of using illicit market shares instead of quantities. First, note that the price coefficients in the illicit quantity estimations are all positive and that three of the four are significant at the 5% level. The price coefficient now attains significance at the 1% level in IV 4.1. Also, note that the size of the impact is not small. The price coefficients range from 1.0 to 2.4. These elasticities imply that, at the sample average price of €0.186/stick, a 10% price increase would be associated with an increase in illicit cigarettes sold of 7.5% to 25.4%. At the sample average of 2.524B illicit sticks/year within a country, those figures represent between 190M and 641M additional illicit cigarettes traded per year per country on average.

C. Alternative measures of illicit trade

The Euromonitor data on IRTC, although widely used, are not the only comprehensive data on illicit cigarettes available for Europe. In this section we discuss the relative advantages of the various ways to measure IRTC and explore two alternative ways to estimate the impact of prices

endogeneity. A referee questioned whether the exogeneity assumption would fail to hold due to a connection between the instruments and disposable income. Adding real disposable income as an additional regressor in IV 3.1 below barely changes the resulting coefficients, the strength of the instrument, or the conclusion from the exogeneity test.

[30] If the dependent variable is changed to the log of illicit quantity divided by the number of persons of legal smoking age in the country, the coefficients are similar in magnitude to those from estimations FE 4.1 and 4.2 and the significance levels are identical.

on IRTC. The first uses data from a consulting firm, and the second involves a "gap analysis" based on differences between stated and actual tobacco consumption.

The Euromonitor data provide a large panel of consistently-defined variables from which illicit shares can be computed. The data have been used in previous reports for the European Commission and its Executive Agencies (Pedersen et al., 2014). Stoklosa (2015) of the American Cancer Society, who criticizes the Euromonitor data elsewhere, states: "Although there are some concerns around the reliability of Euromonitor illicit trade data, no other comparable global data exist" (p. 1). However, Euromonitor does not disclose exact methodology for its estimates of the illicit tobacco market, but says that it uses "on-the-ground analysis" as well as "interview and secondary research including estimates made by governments (customs agencies, revenue departments, etc.), estimates based on seizures of illicit cigarettes, as well as by companies using other means of estimation, such as discarded, or empty pack surveys" (Euromonitor, 2014b, p.3). Euromonitor also provides a list of sources consulted while developing each country's estimates.[31]

Euromonitor's data on illicit tobacco have been questioned by some researchers (e.g., Stoklosa and Ross, 2013; Blecher et al., 2015; van Walbeek & Shai, 2015), although usually not regarding Europe.[32] The main criticisms leveled against the Euromonitor data by tobacco-control advocates is that for some countries the estimates are overstated and that there are instances in which the data for a country are revised retrospectively without explanation. From the evidence presented in Blecher et al. (2015) it appears that the form of the revisions is typically to adjust the *level* of the past trend without changing the *shape* of the trend much. To the extent that this is generally the case, our fixed-effect estimations remove any bias in the regression estimates caused by incorrect levels of the trends. And, as a report for the European Commission (Pedersen et al., 2014) noted: "Due to the market's contentious nature, various parties have vested interests in either deflating or inflating illicit trade figures, though Euromonitor strives to present the most accepted and realistic estimate of the market"(p. 39).[33]

The UK consulting firm KPMG LLP makes available another set of estimates of IRTC for the E.U. Since 2006, the KPMG has produced its series of Project Star and Project Sun reports.[34] The reports are funded by Philip Morris International, the largest producer of cigarettes sold in Europe, pursuant to a legal agreement with the EU. Despite the fact that the KPMG estimates of

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[31] For example, five governmental sources are listed for the UK data (Eurostat, Framework Convention on Tobacco Control, HM Customs & Excise, HMRC - Statistics Illicit, and USDA Foreign Agricultural Service), five trade associations, eight publications from the trade press, 29 company sources, and five other sources. However, no individual statistic in the data is linked to a particular source.

[32] These criticisms involve the estimates for South Africa, Mexico, Guatemala, the United Arab Emirates, and Bulgaria. Only the last of these is in our data.

[33] The report further mentions that "Euromonitor's business model depends on its provision of non-biased data that are as accurate as possible. The data have been used in previous reports for the European Commission and its Executive Agencies" (Ramboll, 2014, p.29).

[34] See Gilmore et al. (2014) for background on the reports. The earlier reports are not publicly available; we examined copies under arrangement from Altria Client Services. Data from the reports on illicit consumption during 2006-2013, however, are reproduced in Table 1 of the annex to Transcrime (2015), available at transcrime.it/wp-content/uploads/2015/01/Methodological-Annex.pdf.

illicit trade are used by the European Commission and national governments, their accuracy is contested by some tobacco-control researchers (e.g., Gilmore et al., 2014). Since these data have been criticized for being provided under contract to the tobacco industry, and are not available before 2006, we do not rely on them for our main estimations. However, these alternative data provide additional corroborating evidence for our main conclusions.[35]

In the regressions using the KPMG data, the dependent variable is the share of counterfeit and contraband consumption out of total consumption.[36] The new variable is highly correlated ($r = 0.78$) with illicit market share computed from the Euromonitor data, and the imperfect correlation shows that the latter data do not simply rely solely on the industry-funded Project Sun/Star. The estimations here employ price data from the KPMG reports as well, instead of the prices from Euromonitor.[37] The repetition of the main estimations (FE 3.1, FE 3.2, IV 3.1, and IV 3.2) from Table 3 with the illicit market share and price data from KPMG yields the analogous estimations summarized in Table 5 and reported in full in Table A.6. Due to smaller sample size, not all estimates are significant at the 5% level. In each case, however, the coefficients are positive. These results thus strengthen—or at least provide no evidence against—the conclusions found above. The elasticities from the fixed effects regressions are a bit higher (compared to the same regressions with the Euromonitor data); the elasticities from the IV regressions are lower (but still higher than the previous fixed effects results).

We also explore a third measure of IRTC. To complement the estimations using the Euromonitor and KPMG data, we calculated our own estimates of illicit market share. Our consumption gap analysis has the advantage of avoiding industry- and third-party estimates of IRTC that lack fully transparent methodology. Following the approach suggested by Blecher (2010), we compare survey estimates of total cigarette consumption within each country to the amount of licit sales and ascribe gaps between the two to consumption of illicitly obtained cigarettes. Consumption estimates are the Eurobarometer (various years) surveys. The estimation of the marginal effects of the regressors accounts for an unobserved degree of underreporting in stated consumption, which is a well-known feature of survey responses to questions about smoking. The marginal effect of prices can be identified either to scale with other coefficients (so that only the statistical significance but not the magnitude of the marginal effect can be assessed) or, by making use of external objective (non-self-reported) estimates of consumption, to an exact level. Construction of the data and the analysis contains many steps, which are detailed the appendix (section D). The results (summarized in Table 5 and presented in full in Table A.11) provide further evidence that licit cigarette prices have statistically significant positive impacts on illicit market share. The marginal effects of price on the IRTC share by this method, when their levels

[35] Transcrime (2015) notes that "despite the concerns raised by the literature, KPMG data are the best available data on the illicit cigarette market in the EU" and "…the national estimates produced by Project Star and Project Sun are at present the most reliable sources…." Transcrime also asserts that estimates not from the tobacco industry are based on smaller samples, rely on surveys that have underreporting biases, and are not available annually.

[36] KPMG defines contraband similarly to Euromonitor, except that the former includes inflows that exceed legal border limits even if taxes were paid in another country.

[37] Given that the correlation between the price variables from the two sources is 0.986, it makes little difference to the results which is used in the regressions here.

are identified by using external estimates of consumption, are estimated to be somewhat larger than our main results above, although we discuss in the appendix why there may be some upward bias.

D. Other robustness checks

This section reports results from many robustness checks to confirm the conclusions of the previous estimations.[38]

1. The separate impacts of cigarette prices and taxes

In theory, consumers care not about the components of the cigarette price but just the out-of-pocket total price. Nevertheless, here we explore including taxes directly in the regression specifications, following, e.g., Goolsbee, Lovenheim, and Slemrod (2010). Even though consumers may not be sensitive to the division of retail price into tax and other components, suppliers of illicit cigarettes probably are. Taxes can be fully avoided by illicit supply, whereas the non-tax part of the price reflects local cost conditions that may affect illicit traffickers as well. For the latter reason, if any difference in impacts is to be found, we expect that taxes have more impact on IRTC than the non-tax part of the final price.

The new regressors are the total excise tax per stick and the price including VAT but excluding excise taxes. The results (see Table A.5 in the appendix) show that the marginal effects of tobacco-specific taxes are more important the rest of the price, both numerically and in terms of significance. The implied tax elasticity of illicit market share is 3.2, which is similar to the total-price elasticities from FE 3.1 and 3.2. On the other hand, the non-tax part of the price has an insignificant coefficient and an associated elasticity of only 0.48. Treating the price or tax as endogenous does not materially affect the results (as discussed in the appendix).

2. Weighted estimation

Some researchers use weighted least squares (WLS) to improve the performance of cross-country regressions. The difference between the unweighted and WLS estimates can also be used as a diagnostic for model misspecification (i.e., misspecification of the conditional mean by not including relevant regressors or through incorrect functional form; Solon, Haider, & Wooldridge, 2015).[39] In estimation FE A6.1 in Table A.6, estimation FE 3.2 is repeated using the number of persons aged 15 and up (data from World Bank) as weights. The results show that even though the price coefficient is a bit smaller than in FE 3.2, it has a higher significance level. Given the small difference in price coefficients (0.175 vs. 0.167), there is no strong evidence that WLS estimation is needed to correct bias in the unweighted estimations or that the regression specification is incorrect.

[38] The working paper also contains additional robustness tests not mentioned here.
[39] If the regression specification for the mean is correct, then WLS and unweighted estimation are both consistent and employing weights should not materially change the results.

3. Alternative regressors

There are many other control variables that can be used in place of the particular measure of corruption employed above. We repeat estimation OLS 2.3 with several alternative measures of corruption. The alternatives include corruption measures from Transparency International, indices of a country's rule of law and the effectiveness of government from the World Bank, and United Nations data on police per capita. See the appendix (section E) for information on these variables and regressions employing them. Using these alternative regressors made virtually no impact on price coefficient or its significance.

There are also many IRTC-relevant factors in other countries that can be used in place of, or in addition to, the maximum price difference per km between countries (the regressor from OLS 2.4). These include the distance to countries with lower prices, distance to criminal hubs, maximum price differentials or ratios between countries, and other similar measures. Results for these regressors are in the appendix (section F). The results of all the alternative estimations and tests reported there strongly support the conclusion that higher licit prices and price differentials with other locations lead to higher illicit market shares due to smuggling.

V. Policy discussion and conclusions

Table 6 summarizes the results of the main regressions. IRTC is highly responsive to licit cigarette prices. The price elasticities range from 2.5 to 8.0 for illicit share and from 0.8 to 2.5 for illicit quantity. In all cases for the latter, the confidence interval for the elasticity admits the elastic region (greater than one). The table also shows the estimated effects of €1/pack tax increase within a single country. A regression with country and year fixed effects (and no other regressors; results not shown) shows that a €1/pack tax increase may be expected to raise prices by €1.13/pack on average. Remarkably similar tax pass-through rates for cigarettes were also found in US markets by Keeler et al. (1996) and Sullivan and Dutkowsky (2012); pass-through was 1.11 in the former study and 1.07 to 1.14 in the latter. Our estimate is also between the bounding estimates of Delipalla and O'Donnell (2001) for cigarette tax pass-through in European markets.[40] That price increase, coupled with the fitted models in Table 3 and Table 4, allows calculation of the expected change in illicit market share or illicit cigarette quantities.

The estimates are calculated as the average of the discrete changes in the dependent variable in the sample (details of the calculation are in the appendix, section G). The price increase is associated with an expected 2.5 to 3.5 percentage points of illicit market share from the fixed-effects regressions (see the first three rows of Table 6). These are large increases when compared to the average illicit share of 10.0% in the sample. If the IV regression estimates are used instead for the calculations, the implied impact is between 7.9 and 8.4 percentage points. The price increase is estimated from the fixed-effects regressions to lead to additional illicit sales of between

[40] These authors split their sample into two groups, one of which had ad valorem pass-through of 0.7 and specific-excise pass-through of 0.9, while a second group had ad valorem pass-through of 1.5 and specific-excise pass-through of 2.2. Our estimate of the total excise pass-through (1.1) lies within these bounds, as would be expected due to our averaging across countries and tax types.

735 and 739 million cigarettes within a country and year; the IV estimates are an additional 2.0 to 2.4 billion sticks. Again, these are large impacts compared to the average illicit volume of 2.5 billion sticks—increases of 29% to 95% of the average.

In conclusion, we find that while the overall correlation between licit cigarette prices and illicit market share is negative, raising prices in any one country would lead, ceteris paribus, to substantial increases in the expected illicit market share and volume. Controlling for corruption does not substantially change the role of prices in stimulating IRTC, at least in the European data examined here. Finally, the same general conclusions about the importance and impact of prices on IRTC hold whether examining illicit market shares or illicit volumes.

It is also important to note that the impacts of raising prices that we estimate are for a country unilaterally raising its tax. Since the work above showed that price differentials among countries affect IRTC, raising prices to harmonize them across the EU would involve competing effects on illicit activity: raising prices would tend to increase IRTC while eliminating price differentials among countries would tend to reduce it.

This analysis addresses only one consideration in determining how cigarettes should be taxed. Evidence from other studies strongly suggests that, within the range of empirical experience, higher taxes bring in greater revenue despite their intended effect of decreasing smoking and their unintended effect of increasing smuggling (Chaloupka, Yurekli, & Fong, 2012). Our estimates do not contradict those results, but highlight that some potential tax revenue is lost to the illicit market. Furthermore, the econometric results are for the expected impacts on illicit trade of raising prices while holding all else fixed, and do not speak to direct or indirect effects of other policy measures that may change when raising taxes. Policymakers need not (and should not) leave enforcement and other activity designed to further compliance unchanged if they intend to increase taxes. In any case, the impact on illicit trade is only one aspect of policy analysis of increasing cigarette prices. A complete cost-benefit analysis of tax policy toward tobacco would include the expected impacts on tax revenue and public health in addition to the unintended consequences examined here.

References

Abdolahinia, Ali, Vahid Moosavi, Simin Shafiefar, Nasrin Taheri, Makan Sadr, and Mohammad R. Masjedi. (2013). "Raising cigarette prices decreases consumption without increase in smuggling: A study from Iran." *European Respiratory Journal*, **42**(Suppl 57) .

Ajmal, Ali, and Veng I. U (2015). "Tobacco tax and the illicit trade in tobacco products in New Zealand." *Australian and New Zealand Journal of Public Health,* **39**(2):116–120.

Baltagi, B.H., and D. Levin, (1986). "Estimating dynamic demand for cigarettes using panel data: The effects of bootlegging, taxation and advertising reconsidered." *Review of Economics and Statistics*, **68**:148–55.

Becker, G.S., M. Grossman, and K. Murphy. (1994). "An empirical analysis of cigarette addiction." *American Economic Review*, **84**(3):396–418.

Blecher, Evan. (2010). "Commentary on Joossens *et al*. (2010): Eliminating the global illicit cigarette trade—what do we really know?" *Addiction*, **105**:1650–1651.

Blecher, Evan, Alex Liber, Hana Ross, and Johanna Birckmayer. (2015). "Euromonitor data on the illicit trade in cigarettes." *Tobacco Control,* **24(**1):100–101.

Cameron, A. Colin, Jonah B. Gelbach, and Douglas L. Miller. (2008). "Bootstrap-Based Improvements for Inference with Clustered Errors." *Review of Economics and Statistics*, **90**(3): 414-427.

Chaloupka, Frank J, Ayda Yurekli, & Geoffrey T. Fong. (2012). "Tobacco taxes as a tobacco control strategy." *Tobacco Control*, **21**:172–180.

Chiou, Lesley, and Erich J. Muehlegger. (2008). "Crossing the Line: The Effect of Cross-Border Cigarette Sales on State Excise Tax Revenues." *BE Journal – Economic Analysis and Policy (Contributions)*, **8**:1. Article 48.

Coats, R. Morris. (1995). "A Note on Estimating Cross-Border Effects of State Cigarette Taxes," *National Tax Journal*, December 1995, 573

DeCicca, P., D. Kenkel, and F. Liu. (2013). "Excise tax avoidance: the case of state cigarette taxes." *Journal of Health Economics*, **32**(6), 1130–1141.

Delipalla, S., O. O'Donnell. (2001). "Estimating tax incidence, market power and market conduct: The European cigarette industry." *International Journal of Industrial Organization*, **19** (6), 885–908.

Euromonitor International. (2014a). "Cigarettes in the US." Report retrieved from the Passport database.

Euromonitor International. (2014b). "Illicit Trade in Tobacco Products 2013." Report retrieved from the Passport database.

Euromonitor International. (2014c). "Tobacco 2014: New Insights and System Refresher." Report retrieved from the Passport database.

Euromonitor International. (2015). "Tobacco Industry Illicit Trade Penetration." Data set retrieved from the Passport database, June 3, 2015.

Europol. (2011). *OCTA 2011: EU organised crime threat assessment*. The Hague: European Police Office.

Galbraith, J. W., and M. Kaiserman. (1997). "Taxation, smuggling and demand for cigarettes in Canada: Evidence from time-series data." *Journal of Health Economics*, **16**(3):287–301.

Gilmore, Anna B, Andy Rowell, Silvano Gallus, Alessandra Lugo, Luk Joossens, and Michelle Sims. (2014). "Towards a greater understanding of the illicit tobacco trade in Europe: A review of the PMI funded 'Project Star' report." *Tobacco Control*, **23**:e51–e61.

Goel, R.K. (2008). "Cigarette smuggling: Price vs. nonprice incentives." *Applied Economics Letters*, **15**(8):587–592.

Goolsbee, Austan, Michael F. Lovenheim, and Joel Slemrod. (2010). "Playing with fire: Cigarettes, taxes, and competition from the Internet." *American Economic Journal: Economic Policy*, **2**(1):131–154.

Gruber, Jonathan, Anindya Sen, and Mark Stabile. (2003). "Estimating price elasticities when there is smuggling: The sensitivity of smoking to price in Canada." *Journal of Health Economics*, **22**(5):821–842.

Harding, Matthew, Ephraim Leibtag, Michael Lovenheim (2010). "The Heterogeneous Geographic and Socioeconomic Incidence of Cigarette Taxes: Evidence from Nielsen Homescan Data," working paper.

Joossens, Luk, Frank J. Chaloupka, David Merriman, and Ayda Yurekli. (2000). "Issues in the smuggling of tobacco products." In Jha, P., and F. Chaloupka, eds. *Tobacco Control Policies in Developing Countries*. Oxford: Oxford University Press, 393–406.

Joossens, Luk, Alessandra Lugo, Carlo La Vecchia, Anna B. Gilmore, Luke Clancy, Silvano Gallus. (2014). "Illicit cigarettes and hand-rolled tobacco in 18 European countries: a cross-sectional survey." *Tobacco Control*, **23**:e17-e23.

Joossens, Luk, David Merriman, Hana Ross, and Martin Raw. (2009). "How eliminating the global illicit cigarette trade would increase tax revenue and save lives." Paris: International Union Against Tuberculosis and Lung Disease.

Joossens, Luk, David Merriman, Hana Ross, and Martin Raw. (2010). "The impact of eliminating the global illicit cigarette trade on health and revenue." *Addiction*, **105**(9):1640–1649.

Joossens, Luk, and Martin Raw. (1998). "Cigarette smuggling in Europe: Who really benefits?" *Tobacco Control*, **7**:66–71.

Joossens, Luk, and Martin Raw. (2000). "How can cigarette smuggling be reduced?" *BMJ: British Medical Journal*, **321**(7266):947–949.

Joossens, Luk, and Martin Raw. (2012). "From cigarette smuggling to illicit tobacco trade." *Tobacco Control*, **21**(2):230–234.

Kaufmann, Daniel, Aart Kraay, and Massimo Mastruzzi. (2011). "The worldwide governance indicators: A summary of methodology, data and analytical issues." *Hague Journal on the Rule of Law*, **3**(2):220–246.

Keeler, Theodore E., Teh-wei Hu, Paul G. Barnett, Willard G. Manning, and Hai-Yen Sung. (1996). "Do cigarette producers price-discriminate by state? An empirical analysis of local cigarette pricing and taxation." *Journal of Health Economics*, **15(**4): 499–512.

KPMG. (2017). *Illicit cigarette trade in the Maghreb region*. London: KPMG LLP. Available from: assets.kpmg.com/content/dam/kpmg/uk/pdf/2017/07/illicit-cigarette-trade-in-the-Maghreb-region.pdf

Levi, Michael, Ognian Shentov, and Boyko Todorov (Eds.). (2015). *Financing of Organised Crime*. Sofia: Center for the Study of Democracy.

Lovenheim, M.F. (2008). "How far to the border? The extent and impact of cross-border casual cigarette smuggling." *National Tax Journal*, **61**(1):7–33.

Merriman, David, Ayda Yurekli, and Frank J. Chaloupka. (2000). "How big is the worldwide cigarette smuggling problem?" In Jha, P., and F. Chaloupka, eds. *Tobacco Control in Developing Countries*, Oxford: Oxford University Press, 365–392.

Nonnemaker, James, Eric Finkelstein, Mark Engelen, Thomas Hoerger, and Matthew Farrelly. (2009). "Have efforts to reduce smoking really contributed to the obesity epidemic?" *Economic Inquiry*, **47**(2): 366–376.

Norton, D. A. (1988). "On the economic theory of smuggling." *Economica*, **55**, 107–18.

OECD. (2015). Illicit Trade: Converging Criminal Networks. Preliminary Version. Available from oecd.org/gov/risk/illicit-trade-converging-criminal-networks.pdf.

Pedersen, Henrik Stener, Alexandru Floristean, Lorenzo Iseppi, Ross Dawkins, Chris Smith, Christina Mørup, Helene Bundgaard Rohde, Sida Yin, Peter Schoen, and Xavier Le Den. (2014). "Study on the Measuring and Reducing of Administrative Costs for Economic Operators and Tax Authorities and Obtaining in Parallel a Higher Level of Compliance and Security in Imposing Excise Duties on Tobacco Products." Report TAXUD/2012/DE/341 prepared by Ramboll, The Evaluation Partnership, and Europe Economics for the European Commission.

Prieger, James E., and Jonathan D. Kulick. (2014). "Unintended consequences of enforcement in illicit markets." *Economics Letters*, **125**:295–297.

Prieger, James E., and Jonathan D. Kulick. (2015). "Violence in illicit markets: Unintended consequences and the search for paradoxical effects of enforcement." *The B.E. Journal of Economic Analysis & Policy*, **15**(3):1263–1295.

Prieger, James E., and Jonathan D. Kulick. (2017). "Cigarette Taxes and Illicit Trade in Europe: Online Appendix." Pepperdine University, School of Public Policy Working Papers No. 71. https://digitalcommons.pepperdine.edu/sppworkingpapers/71

Reuter, P., & Majmundar, M. (2015). *Understanding the U.S. Illicit Tobacco Market: Characteristics, Policy Context, and Lessons from International Experiences*. Washington: Committee on the Illicit Tobacco Market: Collection and Analysis of the International Experience; National Research Council.

Roodman, David. (2015). "BOOTTEST: Stata module to provide fast execution of the wild bootstrap with null imposed." Statistical Software Components S458121, Boston College Department of Economics, revised 31 Jul 2017. Available from ideas.repec.org/ c/boc/bocode/ s458121.html.

Ross, Hana, Nicole Vellios, Katherine Clegg Smith, Jacqueline Ferguson, and Joanna E. Cohen. (2015) "A closer look at 'Cheap White' cigarettes." *Tobacco Control*. Advance online version doi:10.1136/tobaccocontrol-2015-052540.

Saba, R.R., T.R. Beard, R.B. Ekelund, and R. Ressler. (1995). "The demand for cigarette smuggling." *Economic Inquiry*, **33**(2):189–202.

Stehr, M. (2005). "Cigarette tax avoidance and evasion." *Journal of Health Economics*, **24**(2):277–297.

Stoklosa, Michal. (2015). "Is the illicit cigarette market really growing? The tobacco industry's misleading math trick." *Tobacco Control*. Advance online version doi:10.1136/tobaccocontrol-2015-052398.

Stoklosa, Michal, and Hana Ross. (2014). "Contrasting academic and tobacco industry estimates of illicit cigarette trade: Evidence from Warsaw, Poland." *Tobacco Control*, **23**:e30–e34.

Sullivan, R.S. and Dutkowsky, D.H. (2012). "The effect of cigarette taxation on prices: An empirical analysis using local-level data." *Public Finance Review,* **40**(6):687–711.

Taxation and Customs Union and Eurostat (TCU Eurostat). (2014). *Taxation trends in the European Union (2014 edition)*. Luxembourg: Publications Office of the European Union.

Townsend, Joy. (2015) "Economics of tobacco use and control." In R. Loddenkemper & M. Kreuter (eds.), *The tobacco epide*mic, ed. 2 (pp. 121-135). Basel: Karger.

Thursby, M., R. Jensen, and J. Thursby (1991) "Smuggling, camouflaging, and market structure." *The Quarterly Journal of Economics*, **106**(3):789–814.

Thursby, J.G., and M.C. Thursby. (2000). "Interstate cigarette bootlegging: Extent, revenue, losses, and effects of federal intervention." *National Tax Journal*, **53**(1):59–77.

Transcrime. (2015). *European Outlook on the Illicit Trade in Tobacco Products*. Trento: Transcrime – Università degli Studi di Trento.

U.S. Department of State. (2015). "The Global Illicit Trade in Tobacco: A Threat to National Security." Washington.

U.S. National Cancer Institute (US NCI). (2016). *The Economics of Tobacco and Tobacco Control*. NCI Tobacco Control Monograph 21. NIH Pub. No. 16-CA-8029A. Bethesda, MD.

van Walbeek, Corne, and L. Shai. (2015). "Are the tobacco industry's claims about the size of the illicit cigarette market credible? The case of South Africa." *Tobacco Control*, **24**:e142–e146.

World Health Organization (WHO). (2010). *WHO technical manual on tobacco tax administration*. Geneva: World Health Organization.

Yurekli, A. and Sayginsoy, O. (2010). "Worldwide organized cigarette smuggling: an empirical analysis." *Applied Economics*, **42**: 545–561.

Tables and Figures

Table 1: Summary statistics

Variable	Mean	S.d.	Minimum	Maximum
Illicit market share	0.104	0.092	0.004	0.538
Illicit cigarette quantity	2,533.7	2,803.1	57.00	14,828.2
Cigarette price per stick	0.188	0.085	0.056	0.476
Specific excise tax per stick	51.061	49.524	3.827	230.214
Ad valorem tax rate (% of retail sales price)	33.277	15.189	0.950	58.430
Excise tax per stick	0.110	0.054	0.017	0.284
Hypothetic excise tax per stick	0.111	0.045	0.020	0.260
Max. price difference with other European country/km	3.68E-4	3.27E-4	3.08E-4	1.77E-3
Income (real GNI per capita)	24.000	11.339	4.197	46.598
Control of corruption	1.163	0.835	-0.303	2.586

Data cover years 1999 to 2014; $N = 327$. Variables entering regressions in logs are shown in levels here. For additional variables used in robustness tests, see Tables A.2 and A.3 in the appendix.

Table 2: Pooled OLS regressions of IRTC share on cigarette prices

	OLS 2.1	OLS 2.2	OLS 2.3	OLS 2.4
Y = illicit market share	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
Log(real cigarette price)	-0.048	0.002	0.081	
	[0.258]	[0.962]	[0.124]	
Log(max. price difference/KM)				0.044***
				[0.007]
Control of corruption		-0.041**	0.003	-0.007
		[0.039]	[0.858]	[0.741]
Income (GNI) per capita (€1,000)			-0.015***	-0.013**
			[0.008]	[0.021]
GNI per capita squared			1.98E-4**	1.90E-4**
			[0.031]	[0.042]
constant	0.019	0.156	0.474***	0.661***
	[0.791]	[0.187]	[0.001]	[0.000]
F statistic	1.71	3.23	4.26	3.92
R^2	0.051	0.136	0.277	0.317
Adjusted R^2	0.049	0.131	0.268	0.308
N	327	327	327	327

* $p<0.1$; ** $p<0.05$; *** $p<0.01$. Note: p-values (in square brackets) are calculated using the wild cluster bootstrap of the t statistic (3999 repetitions, with the null imposed; see Cameron, Gelbach, and Miller (2008), and account for clustering by country.

Table 3: Fixed-effects panel regressions of IRTC share on cigarette prices

Y = illicit market share	**FE 3.1** Country fixed effects (FE)	**FE 3.2** Country FE + Year FE	**FE 3.3** Country FE + Country Trends	**IV 3.1** Instrument: Total tax	**IV 3.2** Instruments: Tax components
Log(real cigarette price)	0.170***	0.175**	0.126**	0.395**	0.423**
	[0.001]	[0.019]	[0.038]	[0.014]	[0.012]
Corruption	0.015	0.017	0.031	-0.031	-0.037
	[0.589]	[0.709]	[0.520]	[0.618]	[0.564]
Income (GNI) per capita (€1,000)	-0.009	-0.009*	-0.007	-0.019**	-0.020**
	[0.349]	[0.082]	[0.108]	[0.034]	[0.031]
GNI per capita squared	1.06E-4	9.13E-5	7.67E-5	3.05E-4*	3.31E-4*
	[0.392]	[0.235]	[0.236]	[0.057]	[0.057]
Implied price elasticity	*3.389*	*3.492*	*2.507*	*7.896*	*8.440*
Country fixed effects	Y	Y	Y	Y	Y
Year fixed effects	N	Y	Y	Y	Y
Country-specific linear time trends	N	N	Y	N	N
1st stage *F* statistic on excluded instruments				66.59	35.06
Hansen *J* statistic (*p*-value)					0.814
N	327	327	327	327	327

* $p<0.1$; ** $p<0.05$; *** $p<0.01$.

Note: *p*-values (in square brackets) are calculated using the wild cluster bootstrap (see notes to previous table). In estimation IV 3.1, the instruments for price are the hypothetical total excise tax as described in the text; in IV 3.2 instruments are the ad valorem excise tax rate, the specific tax rate, and their product. The IV estimation method is two-stage least squares.

Table 4: Fixed-effects panel regressions of IRTC quantities on cigarette prices

Y = log illicit cigarette quantity	**FE 4.1** Country fixed effects (FE)	**FE 4.2** Country FE + Year FE	**IV 4.1** Instrument: total tax	**IV 4.2** Instruments: Tax components
Log(real cigarette price)	0.951**	0.956*	2.142***	2.398**
	[0.025]	[0.077]	[0.008]	[0.036]
Freedom from Corruption (WGI)	-0.047	0.031	-0.227	-0.283
	[0.802]	[0.960]	[0.592]	[0.586]
Income (GNI) per capita (€1,000)	-0.067	-0.063*	-0.119***	-0.132**
	[0.213]	[0.057]	[0.008]	[0.024]
GNI per capita squared	9.38E-4	5.99E-4	1.75E-3**	1.69E-3*
	[0.228]	[0.353]	[0.048]	[0. 096]
Implied price elasticity	*0.951*	*0.956*	*2.142*	*2.398*
Country fixed effects	Y	Y	Y	Y
Year fixed effects	N	Y	Y	Y
1st stage F statistic on excluded instruments			66.59	35.06
Hansen J statistic (p-value)				0.292
N	327	327	327	327

* p<0.1; ** p<0.05; *** p<0.01; SEs (in parentheses) account for clustering by country.

Note: p-values (in square brackets) are calculated using the wild cluster bootstrap (see notes to Table 2). The IV estimations and instruments are as described in the notes to Table 3. The coefficients for log price are elasticities.

Table 5 Regressions using alternative data sources for IRTC share

Regression specification similar to…	KPMG data on IRTC			Gap analysis	
	Coef. on log price (asy. stars)	Wild bootstrap *p*-value	Elasticity	Sign and significance of log price coef. when identified to scale	Coef. on log price
FE 3.1 (country FE)	0.148*	0.019	3.45	+**	0.406**
FE 3.2 (country FE + Year FE)	0.192*	0.041	4.49	+***	0.558**
IV 3.1 (instrument: total tax)	0.233*	0.222	5.47		
IV 3.2 (instruments: tax components)	0.256**	0.153	6.03		

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

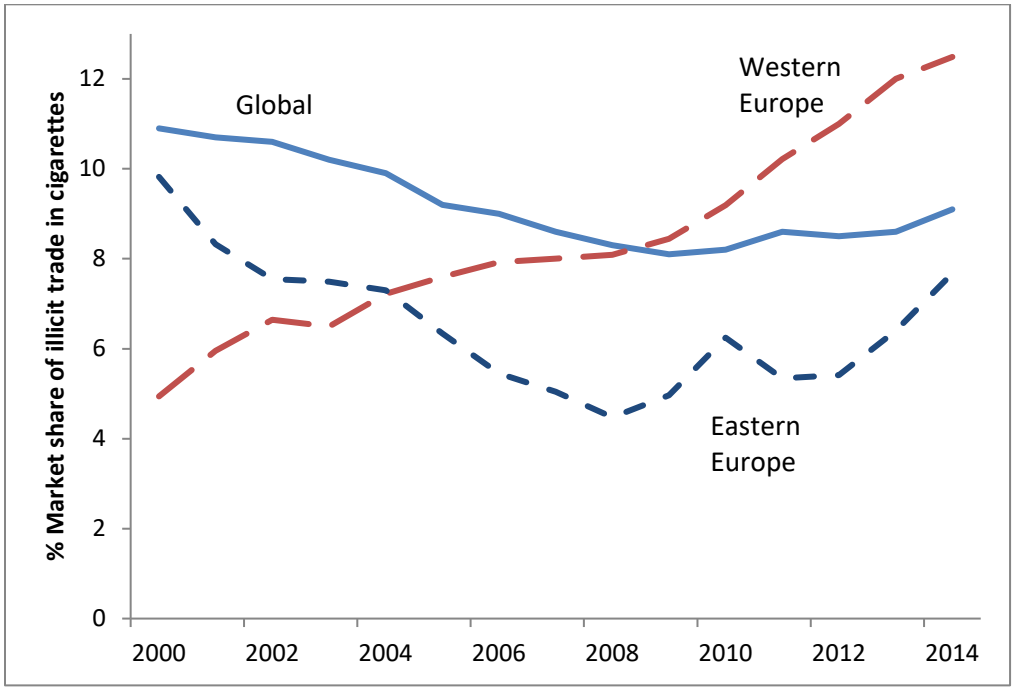
Note: Results here are drawn from the complete regression results shown in Table A.6 and Table A.11. Significance stars are computed from the usual asymptotic sandwich estimator for clustered data; wild bootstrap p-values are provided for comparison for the first set of regressions but are unavailable for the nonlinear SUR regressions for the gap analysis. Refer to discussion in the appendix (section D) for explanation of the gap analysis and its results.

Table 6 Estimated impact of a €1/pack tax increase

	Illicit share	**Price Elasticity**		**Increase in illicit share**	
Estimation	*Average in sample*	*Point estimate (average in sample)*	*95% confidence interval*[*]	*Point estimate (average in sample)*	*95% confidence interval*[*]
FE 3.1	0.104	3.389	[1.30, 6.06]	0.048	[0.018, 0.085]
FE 3.2	0.104	3.492	[0.36, 8.17]	0.049	[0.005, 0.115]
FE 3.3	0.104	2.507	[0.11, 5.39]	0.035	[0.002, 0.076]
IV 3.1	0.104	7.896	[1.13, 15.11]	0.111	[0.016, 0.212]
IV 3.2	0.104	8.440	[1.37, 16.71]	0.118	[0.019, 0.235]
	Illicit quantity			**Increase in illicit quantity**	
FE 4.1	2,533.7	0.951	[0.18, 1.66]	735.1	[120.7, 1446.8]
FE 4.2	2,533.7	0.956	[-0.11, 2.07]	739.6	[-73.6, 1942.5]
IV 4.1	2,533.7	2.142	[0.43, 3.34]	2,042.6	[304.6, 4023.9]
IV 4.2	2,533.7	2.398	[0.48, 3.80]	2,399.9	[343.7, 5029.2]

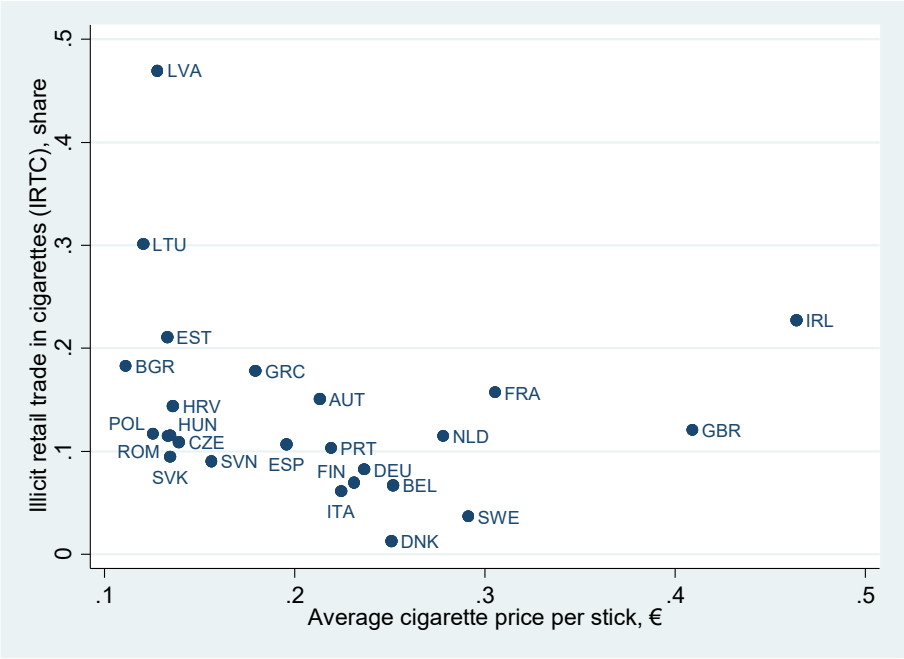
*The confidence interval for the increases in illicit share and quantity are derived from the bootstrap confidence intervals for the price coefficient. See text for details.

Figure 1. Estimated market share of illicit trade in cigarettes



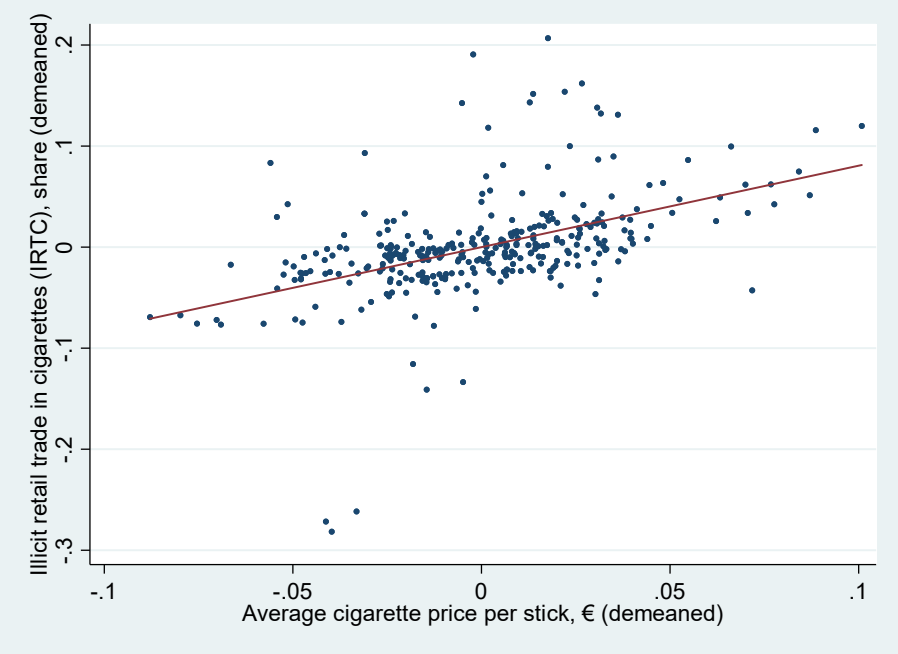
Notes: Data from Euromonitor. Market share is in terms of quantities of cigarettes.

Figure 2: Cigarette prices and IRTC shares in the EU, 2013



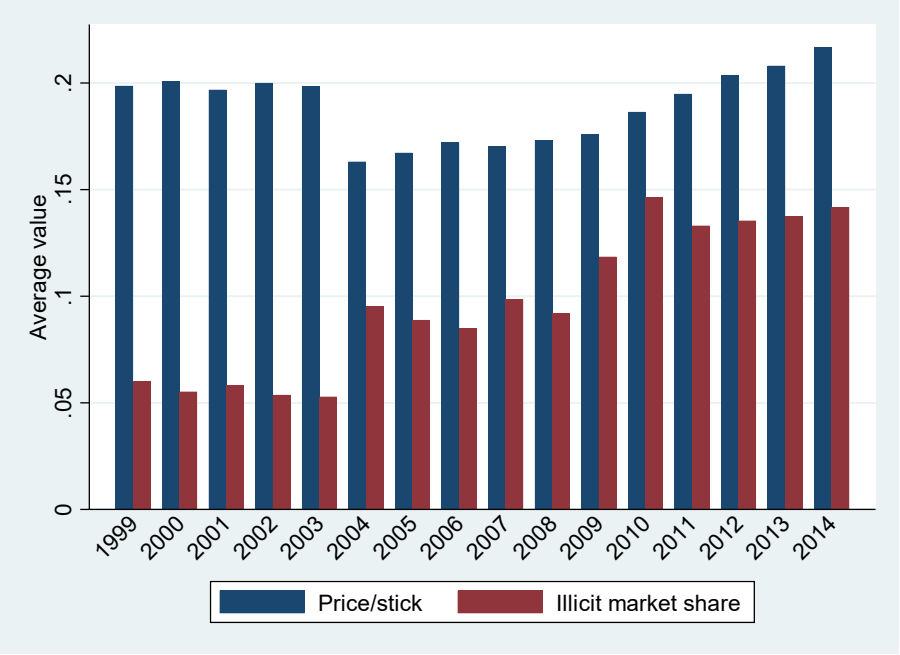
Notes: Variables constructed using source data from Euromonitor as described in the text. Currency units are 2010 euros.

Figure 3: Country-demeaned cigarette prices and IRTC shares in the EU, 1999-2014



Note: For each country, the average of the time-series of each variable has been subtracted from the data. The line of best fit (slope = 0.83) is calculated via OLS regression. See also notes to Figure 2.

Figure 4: Cigarette prices and illicit market share in the EU, 1999-2014



Note: see notes to Figure 2.