Cigarette Taxes and Illicit Trade in Europe

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Highlights:

- On average in Europe, countries with higher cigarette prices have less illicit retail trade in cigarettes (IRTC).
- Notwithstanding, after controlling for income, increases in cigarette prices are associated with increased IRTC in pooled regression.
- As determinants of IRTC, the corruption level of a country matters less than per capita income.
- After controlling for country-specific unobserved factors, increases in cigarette prices remain associated with large increases in IRTC (whether measured by illicit shares or illicit volume).

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 (more precisely, at higher differentials between licit and black-market prices) 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. The existing literature includes claims that taxes are not an important factor determining the scale of IRTC. We investigate these claims with data from 1999–2013 in 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, on average, 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 25% to 120% of the average consumption. We also find that the role of prices in stimulating IRTC is, empirically, far more important than the role of corruption. The results are robust to a host of alternative specifications and sources of data.

JEL Codes: I18, H26, K42, L66

I. Introduction

Worldwide, trade in tobacco products is subject to an array of taxes and other controls. Taxes are intended to raise revenue (to fund public-health measures that mitigate the harms from tobacco consumption or other expenditures, or to reduce other taxes) and to discourage tobacco use (on both external-cost and paternalistic grounds). Not all taxes imposed are fully paid: efforts to avoid or evade paying taxes due include counterfeiting, theft and resale of not-yet taxed product, and smuggling—either of legally purchased products, from lower-tax to higher-tax jurisdictions, or of entirely non-tax-paid products. Estimates of the scope of the global illicit trade in tobacco products vary widely, as methodologies for estimating criminal activities are necessarily subject to considerable uncertainty and as many parties conducting such estimates have an interest in their size (Blecher, 2010). An estimate on the order of $40 billion in annual lost tax revenue globally is generally accepted (Joossens & Raw, 2008, 2012).

We focus here on estimating the relationship between taxes and illicit trade in cigarettes, which are by far the most popular form of tobacco. Although tobacco usage has fallen in recent decades, prevalence in European countries still ranges from about a quarter to a half of adults.[1] The illicit retail trade in cigarettes (IRTC) is, by one widely used source of data, approximately ten percent of the global retail market (see Figure 1), with a strong upward trend in Western Europe. These shares vary considerably by country, varying from near zero to over one-half of all consumption in the data we introduce below. Illicit trade in Europe takes several forms, listed in order of prevalence:[2] contraband

[1] 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. See emcdda.europa.eu/data/stats2015.

[2] Transcrime (2015) estimates average shares of the illicit cigarette market in 2013 for Europe to be 65% for contraband, 28% for cheap whites (see next footnote), and 7% for counterfeit.

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.[4] In addition to the direct loss of tax revenue, other ills such as violence and funding for terrorism may be associated with IRTC (Prieger & Kulick, 2014, 2015; Center for the Study of Democracy, 2015; OECD, 2015; U.S. Department of State, 2015).[5] 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).

The influence of taxes—and tax differentials with respect to other jurisdictions—on the variation in the extent and kind of IRTC is hotly disputed. How taxation affects IRTC is of more than academic interest; if cigarette tax-rate increases are determined, at least in part, by estimates of the anticipated decline in consumption due to higher prices, those estimates should account for the *actual* prices faced by consumers, which of course are composed in part by the lower prices of illicit cigarettes. While price differentials present a *potential* for profit from smuggling, the appeal of such tax evasion depends also on enforcement—the likelihood and consequences of being caught—and on other risks associated with criminal activity.

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 smuggling" and

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

[4] Counterfeit product is untaxed even if the consumer does not realize it, because some (but not all) counterfeit packs display counterfeit tax stamps and may be sold to unsuspecting consumers as licit product.

[5] A recent OECD (2015, ch.5) report contains excellent discussion of past and present documented links between illicit tobacco trade and financing of terrorism, and mentions that "[a]cademics have documented connections between cigarette smuggling in general and to specific terrorist organisations, such as AQIM, the Kosovo Liberation Army (KLA), PKK, RIRA and Hezbollah" (p.144).

nonprice influences (own or border corruption) are statistically insignificant. Others contend that prices matter little in determining the incidence of cigarette smuggling, particularly outside the United States. Merriman, Yurekli, and Chaloupka (2000), looking at cross-sectional data across countries, find that "cigarette taxes that increase cigarette prices are only one, and probably not the most important factor in cigarette smuggling. The perceived level of corruption statistically explains more of the variance in experts' estimates of cigarette smuggling than do cigarette prices" (p. 385).

Joossens and his coauthors have made the most vigorous claims that prices only minimally affect IRTC and that other factors are more important. For example, Joossens et al. (2009) write, "higher income countries, where cigarettes are more expensive, have lower levels of cigarette smuggling than lower income countries. Other factors, including the presence of informal distribution networks, organized crime, industry participation, and corruption, probably contribute more to cigarette smuggling than price levels" (p. 17). Joossens is one of the most highly visible commentators in the tobacco-control policy arena, and these arguments are widely cited.[6] 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. Experience in a broad range of circumstances is consistent with this expectation, from agricultural goods (Norton, 1988) to diesel fuel (Marion & Muehlegger, 2008). Indeed, Webber and Wildavsky (1986) observe that tax evasion has been with us for as long as there have been taxes. Given the importance of the public-policy issue and the frequent repetition of these assertions minimizing the role of taxes in stimulating IRTC, these intriguing claims warrant careful consideration.

In this paper we use a more complete set of panel data than the cross-sectional data used previously, to estimate the relative contributions of prices and other factors to the incidence of IRTC in

[6] 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).

countries of the European Union in recent years. We find that higher licit prices for cigarettes within a country indeed spur more illicit trade, whether measured by illicit market share or quantity. Raising taxes within a single country by one euro per pack, and holding other things equal, is estimated to increase illicit market share by no less than 50% and perhaps more than 100%. That means increasing the quantities of illicit cigarettes consumed by 25%–120%. The main findings are corroborated by a host of alternative econometric specifications and data on illicit trade.

II. Policy setting and literature review

Joossens and his coauthors point out that higher income countries (which tend to have higher taxes and so more expensive cigarettes) tend to have lower levels of smuggling than lower income countries. We identify several principal claims in this literature.

- Claim 1a: High cigarette prices are associated with low levels of IRTC.
- Claim 1b: Raising cigarette taxes does not tend to increase IRTC.

The quotation in the introduction from Joossens et al. (2009) is a typical example of Claim 1a. Elsewhere, Joossens et al. (2014) state that "our data show that illicit trade is not directly related to tobacco prices." Claim 1a follows from the analysis of cross-country data. These authors then use Claim 1a to imply or assert Claim 1b. The latter claim is either taken as self-evidently following from the former claim, or is part of a general dismissal of basic economics: "[C]igarette smuggling is not caused principally by 'market forces'; it is supply driven, and caused mainly by fraud through the illegal evasion of taxes" (Joossens & Raw, 2003). These claims are not unique to Joossens, but also appear in the tobacco-control literature more generally regarding countries outside the United States. For example, a study by Abdolahinia et al. (2013) concludes that "…raising tobacco prices does not lead to increase in amount [sic] of smuggling" in Iran and another by Ajmal and U (2015, p. 116) finds that "tax increases …

have had a minimal impact on encouraging the use and procurement of illicit tobacco" in New Zealand. The studies that reach such conclusions tend to have inadequate controls for other factors, as we demonstrate below. We show that market forces in fact work exactly as predicted by microeconomic theory, after holding other things equal: the fraud and tax evasion occurs because greater price differentials between licit and illicit cigarettes cause some consumers to substitute toward the cheaper product.

In other places in this literature, Claim 1b is softened; there the claim is that, while raising prices might theoretically increase IRTC, other factors predominate:

- Claim 2: Corruption in a country is a more important determinant of IRTC than are taxes.

For example, in Joossens et al. (2000, p .398): "Tax and price differentials among countries are not the only determinants of this type of smuggling, and may not be the most important…. Other factors that make large-scale cigarette smuggling more likely include corruption, public tolerance, informal distribution networks, widespread street-selling, and the presence of organized crime."[7] This formulation treats distribution networks, street-selling, and organized crime as exogenous factors instead of as endogenous reactions to the opportunities for profit created by the price differentials.

Another argument in the tobacco-control literature is:

- Claim 3: Examining IRTC in levels instead of as a share of total cigarette trade would lead to opposite conclusions about the impact of taxes on IRTC.

[7] See also Joossens et al. (2009, p.2): "Other factors, including the presence of informal distribution networks, organized crime, industry participation, and corruption, probably contribute more to cigarette smuggling than price levels."

This point has been made by Stoklosa (2015), who asserts that focusing on illicit-cigarette market share is "the tobacco industry's misleading math trick." The argument is that 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. Note that, for European cigarette markets, the basic patterns in illicit market share seen in Figure 1 carry over to illicit volumes as well (Figure 2). Thus, at least for Europe, we expect to find—and indeed do find—similar results when we change our dependent variable from illicit market share to illicit volume (see section IV.B.4).

These claims are the focus of our analysis. We find support for Claim 1a but soundly reject the other claims. 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).[8] Our estimates are consistent with those results, but highlight that some potential tax revenue is lost to the illicit market.

In contrast to the tobacco-control literature, studies by economists generally find the expected positive relationship between taxes and illicit trade. 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; Saba et al., 1995; Galbraith & Kaiserman, 1997; Thursby & Thursby,

[8] Higher taxes increase revenue if cigarette demand is inelastic, which is well established in the literature (see Gallet and List (2003) and the studies cited therein).

2000; Stehr, 2005; Chiou & Muehlegger, 2008; Goel, 2008; Lovenheim, 2008; DeCicca, Kenkel, & Liu, 2013). In contrast, there is less work examining the multi-country European or worldwide markets, and much of the work is cross-sectional (Merriman, Yurekli, & Chaloupka, 2000; Yurekli & Sayginsoy, 2010). A recent review of the state of research regarding IRTC cites the econometric literature regarding the United States but, for Europe, references narrative and case studies only (van Walbeek et al, 2013). The present research helps fill this lacuna in the literature.

III. Data on the cigarette industry and smuggling

In this section we describe the data and summarize illicit trade, prices, taxes, and other market characteristics.

A. Sources and construction of the data

Countries included in the study are all those in the European Union except Cyprus, Luxembourg, and Malta, for which market data are unavailable. For countries joining the EU since 1999, only the years of membership are included (see Table 1 for a list of countries and years). Some calculations below involve prices in and distances to other countries outside the EU. Such related countries include all other countries in Europe for which market data were available (including Balkan countries, Turkey, and Russia).

Data for the study span 1999 to 2013 and come from a variety of sources. Industry statistics come mainly from Euromonitor International's Passport database, vintage June 2015. 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 (EPS)" (Euromonitor, 2014b, p.3). Euromonitor also provides a list of sources consulted while

developing each country's estimates.[9] Non-academic estimates of IRTC are sometimes attacked in the literature for being artificially high,[10] and Euromonitor's data on illicit tobacco have been questioned by some researchers (e.g., Blecher et al., 2015; van Walbeek & Shai, 2015), although usually not regarding Europe.[11] Despite this, after an extensive search for alternative data we concur with Stoklosa (2015) of the American Cancer Society, who states: "Although there are some concerns around the reliability of Euromonitor illicit trade data, no other comparable global data exist" (p. 1). 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).[12] We show below that the Euromonitor estimates of IRTC are highly correlated with data from an alternative source.

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[9] 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 (FAS)), five trade associations, eight publications from the trade press, 29 company sources, and five other sources. However, no one statistic in the data is linked to a particular source.

[10] In one of the few direct comparison of estimates from academic and industry sources, Stoklosa and Ross (2013) calculate that 15.6% of packs found in 2011 in Warsaw were not intended for the Polish market, compared to an industry estimate of 22.9% (the latter source was not Euromonitor). For comparison, the Euromonitor data estimate that 11.4% of cigarettes in Poland in 2011 were not duty-paid.

[11] 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. The main criticisms leveled against the Euromonitor data by tobacco-control advocates is that 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 below will remove any bias in the regression estimates caused by incorrect levels of the trends.

[12] 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).

Key variables from Euromonitor include the number of licit and illicit cigarettes traded in the retail market within each country, both in units of millions of sticks. Licit trade includes retail sales of duty-paid cigarettes, including legitimate sales for consumption in other countries, based on industry and governmental data. Illicit trade, measured with variable *IllicitQty*, includes all cigarettes for which duty has not been paid, and thus includes smuggled, gray-market,[13] and counterfeit cigarettes and any produced domestically for black-market sales.[14] Legitimate cross-border sales are excluded. From these two variables, our main dependent variable for the illicit trade share, *IllicitMktShare*, is calculated as the ratio of illicit retail-trade volume to total (licit plus illicit) retail-trade volume. To the extent that *IllicitMktShare* 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, it will not bias the coefficient estimates.

Other industry variables include prices and taxes. Average licit cigarette price, *CigPrice*, is calculated as the total industry retail value of licit trade in cigarettes (from Euromonitor) divided by total licit retail-trade volume. The prices, as with all monetary variables in the dataset, are deflated to reflect the real price in 2010 euros per stick.[15] Prices for illicit product are unavailable.[16] Total excise taxes on a

[13] 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.

[14] 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 *IllicitQty* for that country. Cheap whites are often smuggled abroad, in which case they are part of the smuggled product counting toward *IllicitQty* in the receiving country (Joossens & Raw, 2012).

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

per-cigarette basis are in variable *ExTax*, which is calculated from data on specific excise taxes per stick (variable *SpecTax*), ad valorem excise taxes as a percentage of retail sales price (variable *AVtax*), and cigarette prices.[17] Other tax-related variables are described in section IV.B.1 below.

Other variables are used to control for potentially confounding factors related to illicit trade and consumption. Corruption is measured in various ways in the literature. In our main estimations, we use variable *NotCorrupt*, a measure of control of corruption from the World Bank.[18] Higher values of this variable are associated with less corruption in a country. 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). Unlike some measures of corruption, this measure is suitable for use in panel data because it is comparable across time. The income level of a country is measured with Gross National Income from the World Bank, converted to real €1,000.[19] The names, definition, and sources of these and other variables to be introduced below are presented in Table 2.

B. Summary of the market

Summary statistics for the data are shown in Table 3. The illicit market share of cigarettes averages close to 10% and ranges in the EU over the years from virtually nil (0.4%, Italy in 2003) to over

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[16] Based on informal evidence, Transcrime (2015) assumes that illicit prices are two-thirds that of licit prices for comparable product.

[17] In the nomenclature of excise taxes, a *specific* 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.

[18] Data are from The Worldwide Governance Indicators, 2014 Update, available from govindicators.org. A complete description of the data and methodology is available from Kaufmann, Kraay, and Mastruzzi (2011). Data are unavailable for 1999 and 2000 and are linearly interpolated from the surrounding years for all countries.

[19] 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).

half the market (53.8%, Latvia in 2010). Countries with more than 20% illicit market share for at least some years are Bulgaria, Estonia, Hungary, Ireland, Latvia, Lithuania, Romania, and the UK (the latter only in 2000 and 2001). The countries with less than 5% illicit market share in at least half of the years are Denmark, Italy, Portugal, Spain, and Sweden. Prices average 18.6 euro cents per cigarette, and range from 5.6 euro cents in Latvia upon first joining the EU[20] to 46.4 euro cents in Ireland; prices are nearly as high in the UK. Excise taxes average about 11 euro cents; the same countries with the extreme prices have similarly extreme taxes. Corruption and income range widely across the EU. The Scandinavian countries, Finland, the Netherlands, and the UK have the highest values of *NotCorrupt* and *GNIpc*, while the Eastern European countries (particularly Bulgaria and Romania) have the lowest. Corruption and income 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.

As Joossens et al. (2009) and others rightly point out regarding Claim 1a, there is no obvious correlation between IRTC and taxes. Some countries have high prices and taxes and little illicit trade. To illustrate this point, prices and illicit market shares for EU countries in 2013 are plotted in Figure 3. 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. If anything, the relation between prices and IRTC appears to be mildly negative in the pooled data (at least for all but the highest prices), as the line of best fit for all observations shown in Figure 4 shows.

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 the impact be on IRTC? There are many confounding factors across countries and years, and those differences must be held constant

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

to isolate the impact of prices on IRTC. Many of the potentially confounding factors, such as corruption, resources devoted to law enforcement, attitudes toward participation in black markets, and income vary much more across countries than over time. To illustrate the basic idea behind the fixed-effects econometrics approach below, consider what the data in Figure 4 look like when the country-specific time-averages of prices and *IllicitMktShare* are removed. The remaining within-country variation in prices and IRTC is untainted by any confounding factor that varies among countries (but not over time). The positive correlation is obvious in Figure 5 for the demeaned variables. While Figure 4 shows that the *levels* of prices and IRTC have little obvious relationship, Figure 5 indicates clearly that increases in cigarette prices are associated with increases in IRTC. While our main story is evident in Figure 5, 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

The progression of this section is as follows. 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 omitted-variables bias. The impacts of corruption, national income, and IRTC-relevant factors such as prices in neighboring countries are also explored. 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 section C, the robustness of the conclusions is verified by exploring alternative measures of IRTC, prices, and taxes.

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, in this section 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: Figure 6 shows that most (93.1%) of the variation in real cigarette prices is explained by variation in taxes. The high correlation stems from the near one-to-one relationship between taxes and prices, as we document in the concluding section. (Whether taxes and prices affect IRTC differently is examined in section B.2 below.) The price regressor is in logs to reduce the impact of outliers due to the right-skewness of the distribution of prices in the sample.

The simplest possible estimation is a regression of IRTC share on the log of real cigarette prices. This regression, the results of which are labeled OLS 4.1 in Table 4, calculates the line of best fit through the scatterplot of the data in Figure 4. The line of best fit by the least-squares criterion, as shown in Figure 4, has a slope of –0.05 that is not statistically significantly different from zero (*p*-value = 0.19). If the same regression is run for the 2013 cross sectional data, the estimate is about the same (–0.07) and similarly insignificant. Such cross-sectional or pooled regressions provide empirical support for Claim 1a, although in much of the tobacco-control literature the claim is supported with less than systematic evidence (e.g., case studies or purely graphical expositions).

Claim 2, that corruption is a more important determinant of IRTC than are cigarette prices, is based on the observation that countries with less corruption and a stronger rule of law, such as the Scandinavian countries, have lower IRTC than more corrupt countries such as some of those in Eastern Europe (Merriman, Yurekli, and Chaloupka, 2000, Joossens et al., 2009). To formally investigate this

claim, the estimation OLS 4.2 in Table 4 adds regressor *NotCorrupt*. The coefficient on *NotCorrupt* is indeed negative and statistically significant while the price variable remains insignificant. Thus Claim 2. However, corruption is correlated with many other characteristics of the country that are omitted from the regression. In particular, *NotCorrupt* has 80% correlation with the country's income level, *GNIpc*, which may greatly affect the IRTC share. If so, then the coefficients for price and *NotCorrupt* in estimation OLS 4.2 suffer from omitted variable bias. To test this, *GNIpc* in levels and squares is added in estimation OLS 4.3. The impact of income on IRTC share is negative, as to be expected in illicit product is an inferior good: wealthier countries experience less IRTC.[21] More importantly, with income in the regression, the corruption variable loses significance and the impact of price on IRTC turns positive and significant. Regression OLS 4.3 provides evidence against Claims 1b and 2, even before correcting for the potential bias from unobserved differences among countries with panel regression or the potential endogeneity of prices. Despite the insignificance of the corruption measure, 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

Before turning to fixed-effects regressions, we also investigate factors in other countries that are 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. 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, as asserted in Claim 1b, then

[21] Globally, the impact of per capita income is U shaped, but the minimum of the U is far beyond the range of incomes in the sample, and so the marginal effect of income is negative across the sample.

after controlling for the domestic price, prices in and distances to other countries should have no effect (or only a negative impact) on the IRTC share.[22] 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. Variables such as distances to other countries do not vary over time, and so cannot be investigated once fixed effects are included in the model. Thus, these variables are explored in pooled estimations here.

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, Yurekli, & Chaloupka, 2000; Chiou & Muehlegger, 2008; Goel, 2008; Lovenheim, 2008). Rather than arbitrarily choosing one of the available measures, we computed many possible measures to show that the regression results are generally similar regardless of which measures are included. The variables explored here are:

1. *LowPrDistEU*: The distance (in 1000 km) to the closest EU country with lower cigarette prices.[23] EU countries are differentiated from other countries between this variable and the next because travel and transport of goods is easier within most of the EU, due to the lack of border control and free trade among states.[24] Transcrime (2015) states that

[22] Recall that IRTC measured here does not include legal nondomestic purchases (circumvention), so if lower prices in other countries spur addition legal circumvention, if anything more attractive conditions in the other countries would *decrease* the IRTC as a *share* of total legal sales.

[23] Distances for this and succeeding variables are calculated between the closest major cities (defined as having population greater than 500,000 or the largest in the country) in the pair of countries. *LowPrDistEU* is missing for the lowest-priced country within the EU each year. In all these variables, prices are always the real average price for the country and year as described above.

[24] Neither the free travel nor the free trade areas are the same as the EU country list, but there is a high degree of accord. The Schengen Area, in which there is no passport control, consists of 22 of the 28 EU members and Iceland,

the most frequent (but not the highest volume) illicit flows are characterized by geographic proximity. The top two such countries are Poland and the Netherlands.

2. *LowPrDistNonEU*: The distance (in 1000 km) to the closest country outside the EU with lower cigarette prices. For about half of the data, the closest such country is Switzerland, Bosnia-Herzegovina, or Algeria.
3. *CChubDist*: The distance (in 1000 km) to the closest major hub for contraband and counterfeit (CC) cigarettes in Europe, where the three such areas are Russia, Turkey, and the Northeast Criminal Hub of Lithuania, Estonia, Latvia, and the Russian exclave of Kaliningrad.[25] Transcrime (2015) finds that the highest volume of illicit cigarette flows originate mainly from outside the EU, often entering through these hubs.
4. *MaxPdiff*: The maximum difference in cigarette prices between the home country and contiguous countries (whether or not the other countries are in the EU). Contiguous countries are the easiest sources to access for bootlegging and casual smuggling. Cross-border prices have been found to be associated with cigarette smuggling by Baltagi and Levin (1986), Saba et al. (1995), Thursby and Thursby (2000), Stehr (2005), Chiou and Muehlegger (2008), and Goel (2008).

Liechtenstein, Norway, and Switzerland. The EU Customs Union, which requires free trade among members and a common external tariff, includes EU countries and Andorra, Monaco, San Marino, and Turkey.

[25] There are other areas of significant smuggling activity, for example in and through the Balkans, but the chosen three represent the outside-EU sources for most of the other areas. The product often reaches the Balkan countries from Turkey via Greece. Similarly, the significant smuggling routes through the Baltic states typically carry product produced in Kaliningrad and transferred via St. Petersburg in Russia to Estonia, Latvia and Lithuania. See Europol (2011) for details on the areas of criminal activity regarding cigarettes, from which we also take the term “Northeast Criminal Hub”. The only other significant source that report mentions is the UAE, but including UAE in the calculation of the variable *CChubDist* would not change the results because the other three areas are always closer.

5. *MinPratio*: The minimum over all contiguous countries of the ratio of the other country's price to the home country's price.
6. *MaxPdiffKM*: The maximum price difference per km between the home country and any other European country in the dataset (whether or not the other countries are in the EU).

If *IllicitMktShare* is a true measure of IRTC and Claim 1b is false, then in regressions we expect *LowPrDistEU*, *LowPrDistNonEU*, *CChubDist*, and *MinPratio* to have negative coefficients and *MaxPdiff* and *MaxPdiffKM* to have positive coefficients. The first regression results with these additional IRTC-relevant variables are in Table 5, where the new regressors are added singly to the regression specification from estimation OLS 4.3. The coefficients all have the expected sign, although some are significant only at the 10% level. Further investigation of *MaxPdiff* revealed nonlinearities in its marginal effect on IRTC, and so in regression OLS 5.5 it enters the specification with a three-part linear spline.[26] Up to its median in the sample (a real price difference of 0.074€/stick, or 1.48€/pack, in licit prices), *MaxPdiff* has a positive, significant marginal effect on IRTC share. Between the median and the 90th percentile (0.16€/stick, or 3.15€/pack) there is no significant effect of price differences in contiguous countries on IRTC share. Beyond the 90th percentile, the marginal effect of *MaxPdiff* again turns positive, with significance at the 10% level. Note also that the own-country price effect is highly significant and about the same magnitude in all these regressions as in OLS 4.3.

In the next set of regression results (Table 6), groups of other-country variables enter the regression at once. Since some of these variables are proxies for similar notions, it does not make sense

[26] The knots were place at the median and 90th percentiles based on visual inspection of the partial fit resulting from a Generalized Additive Model estimation with specification like OLS 4.3 with the addition of *MaxPdiff* entering flexibly.

to add all of them at once.[27] Only one variable pertaining to the distance to a source outside the EU for illicit product (*LowPrDistNonEU* or *CChubDist*) is used in any one regression. Similarly, only one of the variables comparing the home country's price with prices in its contiguous neighbors (*MaxPdiff* or *MinPratio*) enters any one specification. Examining all possible combinations among these choices yields the four regressions in Table 6. We show the results for all combinations of these variables to avoid the appearance of presenting only the strongest results. The most relevant statistic in Table 6, shown in the last row, is the *p*-value from the joint hypothesis test that the coefficients on all the included other-country variables are zero. This is our omnibus test of whether these variables that are expected to impact IRTC indeed do so. In two of the regressions, OLS 3.1 and OLS 3.3, the hypothesis that these other-country variables have no impact on IRTC is rejected at better than the 1% level. In the other two, rejection is at the 5% level. The results of all these estimations and tests support the conclusion that higher licit prices and price differentials with other locations lead to higher illicit market shares due to smuggling and bootlegging.

B. Fixed-effect panel regressions

The results from estimation OLS 4.3 show that higher cigarette prices are indeed correlated with higher IRTC shares after accounting for differences in income levels. However, that simple regression does not address directly whether raising cigarette prices (by increasing the taxes) will increase IRTC (Claim 1b). Pooled regression does not account for the many ways in which countries differ apart from the factors controlled for in the regression, and some of those differences must be held constant to isolate the impact of prices on IRTC. Fixed-effect panel regressions allow us to control for unobserved country-specific factors that would otherwise bias the estimation.

The fixed-effects model is:

[27] Although if we do, the *F*-test for their joint significance has a *p*-value of 0.004.

$$IllicitMktShare_{it} = \alpha_i + \beta' x_{it} + \varepsilon_{it}$$

where the vector *x* consists of observed regressors including *CigPrice*, and ε_{it} is an econometric error term representing idiosyncratic differences between the dependent variable and its mean conditional on the regressors. The fixed effect is α_i, which varies across countries *i* but not over time. The great advantage of fixed-effects regression is that *any* country-specific factor, even those that are unobserved to the econometrician, are absorbed into the fixed effect. This is important because if such an unobserved factor "matters" (in the sense that it is correlated with illicit market share) and is also correlated with prices, then leaving it out of a regression would cause bias in the estimate of the price coefficient. The inclusion of the fixed effect into the model solves this problem.

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 source of illicit supply are all examples. While each of these 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 country-level averages (i.e., the average over time within a country) on IRTC that would bias estimates from a cross-sectional or pooled regression.

1. Illicit market share and cigarette prices

Table 7 contains several regressions of the IRTC share on cigarette prices, all including country fixed effects. The first estimation, labeled FE 1, is identical to the specification of estimation OLS 1.3 but includes fixed effects. Correcting for omitted factors increases the magnitude of the price coefficient, which is significant at the 5% level. The coefficient of 0.164 in this linear-log regression means that a 10% increase in the real cigarette price is associated with an increased illicit market share of 1.64

percentage points. The implied average price elasticity of illicit market share is about 3.4.[28] There is no apparent impact of corruption, most likely because the income level is more important (as seen in estimation OLS 4.3) and because there is not a lot of variation in corruption within these countries over this period.[29]

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 on average generally rose across the EU after 2004, as shown in Figure 7.[30] The general trend for IRTC share (shown in the same figure) is upward during the entire period. If the latter is actually caused by factors other than rising prices, then the association between prices and IRTC may stem from spurious correlation of trending variables. Adding year fixed effects to control for such trends[31] (estimation FE 2 in Table 7) changes the size of the price coefficient only slightly, although the *p*-value drops to 0.06. The implied average price elasticity of illicit market share in the sample is 3.3— a sizeable effect.

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 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. The actual price faced by

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[28] The price elasticity gives the percentage increase in illicit market share (not the change in percentage points, note) associated with a one percent increase in price. The elasticity is calculated as the sample average of $\beta_{logprice}/Y_i$.

[29] The "between" standard deviation of *NotCorrupt* is 0.83, whereas the "within" s.d. is only 0.15.

[30] Average price in the EU fell between 2003 and 2004 due to the admittance of several Eastern European countries that had lower cigarette prices. The newly admitted countries were not required to immediately adhere to the EU minimums for tobacco excise taxes.

[31] Adding year fixed effects to the regression nonparametrically controls for trends, by effectively detrending the data by removing the yearly mean (across all countries) from each variable in the regression.

any one consumer in any single transaction will be unequal to the price variable used here.[32] Measurement error in a regressor leads to attenuation bias in its coefficient. Second, there may be unobserved factors varying by country and year that bias the price coefficient due to endogeneity. Because licit and illicit cigarettes are substitutes, an unobserved "shock" that increases demand for smuggled cigarettes may lower the equilibrium price of licit product. This would create an expected downward bias on the price coefficient. Third, it is theoretically possible (although not likely during the period examined)[33] that there is reverse causality between illicit trade and tax rates if, for example, the tobacco industry uses rising IRTC to successfully lobby for lower taxes. This would also create spurious negative correlation between IRTC and prices and therefore downward bias in a positive price coefficient. However, taxes generally rose or stayed level in each country in our sample (as demonstrated in the appendix, section A) and it appears unlikely that reverse causality could materially affect the results.[34]

To investigate endogeneity, we estimated a fixed-effects instrumental variables (IV) regression using general and excise tax instruments. The general tax instruments for cigarette prices employed here are *LaborTax*, the labor tax rate[35] and *VAT*, the value-added tax (VAT) as a fraction of retail sales price. Both of these may be expected to be positively correlated with the retail prices of all goods,

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[32] Assuming the data on revenue and quantities are accurate, the price variable will be correct on average but not in specific for any given transaction. Such aggregation bias potentially afflicts most market-level demand estimations in the literature.

[33] Joossens et al. (2000) state that Canada and Sweden reduced their taxes in the 1990s on tobacco products because of concern about increased smuggling. Canada is not in our dataset and the tax reduction in Sweden is from 1998, predating our sample.

[34] The appendix also shows that when the few countries that lower taxes are dropped from the estimation, little changes in the results.

[35] The variable is the total revenue from taxes on employed labor income as a percentage of GDP. Taxes included are those "susceptible of increasing the cost of labor" (TCU Eurostat, 2014, p.273).

including cigarettes, while remaining exogenous to illicit-demand shocks since neither is affected directly by changes in cigarette prices. 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, *ExTaxHypo*, is the 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, *SpecTax*) and an ad valorem component (*AVtax)*. Details of the calculation are in the appendix. *ExTaxHypo* 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. While this instrument has a strong claim to exogeneity, it may in fact be partly endogenous if the fixed component of cigarette taxes, *SpecTax,* is adjusted by the authorities in some fashion depending on actual price levels or if cigarette taxes are endogenously lowered in response to smuggling, which appears to be at most the rare exception across Europe (as shown in the appendix). For this reason, we perform IV regression both with and without instrument *ExTaxHypo*. When prices are in logs, this instrument is, too.

The three instruments *labortax*, *VATrate*, and log *ExTaxHypo* are positively correlated with log real cigarette prices (the correlation is 0.31, 0.16, and 0.74, resp.). In the first-stage regression of log prices on the instruments and the exogenous regressors, the coefficients for the instruments are all positive as expected (see Table 8). The instruments appear to be reasonably strong. The *F* statistic on the excluded instruments is 10.26 when only *labortax* and *VATrate* are included and 18.40 when *ExTaxHypo* is added. The advantage of having multiple instruments available is that overidentification tests can be performed on the exogeneity of the instruments. The Sargan-Hansen statistic has a *p*-value of 0.38 in the former regression and 0.57 in the latter, and so the tests fail to find any evidence that the instruments are invalid due to endogeneity.

The second-stage results are in Table 7, labeled IV 7.1 (when the instruments are *labortax* and *VATrate*) and IV 7.2 (when all three instruments are included). As expected, when the downward bias from endogeneity is removed, the price coefficient rises. Note, however, that the 95% confidence intervals on the price coefficients are wide enough to include the estimate from FE 7.2. The price coefficients of 0.371 to 0.386 imply that a 10% increase in cigarette prices (for example, due to tax increases) causes illicit market share to rise by about 3.7 to 3.9 percentage points. At the mean illicit share, that would be an increase from 10.0% of the market to 13.7–13.9%. Stated another way, the 10% increase in cigarette prices would lead to a 37 to 39% increase in illicit market share. The implied elasticity of illicit market share with respect to real cigarette prices is 7.4 to 8.0. These appear to be sizable effects.[36]

2. The separate impact of cigarette prices and taxes

In theory, consumers should not care about the components of the cigarette price, just the out-of-pocket total price. However, we now explore including taxes directly in the regression specifications for three reasons. First, the policy question has most directly to do with the impact of raising taxes. Second, some previous studies disaggregated the tax components of the price (e.g., Coats, 1995; Goolsbee, Lovenheim, & Slemrod, 2010). Finally, 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 in part 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.

[36] Due to limited availability of some of the instruments, the sample sizes in estimations IV 7.1 and 7.2 are lower than in the first two columns of Table 9. The increased price coefficients are not merely due to composition bias from the changed sample. If FE 7.2 is re-estimated using the IV samples, the price coefficients remain close to the original 0.162, at 0.176 and 0.215.

Since *CigPrice* = $P_{pre\text{-}excise\text{-}tax}$ + *ExTax*, a linear additive specification is appropriate for the regressions. Therefore we switch to using price and tax levels instead of logs. In estimation FE 9.1 (Table 9), we first re-run the specification from FE 7.2 but with the price in levels instead of logs. The coefficient is not directly comparable to those in the previous tables due to switching away from the linear-log specification, but it is highly significant as before. The price coefficient of 0.685 means that a one euro cent increase in the cigarette price per stick would lead to an expected increase of 0.69 percentage points in illicit market share. That is a sizeable effect: the implied average price elasticity of illicit market share in the sample is 2.74.

Separating the total price into its components yields estimation FE 9.2. The first regressor is the price including VAT but excluding ad valorem and specific excise taxes on tobacco, and the second regressor is the total excise tax per stick. The results show that if a distinction is to be made between tobacco-specific taxes and the rest of the price, then taxes are more important, both numerically and in terms of significance. An increase of 1 euro cent in the tax per stick is associated with a statistically significant increase of 1.3 percentage points in illicit market share. The implied tax elasticity of illicit market share is 2.9, which is similar to the total-price elasticities from FE 7.1 and 7.2. On the other hand, the non-tax part of the price has a smaller, insignificant coefficient, with an associated elasticity of 0.71. Instrumenting the price with the *labortax* and *VATrate* (estimation IV 9.1, also in Table 9) does not change the insignificance of the price coefficient, although it increases its size. When the tax variable is also treated as endogenous (estimation IV 9.2), results are similar.[37]

Switching from the linear-log specification in the previous section to the fully linear specification here increases the chance that outliers in prices or taxes unduly influence the estimates. To investigate

[37] Additional instruments used for the excise tax are *ExTaxHypo* and an index of fiscal freedom from various years of the Index of Economic Freedom published by the *Wall Street Journal* and the *Heritage Foundation* (see heritage.org/index/about). The latter variable takes lower values the higher the general tax burden in a country.

this possibility, the extra terms in a quadratic expansion in the tax and the rest of the price variables are added to estimation FE 9.3.[38] The results indicate that the average marginal effect of taxes is 1.71 (*p*-value = 0.02), compared to the linear coefficient of 1.41 from the otherwise comparable estimation FE 9.2; prices and taxes are still jointly significant (*p*-value = 0.02). Coefficients on the higher-order terms are not jointly significant (*p*-value = 0.43) and therefore do not appear to be necessary.

3. Impact of IRTC-relevant factors in other countries

The factors explored in section A.2 above, those involving price differentials and distances to other countries with lower prices, etc., exhibit most of their variation in the cross-section rather than the time series. For example, if the same other country has the lower price during the sample timeframe, then the variables for *LowPrDistEU* and *LowPrDistNonEU* will show no within-country variation. Variable *CChubDist* never varies within country. Thus these variables are less useful once fixed effects are added to the model, and even when they do vary over time the amount of variation is likely too small to estimate the coefficients precisely. Nevertheless, for the sake of completeness we repeat the estimations in Table 6 with the fixed-effects specification. The results (not shown) indicate that none of the additional variables have significant coefficients at the 5% level (although in two of the four regressions the other-country variables are jointly significant at that level).

4. 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. We turn now to Claim 3: is it the case that the results above are misleading, because higher prices merely shrink the denominator in the calculation

[38] Since log price was the original regressor, this procedure can be formally justified as a second-order expansion (using Taylor's Rule) of the function $\log p = \log(r + t)$, where *p* is the total price, *t* is the tax per stick, and *r* is the rest of the price.

of illicit share instead of actually increasing the volume of IRTC? To investigate, we repeat the estimations from Table 7 with the new dependent variable of illicit quantities instead of shares. In particular, the dependent variable is the log of *IllicitQty*, the quantity of illicit cigarette. 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.[39]

The results, shown in Table 10, demonstrate that the results above are not merely a "misleading math trick" or "sleight of hand" (to use the phrases of Stoklosa (2015)). First, note that the sign and significance levels of the price coefficients in the new estimations in Table 10 are the same as the corresponding regressions in Table 7. Also, note that the size of the impact is not small. The log-log specification implies that the price coefficients, which range from 0.75 to 2.5, are elasticities. 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. Robustness checks

This section contains several robustness checks to confirm the main conclusions of the previous estimations. First, weighted estimates are compared with the unweighted estimates above. Next, alternative measures of illicit trade are explored. Finally, various alternative regressors for prices and measures of corruption and the rule of law are employed. Out of the 16 additional estimations performed here, and several more in the appendix, only one fails to concur with our main findings that

[39] 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 10.1 and 10.2 and the significance levels are identical.

Claims 1b and 2 are false. In the single exception (noted below), the sign of the price coefficient is also against Claim 1b but a lack of strong instruments leads to its insignificance.

1. Weighted estimation

Some researchers use weighted least squares (WLS) to improve the efficiency of cross-country regressions. The difference between the unweighted and WLS estimates can then 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).[40] In estimation FE 11.1 in Table 11, estimation FE 7.2 is repeated using the number of persons of legal smoking age (data from Euromonitor) as weights. The results show that even though the price coefficient is a bit smaller than in FE 7.2, it has a higher significance level. Given the relatively small difference in price coefficients compared to the size of the standard errors, there is no strong evidence that WLS estimation is needed to correct bias in the unweighted estimations.

2. 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. Since 2006, the UK consulting firm KPMG LLP has estimated IRTC for the EU in its series of Project Star and Project Sun reports. The reports are funded by Philip Morris International, the largest producer of cigarettes in Europe (and the world).[41] Despite the fact that the KPMG estimates of illicit trade are used by the European Commission and national governments, their

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[40] 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.

[41] See Gilmore et al. (2014) for background on the litigation leading PMI to fund the reports for the EU. The earlier reports are not publicly available; we examined copies under arrangement from Altria Client Services. Data from the reports on the volume of contraband and counterfeit cigarettes consumed by country (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.

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, we do not rely on them for our main estimations, notwithstanding the fact that Transcrime (2015) states 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…."[42] However, these alternative data can be used to provide additional corroborating evidence for our main conclusions.

The new dependent variable is the share of counterfeit and contraband consumption out of total consumption, as for the variable *IllicitMktShare* used above.[43] The new variable is highly but not perfectly correlated (r = 0.78) with *IllicitMktShare* from the Euromonitor data, which shows that the latter data do not rely solely on data from the industry-funded Project Sun/Star. The estimations here employ price data from the KPMG reports as well, instead of the prices from Euromonitor.[44] The repetition of the main estimations (FE 7.2, IV 7.1, and IV 7.2) from Table 7 with the illicit market share and price data from KPMG yields the analogous estimations reported in Table 11. In estimations FE 11.2 and IV 11.1, the price coefficients are significant and even larger than in the similar estimations using the Euromonitor data. These results thus strengthen the conclusions found above. The price coefficient from IV 11.2, however, is positive but not significant, perhaps due to the lower strength of the instruments here (as shown by comparing the first-stage F statistics between the two tables).

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[42] Transcrime (2015) goes on to assert that estimates of IRTC independent from the tobacco industry are based on smaller samples, rely on surveys that have underreporting biases, and are not available annually.

[43] KPMG defines contraband as genuine branded cigarettes that have been bought in a low-tax country and which exceed legal border limits or were acquired without taxes for export purposes to be illegally resold in a higher priced market. Contraband includes small scale (bootlegging) and wholesale (organized crime) smuggling. Cheap whites are also included in estimates of contraband and counterfeit product.

[44] 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.

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 completely 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. Construction of the data and the analysis contains many steps, which are detailed in the appendix. The results, also in the appendix, provide further evidence that licit cigarette prices have sizeable and statistically significant positive impacts on illicit market share. The marginal effects of price on IRTC by this method are estimated to be somewhat larger than our main results above, although the appendix discusses why there may be some upward bias.

3. Alternative regressors

The European Commission collects data on cigarette prices and taxes that can be used as alternatives to the data from Euromonitor. Details on these data are in the appendix. Using this alternative source, the variable *CigPrice* and the instruments *VAT* and *ExTaxHypo* are reconstructed and employed in regressions similar to FE 7.2, IV 7.1, and IV 7.2. The results are in Table 12. In all estimations, the price coefficients are similar in magnitude and significance to the analogous estimations in Table 7, except that the coefficient has a higher level of significance in estimation FE 12.1 than in FE 7.2.

Finally, there are many other control variables that can be used in place of the particular measure of corruption employed above. Our conclusions, particularly those regarding Claim 2, should not rest only on one specific corruption measure. Accordingly, we repeat estimation OLS 4.3 with several other regressors in place of *NotCorrupt*. 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 for information on these variables.

The results, in Table 13, are virtually identical to OLS 4.3. Claim 2 is rejected in each regression, whether the alternative regressors are included singly or jointly (the latter in estimation OLS 13.6): none of the alternative measures are statistically significant, while the coefficient on price remains highly significant.[45] Furthermore, the size of the price coefficient is essentially the same as that found in estimation OLS 4.3, ranging only from 0.10 to 0.11. When two-way fixed-effects regressions similar to FE 7.2 are estimated with these alternatives to *NotCorrupt*, the results (see Table 14) again are in accord with Claim 2 and the price coefficient remains significant and changes little.

V. Policy discussion and conclusions

Table 15 summarizes the results of the various regressions. The elasticities are generally large, ranging from 3.3 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), indicating that IRTC is highly responsive to licit cigarette prices.[46] 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

[45] Results for the index on government effectiveness are not shown in the tables since they are nearly identical to those for the index on the rule of law.

[46] It is well known that the price elasticity for cigarette consumption is inelastic. The elasticity reported here, however, is a cross-price elasticity (from licit prices to illicit sales).

and O'Donnell (2001) for cigarette tax pass-through in European markets.[47] That price increase, coupled with the fitted models in Table 7 and Table 10, 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. For the market share, the estimated change due to the price increase for a country and year is

$$\Delta E(IllicitMktShare_{it}) = \beta_{LogCigPrice}\Delta LogCigPrice_{it}$$

and the average discrete change is

$$E_N(\Delta E(IllicitMktShare_{it})) = \beta_{LogCigPrice}E_N(\Delta LogCigPrice_{it})$$

where E_N denotes the (unweighted) empirical average operator. For the illicit quantity, the calculation is more involved since the dependent variable is in logs. Assuming the error term in the regressions for log quantity is normally distributed with variance σ_ε^2 conditional on the regressors, the estimated change in quantity from the price change is

$$\Delta E(IllicitQty_{it}) = \exp\left(\beta' x_{1it} + \frac{\sigma_\varepsilon^2}{2}\right) - \exp\left(\beta' x_{0it} + \frac{\sigma_\varepsilon^2}{2}\right)$$

where x_{1it} denotes the regressor vector after the price change and x_{0it} is before.[48] Since the only element of *x* that changes is the price, the expression on the right can be written

$$\Delta E(IllicitQty_{it}) = \exp\left(\beta' x_{0it} + \frac{\sigma_\varepsilon^2}{2}\right)\left[\exp\left(\beta_{LogCigPrice}\Delta LogCigPrice_{it}\right) - 1\right]$$

[47] These authors split their sample into a group comprising Belgium, Denmark, Germany, Ireland, Netherlands, and UK, which had ad valorem pass-through of 0.7 and specific-excise pass-through of 0.9, and a second group containing France, Greece, Italy, Luxembourg, Portugal, and Spain, which had ad valorem pass-through of 1.5 and specific-excise pass-through of 2.2. Our total excise pass-through estimate of 1.1 lies within these bounds, as would be expected due to averaging across countries and tax types.

[48] The expression follows from the formula for the mean of a lognormally distributed random variable.

Again, the average discrete change is calculated as the empirical average of the above expression. Asymptotic standard errors for these estimates are calculated via the delta method.

The price increase is associated with an expected 5 percentage points of illicit market share from the fixed-effects regression (see the first two rows of Table 15). This is a large increase when compared to the average illicit share of 10.1% in the sample. If the IV regression estimates are used instead for the calculations, the implied impact is between 11 and 12 percentage points. The price increase is estimated from the fixed-effects regressions to lead to additional illicit sales of between 620 and 647 million cigarettes within a country and year; the IV estimates are an additional 2.4 to 3.0 billion sticks. Again, these are large impacts compared to the average illicit volume of 2.5 billion sticks—increases of 25% to 120% 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. The role of prices in stimulating IRTC is far more empirically important than that of corruption, 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.

How can it be that Claim 1a is true but Claim 1b is false? Such "sign reversal" of a coefficient is familiar to researchers working with panel data in which unobserved unit-specific factors are likely to cause severe bias. The present data exhibit the well-known Simpson's Paradox: a trend that appears in different groups of data can disappear or be reversed in the aggregate. The latter is Claim 1a; the former is Claim 1b. There is no actual paradox, once the distinction between causality and mere correlation is made (Pearl, 2009, ch. 6).

This analysis addresses only one consideration in determining how cigarettes should be taxed. 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 accompany taxation. Policymakers need not (and should not) leave enforcement and other activity designed to further compliance unchanged if they intend to increase taxes. 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 or lowering prices to harmonize them across the EU would not necessarily lead to similar changes in illicit activity. 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.

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Tables

Table 1: Countries and years included in the data

Country	First year	Last year
Austria	1999	2013
Belgium	1999	2013
Bulgaria	2007	2013
Croatia	2013	2013
Czech Republic	2004	2013
Denmark	1999	2013
Estonia	2004	2013
Finland	2000	2013
France	1999	2013
Germany	1999	2013
Greece	1999	2013
Hungary	2004	2013
Ireland	1999	2013
Italy	1999	2013
Latvia	2004	2013
Lithuania	2004	2013
Netherlands	1999	2013
Poland	2004	2013
Portugal	1999	2013
Romania	2007	2013
Slovakia	2004	2013
Slovenia	2004	2013
Spain	1999	2013
Sweden	2000	2013
United Kingdom	1999	2013

Note: not all years appear in all estimation, due to missing values of regressors or (in the case of Croatia) the inclusion of fixed effects.

Table 2: Variables and definitions

Variable Name	Definition	Source
IllicitMktShare	illicit market share	EM
IllicitQty	illicit cigarette quantity (M sticks)	EM
CigPrice	cigarette price per stick, calculated as average revenue	EM
PriceLessTax	cigarette price per stick, not including excise tax	EM
ExTaxHypo	hypothetical excise tax	EM
LaborTax	total revenue from taxes on employed labor income as a percentage of GDP	TCU Eurostat (2014)
FiscalFreedom	index of fiscal freedom from the Index of Economic Freedom	Heritage Foundation
VAT	general VAT as a percentage of retail sales price	EM
SpecTax	specific excise tax per stick	EM
AVtax	ad valorem excise tax rate on cigarettes, as a percentage of retail sales price	EM
ExTax	excise tax on cigarettes per stick (does not include VAT)	EM
LowPrDistEU	the distance (in 1000 km) to the closest EU country with a lower cigarette price.	Authors' calculations
LowPrDistNonEU	the distance (in 1000 km) to the closest country outside the EU with a lower real average cigarette price	Authors' calculations
CChubDist	The distance (in 1000 km) to the closest major hub for contraband and counterfeit cigarettes in Europe: Russia, Turkey, or the Northeast Criminal Hub of Lithuania, Estonia, Latvia, and the Russian exclave of Kaliningrad	Authors' calculations
MaxPdiff	the maximum difference in cigarette prices between the home country and contiguous countries	Authors' calculations
MinPratio	the minimum over all contiguous countries of the ratio of the other country's price to the home country's price	Authors' calculations
MaxPdiffKM	the maximum price difference per km between the home country and any other country included in the dataset	Authors' calculations
GNIpc	gross national income (GNI; Atlas method) per capita (€1,000)	World Bank WGI
NotCorrupt	control of corruption, an index measuring "perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as 'capture' of the state by elites and private interests" (the index ranges from -2.5 [weak governance] to 2.5 [strong governance]).	World Bank WGI

Note: all monetary amounts are converted to real 2010 euros.

Table 3: Summary statistics

Variable	Obs	Mean	S.d.	Min	Max
IllicitMktShare	302	0.101	0.091	0.004	0.538
IllicitQty	302	2,524.4	2,827.5	5.000	14,828.0
Log(IllicitQty)	302	7.171	1.263	4.043	9.604
CigPrice	302	0.186	0.084	0.056	0.464
Log(CigPrice)	302	-1.778	0.435	-2.882	-0.768
PriceLessTax	262	0.075	0.034	0.006	0.196
ExTaxHypo	262	0.075	0.042	0.019	0.233
LaborTax	266	16.767	4.202	9.031	26.893
FiscalFreedom	302	59.917	16.367	29.000	9.000
VAT	288	16.963	1.679	1.000	21.000
SpecTax	262	0.050	0.048	0.004	0.227
AVtax	263	33.165	15.109	0.000	6.000
ExTax	302	0.109	0.054	0.017	0.284
LowPrDistEU	287	0.479	0.537	0.065	3.610
LowPrDistNonEU	302	0.587	0.372	0.065	2.450
CChubDist	302	1.130	0.779	0.088	3.270
MaxPdiff	301	0.070	0.063	-0.094	0.243
MinPratio	301	0.589	0.325	0.109	1.376
MaxPdiffKM	302	0.000	0.000	0.000	0.002
GNIpc	302	22.792	11.482	1.719	47.120
NotCorrupt	302	1.182	0.832	-0.304	2.586

Data cover years 1999 to 2013; some years are unavailable for some variables.

Table 4: Pooled OLS regressions of IRTC share on cigarette prices

	OLS 4.1	**OLS 4.2**	**OLS 4.3**
Y = illicit market share	Coefficient (s.e.)	Coefficient (s.e.)	Coefficient (s.e.)
Log(real cigarette price)	-0.050	-0.002	0.098
	(0.037)	(0.039)	(0.032)***
Freedom from Corruption (WGI)		-0.039	-0.007
		(0.019)**	(0.015)
Income (GNI) per capita (€1,000)			-0.019
			(0.005)***
GNI per capita squared			0.000
			(0.000)***
constant	0.012	0.144	0.534
	(0.065)	(0.086)	(0.109)***
F statistic	1.80	2.97	5.44
R^2	0.057	0.133	0.332
Adjusted R^2	0.054	0.127	0.323
N	302	302	302

* $p<0.1$; ** $p<0.05$; *** $p<0.01$; SE's (in parentheses) account for clustering by country.

Table 5: Pooled OLS regressions of IRTC share on other-country IRTC-relevant variables

	OLS 5.1	**OLS 5.2**	**OLS 5.3**	**OLS 5.4**	**OLS 5.5**	**OLS 5.6**	**OLS 5.7**
Y = illicit market share	Coef. (s.e.)	Coef. (s.e.)	Coef. (s.e.)	Coef. (s.e.)	Coef. (s.e.)	Coef. (s.e.)	Coef. (s.e.)
Log(real cigarette price)	0.091	0.115	0.115	0.080	0.081	0.095	0.097
	(0.032)***	(0.031)***	(0.034)***	(0.029)**	(0.029)**	(0.030)***	(0.028)***
Distance to closest EU country with lower price	-0.035						
	(0.011)***						
Distance to closest non-EU country with lower price		-0.043					
		(0.023)*					
Distance to closest smuggling area			-0.025				
			(0.012)*				
Max. price difference with contiguous countries (X_1)				0.258			
				(0.137)*			
Max. price difference (X_1) below its median					0.586		
					(0.277)**		
Max. price diff. (X_1) between its median and 90th percentile					-0.368		
					(0.493)		
Max. price diff. (X_1) above its 90th percentile					0.802		
					(0.435)*		
Minimum ratio: other contiguous country price ÷ own price						-0.056	
						(0.032)*	
Max. price difference/KM							66.682
							(27.686)**
Freedom from Corruption (WGI)	0.003	-0.006	-0.010	-0.010	0.000	-0.008	-0.020
	(0.013)	(0.014)	(0.015)	(0.016)	(0.019)	(0.015)	(0.017)
Income (GNI) per capita (€1,000)	-0.020	-0.021	-0.017	-0.018	-0.018	-0.018	-0.020
	(0.005)***	(0.005)***	(0.005)***	(0.005)***	(0.005)***	(0.005)***	(0.004)***
GNI per capita squared	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
constant	0.547	5.66	0.581	0.470	0.456	0.538	0.528
	(0.115)***	0.352	(0.118)***	(0.101)***	(0.106)***	(0.106)***	(0.093)***
F	4.15	0.341	4.54	4.50	8.66	4.52	6.25
R^2	0.375		0.368	0.361	0.377	0.367	0.377
Adjusted R^2	0.364		0.357	0.350	0.362	0.356	0.366
N	287	302	302	301	301	301	302

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

Table 6: Additional Pooled OLS regressions of IRTC share on other-country IRTC-relevant variables

	OLS 3.1	**OLS 3.2**	**OLS 3.3**	**OLS 3.4**
Y = illicit market share	Coefficient (s.e.)	Coefficient (s.e.)	Coefficient (s.e.)	Coefficient (s.e.)
Log(real cigarette price)	0.079	0.084	0.100	0.101
	(0.043)*	(0.040)**	(0.023)***	(0.027)***
Distance to closest EU country with	-0.031	-0.034	-0.030	-0.035
lower price	(0.012)**	(0.011)***	(0.013)**	(0.011)***
Distance to closest non-EU country with	0.014	0.017		
lower price	(0.050)	(0.048)		
Distance to closest smuggling area			-0.015	-0.011
			(0.014)	(0.016)
Max. price difference with contiguous	0.131		0.022	
countries (X_1) below its median	(0.282)		(0.333)	
Max. price diff. (X_1) between its	-0.330		-0.519	
median and 90th percentile	(0.550)		(0.480)	
Max. price diff. (X_1) above its	0.753		0.981	
90th percentile	(0.431)*		(0.421)**	
Minimum ratio: other contiguous country's		-0.004		0.020
price ÷ home country price		(0.046)		(0.042)
Maximum price difference/KM	73.389	71.191	65.407	64.642
	(30.507)**	(35.014)*	(31.829)*	(36.316)*
Freedom from Corruption (WGI)	-0.011	-0.013	-0.011	-0.013
	(0.020)	(0.017)	(0.019)	(0.016)
Income (GNI) per capita (€1,000)	-0.020	-0.020	-0.019	-0.021
	(0.005)***	(0.005)***	(0.005)***	(0.004)***
GNI per capita squared	0.000	0.000	0.000	0.000
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
_cons	0.495	0.518	0.564	0.567
	(0.140)***	(0.125)***	(0.106)***	(0.106)***
F (all regressors)	5.76	3.33	6.40	3.68
R^2	0.426	0.418	0.432	0.420
Adjusted R^2	0.405	0.401	0.411	0.403
N	287	287	287	287
P-value for H_0: all other-country coefficients are zero	0.0050	0.0302	0.0022	0.0189

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

Table 7: Fixed-effects panel regressions of IRTC share on cigarette prices

Y = illicit market share	**FE 7.1**	**FE 7.2**	**IV 7.1**	**IV 7.2**
Log(real cigarette price)	0.164	0.162	0.386	0.371
	(0.061)**	(0.083)*	(0.140)***	(0.143)***
Freedom from Corruption (WGI)	0.022	0.010	-0.014	-0.002
	(0.028)	(0.041)	(0.052)	(0.044)
Income (GNI) per capita (€1,000)	0.001	0.006	-0.009	-0.007
	(0.002)	(0.004)	(0.009)	(0.009)
GNI per capita squared	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Country fixed effects	Y	Y	Y	Y
Year fixed effects	N	Y	Y	Y
Weighted estimation	N	N	N	N
1st stage *F* statistic on excluded instruments			10.26	20.13
Sargan-Hansen statistic (*p*-value)			0.381	0.597
N	302	302	263	238

* $p<0.1$; ** $p<0.05$; *** $p<0.01$; SE's (in parentheses) account for clustering by country.

Note: In estimation IV 7.1, the instruments for price are *LaborTax* and *VAT* as described in the text; in IV 7.2 instrument *ExTaxHypo* is also used.

Table 8: First-stage regressions for the IV regressions of IRTC share on cigarette prices

Y = Log(real cigarette price)	IV 7.1, 1st stage	IV 7.2, 1st stage
VAT	0.053	0.039
	(0.014)***	(0.011)***
LaborTax	0.025	0.037
	(0.015)	(0.013)***
ExTaxHypo		0.326
		(0.059)***
Freedom from Corruption (WGI)	-0.014	-0.002
	(0.052)	(0.044)
Income (GNI) per capita (€1,000)	-0.009	-0.007
	(0.009)	(0.009)
GNI per capita squared	-0.000	-0.000
	(0.000)	(0.000)
N	263	238

* $p<0.1$; ** $p<0.05$; *** $p<0.01$; SE's (in parentheses) account for clustering by country.

Note: Both estimations include country and year fixed effects.

Table 9: Fixed-effects panel regressions of IRTC share on cigarette prices and taxes

Y = illicit market share	FE 9.1	FE 9.2	IV 9.1	IV 9.2	FE 9.3
Real cigarette price, including tax	0.685				
	(0.242)***				
Real cigarette price, not including excise tax		0.467	1.022	1.287	0.140
		(0.412)	(0.952)	(0.814)	(0.882)
Real excise tax per stick		1.342	1.159	1.212	2.134
		(0.491)**	(0.547)**	(0.589)**	(1.871)
Freedom from Corruption (WGI)	0.017	0.021	0.028	0.025	0.023
	(0.029)	(0.024)	(0.031)	(0.032)	(0.026)
Income (GNI) per capita (€1,000)	0.011	0.007	0.009	0.009	0.008
	(0.008)	(0.008)	(0.007)	(0.008)	(0.007)
GNI per capita squared	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Real cigarette price, not including excise tax, squared					-11.582
					(11.594)
Real excise tax per stick, squared					-8.285
					(10.798)
(Cigarette price w/o excise tax)×(excise tax per stick)					17.725
					(17.958)
Joint test of all price & tax coefficients (*p*-value)					0.0273
Joint test of price & tax higher-order coefficients (*p*-value)					0.6840
Country fixed effects	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y
N	302	262	238	238	262

* $p<0.1$; ** $p<0.05$; *** $p<0.01$; SE's (in parentheses) account for clustering by country.

Note: In estimation IV 9.1, the instruments for price are *LaborTax* and *VAT* as described in the text; in IV 9.2 the tax is also treated as endogenous and instruments *ExTaxHypo* and *FiscalFreedom* are also used.

Table 10: Fixed-effects panel regressions of IRTC quantities on cigarette prices

Y = log illicit cigarette qty	**FE 10.1**	**FE 10.2**	**IV 10.1**	**IV 10.2**
Log(real cigarette price)	0.780	0.752	2.538	2.214
	(0.325)**	(0.405)*	(0.930)***	(0.636)***
Freedom from Corruption (WGI)	0.067	-0.046	-0.279	-0.287
	(0.251)	(0.368)	(0.473)	(0.376)
Income (GNI) per capita (€1,000)	0.044	0.095	-0.016	0.017
	(0.026)	(0.047)*	(0.073)	(0.072)
GNI per capita squared	-0.001	-0.001	0.000	-0.000
	(0.000)	(0.001)*	(0.001)	(0.001)
Country fixed effects	Y	Y	Y	Y
Year fixed effects	N	Y	Y	Y
N	302	302	263	238

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

Note: In estimation IV 10.1, the instruments for price are *LaborTax* and *VAT* as described in the text; in IV 10.2 instrument *ExTaxHypo* is also used.

Table 11: Fixed-effects panel regressions of IRTC share on cigarette prices (WLS and alternative dependent variable)

Y = illicit market share	**FE 11.1**	**FE 11.2**	**IV 11.1**	**IV 11.2**
Source for dependent variable:	Euromonitor	KPMG	KPMG	KPMG
Log(real cigarette price)	0.120	0.216	0.478	0.257
	(0.027)***	(0.104)**	(0.205)**	(0.176)
Freedom from Corruption (WGI)	-0.005	-0.003	-0.041	-0.009
	(0.029)	(0.037)	(0.056)	(0.045)
Income (GNI) per capita (€1,000)	0.008	-0.000	-0.010	-0.002
	(0.004)**	(0.010)	(0.014)	(0.011)
GNI per capita squared	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Weighted least squares estimation	Y	N	N	N
1st stage *F* statistic on excluded instruments			4.23	10.1
Sargan-Hansen statistic (*p*-value)			0.274	0.150
N	302	166	166	166

* $p<0.1$; ** $p<0.05$; *** $p<0.01$; SE's (in parentheses) account for clustering by country.

Note: In estimation FE 11.1, the observations are weighted with the legal smoking population. In estimation IV 11.1, the instruments for price are *LaborTax* and *VAT* as described in the text; in IV 11.2 instrument *ExTaxHypo* is also used. All estimations include country and year fixed effects.

Table 12: Fixed-effects panel regressions of IRTC share on cigarette prices (alternative price and tax data from the European Commission)

Y = illicit market share	FE 12.1	IV 12.1	IV 12.2
Log(real cigarette price)	0.187	0.403	0.348
	(0.087)**	(0.123)***	(0.108)***
Freedom from Corruption (WGI)	0.026	0.015	0.021
	(0.040)	(0.053)	(0.048)
Income (GNI) per capita (€1,000)	0.001	-0.015	-0.011
	(0.005)	(0.010)	(0.008)
GNI per capita squared	-0.000	-0.000	-0.000
	(0.000)	(0.000)*	(0.000)
1st stage *F* statistic on excluded instruments		7.37	19.39
Sargan-Hansen statistic (*p*-value)		0.242	0.332
N	303	266	266

* $p<0.1$; ** $p<0.05$; *** $p<0.01$; SE's (in parentheses) account for clustering by country.

Note: Data from the European Commission for price and taxes are used in these estimations. In estimation IV 12.1, the instruments for price are *LaborTax* and *VAT* as described in the text; in IV 12.2 instrument *ExTaxHypo* is also used. All estimations include country and year fixed effects.

Table 13: Pooled OLS regressions of IRTC share on cigarette prices (alternative corruption and rule of law regressors)

	OLS 13.1	OLS 13.2	OLS 13.3	OLS 13.4	OLS 13.5	OLS 13.6
Y = illicit market share	Coef. (se)	Coef. (se)	Coef. (se)	Coef. (se)	Coef. (se)	Coef. (se)
Log(real cigarette price)	0.099 (0.039)**	0.099 (0.030)***	0.098 (0.030)***	0.108 (0.036)***	0.114 (0.035)***	0.112 (0.040)***
Corruption Perceptions Index (TPI)	0.000 (0.001)					-0.001 (0.001)
Corruption Rank (TPI)		-0.073 (0.080)				0.073 (0.169)
Rule of Law (WGI)			0.024 (0.019)			0.084 (0.053)
Police per 100,000 people				-2.47E-05 (8.47E-05)	-2.15E-04 (2.29E-04)	6.54E-05 (1.22E-04)
Income (GNI) per capita (€1,000)	-0.017 (0.005)***	-0.021 (0.004)***	-0.021 (0.004)***	-0.022 (0.005)***	-0.022 (0.004)***	-0.022 (0.005)***
GNI per capita squared	0.000 (0.000)**	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***
constant	0.515 (0.133)***	0.566 (0.113)***	0.532 (0.100)***	0.572 (0.115)***	0.589 (0.114)***	-0.022 (0.005)***
Year fixed effects	Y	N	N	N	N	Y
F statistic	2.96	5.98	6.53	6.52	6.39	25.12
R^2	0.383	0.335	0.338	0.365	0.377	0.455
Adjusted R^2	0.344	0.326	0.330	0.355	0.367	0.410
N	302	302	302	263	249	263

* $p<0.1$; ** $p<0.05$; *** $p<0.01$; SE's (in parentheses) account for clustering by country.

Table 14: Fixed-effects panel regressions of IRTC share on cigarette prices (alternative corruption and rule of law regressors)

	FE 14.1	FE 14.2	FE 14.3	FE 14.4	FE 14.5	FE 14.6
Y = illicit market share	Coef. (se)	Coef. (se)	Coef. (se)	Coef. (se)	Coef. (se)	Coef. (se)
Log(real cigarette price)	0.164 (0.078)**	0.185 (0.083)**	0.162 (0.076)**	0.209 (0.086)**	0.212 (0.086)**	0.210 (0.087)**
Corruption Perceptions Index (TPI)	-0.001 (0.001)					-0.000 (0.001)
Corruption Rank (TPI)		0.203 (0.132)				0.152 (0.164)
Rule of Law (WGI)			0.024 (0.055)			0.086 (0.051)
Police per 100,000 people				-2.07E-04 (2.21E-04)	-2.05E-04 (2.04E-04)	-2.01E-04 (2.06E-04)
Income (GNI) per capita (€1,000)	0.006 (0.004)	0.008 (0.005)	0.006 (0.005)	0.000 (0.006)	-0.001 (0.006)	0.002 (0.006)
GNI per capita squared	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
F statistic	10.81	5.43	6.45	3.55	3.09	3.17
R^2 (within)	0.311	0.322	0.309	0.359	0.344	0.377
Adjusted R^2 (within)	0.267	0.279	0.265	0.314	0.296	0.326
N	302	302	302	263	249	263

* $p<0.1$; ** $p<0.05$; *** $p<0.01$; SE's (in parentheses) account for clustering by country.

Note: All estimations include country and year fixed effects.

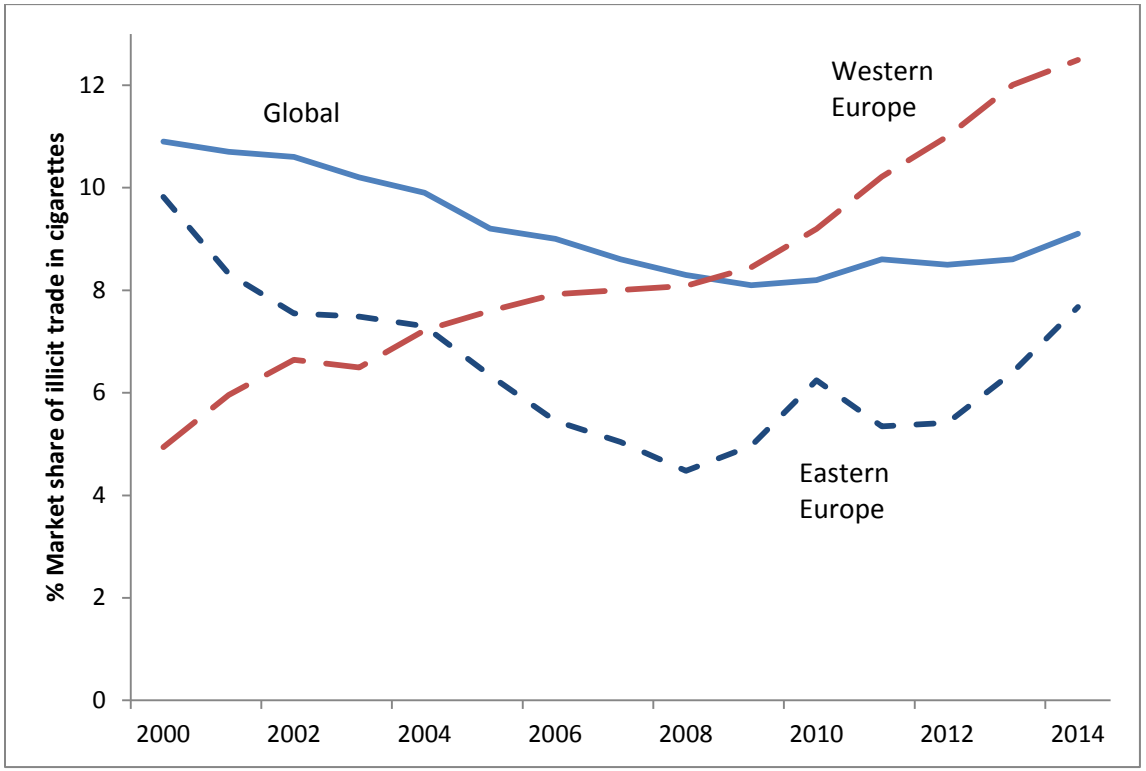
Table 15 Estimated impact of a 1€/pack tax increase

	Illicit share	**Price Coefficient**	**Elasticity**		**Increase in illicit share**	
Estimation	*Average in sample*	*Significance level*	*Point estimate (average in sample)*	*95% confidence interval*	*Point estimate (average in sample)*	*95% confidence interval*
FE 7.1	0.101	**	3.38	[0.77, 6.00]	0.050	[0.011, 0.089]
FE 7.2	0.101	*	3.33	[-0.21, 6.87]	0.049	[-0.003, 0.102]
IV 7.1	0.101	***	8.04	[2.32, 13.77]	0.118	[0.034, 0.202]
IV 7.2	0.101	***	7.38	[1.82, 12.93]	0.114	[0.028, 0.199]
	Illicit quantity				**Increase in illicit quantity**	
FE 10.1	2,524.4	**	0.78	[0.11, 1.45]	646.6	[44.2, 1249.0]
FE 10.2	2,524.4	*	0.75	[-.08, 1.59]	620.2	[-123.9, 1364.2]
IV 10.1	2,524.4	***	2.54	[0.72, 4.36]	2,977.0	[-316.9, 6270.8]
IV 10.2	2,524.4	***	2.21	[0.97, 3.46]	2,425.3	[434.0, 4416.6]

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

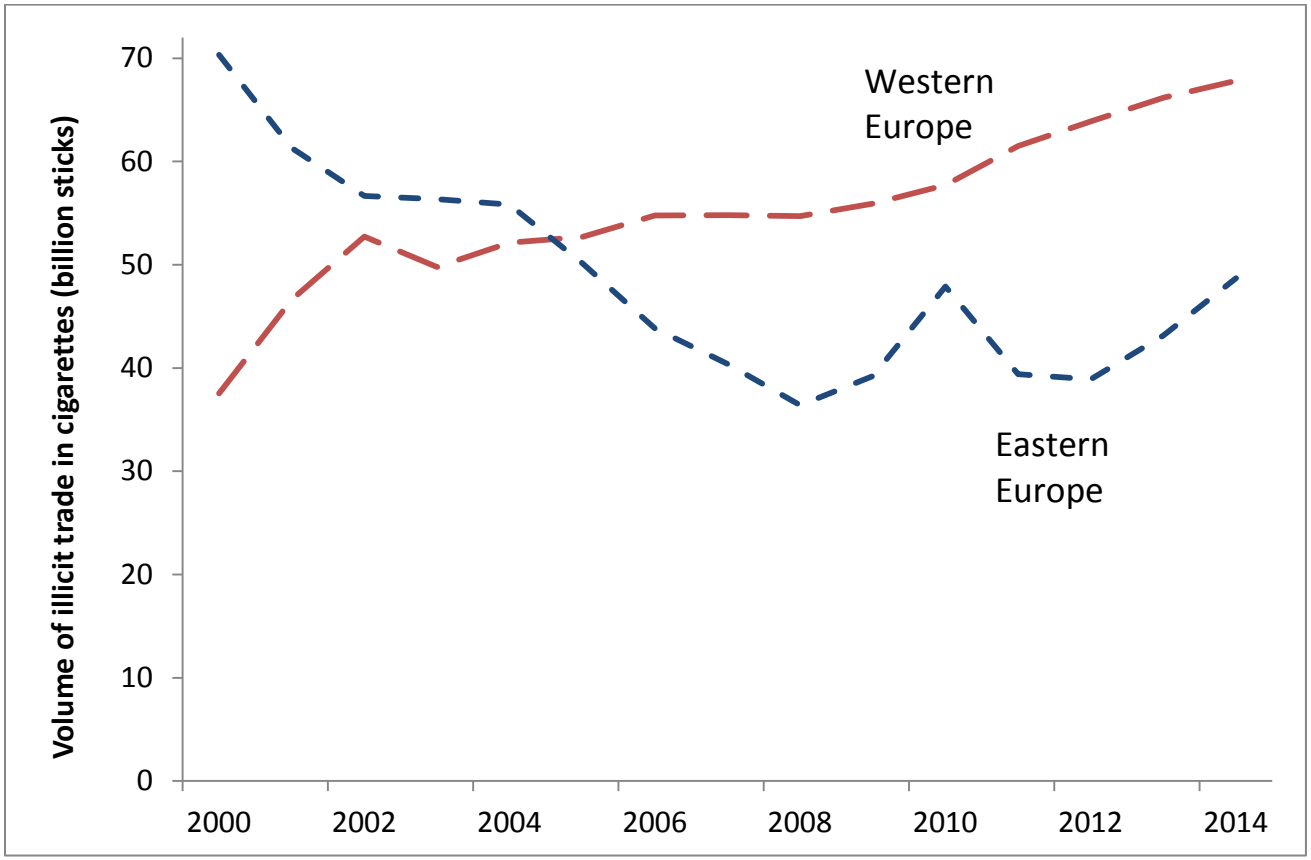
Figures

Figure 1. Estimated market share of illicit trade in cigarettes



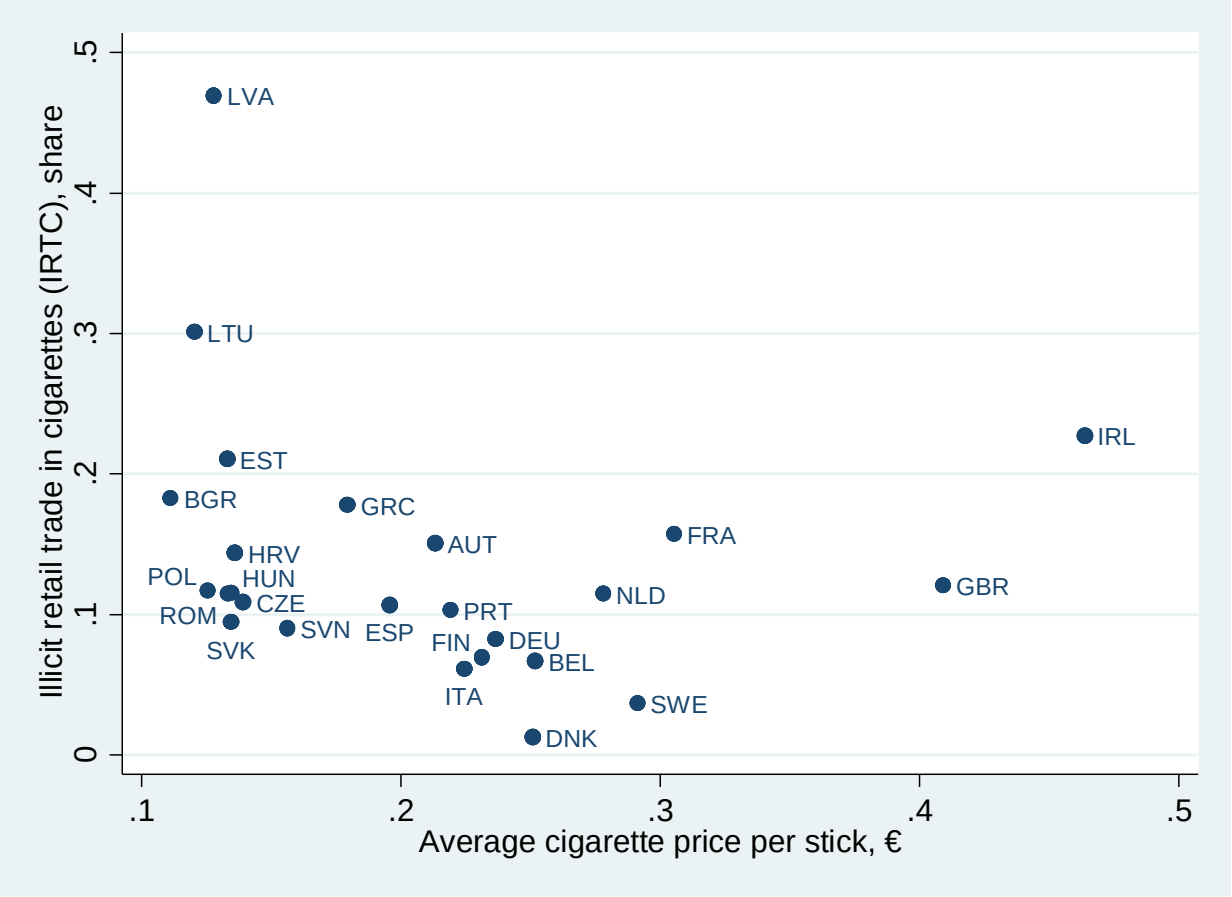
Notes: Data from Euromonitor. Market share is in terms of quantities of cigarettes.

Figure 2. Estimated volume of illicit European trade in cigarettes



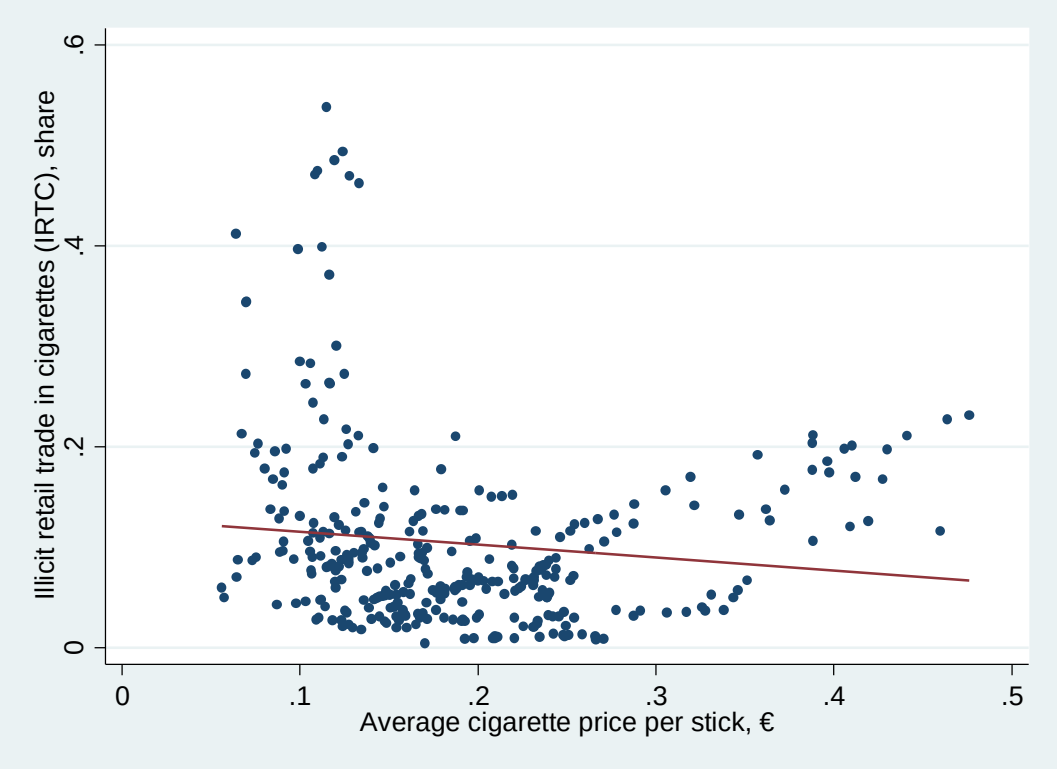
Notes: Data from Euromonitor. Western Europe includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, and the United Kingdom; Eastern Europe includes Belarus, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Latvia, Lithuania, Macedonia, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, and Ukraine.

Figure 3: Cigarette prices and IRTC shares in the EU, 2013



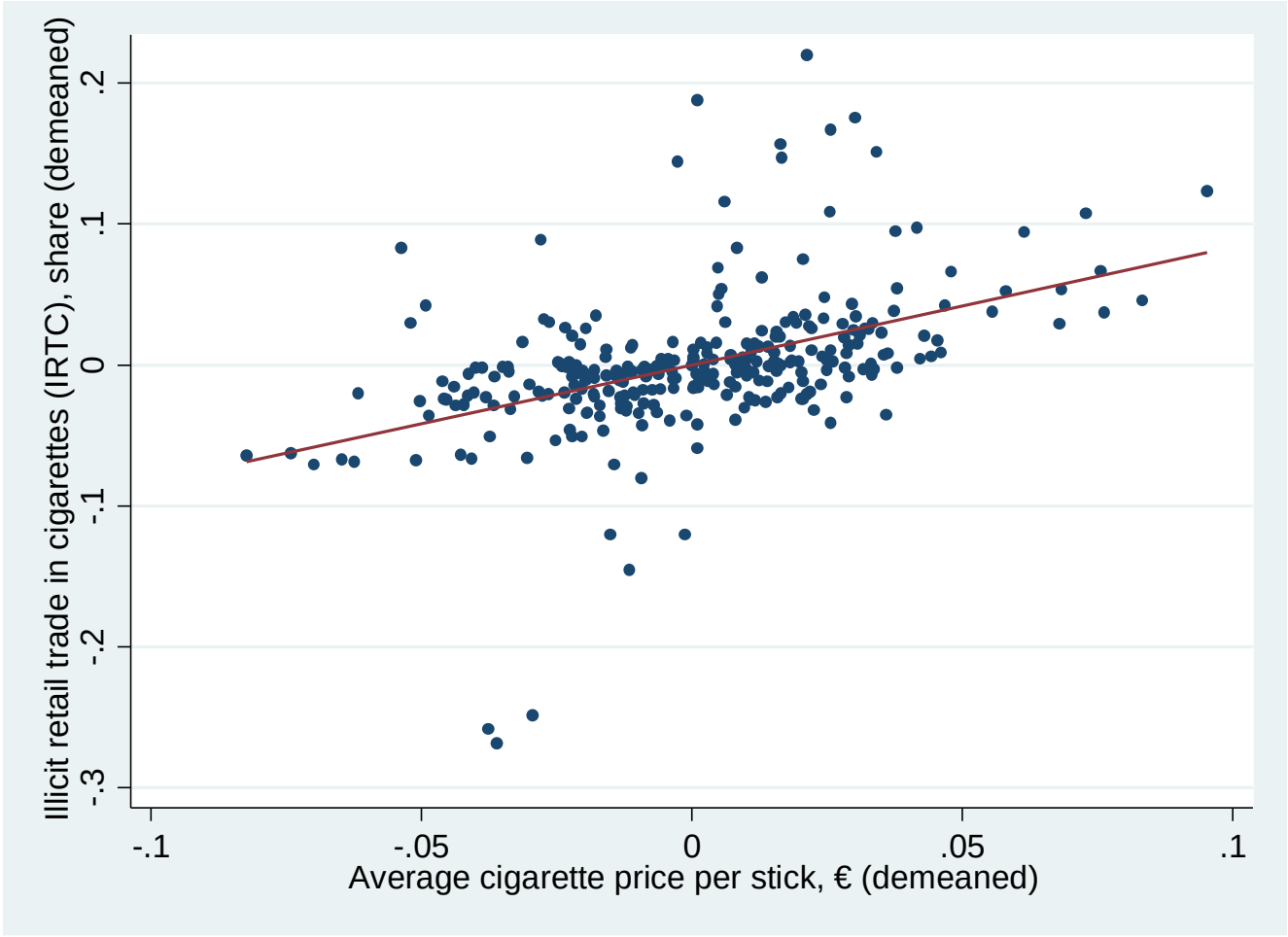
Notes: Variables constructed using source data from Euromonitor as described in the text. Currency units are 2010 euros.

Figure 4: Cigarette prices and IRTC shares in the EU, 2000-2013



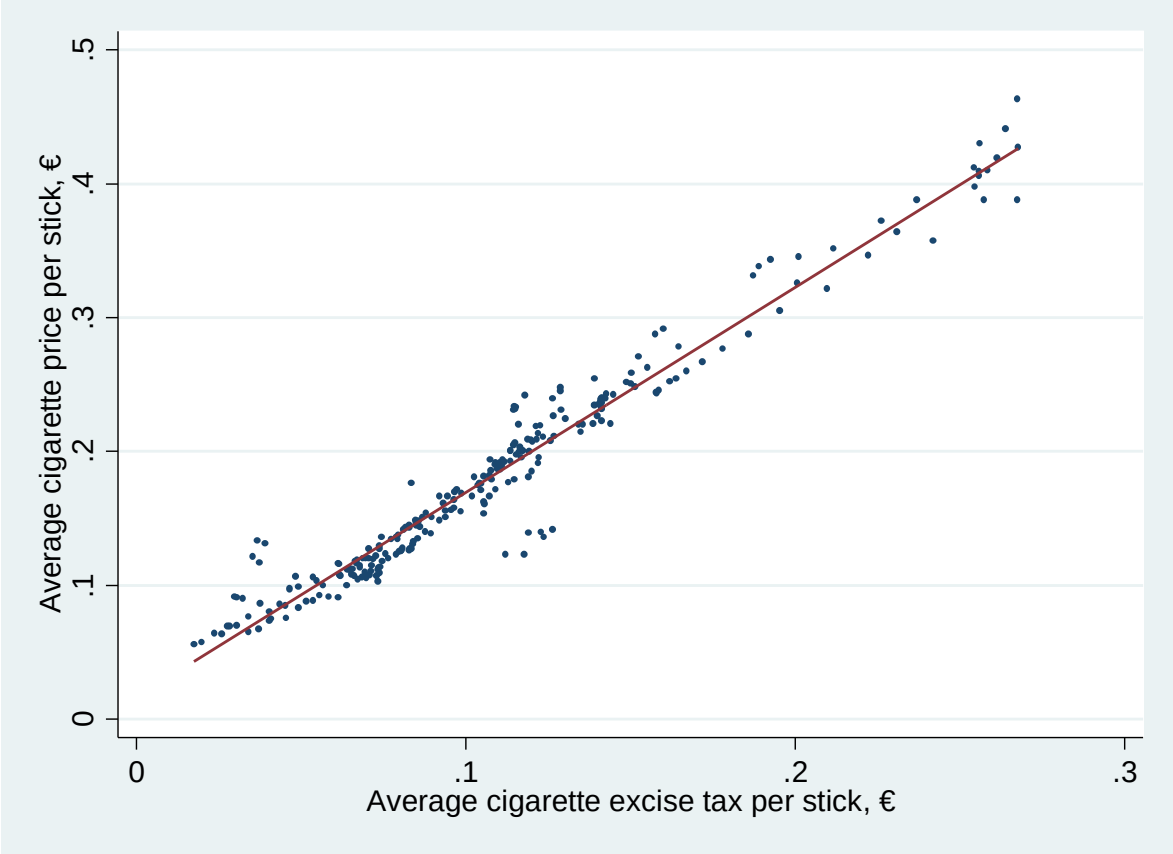
Notes: The line of best fit is calculated via OLS regression. See also notes to Figure 3.

Figure 5: Country-demeaned cigarette prices and IRTC shares in the EU, 2000-2013



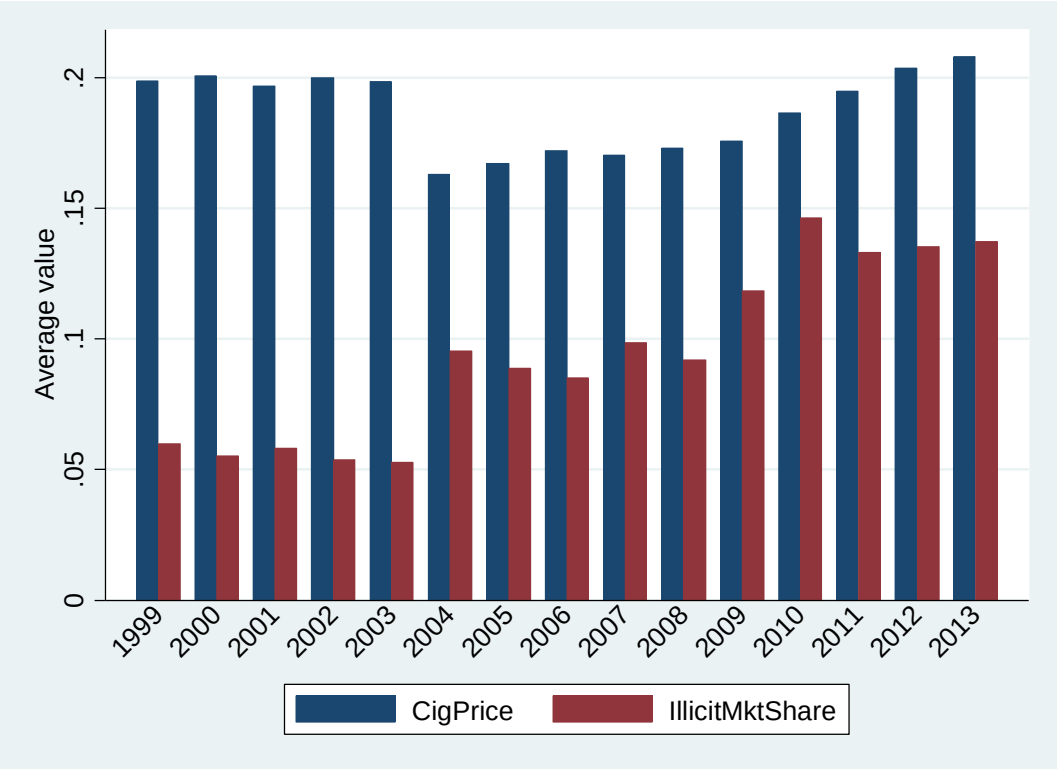
Note: For each country, the average of the time-series of each variable has been subtracted from the data. The line of best fit (slope = 0.83) is calculated via OLS regression. See also notes to Figure 3.

Figure 6: Cigarette prices and taxes in the EC, 2000-2013



Notes: The line of best fit is calculated via OLS regression (R^2 = 0.954). See also notes to Figure 3.

Figure 7: Cigarette prices and illicit market share in the EC, 1999-2013



Cigarette Taxes and Illicit Trade in Europe

Appendix

James E. Prieger and Jonathan Kulick

This appendix contains more complete information about the data and additional regressions to which the main text refers.

A. Are taxes lowered in response to IRTC?

As discussed in the text in section IV.B.1, reverse causality between IRTC and cigarette taxes may cause downward bias in the estimated price coefficient. Since there are claims in the literature that some countries have responded to rising illicit trade by lowering cigarette taxes (Joossens & Raw, 2000)—albeit not for our countries and period—we investigate this further here. First, there are few examples of cigarette taxes falling by any appreciable amount in the data, even though IRTC has been rising, particularly in Western Europe (see Figure 1 in the main text). Figure 8 shows the trends in variable $ExTaxHypo$ by country. The only countries with nontrivial decreases in this cigarette tax index are Bulgaria, Romania, and the U.K. Examination of the co-movements in illicit market share and $ExTaxHypo$ in these countries in Figure 9 shows that only in Bulgaria does the tax index fall when the illicit share rises (and in only one year, 2010).

We repeat estimation IV 7.2 without these three countries. The results in Table 16 show that the price coefficient is indeed higher (and still highly significant) with the smaller sample. However, given the relatively small difference in the two price coefficients compared to their standard errors , there is no clear evidence against the consistency of the main estimates from IV 7.2.

B. Construction of the hypothetical excise taxes

In section IV.B.1 of the text, a hypothetical excise tax is used as an instrument for cigarette prices. Here we describe how that variable, *ExTaxHypo* (or T^h as it is denoted here), is constructed. We begin with the following identities:

$$P^h = P_0^h + T^h \quad \text{(A-1)}$$

$$T^h = T_{as} + T_{av}^h \quad \text{(A-2)}$$

In the expression, *h* superscripts are for hypothetical quantities. P^h is the tax-included retail sales price (TIRSP) with the hypothetical tax, P_0^h is the pre-excise-tax base price to be used in constructing the hypothetical tax, and T^h is the hypothetical overall excise tax (i.e., the sum of the specific and ad valorem excise taxes). In equation (A-2), T_{as} is the actual amount-specific excise tax (taken to be exogenous, thus also used for the hypothetical tax) and T_{av}^h is the hypothetical ad valorem excise tax amount (not the rate). The actual ad valorem tax amount cannot be used since it was calculated from a base that was presumed to be endogenous.

To calculate P^h, define α to be the ad valorem excise tax rate as a percentage of TIRSP. Rate α is taken to be constant for a country and year, even though the actual base from which the ad valorem tax is calculated may differ from country to country. Treating the ad valorem tax as a fraction of TIRSP may appear odd, since TIRSP itself includes excise taxes, but we do this for two reasons. It matches how the tax data are presented in both the Euromonitor and the alternative European Commission data (discussed in a later section of the appendix), as a fraction of TIRSP. Also, EU law requires minimum

taxes on cigarettes,[49] and the minimums are stated as a fraction of TIRSP. Thus, regardless of the actual rate and base each country chooses, policymakers must calculate and consider their taxes in terms of a fraction of TIRSP.

Then, from (A-1), (A-2), and by definition of α, we have

$$P^h = P_0^h + T_{as} + \alpha P^h \tag{A-3}$$

or, after rearranging terms,

$$P^h = \frac{P_0^h + T_{as}}{1 - \alpha} \tag{A-4}$$

Combining (A-1) and (A-4) and rearranging terms yields the final expression for *ExTaxHypo*$_{it}$:

$$T^h = \frac{P_0^h + T_{as}}{1 - \alpha} - P_0^h \tag{A-5}$$

Matching to the data described in the text, T_{as} is *SpecTax*$_{it}$ and α is *AVtax*$_{it}$, both given in the Euromonitor data. The base price P_0^h, which is required to be plausibly exogenous since *ExTaxHypo*$_{it}$ will be used as an instrument, remains to be chosen. Define P_0^a to be the actual TIRSP less the overall actual excise tax (i.e., $P_0^a = \textit{CigPrice}_{it} - \textit{ExTax}_{it}$). Then we choose P_0^h for all observations to be the average value of P_0^a in the sample. Since the result does not vary over time, it cannot be endogenous due to time-varying factors affecting actual prices. Since P_0^h does not vary across countries, it cannot be correlated with endogenous country-specific factors. Instrument *ExTaxHypo*$_{it}$ varies over time and country because both T_{as} and α vary over both.

C. A consumption gap analysis of illicit trade

To complement the main estimations using the Euromonitor estimates of IRTC, we also calculated our own estimates of illicit market share. The consumption gap analysis in this section

[49] See Council of the EU's Directive 2011/64/EU of 21 June 2011 on the structure and rates of excise duty applied to manufactured tobacco.

provides further evidence that higher licit cigarette prices have sizeable and statistically significant impacts on illicit market share, even when avoiding industry- and third-party estimates of IRTC.

Following the approach suggested by Blecher (2010), we compare survey estimates of cigarette consumption within each country with licit sales and ascribe gaps between the two to consumption of illicitly obtained cigarettes. We begin with the identity that the quantity consumed in a country and year must equal the quantity supplied from all sources.[50] Sources of supply include Q^S, domestic licit sales (including domestic production sold in-country, legally imported and taxed foreign product sold in-country, and domestic sales purchased by foreign visitors). Another source of supply is Q^{FL}, foreign legal product that is brought into the market legally by consumers (such as during a cross-border trip). Domestic supply is reduced by X^{FL}, domestic licit sales taken out of country by visitors. The final source of supply is Q^{CC}, counterfeit and contraband illicit product (whether produced domestically or from abroad). If there is outflow of domestically produced illicit product, it is netted out of Q^{CC}. Defining net foreign legal supply as $N^{FL} = Q^{FL} - X^{FL}$, the identity between domestic consumption Q^D and supply is thus

$$Q^D = Q^S + N^{FL} + Q^{CC} \tag{A-6}$$

By definition, Q^D equals S, the number of smokers in the country, times A, the average smoking intensity. While S can be reasonably well estimated from survey data, it is well known that A is likely to be underreported (as $\tilde{A}$) by survey respondents (Warner, 1978; Merriman, 2000). Assume that underreporting is by a constant multiple $0 < \theta < 1$, so that estimated consumption ignoring the misreporting is $\tilde{Q}^D = \tilde{A}S$ but that actual consumption is

$$Q^D = \tilde{Q}^D/\theta \tag{A-7}$$

Rearranging the terms in equation (A-6) yields

[50] We thus set aside issues involving inventories, since cigarettes are perishable product.

$$Q^{CC} = Q^D - Q^S - N^{FL}$$

and so the illicit market share Q^{CC}/Q^D , denoted M^{CC}, is

$$M^{CC} = \frac{Q^D - Q^S - N^{FL}}{Q^D} = 1 - \frac{Q^S + N^{FL}}{\tilde{Q}^D}\theta \tag{A-8}$$

Assume a linear fixed-effects regression model for M_{CC}, so that

$$M_{it}^{CC} = \alpha_i + \beta' x_{it} + u_{it} \tag{A-9}$$

Equating the right sides of equations (A-8) and (A-9), we have:

$$1 - \theta\frac{Q^S + N^{FL}}{\tilde{Q}^D} = \alpha_i + \beta' x_{it} + u_{it} \tag{A-10}$$

$$\frac{Q_{it}^S}{\tilde{Q}_{it}^D} = \frac{1 - \alpha_i}{\theta} - \left(\frac{\beta}{\theta}\right)' x_{it} - \left(\frac{u_{it}}{\theta_i} + \frac{N^{FL}}{\tilde{Q}^D}\right) \tag{A-11}$$

Define y_{it} to be $Q_{it}^S/\tilde{Q}_{it}^D$ and let $\ddot{a}$ represent a variable a that has been demeaned by the within transformation: $\ddot{a}_{it} = a_{it} - \frac{1}{T}\sum_{t=1}^{T} a_{it}$. Then equation (A-10) after transformation becomes:

$$\ddot{y}_{it} = -\left(\frac{\beta}{\theta}\right)' \ddot{x}_{it} + v_{it} \tag{A-12}$$

where the new error term v_{it} is a mean-zero function of the terms in the final parentheses on the right side of equation (A-11) for all periods.

If the original error u was strictly exogenous in equation (A-9), and there is either no net foreign legal supply ($N^{FL} = 0$) or it is also strictly exogenous, then v is exogenous in equation (A-12). However, if cigarette price is an element of x, it is likely correlated with v through the term $N^{FL}/\tilde{Q}^D$. When licit prices rises within the country, then N^{FL} may rise (as consumers obtain more cigarettes abroad and foreigners buy fewer cigarettes within the country) and $\tilde{Q}^D$ may fall (since demand is responsive to price). Since $N^{FL}/\tilde{Q}^D$ enters v negatively, price and the error term are therefore negatively correlated, and we thus expect there to be downward bias on the estimated coefficient $-\beta_p/\theta$ on price in equation (A-11). The bias thus would exaggerate the estimate of β_p, the causal impact of price on actual IRTC.

Conceptually, the bias occurs because part of the impact on observed "illicit trade", as defined by the method above, will actually be increasing net foreign legal supply.

There are three potential responses to this potential bias. The first would be to ignore it, as appears to have been done in previous literature (e.g., Blecher, 2010). The second would be to gather data on net foreign legal supply, so that N^{FL} could be moved out of the error term v. Since the only consistently calculated estimates of which we are aware for the EU during our entire period are those from KPMG in the Project Star reports, we do not follow this approach, since we wish to avoid using KPMG data where possible in this estimation. The third response, which we adopt, is to recognize the issue but argue that the results are illustrative nonetheless. The KPMG data indicate that foreign legal supply from border-crossing by consumers happens, as shown in Figure 10, where it is labeled "non-domestic legal". However, the figure also shows that it is a minor part of overall trade, more stable than illicit trade, and less responsive to price changes.[51] During 2009-2011, for example, prices sharply increased but non-domestic legal consumption did not change. We thus anticipate (but cannot prove) that any bias is limited.

Estimation of regression equation (A-7) yields estimates of coefficient vector β/θ, but the individual elements of β are identified only to scale. Estimation of equation (A-7) by itself therefore can show whether price has a statistically significant effect on illicit trade share but cannot reveal the magnitude of the effect. If data on domestic consumption from KPMG are allowed into the estimation, then scalar θ can be identified. KPMG estimates domestic consumption for the EU in its Project Star reports. The largest part of consumption is from legal domestic sales, which are readily observed from industry and tax data. KPMG then adjusts the figures to arrive at total consumption by adjusting for non-

[51] The standard deviation of the non-domestic legal consumption figures in the graph is 0.6, whereas for illicit consumption it is 1.1.

domestic consumption as estimated from empty discarded pack studies.[52] While the final consumption estimate relies on calculations and estimates by KPMG, the figures should be less contentious than the firm's direct estimates of IRTC. Treating the KPMG consumption data as Q^D, equation (A-2) in logs can be treated as a second regression equation to estimate θ.

Data for S and $\tilde{A}$ are taken from Eurobarometer (various years) surveys. Not all years are available.[53] Furthermore, in some years, $\tilde{A}$ was not directly reported because survey responses were instead quantized (i.e., instead of mean cigarettes per day reported, the fraction of smokers falling into various consumption ranges was given). For such years, mean smoking intensity was estimated from the quantal data by fitting a lognormal distribution to the data via MLE and calculating the implied mean based on the results.[54] With the resulting estimates of $\tilde{A}$ and S, estimates of $\tilde{Q}^D$ were formed as their product. Comparison of these estimates of $\tilde{Q}^D$ with the KPMG estimates of Q^D is in Figure 11. The scatterplot shows that there is very high correlation between the two estimates (0.98). The slope of the line of best fit for the logged data, from estimation OLS 17.1 in the first column of Table 17, is close to one, as it must be if equation (A-2) is correct.[55] The implied value of θ from the regression is 0.63.[56] Thus, for every 10 cigarettes apparently actually consumed, smokers claim on average to have smoked only 6.3.

The results of estimation of equation (A-7), with and without using KPMG data on domestic consumption, are in second and following columns of Table 17. The dependent variable y in the first

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[52] Empty pack surveys are based on a large sample of packs collected via formal sampling plans in various cities throughout the countries. Once packs are collected, they are examined to determine the proportion of packs that did not originate domestically.

[53] Eurobarometer surveys are available covering data from 1995, 2002, 2005, 2006, 2008, 2009, 2012, and 2014.

[54] Each country was allowed to have its own set of location and scale parameters for the lognormal distribution.

[55] The estimated slope of the line is 1.03, with 95% confidence interval spanning one [0.961,1.097].

[56] Given the log form of equation (A-2), θ is the exponentiated constant from the log-log regression.

equation is constructed using domestic licit sales data from Euromonitor for Q^S. Estimation WI-OLS 17.1 (WI for within-transformed data) returns estimates of β/θ from OLS estimation on the pooled, demeaned data. The estimate-to-scale of the impact of cigarette price on illicit share is positive and statistically significant at the 5% level. Estimation WI-OLS 17.2 is similar except that year fixed effects are accounted for; the estimate-to-scale of the impact of price on illicit share is now significant at the 1% level. These results bolster the main conclusions of the paper, namely that price increases spur illicit trade, without indicating the magnitude of the marginal effect. However, if the previous estimate of θ (from estimation OLS 17.1) is employed, the implied estimates of β (the elasticity of illicit market share with respect to licit cigarette price) from estimations WI-OLS 17.1 and 17.2 are 0.30 and 0.47, respectively. These estimates are higher than the elasticities found from the fixed-effects estimates reported in Table 7 (perhaps due to the bias discussed above).

The final two columns of Table 17 contains estimates of β and θ separately, estimated from nonlinear seemingly unrelated regression (NLSUR) estimation of equation (A-7) and the log form of equation (A-2).[57] Joint estimation can improve the precision of the estimates, as well as identifying β. Estimation NLSUR 17.1 does not include year fixed effects, while NLSUR 17.2 does. The implied elasticities of illicit market share with respect to price are 0.41 and 0.56. Again, these estimates are higher than those from Table 7. The estimates of θ are quite close to those from estimation OLS 17.1, and are significant at the 5% level.[58] In summary, the work here using the consumption gap analysis corroborates the finding in the paper that increasing the licit price of cigarettes (e.g., through taxation) has sizeable and statistically significant impacts on IRTC.

[57] Estimation is with the `nlsur` command in Stata 14.1.

[58] The transformation from the estimated ln(θ) to the reported θ is accomplished with the `nlcom` command.

D. Alternative data for prices and taxes

The European Commission produces annual reports on cigarettes prices and taxes.[59] Through 2010, the reported price is for the most popular price category (MPPC; i.e., the average price of the modal type of cigarette sold, usually king-size filter brands). After that year, weighted-average price (WAP; i.e., average revenue for cigarettes) is reported. The variables are converted to real terms using the same method as for all nominal data. Inclusion of year fixed effects in the estimations mitigates any impacts of this discontinuity in the time series. Tax data are also reported, as in the Euromonitor data: ad valorem and specific excise taxes, along with the VAT rate (expressed as a percentage of tax-included retail sales price, TIRSP). There is a high degree of concordance between the European Commission and the Euromonitor data. Log prices from the two sources exhibit correlation of 0.97. The instruments *ExTaxHypo* from equation (1) constructed from the EC and EM sources has correlation of 0.92. The VAT rates from the two sources have correlation of 0.97. Given these high correlations, the similarity of the new results in Table 12 with those in Table 7 is not surprising.

E. Alternative measures of corruption and governance

The estimations in Table 13 and Table 14 employ alternative regressors to *NotCorrupt*. Here these alternatives are described. Two measures from Transparency International are employed.[60] The first is the Corruption Perceptions Index, for which higher values indicate less corruption. Before a methodological change in 2012, the index was valid for cross-sectional comparison of countries but not across years. Therefore in estimations OLS 13.1 and FE 14.1 using this variable, year fixed effects are included to remove the changes over time due solely to the noncomparability of the data across years.

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[59] 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.

[60] Data are from transparency.org, from which the Excel spreadsheet "cpi 1995_2013.xls" was obtained.

The other variable from the same source is the country's cross-sectional rank of its Corruption Perceptions Index. The ranks are rescaled to the unit interval to account for differing number of countries in different years. This variable is another attempt to account for the inherent noncomparability of the index across years. This variable is used in estimations OLS 13.2 and FE 14.2.

The World Bank dataset from which *NotCorrupt* was drawn, World Governance Indicators, also contains indices of the rule of law and the effectiveness of government in the country. The former measure reflects perceptions of the extent to which "agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence."[61] The latter measures "perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies."[62] For both indices a higher score indicates stronger governance. Years 1999 and 2001 are unavailable and were linearly interpolated. These data are constructed to be appropriate for use in panel data, and are comparable in the cross-section and the time-series. The rule of law variable is used in estimations OLS 13.3 and FE 14.3. Similar estimations with the government effectiveness index yielded nearly identical results (which is unsurprisingly, given the 95% correlation between the two regressors) and therefore are not shown in the tables.

Data from the United Nations on total police personnel at the national level per 100,000 people are taken from UN Office on Drugs and Crime (UNODC).[63] The counts include personnel in public

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[61] See info.worldbank.org/governance/wgi/rl.pdf.

[62] While the government effectiveness index may appear to be less germane to IRTC than the other corruption and governance measures, we included it because Melzer (2010) found it to be significant in some of her cross-sectional regressions of illicit cigarette consumption share.

[63] See unodc.org/unodc/en/data-and-analysis/United-Nations-Surveys-on-Crime-Trends-and-the-Operations-of-Criminal-Justice-Systems.html.

agencies whose principal functions are the prevention, detection and investigation of crime and the apprehension of alleged offenders, excluding administrative support staff. Since there were many missing values, linear interpolation was used to fill in the gaps in the data. Estimations OLS 13.4 and FE 14.4 use the linearly interpolated data, while estimations OLS 13.5 and FE 14.5 use only the actual data.

Additional References

The following references are cited only in the appendix.

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Appendix Tables

Table 16: Fixed-effects panel regressions of IRTC share on cigarette prices (reduced sample)

Y = illicit market share	**IV** 16**.1**
Log(real cigarette price)	0.458
	(0.173)***
Freedom from Corruption (WGI)	-0.028
	(0.050)
Income (GNI) per capita (€1,000)	-0.014
	(0.013)
GNI per capita squared	-0.000
	(0.000)
1st stage *F* statistic on excluded instruments	64.8
Sargan-Hansen statistic (*p*-value)	0.480
N	215

* $p<0.1$; ** $p<0.05$; *** $p<0.01$; SE's (in parentheses) account for clustering by country.

Note: The instruments are *LaborTax*, *VAT*, and *ExTaxHypo*. Country and year fixed effects are included.

Table 17: Estimations for the consumption gap analysis

	OLS 17.1	WI-OLS 17.1	WI-OLS 17.2	NLSUR 17.1	NLSUR 17.2
	θ	β/θ	β/θ	β	β
Equation (A-7)					
Log(real cigarette price)		0.481	0.745	0.406	0.558
		(0.184)**	(0.215)***	(0.200)**	(0.272)**
Income (GNI) per capita (€1,000)		0.017	0.023	0.019	0.021
		(0.018)	(0.028)	(0.013)	(0.016)
GNI per capita squared		-0.000	-0.000	-0.000	-0.000
		(0.000)	(0.000)	(0.000)*	(0.000)*
Equation (A-2) in log form					
Coefficient on $\tilde{Q}^D$	1.029			1.028	1.028
	(0.033)***			(0.032)***	(0.033)***
Log(θ)	-0.460			-0.476	-0.482
	(0.308)			(0.302)	(0.311)
θ	0.631			0.621	0.617
	(0.194)†*			(0.188) †**	(0.192) †**
Within-transformed data	N	Y	Y	Y	Y
Year fixed effects	N	N	Y	N	Y
N	98	103	103	74	74

* $p<0.1$; ** $p<0.05$; *** $p<0.01$; SE's (in parentheses) account for clustering by country.

† Significance stars for θ are for the null hypothesis that θ = 1.

Note: Estimates from the WI-OLS estimation are for β/θ from equation (A-7), and thus are not comparable to the direct estimates of β from the NLSUR estimations. The within-transformation and year fixed effects are for equation (A-7) only, when included.

Appendix Figures

Figure 8: The cigarette tax index (ExTaxHypo)

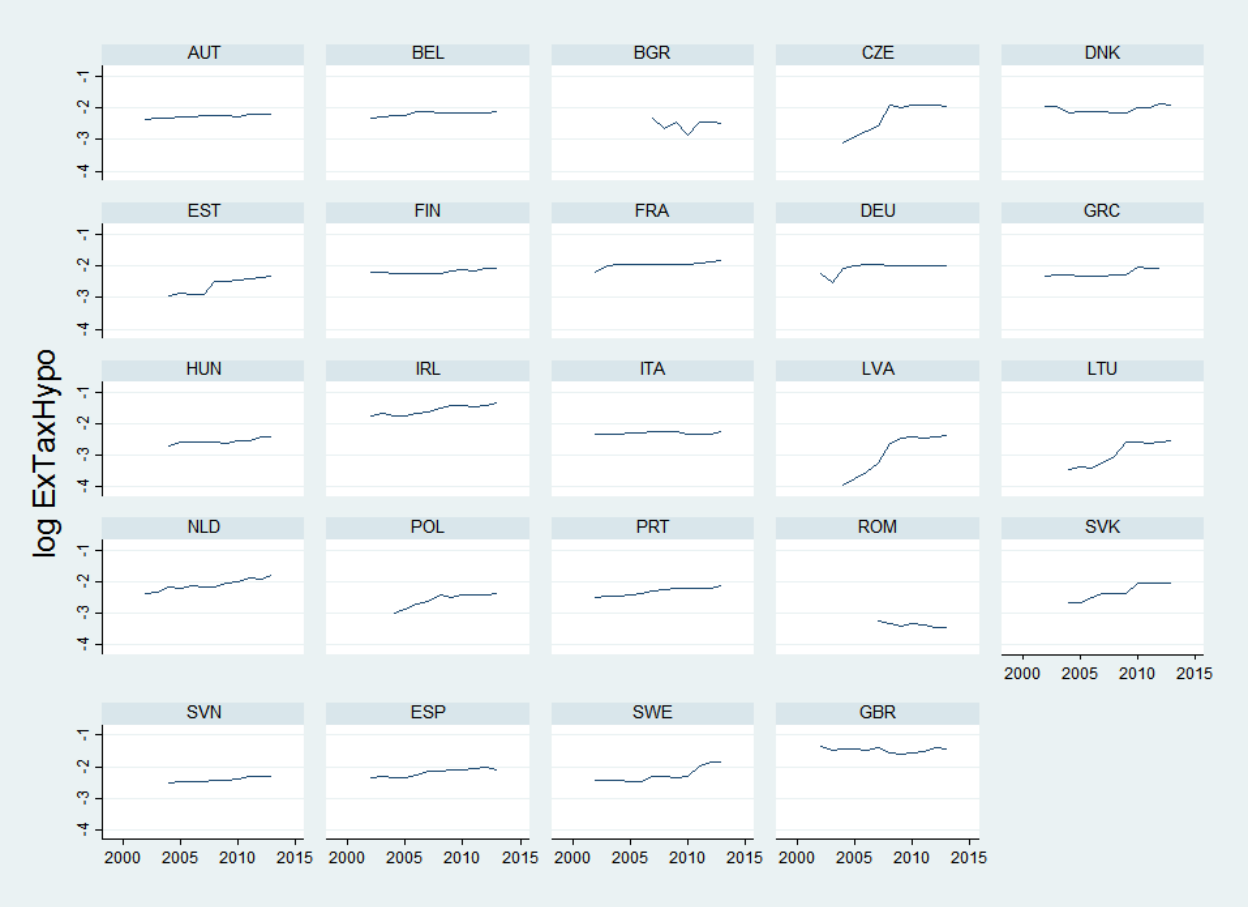


Figure 9: Illicit market share and ExTaxHypo in Bulgaria, Romania, and the U.K.

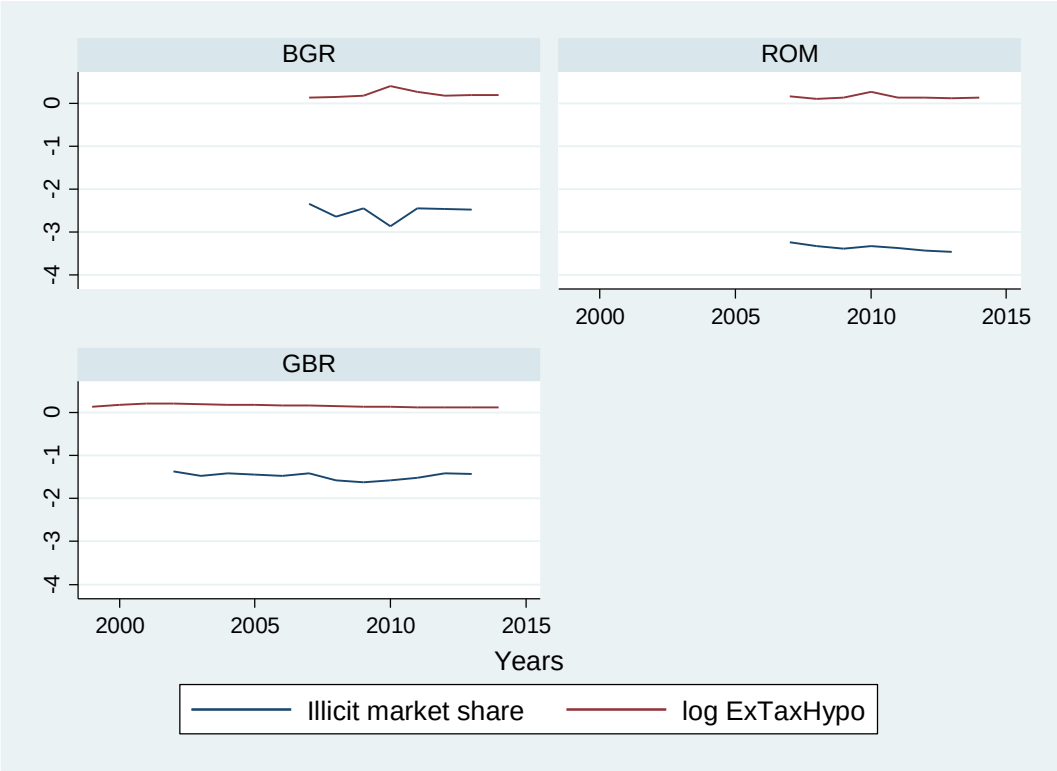
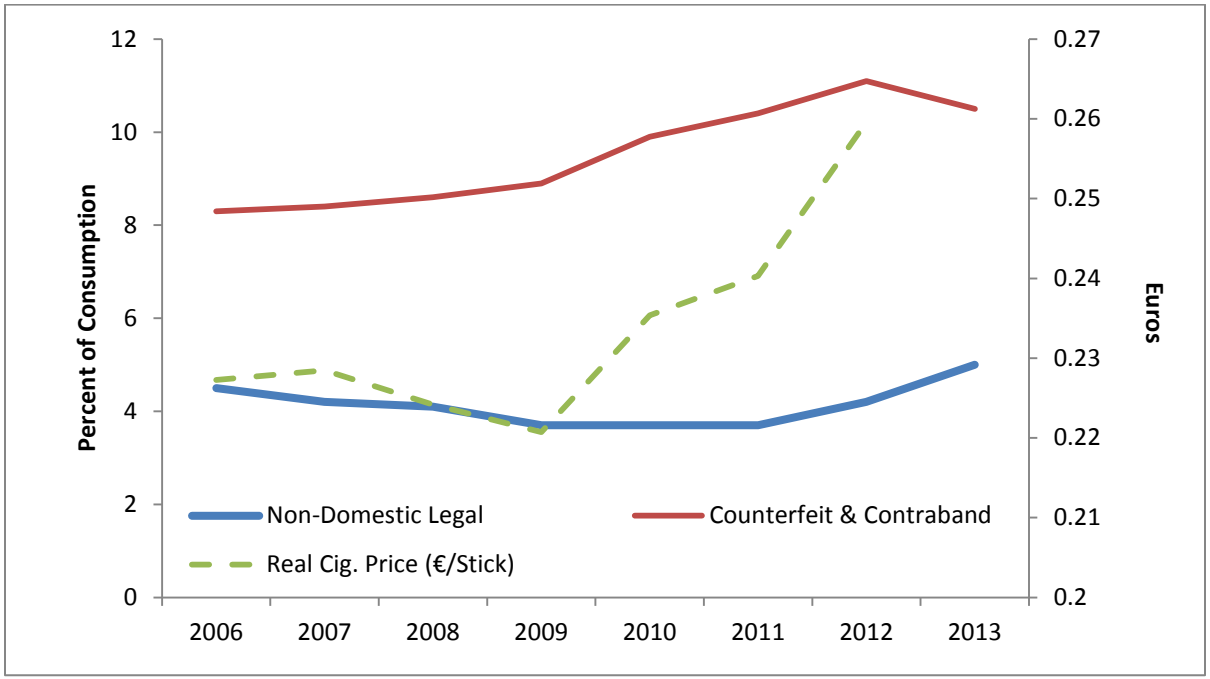


Figure 10: Data from KPMG Project Star for cigarette consumption and prices in the EU



Note: Price are national averages weighted by population. The data source is KPMG Project Star reports, various years.

Figure 11: Stated cigarette consumption vs. estimated actual consumption