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Cross-country and panel data estimates of the price elasticity of demand for cigarettes in Europe

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ABSTRACT

Objective Our goal is to provide estimates of the price elasticity of demand for cigarettes in Europe as a basis for public health policy on tobacco taxation.

Methods We use secondary data on cigarette retail sales including illicit trade, prices, tobacco control measures and income from 2010 to 2020 of 27 European countries from Euromonitor, the WHO, the Tobacco Control Scale and the World Bank. We estimate the price elasticity of demand using instrumental variable regressions as well as panel data regressions taking into account that prices and quantities are determined simultaneously in the market.

Results Based on cross-section data at the country level, we find that during the decade from 2010 to 2020, the demand for cigarettes in Europe has become neither more nor less elastic. Our estimates of the price elasticity based on panel data are around −0.4 (95% CI −0.67 to −0.24), in line with previous estimates for high-income countries. Furthermore, our analysis shows that estimates of the price elasticity of demand that are based on data including illicit trade tend to be lower. This has also been found in the previous literature.

Conclusions By providing state-of-the-art, up-to-date estimates of the price elasticity of demand that are in line with the previous literature, we show that taxation can still be a cost-effective tobacco policy to reduce cigarette consumption and thus, the burden of smoking.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study takes into account that prices and quantities of cigarettes are simultaneously determined in the market by implementing an instrumental variable estimator.
⇒ This study considers explicitly estimates of illicit trade of cigarettes in the estimation of the price elasticity of demand.
⇒ This study uses pooled cross-section data at the country-level weighting observations with the adult population size in each country, therefore, recovering the regression at the individual level.
⇒ Using cross-section and pooled cross-section, this study is only able to estimate a price elasticity of demand for Europe and not for individual European countries; this should be considered when interpreting the results, especially in the absence of a common tobacco policy in Europe.
⇒ The data on illicit trade used in this study, while compiled scrupulously, cannot be verified, and may overestimate or underestimate the true extent of illicit trade.

INTRODUCTION

Since the publication of the Surgeon General's report in the USA in 1964 smoking has been a global public health concern. Tobacco use is one of the biggest single preventable causes of premature death[1] and has been associated with considerable social costs in many countries.[2–4]

According to the WHO[5] raising taxes on tobacco is the most effective way, among tobacco control measures, to reduce tobacco use. To set taxes on cigarettes policymakers must know how much demand for cigarettes responds to price increases, that is, the price elasticity of demand (PED) (for a formal definition see subsection Definition of the PED). Thus, it is crucial for policymakers to base their decisions on tobacco taxation on scientifically state-of-the-art, up-to-date evidence of the PED.

All European countries raise taxes on cigarettes and implement further tobacco control measures (see online supplemental appendix 1 tables A1 and A2). The total tax burden on cigarettes varies across European countries from around 60% of the final consumer price in Switzerland to 88% in Finland in 2020.[1 5–7] Only in 19 European countries does the tax burden exceed the minimal tax burden of 75% recommended by the WHO. While the total tax burden was constant or slightly increased in 16 European countries, it decreased in 11 countries between 2010 and 2020. The extent and degree to which European countries implement further tobacco control measures such as public and workplace bans, public information campaigns, advertisement bans, health warnings (eg, on packaging) and treatment (eg, funding of quit-smoking plans) also varies across European countries. However, most European

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countries have implemented stricter tobacco control measures between 2010 and 2020.[8]

Our main contribution is to provide state-of-the-art, up-to-date estimates of the elasticity of demand for cigarette sales and consumption in Europe based on aggregate data at the country level. Thus, we contribute to the still relatively small literature using cross-country data to analyse tobacco control measures.[9–11] Contrary to most of those studies, we take into account that quantity and price are simultaneously determined in the market and recognise that data are grouped at the country level by weighting country observations with the adult population in our regressions. This allows us to exploit that aggregate data at the country level is representative for the whole country while being able to recover the microdata regression from the individual-level data. Furthermore, we not only consider cigarette sales (excluding illicit trade) but also cigarette consumption (including illicit trade). To the best of our knowledge, there are no recent studies based on cross-country data that take into account simultaneity as well as illicit trade while weighting data appropriately to recover the microdata regression. The recent literature has mostly been concerned with estimating the PED across different income or age groups or for non-cigarette products (eg, e-cigarettes).[12–17]

We estimate elasticities of demand that are similar to previous studies, including studies based on survey data at the individual level. Pooling the annual cross-sections, our preferred model specification, we confirm that the PED in high-income countries, like European countries, is still about −0.4.[18]

METHODS

This section describes in detail the data and empirical methods we used for estimating the elasticity of demand for cigarettes. Since our goal is to estimate the PED for cigarettes in Europe we use (pooled) cross-section data at the country level. To obtain unbiased estimators of the PED we use instrumental variables estimators.

Definition of the PED

The PED measures how much the quantity demanded (Q) of a good, in our case cigarettes, responds to changes in the price (P) of that good. Formally, it is defined as

$$PED \equiv \frac{\%\Delta Q}{\%\Delta P},$$

where $\%\Delta Q$ denotes the percentage-change in the quantity demanded and $\%\Delta P$ the percentage-change in the price.[19] We measure the quantity demanded with the number of packages sold per smoker and the price with the price per 20-cigarette package of the most sold brand (see section Data for details). Besides the price for cigarettes, which is directly affected by taxes, there are other factors that determine the demand for cigarettes such as other tobacco control measures and per capita income.

Data

We compile a comprehensive data set on cigarette consumption (*CIG*), prices (*P*), taxation (*T*) and other tobacco control measures (*TCS*) as well as gross domestic product per capita (*GDP*) for 27 European countries over the time period of 2010–2020. We use data on cigarette consumption from Euromonitor Passport,[20] on cigarette prices and tobacco taxes from WHO,[1 5–7] on TCS from the Tobacco Control Scale[8] and on GDP from the World Bank.[21] See table 1 for a detailed description of the data set. Note that all nominal values are measured in purchasing power parity (PPP)-adjusted international dollars such that they can be compared across countries. Since we want to isolate the effect of the cigarette price on cigarette consumption from other TCS, we consider the TCS score without its price component to avoid double-counting. Online supplemental appendix 1 tables A1 and A2 show detailed information about the taxes and TCS for each country over time.

Table 2 shows the mean and range (in parentheses) of each variable in table 1 across all years from 2010 until 2020 for every country. We note that there is considerable variation across countries in all variables.

At this point, some remarks on the numbers for illicit trade are required. Since by definition illicit trade is not recorded in official statistics as its extent can only be estimated. Our estimates are coming from Euromonitor, and include both non-duty paid (NDP) (ie, contraband) as well as counterfeit (ie, fake). Euromonitor sources include trade press, customs offices, interviews with manufacturers and retailers as well as local knowledge of the market. However, different parties have different interests to overstate or understate the extent of illicit trade. Euromonitor is aware of this problem and strives to present the most accepted and realistic estimate. (Euromonitor states on its website under FAQs (https://www.portal.euromonitor.com/help/faq): By its very nature illicit trade is a market that is difficult to quantify. Euromonitor sources for this include trade press, customs offices, interviews with manufacturers and retailers as well as local knowledge of the market—for example, how porous borders are, how high unit prices are, whether a market is a conduit for cigarettes versus actual consumption (eg, China is a significant exporter of illicit trade, but due to low unit prices of duty-paid cigarettes in the country, its actual consumption of illicit trade is low). Very often illicit trade will be expressed as a proportion of duty paid, legal sales (eg, 'illicit trade is 20% of duty paid') and is a ballpark figure that is quoted by the industry and one that Euromonitor corroborates via interviews with key industry players. 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. Euromonitor's illicit trade figures include both NDP (also known as contraband) and counterfeit (fake). Please note that illicit trade data is not modelled, hence regional and global illicit trade figures are not available

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Table 1 Variables in data set

Variable		Data		
Name	Description	Countries	Years	Source
CIG	*Cigarette consumption* Number of sold cigarette packs per smoker and year (above 15 years old) (20 cigarettes per pack, retail volume alone as well as retail volume plus illicit trade)	All	All	Euromonitor Passport[20]
P	*Cigarette price* Price per cigarette pack (20 cigarettes per pack, most sold brand, international dollars, PPP)	All	2010, 2012, 2014, 2016, 2018, 2020	WHO Report Global Tobacco Epidemic[1 5–7]
T	*Tobacco tax* (Sum of specific and ad valorem tax, in absolute terms, most sold brand, international dollars, PPP)	All	2010, 2012, 2014, 2016, 2018, 2020	WHO Report Global Tobacco Epidemic[1 5–7]
TCS	*Tobacco control measures* Tobacco Control Scale score (without price component; maximum score 70)	All (Croatia for 2010 not available)	2010, 2013, 2016, 2019	Tobacco Control Scale[8]
GDP	*Gross domestic product per capita* (International dollars, PPP)	All	All	World Bank indicators[21]

Notes: Countries include Austria, Belgium, Bulgaria, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and UK. Years include 2010–2020. The maximum score of TCS is 100 including the price component, and 70 excluding the price component.
PPP, purchasing power parity.

on passport (these are discussed instead in our Tobacco Global Briefings).) The estimates by Euromonitor have been criticised in the literature for their lack of transparency and for a few selected countries, although not European countries, for apparent inconsistencies.[22–24] However, there are no more credible alternative data sources available containing estimates of illicit trade of cigarettes for European countries. For example, Prieger and Kulick[25] analyse how taxes affect illicit trade of cigarettes in Europe based on Euromonitor data for illicit trade. They find that their results are robust to alternative data on illicit trade (collected by the consultancy firm KPMG) and their own estimates of illicit trade (comparing survey estimates of total cigarette consumption to the amount of legal retail sales).

Estimation strategy

First, we estimate the PED for cigarettes using variation across countries. This allows us to identify the effect of prices (ie, PED), other TCS and income on cigarette demand. Furthermore, we can compare the estimates over time in order to detect trends. Since cigarette consumption and prices are determined simultaneously on markets, prices are endogenous. Failing to account the endogeneity of prices may result in biased estimators. Thus, we follow the literature[26] and use the method of instrumental variables (IV) with the tobacco tax as an instrument. We argue that the tobacco tax is a valid instrument because it is strongly correlated with cigarette prices but does not directly determine cigarette consumption since consumers make their decisions to buy based on the final consumer price.

We implement the instrumental variables estimator using two-stage least squares (2SLS) as follows.[27] On the first stage, we estimate

$$p_i = \alpha_1 + \rho t_i + \beta_1 tcs_{i,t-k} + \delta gdp_i + e_{1i},$$

where p_i denotes the logarithm of the price for a 20-cigarette-pack of the most sold brand in PPP international dollars in country i, t_i denotes the logarithm of the tobacco tax in absolute terms (specific and ad valorem) based on the price of the most sold brand in country i, $tcs_{i,t-k}$ denotes the logarithm of the TCS score without the price component for country i at time t minus k (ie, the previous year available), gdp_i denotes the GDP per capita in PPP international dollars in country i and e_{1i} denotes the stochastic error term on the first stage.

On the second stage, we estimate

$$cig_i = \alpha_2 + \lambda \hat{p}_i + \beta_2 tcs_{i,t-k} + \delta_2 gdp_i + e_{2i},$$

where cig_i denotes the logarithm of the number of sold 20-cigarette-packs per smoker (retail volume alone as well as retail volume plus illicit trade) in country i, $\hat{p}_i$ denotes the predicted price from the first stage, $tcs_{i,t-k}$ the logarithm of the TCS score without the price component for country i in the previous year available, gdp_i denotes the GDP per capita in country i and e_{2i} denotes the stochastic error term on the second stage. The coefficient λ can be interpreted as the PED for cigarettes. It tells us by how much the number of packages sold per smoker (and year) changes on average if the price of a 20-cigarette package of the most sold brand increases by 1%, ceteris paribus.

Note that we include other TCS reflected in the TCS score as a lagged variable (ie, by using the TCS score in

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Table 2 Summary statistics

	Mean (Range)					
	CIG (Retail volume)	CIG (Retail volume plus illicit trade)	P	T	TCS	GDP
Austria	348 (46)	408 (48)	6.25 (2.62)	3.62 (1.59)	26 (20)	53 380 (4064)
Belgium	239 (48)	254 (51)	7.51 (3.08)	4.43 (1.87)	36 (9)	49 273 (3771)
Bulgaria	232 (73)	274 (123)	6.73 (0.97)	4.65 (0.54)	28 (13)	19 990 (5751)
Croatia	324 (44)	342 (45)	6.50 (2.83)	3.71 (2.30)	30 (9)	25 449 (4987)
Czechia	332 (35)	344 (47)	6.34 (3.73)	3.80 (2.13)	26 (17)	36 380 (7213)
Denmark	323 (151)	330 (148)	6.36 (4.32)	3.57 (2.66)	32 (4)	53 563 (6853)
Estonia	351 (105)	421 (185)	6.19 (3.84)	4.00 (2.90)	32 (7)	31 680 (10 697)
Finland	331 (87)	361 (74)	6.95 (5.24)	4.53 (4.03)	41 (9)	46 460 (3706)
France	165 (45)	197 (40)	9.23 (6.65)	5.98 (4.59)	42 (18)	43 489 (3809)
Germany	263 (25)	286 (28)	7.69 (3.23)	4.18 (1.09)	22 (8)	50 994 (6709)
Greece	221 (175)	271 (139)	6.63 (4.07)	4.14 (2.26)	24 (18)	29 069 (6467)
Hungary	192 (112)	208 (122)	7.81 (5.46)	4.25 (2.44)	34 (25)	27 787 (8126)
Ireland	211 (67)	268 (81)	13.28 (7.08)	7.96 (4.16)	48 (13)	68 255 (35 645)
Italy	350 (83)	373 (84)	7.11 (3.96)	4.13 (2.32)	34 (6)	41 236 (3900)
Latvia	209 (48)	306 (116)	5.59 (4.33)	3.47 (2.66)	30 (9)	26 523 (9835)
Lithuania	218 (73)	297 (101)	6.57 (4.66)	3.78 (2.50)	28 (12)	31 031 (13 120)
Netherlands	169 (34)	180 (33)	8.02 (4.25)	4.53 (2.71)	35 (9)	53 557 (4989)
Norway	176 (105)	192 (95)	10.83 (3.78)	5.10 (0.56)	41 (7)	62 845 (3296)
Poland	214 (53)	242 (46)	7.58 (4.82)	4.60 (2.49)	32 (8)	28 233 (9124)
Portugal	277 (58)	300 (55)	7.51 (3.29)	4.26 (1.27)	29 (8)	31 896 (4837)
Romania	235 (123)	275 (84)	9.33 (4.92)	5.16 (1.98)	32 (17)	24 642 (9554)
Slovakia	252 (23)	259 (23)	5.95 (2.14)	3.74 (0.91)	29 (6)	28 516 (6457)
Slovenia	492 (150)	527 (136)	5.64 (2.71)	3.45 (1.70)	35 (17)	34 862 (6666)
Spain	262 (126)	287 (124)	7.02 (3.47)	4.32 (2.01)	39 (11)	37 639 (5434)
Sweden	327 (31)	357 (41)	6.80 (2.11)	3.38 (0.82)	36 (8)	50 231 (4740)
Switzerland	296 (117)	312 (120)	6.64 (2.79)	3.53 (1.27)	32 (4)	65 714 (4923)
UK	208 (34)	237 (37)	11.64 (6.00)	7.37 (3.82)	52 (8)	44 028 (4779)

Notes: Mean and range over the time period of 2010–2020. The number of observations for CIG (retail volume) and CIG (retail volume plus illicit trade) is 11, for P is 6, for T is 6, for TCS is 4 and for GDP is 11. The number of observations is the same for all countries, except for Croatia the number of observations for TCS is 3. The range is defined as the maximum minus the minimum value and shown in parentheses.
CIG, cigarette consumption; GDP, gross domestic product; P, prices; T, taxation; TCS, tobacco control measures.

the previous year available). The reasoning behind this is that there is evidence that TCS like smoking bans have lagged effects on cigarette consumption.[28]

Further note that we weight observations of a country with the number of the adult population in that country. This recognises that we have grouped data at the level of a country (ie, macro level) instead of data at the individual level in each country (ie, micro level). In principle, weighting by group size recovers the microdata regression.[29]

Second, we implement an instrumental variable panel data estimator (ie, a fixed effects or within estimator). This means that we estimate the model above including country fixed effects (absorbing eg, unobserved inert smoking habits) as well as year fixed effects (absorbing eg, unobserved increase in global health awareness) on the first and second stage. Again, we weight observations of a country by its adult population size. While in the cross-section we identify the PED from variation in prices and quantities across countries, in the panel data we identify it essentially from variation in prices and quantities within countries over years. The panel data allow us to control for unobserved country-specific effects that are constant over time as well as unobserved time trends that are common to all countries. This increases the likelihood of obtaining unbiased estimates of the PED. Thus, this is our preferred model specification. However, we can no longer separately identify explanatory variables that do not vary over time within a country (as they are absorbed in the country fixed effect) and we can no longer analyse

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Table 3 Cross-section estimation results for cigarette sales

	Retail volume without illicit trade Retail volume with illicit trade					
cig_i	2010	2012	2014	2016	2018	2020
CIG_i (mean)	288 335	281 321	261 295	261 290	257 286	259 283
p_i	−0.93*** (0.24) −0.73*** (0.23)	−0.92** (0.37) −0.89** (0.33)	−1.24** (0.45) −1.08*** (0.38)	−0.88** (0.40) −0.73** (0.35)	−0.91** (0.43) −0.62* (0.35)	−0.84** (0.33) −0.61** (0.28)
$tcs_{i,t-k}$	0.10 (0.12) 0.06 (0.12)	0.06 (0.15) 0.09 (0.14)	0.12 (0.13) 0.10 (0.12)	−0.01 (0.12) −0.03 (0.11)	0.03 (0.20) −0.06 (0.16)	0.03 (0.18) −0.01 (0.17)
gdp_i	0.39*** (0.12) 0.17 (0.15)	0.13 (0.13) 0.07 (0.14)	0.25 (0.13) 0.17 (0.12)	0.16 (0.13) 0.10 (0.13)	0.11 (0.16) 0.03 (0.15)	0.19 (0.21) 0.10 (0.18)
N	26	26	27	27	27	27

Notes: The dependent variable of the number of sold cigarette packs per smoker, where sales are measured by retail volume without illicit trade and with illicit trade. All lower-case variables in logarithms. Robust SEs in parentheses. Levels of significances are denoted as follows *** 0.01, ** 0.05 and * 0.10. N denotes the number of observations. In all models, observations of a country have been weighted with the adult population in that country.
CIG, cigarette sales and consumption (packs per smoker).

whether the PED changes over time (as time trends are absorbed in the time fixed effect).

Patient and public involvement

None.

RESULTS

We first discuss the results from the cross-section data before discussing the results from the pooled cross-section data.

Results from cross-section data

The IV estimates for the PED for cigarettes from the cross-section data are shown in table 3. For detailed estimation results including the results of the first stage the reader is referred to online supplemental appendix 1 tables A3 and A4. (Note that the F-statistic on the first stage in every model is well above 10. First-stage F-statistics below 10 would raise concerns about weak instruments. Furthermore, there is a strong correlation between taxes on t_i and the price p_i in every year with coefficients on t_i between 0.8 and 0.95, that are statistically significant at the 1% significance level. Although we find evidence that taxes are almost fully passed through to consumer prices, there is some concern in the literature that the tobacco industry is trying to undermine taxes using various pricing strategies.)[30 31]

The header of table 3 shows in the top rows the year and the definition of the dependent variable cig_i (ie, retail volume excluding (w/o) or including (with) illicit trade), as well as the mean in levels (eg, in the year 2010 the average number of 20-cigarette-packs per smoker sold retail excluding illicit trade was 288).

The row p_i is the estimate for the PED for cigarettes in the respective years. For example, in 2010, our estimate for the price elasticity based on retail volume without illicit trade is −0.93, statistically significant at the 1% significance level. In other words, an increase in the price of cigarettes of 1% in 2010 led to a decrease in the demand for cigarettes by 0.93%. A price increase of 10% translates into a reduction in cigarette demand of around 27 packs in 2010 (ie, 9.3% of 288).

The rows $tcs_{i,t-k}$ and gdp_i show the effect of other TCS and GDP per capita (GDP) on the demand for cigarettes, respectively. First, we note that the coefficient on $tcs_{i,t-k}$ is small, often near zero, and never statistically significant. Second, the coefficient on gdp_i is also relatively small and never statistically significant, with the exception of the year 2010. This implies that other TCS and GDP per capita have no effect on cigarette demand, ceteris paribus. However, due to the low number of observations, we might simply lack the statistical power to pick up statistical significance in these two variables.

Results from pooled cross-section data

The IV estimates for the PED for cigarettes from the pooled cross-section data are shown in table 4. Pooling all years increases the number of observations, and gives us a panel with 162 observations, 27 countries times 6 years (2010, 2012, 2014, 2016, 2018 and 2020).

The header of table 4 shows in the top rows the definition of the dependent variable cig_i (ie, without and with illicit trade), the first stage and the instrumental variables estimates from the second stage of the 2SLS estimator, as well as the mean in levels (eg, the average number of 20-cigarette-packs per smoker sold retail excluding illicit trade during 2010–2020 was 276 and 300 including illicit trade). (The first stage based on panel data is similar to the one based on cross-sections. The F-statistic is 176; well above 10. Thus, there is no concern for weak instruments. There is a strong correlation between taxes t_i and prices p_i that is statistically significant at the 1% significance

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Table 4 Panel data estimation results for cigarette sales

		Retail volume w/o illicit trade	Retail volume with illicit trade
cig_i	First stage	Instrumental variables	Instrumental variables
CIG_i (mean)		267	300
p_i		−0.45*** (0.11)	−0.30*** (0.11)
t_i	0.80*** (0.06)		
$tcs_{i,t-k}$	Omitted	Omitted	Omitted
gdp_i	0.13 (0.09)	0.74*** (0.21)	0.36** (0.16)
F-statistic	176		
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
N	162	162	162

Notes: The dependent variable of the number of sold cigarette packs per smoker, where sales are measured by retail volume without illicit trade and with illicit trade. All lower-case variables in logarithms. Clustered standard errors at the country-level in parentheses. Levels of significances are denoted as follows *** 0.01, ** 0.05 and * 0.10. N denotes the number of observations. In all models, observations of a country have been weighted with the adult population in that country.
CIG, cigarette sales and consumption (packs per smoker).

level. Note that the first stage is identical for both models without and with illicit trade.)

The estimates for the PED in the row p_i are −0.45 without illicit trade and −0.3 with illicit trade. Both estimates are statistically significant at the 1% significance level. (We also estimate the price elasticities based on unit values (ie, we divide retail value by retail volume). The unit value can be interpreted as a weighted average price of all cigarette brands. We estimate very similar price elasticities both from cross-section and pooled cross-section data. The results are available on request from the authors.)

We note that the variable for other TCS $tcs_{i,t-k}$ is omitted when we include country fixed effects. The reason is that there is simply not enough variation within a country over time in that variable to identify its effect. Thus, other TCS cannot be separately identified and are absorbed in the country fixed effects. The coefficients on GDP per capita gdp_i are statistically significant and positive, 0.74 and 0.36 without and with illicit trade, respectively. An increase of 10% in GDP per capita is associated with an increase in cigarette consumption of 7.4% and 3.6%, respectively.

DISCUSSION

First, we discuss the estimates based on the cross-sectional data. Our estimates for the PED based on cigarette retail sales without illicit trade are all of the same order of magnitude, with the exception of the year 2014, and statistically significant at least at the 5% significance level. Similarly, the estimates based on cigarette retail sales with illicit trade are also all of the same order of magnitude, and statistically significant at least at the 10% significance level. Our estimates of the PED ranging from −0.61 to −0.93 over the years (excluding the estimates for the year 2014, which seem to be outliers for reasons unbeknownst to us but may be related to the implementation of Tobacco Products Directive 2014/40/EU) are similar to those of earlier studies for Europe. For example, Gallus *et al*[32] estimate price elasticities of demand between −0.49 (local cigarette brand) and −0.77 (foreign cigarette brand) based on aggregate cross-section data for 52 European countries in the year 2000. This is the only recent study based on aggregate cross-section data at the country-level that we are aware of. However, they do not take into account the endogeneity of the price variable or illicit trade (ie, smuggling). These could be explanations for the differences.

We note that the estimates based on retail sales with illicit trade are systematically lower than the estimates based on retail sales without illicit trade. This is also in line with earlier studies correcting for smuggling.[33]

We further note that there is no apparent trend that cigarette demand, based on retail sales without as well as with illicit trade, has become more or less elastic over the last decade. To the best of our knowledge, there is no other current study that looks into the evolution of the PED over time. Earlier studies have also found no time trend in the PED.[18]

While the estimation of the PED based on aggregate cross-section data at the country-level has its merits as it allows us to compare the estimates over time, from an econometric point of view, the estimates from the IV panel data estimator including country and year fixed effects based on pooled aggregate cross-section data is our preferred model specification. It allows us to control for unobserved country-specific effects as well as common time trends.

There have been numerous studies estimating the PED for cigarettes over the last decades.[18] According to Chaloupka *et al*[34] most studies from industrialised countries produce estimates for the PED in the range from −0.25 to −0.5. However, these estimates are based on a wide range of econometric approaches and data sets (ie, aggregate time-series data, aggregate cross-section data and individual-level survey data). Most recent studies are either based on aggregate time-series data for an individual country[35–38] or individual-level survey data.[14 39] In general, estimates of the PED based on aggregate time-series data (between −0.54 and −0.2) and individual-level survey data (between −0.53 and −0.2) tend to be slightly smaller than estimates based on aggregate cross-section data at the country level. According to Wilkins *et al*[26] individual-level data usually do not include price data. Furthermore, prices at the regional level often do not have sufficient variation in the cross-section to allow identifying the PED. By analysing cross-sectional data at

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the country level, we can exploit that, on the one hand, aggregate data at the country level is representative of the whole population and on the other hand, there is sufficient variation in prices across countries to identify the PED. Furthermore, by pooling cross-sectional data at the country level can exploit panel data estimators. However, it does not allow to identify the price elasticity of demand for cigarettes in an individual European country but only for Europe as a whole.

There seems to be a consensus that in high-income countries, such as the European countries, the PED is about −0.4.[18 40] Our estimates of −0.45 and −0.3 of the PED using panel data based on retail sales without and with illicit trade, respectively, are in line with this.

CONCLUSIONS

We provide state-of-the-art, up-to-date estimates of the PED for cigarettes based on (pooled) aggregate cross-section data for European countries. First, we take into account the endogeneity of price and second, we provide estimates based on both retail sales without and with illicit trade. At the same time, we appropriately weight observations at the country level in order to recover the regression at the individual level.

Our findings are in line with previous studies. On the one hand, analysing annual cross-sections separately we find that demand for cigarettes has become neither more nor less elastic in the last decade. On the other hand, pooling annual cross-section data our estimates confirm that the PED in high-income countries, like European countries, is about −0.4. We show that estimates based on aggregate cross-section country data are close to estimates based on survey data at the individual level if observations are weighted in country-level regressions. Furthermore, estimates based on retail sales including illicit trade (ie, consumption) are lower than those based on retail sales without illicit trade.

The basis of evidence-based policymaking is state-of-the-art, up-to-date research. In this paper, we provide evidence for policymakers that taxes on cigarettes are still an effective option in reducing cigarette consumption and thus, the burden of smoking. In particular, our estimates of the PED help policymakers gauge the effect of taxes on cigarette consumption, especially, in the presence of illicit trade. Thus, policymakers can use this study's results as their decision basis for future tobacco policies to continue including cigarette taxation as a tobacco control measure. However, further research is needed to better understand how taxation interacts with other TCS, as well as its effect on smoking prevalence.

From a research point of view, it is important to have various estimates of the PED based on different estimation strategies and data, in order to assess the sensitivity and robustness of previous findings. Furthermore, our estimation strategy to identify the PED for cigarettes could also be used to estimate the PED for non-cigarette tobacco products such as e-cigarettes.

Contributors AK, LV and RM planned and designed the study. AK and LV collected the data. AK did the empirical analysis. AK wrote the first draft of the manuscript. AK, LV and RM revised the draft and wrote the final version of the manuscript. All authors agreed with the results and conclusions of this article. AK is acting as the guarantor.

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REFERENCES

1 World Health Organization. WHO report on the global tobacco epidemic, 2017: monitoring tobacco use and prevention policies. Geneva, Available: https://www.who.int/publications/i/item/9789241512824 [Accessed 15 Feb 2022].
2 Farcher R, Sylеouni ME, Vinci L, *et al*. Burden of smoking on disease-specific mortality, Dalys, costs: the case of a high-income European country. *BMC Public Health* 2023;23:698.
3 Reed H. The costs of smoking to the social care system and related costs for older people in England: 2021 revision [Lanman Economics for Action on Smoking and Health (ASH)]. 2021. Available: https://ash.org.uk/wp-content/uploads/2021/03/Landman-Economics-CostsOfSmokingToSocialCaresystem-March2021.pdf [Accessed 15 Feb 2022].
4 Action on Smoking and Health (ASH). The cost of smoking to the social care system. 2021. Available: https://ash.org.uk/wp-content/uploads/2021/03/SocialCare.pdf [Accessed 15 Feb 2022].
5 World Health Organization. WHO report on the global tobacco epidemic, 2015: raising taxes on tobacco. Geneva, Available: https://www.who.int/publications/i/item/9789241509121 [Accessed 15 Feb 2022].
6 World Health Organization. WHO report on the global tobacco epidemic, 2019: country profile Switzerland; 2019.
7 World Health Organization. WHO report on the global tobacco epidemic 2021: addressing new and emerging products. Geneva, Available: https://www.who.int/teams/health-promotion/tobacco-control/global-tobacco-report-2021 [Accessed 15 Feb 2022].
8 Tobacco control scale. 2019. Available: https://www.tobaccocontrolscale.org/ [Accessed 17 Nov 2021].
9 Saffer H, Chaloupka F. The effect of tobacco advertising bans on tobacco consumption. *J Health Econ* 2000;19:1117–37.
10 Nelson JP. Cigarette demand, structural change, and advertising bans: International evidence, 1970-1995. *BE J Econ Anal Policy* 2003;2:1–29.

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11 Blecher E. The impact of tobacco advertising bans on consumption in developing countries. *J Health Econ* 2008;27:930–42.
12 Filby S. Cigarette prices and smoking among adults in eight sub-Saharan African countries: evidence from the global adult tobacco survey. *Tob Control* 2022:tc-2022-057626.
13 Kostova D, Ross H, Blecher E, *et al*. Is youth smoking responsive to cigarette prices? Evidence from low- and middle-income countries. *Tob Control* 2011;20:419–24.
14 Kostova D, Tesche J, Perucic A-M, *et al*. Exploring the relationship between cigarette prices and smoking among adults: a cross-country study of low- and middle-income nations. *Nicotine Tob Res* 2014;16 Suppl 1:S10–5.
15 Almeida A, Golpe AA, Iglesias J, *et al*. The price elasticity of cigarettes: new evidence from Spanish regions, 2002-2016. *Nicotine Tob Res* 2021;23:48–56.
16 Selvaraj S, Srivastava S, Karan A. Price elasticity of tobacco products among economic classes in India, 2011–2012. *BMJ Open* 2015;5:e008180.
17 Kjeld SG, Jørgensen MB, Aundal M, *et al*. Price elasticity of demand for cigarettes among youths in high-income countries: a systematic review. *Scand J Public Health* 2023;51:35–43.
18 IARC Handbooks of Cancer Prevention. *Effectiveness of Tax and Price Policies for Tobacco Control*. Lyon, France, 2011.
19 Mankiw NG, Taylor M. *Economics, 3rd ed*. Cengage Learning EMEA, 2014.
20 Euromonitor passport. Available: 2021.https://www.portal.euromonitor.com/portal/magazine/homemain/ [Accessed 17 Nov 2021].
21 The World Bank indicators. 2021. Available: https://data.worldbank.org/indicator [Accessed 17 Nov 2021].
22 Blecher E, Liber A, Ross H, *et al*. Euromonitor data on the illicit trade in cigarettes. *Tob Control* 2015;24:100–1.
23 Stoklosa M, Ross H. Contrasting academic and tobacco industry estimates of illicit cigarette trade: evidence from Warsaw, Poland. *Tob Control* 2014;23:e30–4.
24 van Walbeek C, Shai L. Are the tobacco industry's claims about the size of the illicit cigarette market credible? The case of South Africa. *Tob Control* 2015;24:e142–6.
25 Prieger JE, Kulick J. Cigarette taxes and illicit trade in Europe. *Econ Inq* 2018;56:1706–23.
26 Wilkins N, Yurekli A, Hu T. Economics of tobacco toolkit, tool 3: economic analysis of tobacco demand. Washington, DC World Bank; 2013. Available: https://openknowledge.worldbank.org/handle/10986/16269 [Accessed 17 Nov 2021].
27 Wooldridge JM. *Introductory Econometrics: A Modern Approach, 5th ed*. Cengage Learning EMEA, 2012.
28 Boes S, Marti J, Maclean JC. The impact of smoking bans on smoking and consumer behavior: quasi-experimental evidence from Switzerland. *Health Econ* 2015;24:1502–16.
29 Angrist JD, Pischke JS. Mostly harmless Econometrics: an Empiricist's companion. Princeton University Press; 2009. https://press.princeton.edu/books/paperback/9780691120355/mostly-harmless-econometrics
30 Sheikh ZD, Branston JR, Gilmore AB. Tobacco industry pricing strategies in response to excise tax policies: a systematic review. *Tob Control* 2023;32:239–50.
31 Andrews I, Stock JH, Sun L. Weak instruments in instrumental variables regression: theory and practice. *Annu Rev Econ* 2019;11:727–53.
32 Gallus S, Schiaffino A, La Vecchia C, *et al*. Price and cigarette consumption in Europe. *Tob Control* 2006;15:114–9.
33 Goel RK. Cigarette demand in Canada and the US-Canadian cigarette smuggling. *Applied Economics Letters* 2004;11:537–40.
34 Chaloupka F, Peck R, Tauras J, *et al*. *Cigarette Excise Taxation: The Impact of Tax Structure on Prices, Revenues, and Cigarette Smoking*. Cambridge, MA: National Bureau of Economic Research, 2010.
35 Mindell JS, Whynes DK. Cigarette consumption in the Netherlands 1970-1995: does tax policy encourage the use of hand-rolling tobacco. *Eur J Public Health* 2000;10:214–9.
36 Nguyen L, Rosenqvist G, Pekurinen M. *Demand for Tobacco in Europe: An Econometric Analysis of 11 Countries for the PPACTE Project*. Helsinki, Finland: National Institute for Health and Welfare (THL), 2012.
37 Martín Álvarez JM, Golpe AA, Iglesias J, *et al*. Price and income elasticities of demand for cigarette consumption: what is the association of price and economic activity with cigarette consumption in Spain from 1957 to 2016? *Public Health* 2020;185:275–82.
38 González-Rozada M. Impact of a recent tobacco tax reform in Argentina. *Tob Control* 2020;29:s300–3.
39 Franz GA. Price effects on the smoking behaviour of adult age groups. *Public Health* 2008;122:1343–8.
40 Jha P, Chaloupka FJ. The economics of global tobacco control. *BMJ* 2000;321:358–61.

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Appendix 1

Table A1: Taxes as a % of price of the most sold brand in decimals for the years 2010, 2012, 2014, 2016, 2018 and 2020 by country

	Specific excise						Ad valorem excise						Value added tax / sales tax						Total tax					
Year 20YY	10	12	14	16	18	20	10	12	14	16	18	20	10	12	14	16	18	20	10	12	14	16	18	20
Austria	0.13	0.16	0.16	0.20	0.21	0.20	0.43	0.42	0.41	0.39	0.38	0.38	0.17	0.17	0.17	0.17	0.17	0.17	0.73	0.74	0.74	0.76	0.75	0.75
Belgium	0.07	0.06	0.08	0.13	0.20	0.20	0.52	0.53	0.50	0.46	0.40	0.40	0.17	0.17	0.17	0.17	0.17	0.17	0.76	0.76	0.76	0.76	0.77	0.77
Bulgaria	0.49	0.44	0.46	0.30	0.45	0.44	0.23	0.23	0.23	0.38	0.25	0.25	0.17	0.17	0.17	0.17	0.17	0.17	0.89	0.84	0.86	0.85	0.87	0.85
Croatia	0.20	0.18	0.18	0.19	0.25	0.30	0.33	0.33	0.37	0.38	0.34	0.34	0.19	0.20	0.20	0.20	0.20	0.20	0.72	0.71	0.75	0.77	0.79	0.84
Czechia	0.34	0.33	0.33	0.33	0.31	0.30	0.28	0.28	0.27	0.27	0.27	0.30	0.17	0.17	0.17	0.17	0.17	0.17	0.79	0.78	0.77	0.77	0.75	0.77
Denmark	0.34	0.58	0.54	0.54	0.53	0.57	0.21	0.01	0.01	0.01	0.01	0.01	0.20	0.20	0.20	0.20	0.20	0.20	0.75	0.79	0.75	0.75	0.74	0.78
Estonia	0.33	0.27	0.27	0.31	0.40	0.41	0.33	0.33	0.34	0.30	0.30	0.30	0.17	0.17	0.17	0.17	0.17	0.17	0.83	0.77	0.77	0.77	0.86	0.88
Finland	0.08	0.09	0.10	0.14	0.16	0.17	0.52	0.52	0.52	0.52	0.52	0.52	0.19	0.19	0.19	0.19	0.19	0.19	0.79	0.80	0.82	0.85	0.87	0.88
France	0.06	0.09	0.14	0.14	0.15	0.13	0.58	0.55	0.50	0.50	0.51	0.54	0.16	0.16	0.17	0.17	0.17	0.17	0.80	0.80	0.80	0.80	0.82	0.83
Germany	0.33	0.35	0.35	0.33	0.31	0.28	0.25	0.22	0.22	0.22	0.22	0.22	0.16	0.16	0.16	0.16	0.16	0.14	0.74	0.73	0.73	0.70	0.68	0.64
Greece	0.09	0.11	0.41	0.41	0.36	0.35	0.58	0.52	0.20	0.20	0.26	0.26	0.19	0.19	0.19	0.19	0.19	0.19	0.86	0.82	0.80	0.81	0.81	0.81
Hungary	0.31	0.31	0.25	0.27	0.26	0.29	0.28	0.31	0.31	0.25	0.25	0.23	0.20	0.21	0.21	0.21	0.21	0.21	0.79	0.84	0.77	0.74	0.72	0.73
Ireland	0.43	0.51	0.50	0.50	0.51	0.51	0.18	0.09	0.09	0.09	0.09	0.09	0.17	0.19	0.19	0.19	0.19	0.19	0.79	0.79	0.78	0.78	0.78	0.79
Italy	0.04	0.04	0.05	0.07	0.07	0.07	0.55	0.54	0.52	0.51	0.51	0.51	0.17	0.17	0.18	0.18	0.18	0.18	0.75	0.75	0.76	0.76	0.76	0.77
Latvia	0.30	0.28	0.35	0.37	0.43	0.43	0.35	0.34	0.25	0.25	0.20	0.20	0.17	0.17	0.17	0.17	0.17	0.17	0.81	0.79	0.77	0.80	0.80	0.80
Lithuania	0.35	0.33	0.33	0.33	0.31	0.32	0.25	0.25	0.25	0.25	0.25	0.25	0.17	0.17	0.17	0.17	0.17	0.17	0.77	0.75	0.76	0.75	0.74	0.74
Netherlands	0.36	0.49	0.55	0.54	0.49	0.55	0.21	0.08	0.01	0.01	0.05	0.05	0.16	0.16	0.17	0.17	0.17	0.17	0.73	0.72	0.73	0.72	0.72	0.77
Norway	0.52	0.53	0.49	0.46	0.44	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20	0.20	0.20	0.20	0.20	0.72	0.73	0.69	0.66	0.64	0.62
Poland	0.37	0.29	0.30	0.28	0.27	0.28	0.31	0.31	0.31	0.31	0.31	0.32	0.18	0.19	0.19	0.19	0.19	0.19	0.86	0.80	0.80	0.78	0.77	0.78

Portugal	0.39	0.37	0.39	0.38	0.38	0.46	0.23	0.20	0.17	0.17	0.15	0.14	0.17	0.19	0.19	0.19	0.19	0.19	0.79	0.76	0.75	0.74	0.72	0.79
Romania	0.42	0.34	0.37	0.41	0.39	0.40	0.22	0.20	0.19	0.14	0.14	0.14	0.19	0.19	0.19	0.17	0.16	0.16	0.83	0.73	0.75	0.72	0.69	0.70
Slovakia	0.43	0.42	0.42	0.38	0.37	0.37	0.24	0.23	0.23	0.23	0.23	0.23	0.16	0.17	0.17	0.17	0.17	0.17	0.83	0.82	0.82	0.78	0.77	0.76
Slovenia	0.15	0.24	0.39	0.39	0.39	0.39	0.44	0.39	0.23	0.21	0.23	0.22	0.17	0.17	0.18	0.18	0.18	0.18	0.76	0.79	0.80	0.79	0.79	0.79
Spain	0.06	0.08	0.10	0.10	0.10	0.10	0.57	0.55	0.51	0.51	0.51	0.51	0.15	0.15	0.17	0.17	0.17	0.17	0.78	0.79	0.78	0.78	0.78	0.78
Sweden	0.12	0.53	0.48	0.48	0.47	0.47	0.39	0.01	0.01	0.01	0.01	0.01	0.20	0.20	0.20	0.20	0.20	0.20	0.72	0.74	0.69	0.69	0.68	0.68
Switzerland	0.30	0.29	0.28	0.28	0.28	0.27	0.25	0.25	0.25	0.25	0.25	0.25	0.07	0.07	0.07	0.07	0.07	0.07	0.64	0.62	0.61	0.61	0.60	0.60
United Kingdom	0.38	0.47	0.49	0.47	0.46	0.46	0.24	0.17	0.17	0.17	0.17	0.17	0.15	0.17	0.17	0.17	0.17	0.17	0.77	0.80	0.82	0.81	0.79	0.79

Notes: In Switzerland in each year, in addition to the specific excise, the ad valorem excise and the value added tax / sales tax, there were other taxes of 0.01 of the price of the most sold brand in decimals. A minimum of 75 % tax share of the retail price of tobacco is recommended by the World Health Organization. *Source*: WHO Report on the Global Tobacco Epidemic 2015. 2017, 2019, 2021.

Table A2: Tobacco Control Scale 2010, 2013, 2016 and 2019 by country

	Price (30)				**Public place bans (22)**				**Public info campaign spending (15)[a]**				**Ad bans (13)**				**Health warning (10)**				**Treatment (10)**				**Total (100)**			
Year 20YY	10	13	16	19	10	13	16	19	10	13	16	19	10	13	16	19	10	13	16	19	10	13	16	19	10	13	16	19
Austria	13	11	11	11	7	8	8	20	-	-	-	2	7	7	7	7	1	1	5	5	4	4	5	5	32	31	36	50
Belgium	17	14	14	16	13	13	15	16	2	2	1	3	8	8	8	8	4	4	5	9	6	6	6	6	50	47	49	58
Bulgaria	21	18	16	15	6	15	11	11	-	-	-	1	10	10	11	11	1	1	5	5	2	2	4	5	40	46	47	48
Croatia	-	14	16	16	-	12	11	11	-	-	1	2	-	11	12	12	-	1	1	5	-	2	4	5	-	40	45	51
Czechia	14	12	14	12	7	9	9	15	-	-	-	2	8	8	8	8	1	1	5	5	4	4	4	7	34	34	40	49
Denmark	16	15	13	13	11	11	11	11	3	2	1	3	8	8	8	8	1	4	5	5	7	6	7	7	46	46	45	47
Estonia	14	14	12	13	12	12	12	14	-	-	-	3	10	10	11	11	1	1	5	5	6	6	6	3	43	43	46	49

Finland	17	15	16	18	17	17	18	18	2	3	3	3	10	12	13	13	2	2	5	5	4	6	5	5	52	55	60	62
France	21	20	19	22	17	17	18	18	1	1	1	7	9	9	11	11	1	4	9	9	6	6	6	7	55	57	64	74
Germany	17	14	13	14	11	11	11	11	-	-	-	2	4	4	4	4	1	1	5	5	4	2	4	4	37	32	37	40
Greece	15	15	16	18	7	7	7	20	-	-	-	1	6	6	6	7	1	1	5	5	3	6	6	3	32	35	40	54
Hungary	15	15	15	15	6	13	17	21	-	-	-	1	7	11	11	11	1	3	5	5	5	6	5	6	34	48	53	59
Ireland	27	24	20	18	21	21	22	22	1	1	2	3	12	12	13	13	2	5	5	9	6	7	8	8	69	70	70	73
Italy	16	15	15	15	17	15	14	16	-	2	2	1	8	8	9	9	1	1	5	5	5	5	6	6	47	46	51	52
Latvia	18	14	14	14	14	14	12	12	-	-	-	4	9	8	9	10	3	3	5	5	0	2	4	4	44	41	44	49
Lithuania	17	12	12	12	12	12	13	13	-	-	1	3	8	8	8	10	1	1	5	5	3	2	4	4	41	35	43	47
Netherlands	16	16	14	14	13	13	15	15	1	1	3	3	9	9	9	9	1	1	5	5	6	7	7	7	46	47	53	53
Norway	25	20	20	22	17	17	17	17	2	3	3	2	12	12	13	13	1	4	4	8	5	5	6	4	62	61	63	66
Poland	15	14	14	14	11	11	11	11	-	-	1	1	9	9	11	11	1	1	5	5	7	8	8	7	43	43	50	49
Portugal	18	14	17	18	11	11	11	11	-	-	1	2	8	8	10	10	1	1	5	5	5	7	6	4	43	41	50	50
Romania	21	19	17	16	7	7	19	21	-	-	-	1	7	8	8	8	3	3	5	5	7	7	7	6	45	44	56	57
Slovakia	15	13	11	12	10	10	10	12	-	-	-	2	9	9	9	9	1	1	5	5	6	6	6	6	41	39	41	46
Slovenia	13	12	13	12	15	15	15	16	-	-	-	3	9	9	9	13	1	1	1	9	6	6	5	6	44	43	43	59
Spain	14	15	14	15	17	21	21	21	1	1	1	3	9	9	9	9	1	4	4	5	4	6	6	5	46	56	55	58
Sweden	17	17	14	14	15	15	15	15	2	-	1	2	10	10	11	9	1	1	5	5	6	5	7	7	51	48	53	52
Switzerland	15	13	13	13	11	11	11	11	9	7	8	4	2	2	2	2	5	5	5	5	6	7	7	7	48	45	46	41
United Kingdom	26	27	26	25	21	21	22	22	8	3	3	3	9	10	12	12	4	4	9	9	9	9	9	9	77	74	81	80

Notes: Hyphen means no information available. The Tobacco control scale components illicit trade and tobacco industry interference (Article 5.3), which were newly introduced in 2019, were integrated into the public information campaign expenditure component for 2019. In 2019, Switzerland received one less point in the total because it has not yet ratified the World Health Organization Framework Convention on Tobacco Control. Sources: The Tobacco Control Scale in Europe 2010, 2013, 2016, 2019.

Table A3 and Table A4 show the detailed results of the IV estimation including the results of the first stage.

Table A3: Detailed results for cigarette sales cig_i based on retail volume excluding illicit trade

	2010		**2012**		**2014**		**2016**		**2018**		**2020**	
	First stage	IV	First stage	IV	First stage	IV	First stage	IV	First stage	IV	First stage	IV
CIG_i (Mean)		288		281		261		261		257		259
p_i		-0.93*** (0.24)		-0.92** (0.37)		-1.24** (0.45)		-0.88** (0.40)		-0.91** (0.43)		-0.84** (0.33)
t_i	0.95*** (0.04)		0.94*** (0.08)		0.80*** (0.05)		0.86*** (0.06)		0.80*** (0.09)		0.89*** (0.09)	
$tcs_{i,t-k}$	-0.03 (0.03)	0.10 (0.12)	-0.06 (0.04)	0.06 (0.15)	-0.02 (0.03)	0.12 (0.13)	-0.07 (0.04)	-0.01 (0.12)	-0.04 (0.08)	0.03 (0.20)	-0.17* (0.10)	0.03 (0.18)
gdp_i	0.18*** (0.04)	0.39*** (0.12)	0.07 (0.05)	0.13 (0.13)	0.06 (0.05)	0.25 (0.13)	0.08 (0.05)	0.16 (0.13)	0.11 (0.07)	0.11 (0.16)	0.16** (0.07)	0.19 (0.21)
N	26	26	26	26	27	27	27	27	27	27	27	27
F-statistic	240		201		241		171		56		91	

Notes: The dependent variable is the number of sold cigarette packs per smoker, where sales are measured by retail volume excluding illicit trade. All lower-case variables in logarithms. Robust standard errors in parentheses. Levels of significances are denoted as follows *** 0.01, ** 0.05, and * 0.10. N denotes the number of observations. In all models, observations of a country have been weighted with the adult population in that country.

Table A4: Detailed results for cigarette sales cig_i based on retail volume including illicit trade

	2010		**2012**		**2014**		**2016**		**2018**		**2020**	
	First stage	IV	First stage	IV	First stage	IV	First stage	IV	First stage	IV	First stage	IV
CIG_i (Mean)		335		321		295		290		286		283
p_i		-0.73*** (0.23)		-0.89** (0.33)		-1.08*** (0.38)		-0.73** (0.35)		-0.62* (0.35)		-0.61** (0.28)
t_i	0.95*** (0.04)		0.94*** (0.08)		0.80*** (0.05)		0.86*** (0.06)		0.80*** (0.09)		0.89*** (0.09)	
$tcs_{i,t-k}$	-0.03 (0.03)	0.06 (0.12)	-0.06 (0.04)	0.09 (0.14)	-0.02 (0.03)	0.10 (0.12)	-0.07 (0.04)	-0.03 (0.11)	-0.04 (0.08)	-0.06 (0.16)	-0.17* (0.10)	-0.01 (0.17)

gdp_i	0.18*** (0.04)	0.17 (0.15)	0.07 (0.05)	0.07 (0.14)	0.06 (0.05)	0.17 (0.12)	0.08 (0.05)	0.10 (0.13)	0.11 (0.07)	0.03 (0.15)	0.16** (0.07)	0.10 (0.18)
N	26	26	26	26	27	27	27	27	27	27	27	27
F-statistic	240		201		241		171		56		91	

Notes: The dependent variable is the number of sold cigarette packs per smoker, where sales are measured by retail volume including illicit trade. All lower-case variables in logarithms. Robust standard errors in parentheses. Levels of significances are denoted as follows *** 0.01, ** 0.05, and * 0.10. N denotes the number of observations. In all models, observations of a country have been weighted with the adult population in that country.