15

How big is the worldwide cigarette-smuggling problem?[1]

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Cigarettes have particular appeal to potential smugglers because taxes often account for a large share of their price, making them a highly profitable product to smuggle. Economic models of smuggling are used to develop techniques for measuring the extent and nature of the worldwide cigarette smuggling problem.

We conduct three separate empirical analyses. Our estimates indicate that between 6% and 8.5% of global cigarette consumption is smuggled. The perceived level of corruption, as measured on a published 'transparency index' ranging from 0 (highly corrupt) to 10 (highly clean), statistically explains more of the variance in experts' estimates of cigarette smuggling than do cigarette prices. Using data on relative cigarette prices and travel between European countries, we estimate the extent of bootlegging (the legal purchase of cigarettes in one country for consumption or resale in another country without paying applicable taxes or duties) in Europe. Simulations show that even when the potential for increased smuggling is taken into account, increases in cigarette tax rates result in increased tax revenue. Coordinated multilateral increases in cigarette taxes would result in significantly more tax revenue and less smuggling than unilateral tax increases.

Smuggling is sometimes perceived to be an insurmountable obstacle to higher cigarette tax rates. Our results suggest that countries need not make a choice between higher cigarette tax revenues and lower cigarette consumption. Higher tax rates will achieve both objectives.

15.1 Introduction

The theory of comparative advantage teaches us that unfettered voluntary trade enhances social welfare. Exceptions to this conclusion may occur if there is imperfect information about the traded good or if the good is associated with negative externalities. In this case, optimal policy may require governments to impose taxes that discourage use of the good. Unfortunately, whenever taxes are imposed, an incentive to evade them arises. Evasion of excise taxes on goods by circumvention of border controls is smuggling. Goods may also be smuggled to evade rules prohibiting their sale.

[1] We thank Luk Joossens and other reviewers for useful comments.

A prohibition on sale can be thought of as an infinite tax. Because taxes on cigarettes often account for a large share of their price they are especially appealing to potential smugglers.

The presence of smuggling constrains the use of higher taxes as one element of a comprehensive tobacco-control policy in at least three important ways. First, smuggling reduces the maximum revenue that can be raised by cigarette taxes since, as tax rates increase, the quantity of smuggled cigarettes is also likely to increase. Second, attempts to control smuggling may absorb both private and law-enforcement resources. Third, smuggling may present opportunities for corruption that lower the legitimacy of law enforcement authorities. Estimates of the magnitude and determinants of cigarette smuggling are, therefore, important inputs to the design of tobacco-tax policy.

Two general types of cigarette smuggling may be distinguished. Bootlegging is the legal purchase of cigarettes in one country but consumption or resale in another country without paying applicable taxes or duties. Wholesale smuggling occurs when cigarettes are sold without the payment of taxes or duties, even in the country of their origin. In this paper we use the term 'smuggling' to refer to both bootlegging and wholesale smuggling. A more in-depth discussion of this terminology is found in Chapter 16. Price differentials among countries create incentives for bootlegging, while high cigarette taxes create an incentive for wholesale smuggling—even when tax systems are harmonized.

In 1995, for example, the retail price of a pack of 20 cigarettes in Germany was $3.38.[2] In neighboring Poland and the Czech Republic, cigarette prices were about one-tenth as high (33–37 cents per pack). Disparities in price of more than 100% between neighbor and near-neighbor countries are not unique to Germany and Eastern Europe. Within Western Europe, Scandinavian countries have cigarette prices two to three times as high as those in southern European countries (Italy, Portugal, and Spain). Even more extreme price disparities are found in Latin America and East Asia. Similar disparities exist within some countries (e.g. between states in the United States).

Price disparities create a large incentive for bootlegging. One source estimates that a single truckload of smuggled cigarettes could evade $1.2 million of taxes in the European Union (Joossens 1998, p. 150). Econometric estimates of cigarette smuggling in the United States, discussed in Section 15.3, generally show a low level of smuggling. However, there is reason to believe that the very large price disparities described above may lead to greater smuggling elsewhere, especially in low-income countries where fewer resources may be available to enforce tight smuggling controls. Estimates by experts in the field, discussed in more detail in Section 15.4, suggest that there are many countries in which smuggled cigarettes account for 20% or more of consumption.

Retail price differentials between neighboring countries alone cannot account for the cross-country variance in smuggling. Smuggling requires evasion of border controls or bribery of border guards. A retail network must be available to distribute smug-

[2] Throughout this paper local prices are converted to US dollars using prevailing exchange rates. See Section 15.4 for data sources and methods of adjustment.

gled cigarettes. Conditions that contribute to smuggling include high levels of government corruption, an established informal market for cigarettes (sales of cigarettes by street vendors), and a well-organized criminal establishment.

15.2 Theoretical considerations

Several key questions must be addressed. What determines the total value of smuggling? Why is there more smuggling in some countries than in others? Why do legal trade and smuggling of cigarettes persist simultaneously? If the expected return on smuggled cigarettes is greater than the expected return on legal trade, why do not smugglers out-compete legal sellers and dominate the market? We apply Desmond Norton's (1988) model of bootlegging to the cigarette trade to answer these questions.

Norton considers a firm located abroad at a distance d from home. The firm has a fixed quantity of cigarettes $\bar{q}$ that can be sold abroad, legally exported to home or illegally bootlegged into home. For each pack of cigarettes sold abroad, the firm earns a price p (denominated in dollars for convenience). Home levies a tax t on cigarettes that is not levied abroad (this assumption effectively rules out the possibility of wholesale smuggling). The firm earns $(p + pt + \theta)$ for each pack sold at home. θ may be greater than, equal to or less than zero depending upon whether the local tax is fully embodied in the local price. Hence, the model allows for less-than-perfect competition in the cigarette industry. Norton assumes an 'iceberg' specification of transport costs—some portion of shipped cargo evaporates in transport. He designates the cost per smuggled cigarette as s(d) and the cost per legally exported cigarette as L(d) and assumes that $s'(d)$ and $L'(d) > 0$.

Smugglers face a risk of detection of $(1 - \mu)$ and, if detected, pay a penalty that is proportional to the amount of smuggled cigarettes that are seized. The probability of non-detection, μ, is postulated to be a decreasing function of the amount smuggled and an increasing function of the amount legally exported. That is, Norton assumes that legal exports camouflage bootlegging (see Thursby *et al.* (1991) for a related model of cigarette smuggling).

In Norton's model the firm's objective function is given by:

$$\begin{aligned}\pi(d) = {} & \mu(q^s, q^L)(p + pt + \theta)(1 - s)q^s \\ & -(1 - \mu)\alpha(1 - s)pq^s \\ & +(p + \theta)(1 - L)q^L \\ & -p(q^s + q^L),\end{aligned} \tag{15.1}$$

where q^s = the quantity of cigarettes smuggled into home, q^L = the quantity of cigarettes legally imported to home, and α is the share of revenue from intercepted smuggled cigarettes that offenders must pay as a penalty. The firm's problem is to choose q^s and q^L subject to the constraints that: $q^s + q^L \leq \bar{q}$ and $q^s, q^L \geq 0$.

The first term on the right-hand side of eqn 15.1 is expected revenue from successful bootlegging, the second term is the expected penalty from smuggled cigarettes that are intercepted, the third term is revenue from legal exports, and the fourth term is revenue foregone as a result of reduced sales abroad.

Norton shows that, depending upon the parameters, there are several possible kinds of optimal allocations by the firm. In particular, Norton shows that optimal solutions in which both $q^s > 0$ and $q^L > 0$ are possible. Furthermore, he shows that an increase in the tax rate t will increase the optimal choice of q^s among existing smugglers and increase the number of firms that smuggle, resulting in an increase in the aggregate amount of bootlegging. Norton's model also shows that an increase in the fine paid by smugglers if they are detected (α) reduces the profit-maximizing level of smuggling. In Appendix 15.1 (at the end of the chapter), we extend Norton's model in a straightforward way and show that an increase in the probability of detection reduces the optimal quantity smuggled. Norton's model has clear empirical implications: we should find higher levels of bootlegging into countries with high taxes and low levels of enforcement.

What are the welfare implications of cigarette smuggling? Bhagwati and Hansen (1974) note that, for goods that carry no negative externalities, optimal economic policy requires that small countries impose no tariffs. They go on to say:

> . . . [i]t is commonly argued that smuggling must improve economic welfare since it constitutes (partial or total) evasion of the tariffs (or quantity restrictions)

However, Bhagwati and Hansen reason that, because smugglers must take action to evade detection, smuggling increases transportation costs. They show that if smuggling occurs under conditions of perfect competition and constant costs then, in any circumstances where smuggling and legal trade coexist, 'smuggling must be a welfare-reducing activity' (p. 13).

Cigarette smoking imposes significant negative externalities (see Chapter 4 and Chapter 7; Chaloupka and Warner, in press). If so, taxation of cigarettes, so that consumers internalize negative externalities, is appropriate. Although there has been no formal theoretical welfare analysis of the smuggling of 'bads' (as distinct from 'goods'), which impose negative externalities, it is clear that Bhagwati and Hansen's results can be extended to cover this case. If smuggling of goods reduces welfare, then smuggling of bads must reduce welfare even further, since it circumvents a tax that would otherwise improve national well-being. Smuggling may reduce retail prices below the social cost of the bad.

15.3 Previous empirical literature

Most of the direct evidence about cigarette smuggling comes from high-income countries. However, the general theoretical model of smuggling is applicable to a broad range of societies. Further, as shown elsewhere in this volume, we have considerable direct evidence that the smoking behavior of individuals in middle-income and low-income countries responds to changes in economic incentives. Therefore, it is reasonable to believe that the lessons about cigarette smuggling learned in high-income countries will be more or less applicable to middle-income and low-income countries.

A number of empirical studies have demonstrated that despite its addictive nature, cigarette smoking—like other consumption activities—responds to economic variables. There is clear evidence that increases in price decrease smoking, but there are

mixed empirical results about whether increases in income increase smoking (see Chaloupka and Warner, in press).

Smuggling is inherently difficult to study with econometric methodology. Because of its illegal nature the dependent variable, cigarette smuggling, generally has to be inferred rather than be directly observed. Inferences about smuggling require some confidence about what variables influence the demand for cigarettes in the absence of smuggling and whether illegal behavior, like smuggling, may be influenced by economic incentives. In recent years, economists have reached something approaching consensus on both issues.

In contrast to the difficulty in observing smuggling directly, it is often possible to observe the level of 'tax-paid sales', i.e. the level of cigarette sales on which the government collected excise taxes. The level of smuggling can be inferred by calculating the difference between the demand for cigarettes predicted by econometric models and the observed level of tax paid sales. Furthermore, we may study how sensitive smuggling is to changes in variables that are believed to influence smuggling.

The higher the rewards of smuggling, and the lower the costs, the greater the probability that individuals will engage in it. The reward for smuggling is closely related to the probability of detection, the magnitude of punishment, and the difference in profits from legally sold versus smuggled cigarettes. The costs of smuggling include ordinary economic costs like foregone salaries from other employment and the cost of the capital employed in smuggling. Other costs may also arise, including the cost of bribery or the potential cost of going to jail if the smuggling is discovered.

A number of recent studies that have used this methodology to econometrically measure the degree of cigarette smuggling are briefly outlined in Table 15.1 below. Baltagi and Levin (1986, 1992) studied cigarette bootlegging and legal cross-border shopping between US states. They found that cigarette sales varied inversely with price and that higher prices in neighboring states increased cigarette sales in the state of residence. They reasoned that such price increases reduced the incentive for consumers to cross into neighboring states to make purchases. In their 1992 paper, Baltagi and Levin found that each 10% increase in a neighboring state's price caused an increase of 0.8% in home state sales.

Saba *et al*. (1995) also found significant evidence of citizens crossing US state borders to purchase lower-priced cigarettes. Where many citizens reside in high-tax jurisdictions in close proximity to low-tax jurisdictions (most importantly the District of Columbia and New Hampshire), border-crossing accounted for a substantial portion of sales. However, in most states border-crossing accounted for less than 2% of sales.

A sophisticated study by Thursby and Thursby (2000) allowed for wholesale smuggling, as well as bootlegging and cross-border shopping. Using data from 39 US states, and the District of Columbia from 1972 to 1990, they found that in most years between 3% and 5% of US consumption results from cross-border shopping or smuggling.

Galbraith and Kaiserman (1997) studied smuggling in Canada. They noted that 'virtually all cigarettes smuggled into Canada . . . were previously exported from Canada' (pp. 288–9). Using this insight, they measured the responsiveness of smuggling to changes in taxes. Beginning in the early 1980s, Canada steadily increased its cigarette taxes so that, by 1991, there was a large price differential between US and Canadian cigarettes. In 1994, Canada reduced cigarette taxes due to a perception that smuggling had increased. Galbraith and Kaiserman found that there was a large

Table 15.1 Econometric studies of cigarette smuggling

Study	Geography and period	Results	Notes
Baltagi and Levin (1992)	46 US states 1963–88	10% increase in price in neighboring state causes 0.8% increase in taxed sales of home state	Results largely confirm Baltagi and Levin (1986)
Saba *et al.* (1995)	48 continental US states and DC 1960–86	Excluding DC no state lost more than 2% of sales as a result of purchases in neighboring states in 1986	In many states cross-border sales declined between 1960 and 1986
Thursby and Thursby (1998)	40 US states 1972–90	0.69–7.8% of consumption is smuggled	In most years smuggling is between 3% and 5% of total sales
Galbraith and Kaiserman (1997)	Aggregate Canadian monthly consumption 1980–94	Total consumption is much less responsive to price increases (short-run elasticity of –0.40) than taxed consumption (short-run elasticity of –1.01)	Canada's 1991 cigarette tax increase was rolled-back in 1994 due to belief that high taxes encouraged smuggling

increase in untaxed sales following the increase in Canadian taxes. They estimated a unitary elasticity of taxed cigarette consumption with respect to price: each 1% increase in Canadian taxes causes taxed sales to fall by about 1%. However, Galbraith and Kaiserman found that total consumption (taxed plus smuggled sales) fell by only 0.4%, with smuggled sales increasing by 0.6%. Gailbraith and Kaiserman's estimates suggest that, despite the increase in smuggling, total Canadian tax revenues were not diminished by the tax rate increase, and that total consumption was reduced.

In summary, existing evidence suggests that in the United States interstate smuggling has been, in most cases, a relatively minor annoyance, rather than a major barrier to cigarette taxation. In Canada, cigarette smuggling may be a larger impediment. This difference may stem from the relatively small inter-state price differentials induced by US cigarette taxation compared to the relatively large price differentials brought about by increases in Canadian taxation.

To what extent the experiences of Canada and the US can be extended to other regions of the world is open to debate. Although there are no econometric studies of cigarette smuggling outside North America one careful observer (Joossens 1998, p. 146) notes that:

> . . . it is not always true that the incentive for smuggling is linked to the level of taxes. For example, in countries with the highest taxes in Europe, such as the Scandinavian countries, there is little evidence of smuggling, while in Spain, Italy and many Central and Eastern European

countries, where taxes and prices are much lower, the illegal sale of international cigarette brands is widespread.

There is a small empirical literature on smuggling of contraband into and out of low-income and middle-income countries. This literature finds that there is substantial contraband smuggling and that smuggling increases with the level of tariffs and taxes (Bhagwati 1974; Simkin 1974; Norton 1988). In the next section we discuss three empirical exercises in an attempt to quantify more accurately the worldwide cigarette smuggling problem.

15.4 Quantitative analysis of cigarette smuggling

As noted above, it is difficult to study smuggling activities because of the scarcity of data. We approach this problem by discussing three separate empirical exercises, each of which we believe sheds some light on the extent and nature of the worldwide cigarette smuggling problem.

15.4.1 Comparing recorded imports and exports of cigarettes

One method of assessing the amount of illegal trade in a product is to compare recorded exports and imports. This methodology was pioneered by Bhagwati (1974b), who noted that under-recording of imports may be used as a technique to avoid payment of tariffs; and Simkin (1974) who noted that under-recording of exports may be used to avoid payment of export taxes. Bhagwati (1974b) studied Turkey's recorded imports from several trade partners and each of those trade partners' recorded exports to Turkey. Bhagwati cautioned that there are a number of reasons why the levels of recorded imports may be less than those of recorded exports, including: errors of commodity classification; time lags; misallocation of country-of-origin by the receiving country; and over-invoicing by the exporting country. After careful scrutiny of the data, Bhagwati (p. 145) concludes that there are 'significant discrepancies for which the only explanation appears to be the under-invoicing [of goods received from Turkey's trade partners]'. Simkin conducted a similar analysis of Indonesia's exports and reached 'an estimate of $127 million a year for Indonesia's unrecorded exports . . . against a figure of $435 million for their recorded exports' (p. 169).

It is possible to conduct a similar analysis of the world cigarette market. Table 15.2 (reproduced from Joossens 1998) reports aggregates of world-wide recorded exports and imports of cigarettes. Recorded exports are consistently about 1.3 times as great as imports. While recorded cigarette exports grew about five-fold between 1975 and 1996, recorded imports grew only slightly more than four-fold. In 1996, recorded exports exceeded recorded imports by about 400 billion cigarettes, suggesting that perhaps one-third of all recorded exports were smuggled. Chaloupka and Corbett (1998) estimate that in 1996, nearly 17.5% of all global cigarette production was exported (p. 134). If one-third of all exports were smuggled, this would account for about 6% of world cigarette consumption. To this total may be added both unrecorded exports and wholesale-smuggled cigarettes that do not cross national boundaries.

However, cautious interpretation of these results is advisable. As both Bhagwati (1974b) and Simkin (1974) noted, many factors may explain a discrepancy between

Table 15.2 World cigarette imports and exports (billions of sticks)

Year	Imports	Exports	Ratio exports to imports
1975	171	223	1.30
1980	254	323	1.27
1985	313	356	1.14
1990	418	543	1.30
1991	526	712	1.35
1992	568	804	1.42
1993	600	780	1.30
1994	886	1156	1.30
1995	668	987	1.48
1996	707	1107	1.57

Source: US Department of Agriculture (1997), as quoted in Joossens (1998).

recorded exports and imports. An analysis of data from the United Nations Comtrade databank shows large discrepancies between total reported imports and exports of many products (these data may be accessed at http://www.intracen.org/itc/infobase).

We found that manufactured tobacco (SITC 122) trade follows a pattern similar to that described by Joossens (1998). However, there are also large discrepancies between the total recorded imports and exports of rice (SITC 42) and coca (SITC 72). Between 1992 and 1996 manufactured-tobacco exports were between 133% and 147% of manufactured tobacco imports. Coca exports were between 53% and 62% of coca imports and rice exports were between 78% and 119% of rice imports.

Smuggling is not the only possible explanation for these statistical discrepancies (see Feenstra *et al*. 1999). What makes cigarettes different from other commodities is the consistency with which exports greatly exceed imports. Statistical discrepancies alone would not necessarily lead to any consistent relationship between cigarette imports and exports. The most reasonable explanation for the observed data is that a large and growing fraction of international trade in cigarettes is smuggled.

15.4.2 Analysis of experts' estimates of cigarette smuggling

Offical estimates of cigarette smuggling are not available for most countries. We obtained experts' estimates of the amount of smuggling from several sources. Joossens (1998) compiled quantitative estimates for 11 European countries from a variety of official and non-official sources. A private company, Market Tracking International (MTI), published estimates of smuggling as a percentage of total cigarette sales for many countries in its serial publication *World Tobacco File*. When the two sources conflict we have used data from Joossens (1998). Data compiled from these sources is given in column 3 of Table 15.3.

MTI does not publish information about the methodology used to obtain their estimates of smuggling. In communications with the MTI staff we were told that the estimates were obtained by consultation with local experts, government officials and through review of media coverage of local market conditions. In some cases, MTI's

Table 15.3 Estimates of price, smuggling and transparency

Country	Price/pack US$ (1995)[a]	Estimate of smuggling as a percentage of 1995 domestic sales by expert sources	Source of smuggling estimate	Transparency index[b]
Argentina	1.38	14%	2	3.0
Australia	4.85	na	na	8.7
Austria	2.96	15%	4	7.5
Azerbaijan	na	13%	1	na
Bangladesh	0.09	38%	3	na
Belgium-Lux	3.32	7%	4	5.4
Belarus	na	23%	1	3.9
Brazil	1.05	15%	2	4.0
Bulgaria	0.31	15%	1	2.9
Cambodia	0.05	37%	3	na
Canada	3.98	na	na	9.2
China	0.10	4%	2	3.5
Colombia	0.06	30%	2	2.2
Czech Rep	0.33	7%	1	4.8
Denmark	5.21	na	na	10.0
Ecuador	0.15	na	na	2.3
Estonia	na	16%	1	5.7
Finland	4.49	na	na	9.6
France	2.90	2%	4	6.7
Germany	3.38	10%	4	7.9
Greece	1.90	8%	4	4.9
Hong Kong	1.58	10%	3	7.8
Hungary	0.52	5%	1	5.0
India	0.37	1%	2	2.9
Indonesia	0.00	5%	3	2.0
Ireland	1.69	4%	4	8.2
Italy	2.19	12%	4	4.6
Jamaica	0.37	na	na	3.8
Japan	2.43	na	na	5.8
Kazakhstan	na	17%	1	na
Lao	0.43	na	na	na
Latvia	na	39%	1	2.7
Lithuania	na	30%	1	na
Malaysia	0.68	18%	3	5.3
Mexico	0.62	na	na	3.3
Myanmar	0.56	53%	3	na
Nepal	0.08	1%	2	na
Netherlands	2.99	8%	4	9.0
New Zealand	4.69	na	na	9.4
Norway	7.01	na	na	9.0
Pakistan	0.28	30%	2	2.7
Philippines	0.22	19%	3	3.3
Poland	0.37	15%	1	4.6
Portugal	1.47	na	na	6.5
Romania	0.04	20%	1	3.0

Table 15.3 (*cont.*)

Country	Price/pack US$ (1995)[a]	Estimate of smuggling as a percentage of 1995 domestic sales by expert sources	Source of smuggling estimate	Transparency index[b]
Russia	0.03	6%	1	2.4
Korea Rep.	0.77	9%	3	4.2
Singapore	2.24	2%	3	9.1
Slovakia	0.38	3%	1	3.9
South Africa	1.32	na	na	5.2
Spain	1.38	15%	4	6.1
Sri Lanka	1.05	10%	3	na
Sweden	4.58	2%	4	9.5
Switzerland	2.80	na	na	8.9
Taiwan	0.88	14%	2	5.3
Thailand	0.60	11%	3	3.0
Turkey	0.51	na	na	3.4
UK	4.16	2%	4	8.7
United States	1.94	na	na	7.5
Ukraine	na	5%	1	2.8
Uzbekistan	na	11%	1	na
Venezuela	0.07	na	na	2.3
Vietnam	0.10	28%	3	2.5
Zimbabwe	0.43	na	na	4.2

[1] Source is *World Tobacco File* (1997) Emerging markets in Central and Eastern Europe table 6.1.
[2] Source is *World Tobacco File* (1996) **2**, table 10.4.
[3] Source is *World Tobacco File* (1997) Emerging Asian markets table 6.2.
[4] Source is Joossens (1998) p. 150.
na = not available.

Note: When a source gives a range of smuggling estimates (e.g. 5–10%) we use the midpoint of the range (e.g. 7.5%).

[a] Sources: Unpublished data, World Bank, and Marketfile.
[b] Source: Tranparency International 1998.

reports of the share of smuggling in a country vary a great deal from year to year. For example, its estimate of smuggling in Russia increased from 6% of the market in 1995 to 25–30% of the market in 1996 (Market Tracking International 1997). While we are somewhat skeptical of the accuracy of these estimates, we believe that they represent the most comprehensive compilation of experts' estimates of cigarette smuggling available.

The population-weighted average figure for smuggling as a percentage of the total cigarette consumption is about 8.5%; the unweighted average is 13.3%. The experts' population-weighted estimate of cigarette smuggling is remarkably consistent with our estimate from recorded cigarette imports and exports above. Are the experts' estimates of smuggling consistent with the predictions of economic theory?

Norton's (1988) theoretical model implies that the share of bootlegged cigarettes in the local market should be positively associated with the relative price of cigarettes and inversely correlated with enforcement activities in that market. Although we did

not have direct estimates of local enforcement activities, we obtained a measure of the perception of corruption in a large number of countries.[3]

Transparency International (1998), a non-governmental organization dedicated to increasing government accountability, compiled surveys of perceptions of the degree of corruption as seen by business-people, risk analysts, and the general public. Among other questions, the surveys asked about respondents' perceptions of illegal payments to public officials and policemen, and those monitoring imports and exports. On the basis of these surveys, Transparency International used a 'poll-of-polls' approach to assign each country a composite corruption perception index ranging between 10 (highly clean) and 0 (highly corrupt). We used this index as a measure of the ease with which illegal cigarettes could be imported and distributed. Transparency International's index for countries on which we have cigarette price or smuggling data is shown in column 5 of Table 15.3.

We estimated local cigarette prices by comparing total quantities of cigarettes sold in the legal market with total expenditures on legal cigarettes. The sales data were obtained from Marketfile, which provided data on millions of cigarettes sold. Domestic per capita cigarette sales were estimated by dividing of the total number of cigarettes by 20 and by the total population. Marketfile was also the source for data on the total value of sales in local currency. This value was adjusted to US dollars using the current US market exchange rate. The nominal price per pack of 20 cigarettes was estimated by dividing the total value of sales by the total number of cigarettes and multiplying by 20. Price estimates for 1995 are shown in column 2 of Table 15.3.

In this sample, we do not have sufficient data to control for prices in neighboring countries. We attempt to do this for a sample of European countries in a subsequent subsection. The amount of bootlegging, i.e. the legal purchase of cigarettes in one country but sale in another country without paying applicable taxes or duties, may depend on the price in neighboring countries. Wholesale smuggling, that is, sale without paying applicable taxes even in the country of origin, may be correlated with the absolute price in a country. We expect to observe little bootlegging among countries with high prices if all neighboring countries also have high prices. However, these countries might be attractive destinations for wholesale smugglers with much lower home-country prices. If the price of cigarettes in neighboring countries is correlated with home-country cigarette price (as, for example, in Western Europe where all countries have relatively high prices), the ratio of home-to-neighboring countries' prices may be uncorrelated with home-country price. If so, our estimates of wholesale smuggling may be unbiased. Hence we interpret the coefficient on cigarette price as an estimate of the change in wholesale smuggling with increases in cigarette prices.

Income was represented by the gross domestic product (GDP) per capita, evaluated at the current US exchange rate. We obtained this data from the World Development Indicators (World Bank 1997). A few former socialist countries (such as Russia, the former German Democratic Republic, Slovakia, and the Czech Republic) have missing values. Germany's data is missing after reunification. The missing income data for these countries were estimated using earlier years of data by the exponential end-point method. Using these data we estimated the regressions shown in Table 15.4.

[3] See World Bank (1997) for a discussion of the causes and consequences of government corruption.

Table 15.4 Regressions on experts' estimates of smuggling around the world (t statistics in parentheses)

Specification	1	2	3	4	5
Price per pack in US dollars in 1995	–0.04 (2.50)			–0.002 (0.08)	–0.01 (0.53)
Transparency index		–0.02 (3.38)		–0.02 (1.76)	–0.02 (1.88)
GDP per capita 1995			–4.31E-06 (2.48)		2.61E-06 (0.73)
Constant	0.18 (7.12)	0.22 (6.74)	0.17 (7.13)	0.22 (5.63)	0.23 (5.48)
Adjusted r-squared	0.124	0.246	0.122	0.221	0.208
N	38	33	38	33	33

Specifications 1, 2, and 3 include price, the transparency index and GDP per capita, respectively, as independent variables. Price and GDP per capita have counter-intuitive negative signs, suggesting that smuggling falls as price and income increase. The transparency index has the expected negative sign—the less corrupt the government is, the less cigarette smuggling is perceived by experts to occur. As shown in specifications 4 and 5, when the transparency index is included along with price and GDP per capita, these variables become insignificantly different from zero while the transparency index maintains its expected negative and significant sign. Apparently, the inverse relationship between price (income) and smuggling is illusory. The negative correlation of smuggling and income comes about because poorer countries tend to have more corruption. The negative correlation between smuggling and price comes about because high-income countries tend to be countries with higher prices.

A 95% confidence interval around the coefficient on price includes both positive and negative values. Consistent with the arguments made in Joossens and Raw (1998) we cannot definitively reject Norton's hypothesis that high-price countries have some wholesale smuggling. However, the empirical results suggest that factors other than price, and particularly transparency, are very important.

According to the empirical results, each 1-point increase in a country's transparency index is associated with a 2%-point decrease in experts' estimates of cigarette smuggling. This means that if Pakistan could increase its transparency index from its current level of 2.7 to 4.9 (the level attained in Greece and the median level for countries on which we have data), we would expect experts' estimates of the proportion of cigarettes smuggled in Pakistan to drop from 30% to about 26%.

15.4.3 Analysis of links between recorded cigarette sales and price in neighboring European countries

Our analysis of recorded imports and exports of cigarettes focused on wholesale smuggling. Our analysis of experts' estimates of cigarette smuggling suggested that trans-

parency had a more important influence on wholesale smuggling than the absolute price of cigarettes but shed little light on the causes or magnitude of bootlegging (legal purchase of cigarettes in one country with resale in a higher-tax country). Most previous econometric analyses of smuggling (see Section 15.3) have focused on North America, where bootlegging is believed to be the primary problem. In this section we turn our attention to bootlegging in Europe.

We analyzed data on European cigarette prices, sales, international travel, and other variables in order to obtain quantitative estimates of the extent of bootlegging during the period 1989–95. We provide a brief description of our procedures and discuss the interpretation of our results. (Appendix 15.2 gives more technical details of our econometric procedures.)

We estimated a statistical equation to explain per capita cigarette sales between 1989 and 1995. In this analysis we restricted our investigations to 23 countries in Europe, where we have fairly complete data on consumption and prices (see Table 15.6 for a list of countries). We also explicitly modeled and attempted to empirically measure the extent of bootlegging among these countries.

Specifically, we assume that cigarette sales depend upon domestic price (P), income (Y), and other variables, such as the degree of corruption in the country, (X). From this total we subtract the quantity of cigarettes purchased by citizens while traveling abroad (bootlegged imports), and add the quantity of cigarettes purchased by foreign citizens traveling in the home country (bootlegged exports). Since legal duty-free sales account for only a small portion of these sales, these are ignored in the subsequent analysis (see Joossens *et al.* (Chapter 16) for a more detailed discussion of duty-free sales). In symbolic language we write:

$$\text{sales} = f(P,Y,X) - \text{bootlegged imports} + \text{bootlegged exports}. \qquad (15.2)$$

We estimated eqn 15.2 using data on countries in Europe during the period 1989–95. We used the same price and income data used above in our analysis of experts' estimates of smuggling. Since the extent of bootlegging is not directly observed, we estimated it. We assumed that the incentive to bootleg for any particular traveler is proportional to the difference in price between the home and destination countries. We estimated the total number of cross-border travelers on the basis of data from the World Tourism Organization's *Yearbook of Tourism Statistics* from 1991 through 1995. The World Tourism Organization obtained the data primarily from a questionnaire sent to government offices, supplemented with data published by official sources. Using these data, we created variables that measure the aggregate incentive for bootlegged imports and bootlegged exports. Our procedures were similar to those used by Becker *et al*. (1994) in their study of the demand for cigarettes in the United States. Full details on the construction of these variables are contained in Appendix 15.2.

We also included a dummy variable for each year and a dummy variable for each country. These variables correct for any factors that are constant over time but vary by country (such as the cultural heritage of the country) or are constant across countries but vary over time (such as the state of knowledge about how smoking affects health.)

We do not have multiple estimates of the transparency index for each country. Even if we did have these data, we are skeptical that changes in long-distance smuggling mirror year-to-year changes in perceptions of corruption. To control for the average

Table 15.5 Cigarette consumption in Europe: alternative regression specifications* (t statistic in parens below coefficient)

Specification Sample	1 Europe	2 Europe	3 Europe	4 Europe	5 Europe
No. observations	146	146	101	101	101
No. countries	23	23	18	18	18
Mean of dependent variable	4.39	4.39	4.50	4.50	4.50
Mean price	1.51	1.51	1.14	1.14	1.14
Price-elasticity at the mean	–0.47	–0.24	–0.18	–0.14	–0.13
Adjusted r-square	0.5151	0.9757	0.9592	0.9606	0.9611
Aggregate incentive for bootlegged imports				–0.13 (1.88)	–0.14 (2.16)
Aggregate incentive for bootlegged exports				–0.02 (0.59)	–0.02 (0.67)
Price	–0.31 (9.93)	–0.16 (6.22)	–0.16 (4.19)	–0.12 (2.92)	–0.11 (2.95)
GDP per capita	1.12E-05 (1.03)	3.83E-05 (2.73)	2.83E-05 (1.71)	1.63E-05 (0.94)	1.09E-05 (1.38)
Square of GDP per capita	1.65E-10 (0.41)	–3.47E-10 (0.88)	–6.65E-10 (1.45)	–1.77E-10 (0.35)	
Year dummies	Yes	Yes	Yes	Yes	Yes
Country dummies	No	Yes	Yes	Yes	Yes

* All regression estimated by ordinary least squares.
Dependent variables is natural log of packs of 20 cigarettes per capita.

level of corruption in the country during the period of our study (1989–95) and large-scale organized wholesale smuggling, we used country dummies rather than the country's transparency index.

We obtained the regression results reported in Table 15.5. Specification 1 estimates a classic cigarette demand curve with data on 23 countries in Europe. Our empirical results are typical of empirical studies of cigarette demand. The adjusted r-squared was 0.515. The coefficient on price was negative and significant with an estimated price elasticity of demand of –0.47. The coefficients on GDP per capita and its square, while positive, were not significantly different from zero. As Kenkel and Chen explain (Chapter 8), this result may stem from the positive correlation between education and income. Higher education may lead to higher income but at the same time may discourage cigarette consumption.

In specification 2 of Table 15.5 we added country fixed effects to the specification in column 1. This resulted in a large increase in the adjusted r-squared and a large decline in the coefficient on price. The coefficient on GDP per capita increased and became statistically significant. The large decline in the coefficient on price suggests that coun-

tries with low cigarette prices tend to have other fixed characteristics that result in a relatively high level of smoking. Further research is necessary to investigate precisely which characteristics of these countries resulted in high levels of smoking.

Specification 3 replicated specification 2 with the smaller European sample for which we had sufficient information to construct measures of the incentives for bootlegging. This change in sample resulted in little change in the adjusted r-squared or the coefficients of the independent variables.

Specification 4 adds variables measuring the incentives for bootlegged imports and exports. These are the coefficients of primary interest to us. The estimated coefficient on incentives for bootlegged imports was negative and statistically significant, indicating that an increase in the incentive for home-country citizens to purchase cigarettes abroad lowered domestic sales. This is exactly the result that we would expect. Our variable indicating incentives for bootlegged exports is constructed so that it varies inversely with the incentive for bootlegged exports. Hence we also expect, and find, a negative coefficient on this variable. Although the coefficient on incentives for bootlegged exports was not significantly different from zero, the sum of the coefficients on incentives for bootlegged imports and exports were jointly significantly different from zero. We can be quite confident that a policy that raises incentives for bootlegging (such as a tax increase) will significantly reduce domestic sales. Finally, in specification 5, we dropped the insignificant variable for GDP per capita squared. This resulted in little change in our estimated coefficients.

We investigated many other regression specifications in the course of our research. The qualitative results reported here were generally maintained with alternative specifications. Thus, we have confidence that our findings would not be greatly altered by sensible but arbitrary changes in our statistical procedures. Some discussion of alternative estimates is presented in Appendix 15.2.

What percentage of European domestic sales do we estimate are bootlegged? Since the dependent variable in Table 15.5 is the natural logarithm of per capita sales, the coefficients on incentives for bootlegged imports and exports can be interpreted as the percentage change in sales from a one unit change in these variables. The mean value of the incentives for bootlegged imports in our European sample is 0.23. The estimated coefficient on this variable in specification 5 is (–0.14). If incentives for bootlegged imports fell from its mean level to zero, sales would fall by about 3% ($0.03 \cong 0.23*0.14$). Thus, we estimate that in a European country with the mean level of incentives for bootlegged imports, about 3% of sales are bootlegged cigarettes. On the other hand, the mean level of incentives for bootlegged exports is –0.53. We estimate that in a European country with the mean level of incentives for bootlegged exports a little more than 1% ($0.01 \cong 0.53*0.02$) of sales are bootlegged abroad. This is not necessarily inconsistent with our earlier estimates of the level of cigarette smuggling. In addition to European bootlegging we expect that some sales are the result of wholesale smuggling. While we control for the level of wholesale smuggling by including country-specific dummy variables we do not obtain quantitative estimates of wholesale smuggling in Europe.

The policy significance of our empirical results can be most easily understood by using the regression results to simulate the impact of specific policy changes. We present these simulations in Table 15.6. Columns 1–3 of the table present some of the

Table 15.6 Simulations of cigarette bootlegging in Europe

Country*[a]	Population	Observed	Packs of 20 per capita in 1995							Percent	
	(in 000s)[b]	price (nominal US dollars)[c]	Regression Predicted domestic sales[d]	Predicted domestic sales with no retail imports or exports[e]	Estimated Net bootlegging[f]	Predicted domestic sales with multilateral 10% price increase[g]	Estimated net bootlegging with multilateral 10% price increase[h]	Predicted domestic sales with unilateral 10% price increase[i]	Estimated net bootlegging with unilateral 10% price increase[j]	Predicted change in tax revenue with unilateral 10% tax increase[k]	Predicted change in tax revenue with multilateral 10% tax increase[l]
Austria	8 054	$2.96	89	100	–11	86	–12	83	–14	2.9%	6.4%
Belgium-	10 146	$3.32	79	88	–9	76	–10	74	–12	2.4%	6.1%
Bulgaria	8 409	$0.31	99	99	0	99	0	99	0	9.7%	9.8%
CzeckRep	10 332	$0.33	.	.	ne	ne	ne	ne	ne	ne	ne
Denmark	5 220	$5.21	.	.	ne	ne	ne	ne	ne	ne	ne
France	58 060	$2.90	75	79	–4	73	–5	72	–6	5.8%	7.0%
Finland	5 110	$4.49	.	.	ne	ne	ne	ne	ne	ne	ne
Germany	81 869	$3.38	80	101	–21	76	–22	74	–24	2.6%	4.7%
Greece	10 467	$1.90	138	136	2	136	2	135	1	8.1%	8.6%
Hungary	10 229	$0.52	120	116	3	120	4	119	3	9.5%	9.9%
Ireland	3 586	$1.69	84	81	3	83	3	83	2	8.3%	9.0%
Italy	57 204	$2.19	78	78	0	77	0	76	0	7.8%	8.2%
Netherla	15 460	$2.99	55	57	–3	53	–3	52	–4	4.8%	7.1%
Norway	4 354	$7.01	.	.	ne	ne	ne	ne	ne	ne	ne
Poland	38 612	$0.37	125	118	7	125	8	124	7	9.6%	10.3%
Portugal	9 927	$1.47	82	81	1	81	1	80	0	7.9%	8.9%
Romania	22 692	.	.	.	ne	ne	ne	ne	ne	ne	ne
Slovakia	5 369	$0.38	78	78	0	78	0	78	0	9.4%	9.7%
Spain	39 199	$1.38	103	100	2	102	3	101	2	8.6%	9.1%
Sweden	8 830	$4.58	.	.	ne	ne	ne	ne	ne	ne	ne
Switzerl	7 039	$2.80	109	118	–8	106	–9	102	–13	2.6%	6.9%
Turkey	61 058	$0.51	66	66	0	66	0	66	0	9.6%	9.6%
UK	58 533	$4.58	75	80	–5	72	–6	71	–7	4.6%	5.9%
Median	10 229	$2.50	82	88	0	81	0	80	0	7.9%	8.9%
Mean (unweighted)	23 468	$2.51	90	93	–3	89	–3	88	–4	6.9%	8.2%

[a] Country name.
[b] Population.
[c] Observed price base on Market Facts data.
[d] Estimated sales using coefficients from Table 15.5 specification 5.
[e] Uses regression coefficients from Table 15.5 specification 5 and assumes no incentive for bootlegging.
[f] Column 5 – column 4.
[g] Uses regression coefficients from Table 15.5 specification 5 and assumes multilateral 10% price increase.
[h] Difference between column 7 and estimated sales when multilateral price increase of 10% and no incentive for bootlegging.
[i] Uses regression coefficients from Table 15.5 specification 5 and assumes unilateral 10% price increase.
[j] Difference between column 9 and estimated sales when unilateral price increase of 10% and no incentive for bootlegging.
[k] Ratio (1.10*column 9/column 4) minus 1.
[l] Ratio (1.10*column 7/column 4) minus 1.
ne = not estimated.
* Data are incomplete for some countries in some years.

observed data on key variables about each country in the sample. Observed prices vary from $0.31 per pack in Bulgaria to more than $7 per pack in Norway. We were unfortunately forced to exclude several countries from the complete analysis as a result of missing data.

Column 4 presents predicted sales on the basis of the regression results reported in Table 15.5, specification 5. Because the regression analyses closely tracked the data (the adjusted r-square was more than 96%) the estimates in column 4 are generally quite similar to the observed values. Predicted sales vary between 55 packs per capita in the Netherlands and 138 packs per capita in Greece.

Column 5 reports the predicted value of cigarette sales if there were no bootlegging (i.e. incentives for bootlegged imports and exports are set to zero), and column 6 reports the difference between column 4 and column 5. Thus, column 6 is our estimate of net bootlegging—the balance of trade in bootlegged cigarettes. Some countries have negative numbers in this column, indicating that they are, on balance, net importers of bootlegged cigarettes. Other countries have positive numbers, indicating that they are, on balance, net exporters of bootlegged cigarettes.[4] Net bootlegging varies from exports of 7 packs per capita in Poland to imports of 21 packs per capita in Germany. Importing countries tend to be those with relatively high prices and incomes, such as Austria, Germany and Switzerland. Exporting countries tend to have lower prices and incomes, such as Hungary and Poland.

We examined two policies to determine how they might affect domestic sales and net bootlegging. Policy one (reported on in columns 7 and 8), was a 10% tax increase which we assume is fully reflected in higher retail prices and is undertaken jointly by all countries in Europe. (See Merriman (1994) for some discussion of the assumption that increased taxes translate into increased retail prices). A 10% increase in price would require a price increase of $0.34 in Germany but only $0.04 in Poland. Because all countries raise their prices, domestic sales fall in every country (compare columns 7 and 4) with sales falling from 82 to 81 packs per capita in the median country.

Countries with relatively high prices experience a bigger absolute increase in price and so may experience a decline in net bootlegging (e.g. Germany and Austria). On the other hand, countries with relatively low prices may experience an increase in net bootlegged exports (e.g. Poland). In the median country there is zero net bootlegging in both the baseline case (column 6) and when we simulate a multilateral 10% tax increase (column 8). Because all countries simultaneously raise their prices, no country's net bootlegged exports fall precipitously (compare columns 8 and 6) and the net effect is that European cigarette consumption falls.

Compare this with the policy simulation presented in columns 9 and 10. Here we ask what happens if a single country (say Austria) increases its price by 10% while other countries do not change their price. In about half the countries, domestic sales drop by three packs per capita or more with median domestic sales dropping from 82 to 80 packs per capita (compare column 4 with column 9). However, in several cases, domestic consumption drops much less than sales because bootlegged exports drop substantially (compare column 10 with column 6). In Germany, for example, we

[4] Theoretically, the population-weighted average of net exports ought to be zero, since imports to one country have to come from another country. We have not econometrically imposed this restriction.

estimate that a unilateral 10% price increase would cause domestic sales to drop from 80 to 74 packs per capita, a drop in sales of 6 packs. However, we predict that net bootlegged imports would increase by 3 packs per capita from 21 to 24 packs per capita. Hence, the drop in domestic consumption would be only one-half the drop in domestic sales. With a multilateral price increase we predict that German domestic consumption would also drop by three packs per capita but domestic sales would drop only four, rather than six, packs per capita.

The simulations also suggest that there are a number of European countries that are relatively immune to bootlegging. According to our estimates a unilateral 10% price increase in Bulgaria, Hungary, Italy, Poland, Slovakia, Spain, and Turkey would have almost no effect on bootlegging in these countries. These relatively low-priced countries need not fear increases in bootlegging from small to moderate increases in price.

Bootlegging may be a larger problem in relatively high-priced countries, such as Germany and France. In these countries, policies that emphasize coordinated increases in cigarettes taxes and prices will reduce consumption with the smallest increase in bootlegging.

Our simulation results may also be used to examine the relationship between cigarette tax increases and government revenues. Since governments can tax only domestic cigarette sales, bootlegged imports reduce tax revenue. On the other hand, bootlegged exports increase tax revenue.

If domestic demand was purely inelastic and bootlegged imports and exports were constant, a 10% tax increase would increase revenue by 10%. However, as shown in Table 15.5, specification 5, domestic sales fall, bootlegged exports decrease, and bootlegged imports increase, when price (or taxes) increase. Column 11 shows our prediction for each country's tax revenue as a result of a unilateral 10% tax increase. Our empirical results imply that increased revenues from a higher tax on remaining domestic sales are sufficiently high to offset losses in revenue due to declines in domestic sales. Thus, for every country in our sample, tax revenues would increase even from a unilateral tax increase. In some countries (Austria, Germany, and Switzerland) the revenue increase would be small because bootlegged imports would increase substantially. Countries with less vulnerability to bootlegged imports (such as Bulgaria or Hungary) would have larger revenue gains. The median country has an increase in tax revenue of 7.9% as a result of a unilateral 10% tax increase, even when we take into account increased bootlegging.

A multilateral tax increase would result in even greater revenue gains, as shown in Table 15.6, column 12. The reason for this is that neighboring countries' tax increases diminish the incentive for home-country bootlegged imports and increase the incentive for home-country bootlegged exports. Some countries (such as Austria, Belgium, Germany and Sweden) have much greater revenue gains with a multilateral tax than with a unilateral tax. Other countries (such as Bulgaria, Slovakia and Turkey) have nearly identical revenue gains. It is even possible that a country's total taxed sales increase as a result of a multilateral tax increase.

In conclusion, our simulation shows that moderate increases in cigarette tax rates for European countries will result in increases in revenue—even if the tax increases are undertaken unilaterally. Multilateral tax increases will lead to greater revenue gains.

15.5 Summary of empirical results

Because cigarette smuggling is an illegal and hidden activity it is notoriously difficult to study using econometric methodology. In view of the imperfect data at our disposal we undertook three separate, but limited, empirical exercises. Each analysis was designed to produce an independent estimate of the share of total cigarette consumption that is smuggled.

Table 15.7 summarizes the results. First, we compared aggregate recorded cigarette exports with imports for the period 1975–96. We found that exports exceeded imports by about 33% in recent years. A little less than one-fifth of cigarette production is exported in a given year. This suggests that roughly 6% of all cigarette consumption is smuggled. This methodology has several potential sources of error. Some cigarette imports are inadvertently misclassified. On the other hand, some cigarette exports may also be misclassified. Our analysis of United Nations data on imports and exports of a variety of goods suggests that the magnitude of disagreement between aggregate exports and imports is large for many goods. On the whole, we believe that this estimate has a downward bias because it does not measure smuggling of cigarettes that do not officially cross national boundaries and thus do not appear in the export statistics.

The population-weighted average of experts' estimates of smuggling in more than 30 countries was 8.5%. This estimate is in remarkably close agreement with the answer obtained from the analysis of cigarette import and export data. Cigarette industry

Table 15.7 Summary of empirical results

Exercise	Methodology	Estimate of smuggling as a percentage of worldwide domestic cigarette sales	Some possible sources of bias Direction of bias		
			Upward	Downward	Unknown
1	Compare recorded recorded exports and imports.	6%	Some imports misclassified.	Some exports misclassified. Smuggling that does not cross national boundaries is not identified.	
2	Population weighted average of experts' estimates.	8.5%	Tobacco industry experts may overstate the problem.	Police and anti-smoking sources may understate the problem.	
3	Correlation between recorded consumption and incentives for short-distance imports and exports in Europe.	Short distance imports about 3% in typical country. Short distance exports about 1% in typical country.		Wholesale smuggling is not investigated.	Price data refers to all brands but only higher priced brands are usually smuggled.

experts may have an incentive to exaggerate the smuggling problem (in order to lobby for reduced taxation of their product), while public health advocates may have an incentive to downplay smuggling. Police officials also may understate the problem to bolster public opinion about their job performance. Since we do not have precise information about which experts provided estimates of smuggling, we cannot completely evaluate the bias inherent in these estimates.

Our econometric analysis of experts' estimates of smuggling (see Table 15.4) was reassuring. Experts estimated lower levels of smuggling in countries generally viewed as having 'transparent' governments. We found no significant correlation between experts' estimates of smuggling and either the average price of cigarettes or the income in a country.

In our final analysis we used a more conventional methodology to measure bootlegging. We adapted procedures used in various studies of the United States (e.g. Thursby *et al*. 1991; Becker *et al*. 1994). Like these researchers, we reasoned that the lower the price in neighboring countries, the greater the incentive to smuggle into the home country. We measured neighbors by frequency of travel between countries rather than simple geographic proximity. We found that, consistent with our expectations, the greater the incentives for illegal importation, the lower were recorded sales. Similarly, the greater the incentives for illegal exportation, the higher were recorded sales. We estimated that, in a typical European country, bootlegged cigarettes accounted for about 3% of domestic consumption.

This analysis measured only bootlegging and not wholesale smuggling. As expected our estimates of smuggling using this method are less than our estimates using other methods. Our findings for Europe are similar to those obtained in studies of US states (Saba *et al*. 1995; Thursby and Thursby, 2000).

15.6 Conclusions and policy implications

Judging from the results of our three empirical analyses, a reasonable lower bound on the total amount of worldwide smuggling is 6% of all cigarettes consumed worldwide. In view of previous studies of bootlegging in the United States and our own study of bootlegging in Europe, we believe that the greatest part of worldwide smuggling is wholesale smuggling, i.e. smuggling in which cigarette taxes are never paid, even in the country of origin. Our best estimate of an upper bound on the amount of cigarette smuggling worldwide is 8.5%, although smuggling almost certainly exceeds this level in some countries.

Future research to confirm or challenge our estimates would certainly be worthwhile. Future studies should seek to explain discrepancies between reported cigarette exports and imports for particular pairs of countries. Explanations other than smuggling should also be carefully explored. Systematic surveys with carefully designed and documented procedures could provide better evidence about experts' judgments on the extent of cigarette smuggling in different countries. More complete data on cigarette prices, brands and retailing practices would facilitate better estimates of bootlegging between neighboring countries. Future research should also attempt to link specific types of corruption (such as lax border controls) with cigarette smuggling.

However, on the basis of the preliminary research we have done, some tentative conclusions may be drawn. Perhaps most importantly, we have learned 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. Other important determinants of the level of cigarette smuggling in a country include cigarette prices in nearby countries and the amount of travel between the home country and lower-priced countries.

Even when the potential for increased smuggling is taken into account, our simulations show that a unilateral increase in the cigarette tax rate results in an increase in tax revenue in all European countries. A multilateral tax increase would bring even greater increases in revenue.

Our results have important policy implications. Countries need not make a choice between higher cigarette tax revenues and lower cigarette consumption. Higher tax rates can achieve both objectives. Cigarette tax revenues can be enhanced still further by effective methods to reduce corruption that will result in diminished cigarette smuggling and increased tax collections. Lastly, cooperative multilateral efforts to increase cigarette tax rates on a regional basis are likely to be an effective way to combat smuggling.

Appendix 15.1 On the relationship between enforcement activity and smuggling

We generalize Norton's model by allowing μ (the probability of non-detection of smuggling) to depend on a parameter κ which represents the stringency of enforcement activity. We assume that enforcement activity increases with κ. We also assume that increases in κ do not influence the ability of firms to camouflage their bootlegging activity. In mathematical notation we assume:

$$\frac{\partial \mu(q^s, q^L|\kappa)}{\partial \kappa} = \mu_\kappa < 0 \quad \text{and}$$
$$\frac{\partial \mu(q^s, q^L|\kappa)}{\partial q^s \partial \kappa} = \mu_{s\kappa} = \frac{\partial \mu(q^s, q^L|\kappa)}{\partial q^L \partial \kappa} = \mu_{L\kappa} = 0.$$

The firm's objective function is given by:

$$\begin{aligned}\pi(d) = {} & \mu(q^s, q^L|\kappa)(p + pt + \theta)(1 - s)q^s \\ & -(1-\mu)\alpha(1-s)pq^s \\ & +(p+\theta)(1-L)q^L \\ & -p(q^s + q^L).\end{aligned} \tag{A1.1}$$

As in Norton we set up the Lagrangean:

$$V = \pi + \lambda(\bar{q} - q^s - q^L) \tag{A1.2}$$

and derive the Kuhn–Tucker conditions (they are the same as Norton p. 111.)

$$\frac{\partial V}{\partial q^s} \leq 0 \Rightarrow (p + pt + p\alpha + \theta)(1 - s)(\mu + q^s\mu_s) - p - p\alpha(1 - s) \leq \lambda \tag{A1.3}$$

$$\frac{\partial V}{\partial q^L} \leq 0 \Rightarrow (p + pt + p\alpha + \theta)(1 - s)(q^s\mu_L) + \theta - pL - \theta L \leq \lambda \tag{A1.4}$$

$$\frac{\partial V}{\partial \lambda} \geq 0 \Rightarrow (\overline{q} - q^L - q^s) \geq 0. \tag{A1.5}$$

To simplify the notation let:

$$(p + pt + p\alpha + \theta)(1–s) = A$$
$$B = –p – p\alpha\ (1–s)$$
$$C = \theta – pL – \theta L.$$

We consider interior solutions in which constraints in eqn A1.3 and A1.4 are both binding:

$$A(\mu + q^s\mu_s) + B = A(q^s\mu_L) + C, \tag{A1.6}$$

solve for q^s:

$$q^s A(\mu_s - \mu_L) = C - B - A\mu, \tag{A1.7}$$

divide through to get:

$$q^s = \frac{(C - B - A\mu)}{A(\mu_s - \mu_L)}. \tag{A1.8}$$

Now differentiate with respect to the parameter κ:

$$\frac{\partial q^s}{\partial \kappa} = \frac{(-A\mu_\kappa)}{A(\mu_s - \mu_L)} - \frac{(C - B - A\mu)}{[A(\mu_s - \mu_L)]^2}[A(\mu_{s\kappa} - \mu_{L\kappa})] \tag{A1.9}$$

Since $\mu_L > 0$ and $\mu_S < 0$ (p. 110 of Norton) and the cross-partials are zero by assumption (this is a parallel shift) equation (A1.9) reduces to:

$$\frac{\partial q^s}{\partial \kappa} = \frac{(-\mu_\kappa)}{(\mu_s - \mu_L)} < 0. \tag{A1.10}$$

The optimal amount of bootlegging unambiguously falls with increased enforcement activity.

Appendix 15.2 Technical notes on econometric methodology

This appendix provides more complete details on the econometric analysis of links between recorded cigarette sales and prices in neighbouring European countries described in Section 15.4.

Basic methodology

Our basic econometric methodology is derived from Becker *et al*. (1994). Like them we estimate an aggregate cigarette demand function with price, income, country dummies, time dummies, and variables representing incentives to import and export as independent variables. Among other models, Becker *et al*. estimate a rational addiction model that allows current consumption to depend upon past and future consumption as well as the variables listed above. We focus on more conventional (static) functional forms for cigarette demand because our goal is to study smuggling rather than demand *per se*.

Construction of short-distance import and export variables

Construction of variables that represent consumption, price and income are relatively straightforward and are explained in the text. Construction of the variables for imports and exports are more complex and are explained below:

The basic logic behind Becker *et al*.'s short-distance import and exporting variables is that short-distance importing and exporting depends upon the relative prices and the amount of cross-border traffic among neighboring states. We generalize this idea to include countries that have frequent cross-border traffic, though they may not literally share a border (e.g. UK and France.)

If prices in country i are less than or equal to those in country j we assume that travelers from country i do not purchase cigarettes in country j. If cigarette prices in country i exceed those in j, we assume that each traveler from i makes a cigarette purchase in j. For each dollar that country i's price exceeds country j's price, each traveler from country i purchases b1% of his or her yearly cigarette consumption in country j.[5] The total share of country i's consumption purchased in country j is:

$$\left(b1 * \left(p_i - p_j\right) * \frac{trav_{ij}}{pop_i} \right) \text{given that } \left(p_i > p_j\right), \tag{A2.1}$$

where $trav_{ij}$ is the number of travelers from country i to country j and pop_i is the population of country i. $(trav_{ij}/pop_i)$ is the number of times the average resident of country i travels to country j in a year.

The total share of consumption purchased abroad by travelers from country i is:

$$b1 * \frac{1}{pop_i} \sum_{j=1}^{n} \left(p_i - p_j\right) trav_{ij} = b1 * sdimp_i. \tag{A2.2}$$

The summation in eqn A2.2 is taken over countries with lower priced cigarettes than country i; sdimp is our measure of the aggregate incentive for bootlegged imports. Note that by construction $sdimp_i > 0$.

[5] For example, suppose that b1 = 0.14 and country j's price exceeds country i's price by one-half dollar per pack. Then each traveler from country i to country j would buy 7% of his or her yearly consumption per trip to country j. Since there are a large number of travelers and we are only concerned with aggregate purchases we study a representative traveler and do not take variance in travelers' behavior into account.

Analogously, if cigarette prices in country j exceed those in i, we assume that each traveler from j buys cigarettes when he or she visits country i. For each dollar that country i's price is below j's, each traveler from j buys b2% of country i's yearly consumption.[6] The total share of country i's consumption sold to visitors from country j is:

$$\left(b2 * (p_i - p_j) * \frac{trav_{ji}}{pop_i} \right) \text{given that } (p_i < p_j), \tag{A2.3}$$

where $trav_{ji}$ is the number of travelers from country j to country i

The total share of sales in country i purchased by travelers from abroad is:

$$b2 * \frac{1}{popi} \sum_{j=1}^{n} (p_i - p_j) trav_{ji} = b1 * sdexp_i . \tag{A2.4}$$

The summation in eqn A2.4 is taken over countries with higher priced cigarettes than country i; sdexp is our measure of the aggregate incentive for bootlegged exports. Note that by construction $sdexp_i < 0$.

Note on missing values

Because the summations in eqns A2.2 and A2.4 are taken over all countries in Europe, and since the origin–destination matrices for travelers are not always complete, missing values are a significant problem.

We have used the following procedure: $sdimp_i$ is coded as missing if we have data on travel from country i to less than three other countries for which we have price data. Analogously, $sdexp_i$ is coded as missing only if we have data on travel to country i from less than three other countries for which we have price data.

The logic for this coding is that we are most likely to have data on substantial tourist flows. Therefore, missing data is likely to be close to zero when we have some data on traffic flows.

Further comments on estimation of $Trav_{ij}$ and $Trav_{ji}$

We have two kinds of data on foreign visitors. In some countries we are told the total number of tourists from abroad in all accommodation establishments. We call this category 1 data. Countries for which we have category 1 data are Austria, Belgium–Luxembourg, Germany, Netherlands, and Switzerland. In other countries we are told the total number of tourists arriving at the frontier. We call this category 2 data. We have category 2 data for all other countries in our sample.

Category 2 data are necessary to estimate sdimp and sdexp as specified above. Therefore, we designate the number of travelers from country i arriving at the frontier of country j as $Trav_{ij}$. We assume that tourists staying in accommodations are a constant

[6] For example, suppose that b2 = 0.02 and country j's price exceeds country i's price by one-half dollar per pack. Then each traveler from country j to country i would buy 1% of the average yearly consumption in country i during each visit from country j.

Table A2.1 Primary travel partners of European countries, 1995

Country	Primary origin of travelers to country listed in column 1	Number of travelers from primary origin as a share of population of country listed in column 1	Primary destination of traveler from country listed in column 1	Number of travelers to primary destination as a share of population of country listed in column 1
Austria	Germany	124.33%	Italy	74.03%
Belgium–Lux	Netherlands	15.85%	France	72.02%
Bulgaria	Turkey	21.70%	Romania	8.49%
CzeckRep	na		Poland	146.17%
Denmark	na		Germany	12.28%
France	UK	19.24%	Spain	34.93%
Finland	na		Russia	24.98%
Germany	Netherlands	2.81%	Poland	57.62%
Greece	Germany	21.72%	Italy	5.70%
Hungary	Germany	33.36%	Romania	6.25%
Ireland	UK	80.17%	UK	55.44%
Italy	Switzerland	15.70%	France	8.82%
Netherlands	Germany	15.92%	France	34.84%
Norway	na		UK	9.94%
Poland	Germany	122.17%	Russia	1.73%
Portugal	Spain	45.80%	Spain	51.59%
Romania	Russia	9.28%	Hungary	14.53%
Slovakia	CzechRepulic	4.01%	Poland	81.04%
Spain	France	51.74%	Portugal	11.60%
Sweden	na		Germany	6.65%
Switzerland	Germany	29.99%	Italy	127.61%
Turkey	Germany	2.71%	Bulgaria	2.99%
UK	France	5.50%	France	19.09%
Russia	Finland	0.86%	Hungary	1.80%

fraction of those arriving at the frontier. We introduce a new variable called $Etrav_{ij}$ and define it as follows:

$$ETrav_{ij} = \begin{cases} (b3 * Trav_{ij}) & \text{in Austria, Belgium}-\text{Luxembourg, Germany, Netherlands and Switzerland} \\ Trav_{ij} & \textit{otherwise} \end{cases}$$

We estimate versions of the model assuming b3 equal to 1, (1/2), and (1/3). We found that the estimated coefficients of the model were hardly altered by changing our assumption about b3. In the regression discussed in the text (Table 15.5), we adopted the assumption that b3 = (1/2).

Table A2.2 Cigarette consumption in Europe: sensitivity analysis (t statistic in parens below coefficient)

	1	2	3	4*	5
Method	OLS	OLS	OLS	OLS	OLS
Dependent variable	Lnc	Lnc	Lnc	Lnc	C
Sample	Europe	Europe	Europe	Europe	Europe
No. observations	101	101	101	101	101
No. countries	18	18	18	18	18
dep. mean	4.50	4.50	4.50	4.50	92.11
Mean price	1.14	1.14	1.14	1.14	1.14
Price elasticity at the mean	–0.13	–0.13	–0.13	–0.19	–0.09
Assumption about b3	1/2	1.00	1/3	1/2	1/2
Adjusted r-square	0.9611	0.9610	0.9611	0.9612	0.9611
Aggregate incentive for bootlegged imports	–0.14 (2.16)	–0.14 (2.11)	–0.14 (2.23)	–0.12 (1.76)	–11.93 (1.98)
Aggregate incentive for bootlegged exports	–0.02 (0.67)	–0.03 (0.81)	–0.02 (0.53)	–0.01 (0.29)	–2.87 (0.90)
Price	–0.11 (2.95)	–0.12 (3.04)	–0.11 (2.87)	–0.07 (1.17)	–7.49 (2.05)
Price times dummy for high income				–0.10 (1.11)	
GDP per capita	1.09E-05 (1.38)	1.12E-05 (1.41)	1.07E-05 (1.35)	1.14E-05 (1.44)	0.001 (1.01)
Year dummies	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes

1 Aggregate incentives for bootlegged imports and exports are estimated assuming that incentive to cross-border shop for cigarettes depends on price differential and that amount of cross-border smuggling is proportional to number of cross-border travelers. See text of appendix for more details.
2 Price and GDP per capita are measured in real US dollars in 1982–84.
3 All specifications assume price is exogenously determined.
4 In column 4, price-elasticity is price elasticity for high income countries only.

We calculated short-distance importing and exporting variables using the World Tourism Organization data discussed in the text. Table A2.1 presents an extract of our data that may be useful in understanding the results. For each country in the sample we show the primary travel partners in 1995. For example, the country that sends the most travelers to Austria is Germany. The total number of Germans traveling in Austria is 124% of Austria's domestic population. The country that Austrians most travel to is Italy. The number of Austrians traveling to Italy is 74% of Austria's population. Of course, this does not mean that nearly three out of four Austrians visited Italy in 1995. It is quite possible for a single Austrian to make multiple trips to Italy. Analysis of this data shows that a country's primary travel partners are likely to be, but are not always, those with which they share a border.

Results from alternative regression specifications

Results from a number of alternative regression specifications are contained in Table A2.2. Column 1 simply reproduces some of the results reported in Table 15.5. Columns 2 and 3 test the sensitivity of these results to changes in the value used for b3. The empirical results are very similar regardless of which value of b3 is adopted. We use b3 equal to 1 (there are twice as many frontier arrivals as accommodation arrivals) in the text because this seems most reasonable to us.

Column 4 interacts price with a dummy variable equal to one for 'high-income' European countries since these countries may have a different responsiveness to price than low-income countries. The interacted variable is not significantly different from zero although including this variable raises the absolute value of the price elasticity in high-income countries and lowers the estimated price elasticity for low-income countries.

Finally, column 5 uses the un-transformed value rather than the natural log of consumption as the dependent variable. This is the dependent variable used by Becker *et al*. (1994). In the text we use the natural log of consumption as the dependent value since this restricts the predicted value of consumption to be a positive number. However, simply using the value of consumption as the dependent variable gives us similar qualitative results (coefficients on aggregate incentive for bootlegged imports and price are significant while other coefficients are not, estimated price elasticity of demand is quite low).

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