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Estimating price elasticities when there is smuggling: the sensitivity of smoking to price in Canada

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Abstract

A central parameter for evaluating tax policies is the price elasticity of demand for cigarettes. But in many countries this parameter is difficult to estimate reliably due to widespread smuggling, which significantly biases estimates using legal sales data. An excellent example is Canada, where widespread smuggling in the early 1990s, in response to large tax increases, biases upwards the response of legal cigarette sales to price. We surmount this problem through two approaches: excluding the provinces and years where smuggling was greatest; and using household level expenditure data on smoking. These two approaches yield a tightly estimated elasticity in the range of −0.45 to −0.47. We also show that the sensitivity of smoking to price is much larger among lower income Canadians. In the context of recent behavioral models of smoking, whereby higher taxes reduce unwanted smoking among price sensitive populations, this finding suggests that cigarette taxes may not be as regressive as previously suggested. Finally, we show that price increases on cigarettes do not increase, and may actually decrease, consumption of alcohol; as a result, smuggling of cigarettes may have raised consumption of alcohol as well.

JEL classification: I1; H2

Keywords: Tax policies; Elasticity; Taxation

1. Introduction

One of the most common sources of government revenue raising around the world is the taxation of tobacco products. A central determinant of the optimal level of tobacco

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taxation is the price sensitivity of demand for cigarettes. This parameter has been estimated repeatedly in the US context, with a consensus estimate of 0.4–0.5 (Chaloupka and Warner, 2000), but with recent estimates at 0.6 (Gruber and Koszegi, 2000, 2002; Yurekli and Zhang, 2000). But estimating this parameter in many other countries faces a fundamental difficulty which is not a real barrier in the US context: widespread smuggling. Smuggling of cigarette products can significantly bias price elasticities estimated using legal sales data, as the shift from legal to illegal product will appear to be a price sensitivity of overall demand.

A classic example of this problem is the experience of Canada in the early 1990s. Between 1989 and 1993, excise taxes at the federal and provincial level rose sharply from an average of CAN$ 1.90 to 3.50 per pack. In response to these large tax increases, there was an enormous increase in smuggling in Canada through legal export and illegal re-import. Indeed, by the typical measure of smuggling used to describe this experience, smuggled cigarettes represented roughly one-third of all domestic cigarette consumption at their peak. Then, in the face of enormous smuggling, federal and provincial taxes were halved in 1994. In recent years, however, there has again been a trend towards increasing these taxes in response to reports that the decline in cigarette prices has resulted in a significant increase in smoking by Canadians.[1]

In this paper, we provide a framework for estimating elasticities in the context of widespread smuggling. In particular, we estimate demand models for Canada that attempt to correct for the smuggling problem in two different ways. First, we use legal sales data, and exclude the regions and years where the smuggling problem was the worst. Second, we use micro-data on consumer cigarette expenditures. We find that the estimates from these two sources are quite divergent initially, but become more similar (in the range of -0.45 to -0.47) when smuggling provinces and years are excluded. This suggests that a fairly reliable estimate of the elasticity of demand for cigarettes can be provided for Canada despite the large smuggling problem.

We then extend the analysis in two important directions. First, we estimate the price sensitivity of demand by different income groups. It is well known that lower income groups spend a larger share of their incomes on cigarettes, so that tobacco taxes have been traditionally viewed as regressive. But, as we discuss further below, under alternative (plausibly more reasonable) models of the smoking decision, tobacco taxes may not be regressive if lower income groups are much more price sensitive. It therefore becomes critical to explore the price sensitivity of smoking by income group. We do so using our micro-data on tobacco expenditure, and show that the lowest income group is much more price sensitive than higher income groups; this finding suggests that tobacco taxes in fact may *not* be regressive in the context of plausible alternative models.

Second, we estimate the impact of cigarette price changes, and of smuggling of cigarettes, on demand for alcohol. If cigarettes and alcohol are substitutes, then one potential advantage of smuggling is that it reduces a shift into this alternative "bad". But, if these activities are complements, then a further cost of smuggling is that it increases not only cigarette

[1] For further details please see "Martin hints at tobacco price increase: with conditions" (Canadian Press Newswire, 19 September 1996), "Governments raise tobacco taxes, Ottawa restricts tobacco ads" (Canadian Press Newswire, 28 November 1996) and "Provinces with low tobacco taxes had higher smoking rates" (Canadian Press Newswire, 17 April 1995).

consumption but also alcohol consumption as well. We find some evidence using legal sales data that cigarettes and alcohol are complements; higher cigarette taxes lead to lower alcohol consumption, and that smuggling lead to increased alcohol consumption. We do not find confirmatory evidence in the expenditure data, however; thus, while it is clear that these goods are not substitutes, there is mixed evidence on whether they are complements.

Our paper proceeds as follows. Part 2 provides some background on the literature on the price elasticity of demand for cigarettes, and on cigarette taxation in Canada and the US. Part 3 describes our data, and Part 4 discusses our empirical methodology. Part 5 presents our basic results on demand elasticities. Part 6 discusses estimated elasticities by income group, and Part 7 presents evidence on the substitutability of cigarettes and alcohol. Part 8 concludes.

2. Background

There is an enormous literature in the United States that has been devoted to estimating the price elasticity of demand for cigarettes. This literature has taken advantage of the fact that there is substantial variation in the price of cigarettes across the US states, and significant changes within states over time, due to variable state excise tax policies. For example, in 2001, the excise tax on cigarettes varied from a low of 2.5 cents in Virginia to a high of US$ 1.11 in New York.

The US literature is reviewed in detail in Chaloupka and Warner (2000). The consensus estimate of the price elasticity of demand in their review is −0.45. Recent estimates, using updated data through the 1990s, have suggested that the elasticity may be higher. Gruber and Koszegi estimate an elasticity of −0.6 in legal sales data, and of −0.66 in micro-data on consumption (Gruber and Koszegi, 2000, 2002); Yurekli and Zhang (2000) estimated an elasticity of −0.62 in legal sales data.

Another issue that has been addressed in the US is the impact of smuggling on elasticity estimates. A number of articles have included indirect controls for smuggling in the United States. A typical example is the approach taken in a recent paper by Farrelly et al. (2001). They estimate models of aggregate cigarette sales by US state, and they include in their models controls for “importing” and “exporting” which are the gap in price between the state and its neighbors, weighted by the population densities near the border of the state. This type of approach will capture price incentives for smuggling, and indeed the results using this approach suggest that sales shift from high to low tax states. Other papers have augmented this approach by including the price differentials between the state and the low price tobacco producing states (Kentucky, North Carolina, and Virginia; see, for example, Becker et al. (1994) or Yurekli and Zhang (2000)).

But this approach provides a somewhat crude proxy for the actual amount of smuggling. To the extent that smuggling is related to non-price factors, it will not be captured. Even if price is the only determinant of smuggling, the actual functional form of how price relates to smuggling may differ from the ones imposed by these models (e.g. non-linear terms of the price may be relevant). In the US, where smuggling is a relatively minor issue, this may not be an important problem for estimating demand elasticities; but in Canada, as noted below, it could be a more significant issue.

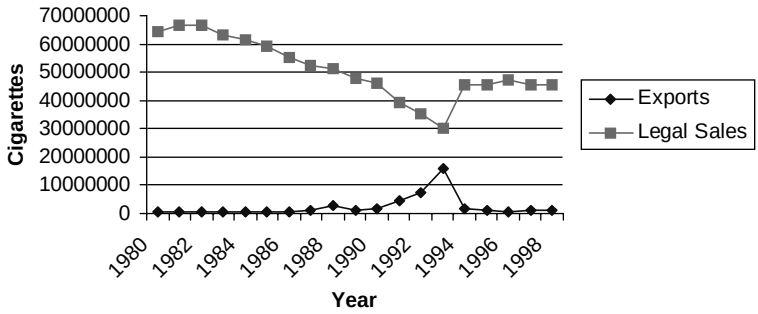

Fig. 1. Exports and legal sales. *Source*: National Clearinghouse on Tobacco and Statistics Canada.

There are two reasons to think that the elasticity estimates from the US may not apply in the Canadian context. First, prices are much higher in Canada. On average, over the 1980s and 1990s, the real price of cigarettes was US$ 1.86 in the US (in US$, 1999). It was roughly 25% higher at US$ 2.33, in Canada (in US$, 1999) over the same time period. There is little evidence on how the elasticity of demand varies with price. But the general presumption is that the elasticity of demand falls with prices; at higher prices, only the most addicted smokers remain in the smoking pool.

A second, and critical, difference is smuggling. There is modest cross-state smuggling in the US, which has been estimated to be on the order of 3–4% of consumption in the 1970s (Thursby and Thursby, 2000), and 6% of tax revenues in 1995 (Yurekli and Zhang, 2000). But smuggling of cigarettes into Canada in the 1990s was on a very different scale. In the face of rising taxes in the early 1990s, smuggling of cigarettes increased dramatically through a particular mechanism: legal export to the US, and then illegal re-import across the US/Canadian border, in particular through Indian reservations which straddle the border. There exists evidence which suggests that virtually all cigarettes smuggled into Canada in the early and mid 1990s, were previously exported from Canada to the United States, and previous research has employed these exports as a proxy for smuggling (see Galbraith and Kaiserman, 1997, for example). Further support for this assumption stems from the lawsuit launched by the Government of Canada in October 1999 in the United States Federal Court against RJR-Macdonald Inc., RJ Reynolds Tobacco Holdings Inc., and several related companies claiming that the RJ Reynolds companies conspired with known distributors and smugglers to illegally smuggle their tobacco products into Canada.[2]

The typical means of estimating contraband sales in Canada in the early 1990s is therefore to consider increases in cigarette exports relative to the pre-1990 baseline. This is shown in Fig. 1. Legal sales of cigarettes, after slowly declining until 1990 (mirroring the decline in the US), suddenly dropped precipitously until 1993, before jumping back up again in 1994. There is a mirror-image increase in cigarette exports over these years. As Fig. 2 shows, exports rose from a pre-1990 level of less than 1.5% of legal sales to a level in 1993 of

[2] The actual press release can be found at http://canada.justice.gc.ca/en/news/nr/1999/doc_24494.html. On 30 June 2000, the United States District Court dismissed Canada's case on points of law, citing the Revenue Rule as the reason for dismissal. In response, the Government of Canada filed a notice of appeal on 28 July 2000.

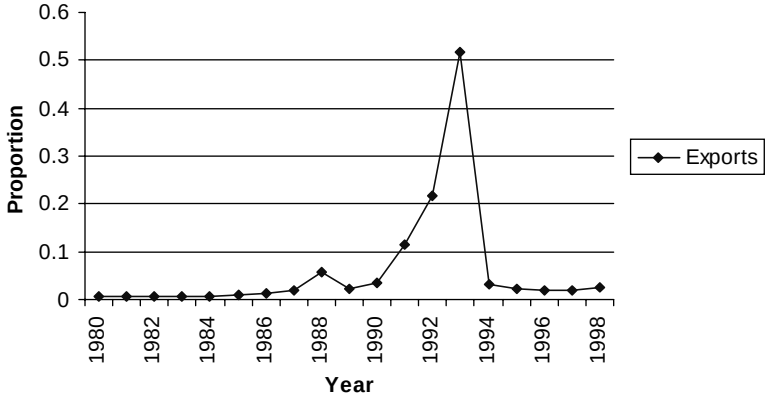

Fig. 2. Exports as a proportion of legal sales. *Source*: National Clearinghouse on Tobacco and Statistics Canada.

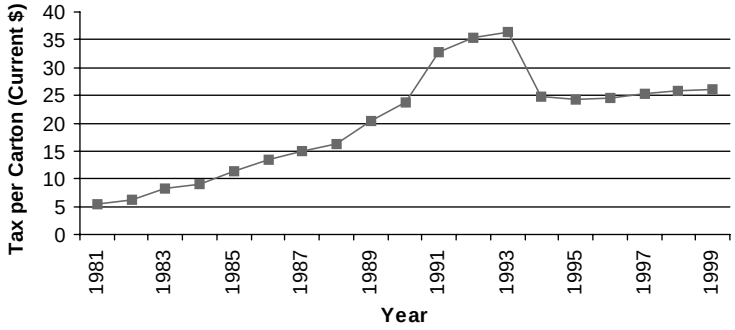

Fig. 3. National average cigarette tax. *Source*: National Clearinghouse on Tobacco and Statistics Canada.

roughly half of legal sales, before plummeting again in 1994 as taxes declined. This suggests smuggling on a much larger scale than has been seen in the US context.

This period is also the time period of greatest movement in cigarette taxes (and prices). As shown in Fig. 3, average excise and sales taxes on cartons of cigarettes rose steeply until 1993, then fell sharply in 1994 in response to growing concerns of the effects of smuggling. In particular, there was a decline in both federal excise taxes and provincial taxes in the five eastern provinces where smuggling was considered to be significant (Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island) from 9 February to 15 April 1994.[3] The federal government cut its excise tax (levied at the manufacturer's end) from CAN$ 10.36 to 5.36 per carton of 200 cigarettes in February 1994. After the federal tax cut, the five eastern provinces dropped their provincial tax rates (levied at the retailer's

[3] The Canadian prime minister, Jean Chretien, stated that smuggling was attracting organized-crime gangs, increasing the danger to law-enforcement officials and others as smugglers use assault weapons, creating hardship for owners of small stores that rely heavily on cigarette sales, and costing millions in lost tax revenue to provincial and federal treasuries (Gunby, 1994).

end) as well. Quebec dropped its tax rate in February 1994, and it was soon followed by New Brunswick, Ontario, Prince Edward Island and Nova Scotia. The federal government then cut the cigarette excise tax even further in these five provinces.[4] By April 1994, the combined federal and provincial cuts had reduced tax rates in these provinces between US$ 14 and 21 per carton (Hamilton et al., 1997a). The above policy details indicate which provinces were the hardest hit by smuggling: those eastern provinces in which it was easiest to re-import legally exported cigarettes to the US.

The few studies that have attempted to estimate the price elasticity of demand in Canada either fail to address the impact of smuggling or suffer from other shortcomings. Reinhardt and Giles (2001) find a price elasticity of −0.62. Their study uses time-series national level data between 1968 and 1990, which precedes the serious smuggling period of the early 1990s. However, they rely solely on national time-series variation; any other contemporaneous trends in the demand for cigarettes (such as the overall fall in demand that was observed in the US as well) could bias their estimates.

Galbraith and Kaiserman (1997) also employ national time-series data on legal cigarette sales and prices, their data come from 1980 to 1994. In order to account for the smuggling between 1990 and 1994, the authors combine legal sales figures with export numbers to come up with an estimate of total consumption. They find short run elasticities of legal and total consumption with respect to legal prices to be −1.01 and −0.40, respectively. Their model does control for linear time trends in smoking, but it is unclear if this is sufficient to control for underlying trends in smoking demand that might be correlated with (but not caused by) price changes.

Hamilton et al. (1997b) examine the response to changes in cigarette prices in Canada between 1985 and 1995. They use micro-data on cigarette consumption over time and across provinces and estimate elasticities in the range of −0.3. These estimates exploit the significant variation in prices across the provinces over the 1990s, but again do not control for the impact of smuggling over this period. Nor do they include province fixed effects to control for differences across provinces in tastes for smoking.

In short, none of the Canadian literature has approached the sophistication of the US literature, which uses “difference-in-difference” estimates based on tax variation within states over time to control for state-specific tastes for smoking and for national trends in smoking. And the issue of smuggling has also either been ignored or addressed in a rudimentary fashion. Thus, it seems to us appropriate to revisit a Canada-specific estimate of the elasticity of cigarette demand. It is this estimate that we pursue below.

3. Data

3.1. Tax, price, and legal sales data

There exists significant cross-province and time-series variation in both federal and provincial cigarette taxes. Federal taxes consist of excise taxes, excise duties, and sales

[4] Unlike other federal taxes, the federal government sets province specific federal excise taxes on cigarettes. We discuss this in further detail below.

taxes (the federal sales tax until 1991, and the goods and services tax (GST), thereafter). There is considerable variation in these taxes over time. Moreover, unlike other federal taxes, federal taxes on cigarettes also differ across provinces at a point in time. Specifically, while federal excise duties and sales taxes are similar across provinces there are pronounced differences in federal excise taxes after February 1994, when federal excise taxes dropped from CAN$ 10.35 per 200 cigarettes to CAN$ 5.35 (nominal CAN$) in British Columbia, Alberta, Saskatchewan, Manitoba, and Newfoundland. By contrast, federal excise taxes fell from CAN$ 10.35 to 0.75, 0.35, 3.35, 3.35, and 1.10 in Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island, respectively. Provinces also levy their own tobacco tax and sales taxes, and further provincial variation results from whether or not a provincial sales tax is applied to tobacco products.[5] The result of this web of taxes is that there is significant variation in effective excise and sales taxes on cigarettes within provinces over time.

Average prices (nominal) per 200 cigarettes for each province between 1989 and 1993 were obtained from Statistics Canada. Average province specific prices for other years between 1981 and 1998, and 1994 and 1999) were then extrapolated using cigarette price indices for each province from Statistics Canada.[6] The problem with computing prices in this manner, however, is that the index is only available annually, and there are important movements in taxes (and therefore prices) within the year. We therefore compute a pre-tax annual price by subtracting from the nominal price the average excise and sales tax level during the year. We then compute a new after-tax price by adding to this annual average pre-tax price the monthly value of the excise and sales tax.

We obtained data on total legal sales of cigarettes for each province between 1981 and 1999 from the National Clearinghouse on Tobacco and Health Program, an organization funded by the federal government as well as the provinces, which acts as a public repository for data relevant to tobacco control. Our dependent variable, legal cigarette sales per capita, is created by dividing sales by the population age 15 and older in each province and year.

Table 1 contains average real prices and taxes (in CAN$, 1992) per 200 cigarettes, and legal sales per capita, from the end points of the sample (1981 and 1999) separately for provinces where there was less smuggling (British Columbia, Alberta, Saskatchewan, Manitoba, and Newfoundland) and where smuggling was concentrated (Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island).[7,8] We also divide this period into several sub-periods of interest: 1981–1989 (before smuggling was a major issue); 1990–1993

[5] Data on federal and provincial taxes from 1971 onwards were obtained from the Ministry of Finance, and counter checked against relevant editions of the *National Finances*, and *Provincial and Municipal Finances*.

[6] Cigarette prices are collected by Statistics Canada on a quarterly basis to calculate the average yearly price.

[7] Nominal prices and taxes were deflated with province specific consumer price indices, obtained from Statistics Canada.

[8] This division comes from the fact that the primary conduits for smuggling cigarettes into Canada were across the St. Lawrence River and Indian reserves that separate the eastern provinces (Ontario, and Quebec and the Maritimes) from the US ("Contraband cigarettes hurt Canada's cigarette makers." The Economist, vol. 330, 15 January 1994, p. 68). Moreover, this division is confirmed by the fact that our set of "smuggling" provinces is exactly the set where both provincial and federal taxes were slashed in response to the smuggling "crisis"; thus, these are the provinces for which policy-makers viewed the smuggling problem as worst. Smuggling apparently was not significant in Newfoundland due to its distance from the US border. This explains why it did not lower its tobacco taxes in 1994 along with other eastern provinces.

Table 1
Cigarette taxes, price and sales over time and across smuggling and non-smuggling provinces

	Per capita cigarette consumption for population aged 15 years and over		Tax per 200 cigarettes (US$ 1992)		Price per 200 cigarettes (US$ 1992)	
	Non-smuggling	Smuggling	Non-smuggling	Smuggling	Non-smuggling	Smuggling
1981 levels	3449.6	3371.76	8.99	8.87	15.89	16.44
Change (%)						
1981–1989	−42.4	−37.07	181.29	153.09	104.64	90.86
1990–1993	−25.199	−40.65	55.62	55.63	50.219	49.44
1993–1994	−0.03	63.96	−14.94	−51.71	−12.28	−35.33
1995–1999	5.75	−5.61	−5.26	17.31	−0.36	13.49
1999 levels	1434.83	1873.21	28.79	18.04	40.66	31.59

Source: Statistics Canada and National Clearinghouse on Tobacco and Health Program.

(the period of major smuggling); 1993–1994 (the period of reaction to the smuggling problem); and 1995–1999. In 1981, at the start of our period, these two sets of provinces looked quite similar in terms of per capita legal sales, taxes, and prices. They also had similar changes in sales, taxes, and prices over the 1981–1989 period. Over the 1990–1993 period, the change in price and tax was also similar in the two sets of provinces, but there were quite different changes in legal sales. In the non-smuggling provinces, legal sales fell by 25%; but, in the smuggling provinces, sales fell by 40%. This higher price sensitivity in the "smuggling provinces" is very consistent with the notion of smuggling into these provinces eroding the legal sales base.

From 1993 to 1994, there were much larger reductions in taxes and prices in the smuggling provinces; as noted above, these were the response to the smuggling problem.[9] There was an associated dramatic increase in legal sales in those provinces relative to the non-smuggling provinces; this response to the price change once again highlights the impact of smuggling on price sensitivity of legal sales. Finally, in the last period, taxes began to rise again in the smuggling provinces, and legal sales to fall. By 1999, the result of these actions was that taxes and prices were significantly lower in the smuggling provinces, and per capita consumption was significantly higher.

The results in Table 1 confirm that smuggling was a major problem in Canada in the 1990–1993 period. Since price changes were similar over the 1990–1993 period in the two sets of provinces, we can infer that the 15.45% larger drop in legal sales in the smuggling provinces represented the impact of smuggling. Multiplying this by per capita sales, and then by population, we obtain an estimate of a 4.6 billion reduction in the number of cigarettes

[9] This decline in cigarette taxes in non-smuggling provinces was primarily due to the drop in federal excise taxes from US$ 10.35 per 200 cigarettes to US$ 5.35 (nominal US$), as other relevant federal and provincial taxes remained unchanged. As discussed earlier, the fall in federal excise taxes in the smuggling provinces was much more dramatic. Provincial tobacco taxes fell from: US$ 13 to 3.40 in Ontario; US$ 13.76 to 2.76 in Quebec; US$ 13.60 to 6.60 in New Brunswick; US$ 13.60 to 6.60 in Nova Scotia; and US$ 19.60 to 10.36 in Prince Edward Island, respectively. Federal excise duties (which are different from the federal excise taxes) remained constant across all provinces at US$ 5.50.

sold legally. According to the export data cited earlier, over the 1990–1993 period exports of cigarettes averaged 7.6 billion per year. This represented a rise of 5.3 billion cigarettes per year over the 1988–1989 ("pre-smuggling") baseline. So our estimate using the legal sales data is only about 13% $(1 - (4.6/5.3))$ lower than the export estimate of smuggling. Moreover, our estimate should be a lower bound on smuggled cigarettes, since we assume zero smuggling into all of the other provinces in Canada when there may have been some small amount of smuggling.[10]

3.2. FAMEX data

Our second data source is the Canadian Survey of Family Expenditure (FAMEX), renamed the Survey of Household Spending after 1996. We use information from this survey to track household cigarette expenditure over time and across Canada. We use every available survey year between 1982 and 1998, namely 1982, 1984, 1986, 1990, 1992, and 1996–1998. The survey is a national survey, although some of the survey years focus on urban centres, while others include both urban and rural populations.[11]

Each survey collects information on how much the household spent on cigarettes (as separate from other tobacco products) in that year. We use this question as our measure of cigarette expenditure. The survey also collects limited demographic information which we include in our analysis, including the after tax income of the household, the family size of the household, and the sex of the head of the household. The survey also reports total expenditures on all goods by the household, which we use later in our analysis. While education information is available in earlier surveys, these questions were unfortunately dropped from the later years of the survey and so we do not include education controls here.

While ideally we would like to know the province of residence, the FAMEX data reports consistent information for region of residence only. The region variable groups the Maritime provinces together and the Prairie provinces together. Therefore, the data contain information on five regions: the Maritimes, Quebec, Ontario, the Prairies, and British Columbia. Beginning in 1986 the data contain a separate regional identifier for Alberta and beginning in 1992 the data identify all 10 provinces. In our analysis we use the five regional dummies available throughout our sample as regional controls. In order to assign cigarette taxes to provinces we exploit the maximum amount of regional information available in that survey year and when necessary assign the average of the tax rates across the region when the specific province is not identifiable. We drop a small number of observations (362) for which regional information is missing. All expenditure and income information is transformed into 1992 Canadian dollars. The resulting data set consists of 81,479 observations across eight survey years.

[10] The numbers in Table 1 suggest that the change between 1990 and 1993 was considerably smaller in the non-smuggling provinces. Further, there was very little change in tax and consumption in the non-smuggling provinces. These numbers, along with the media documentation at the time and afterwards (Robinson, 1998) suggest that the smuggling problem was limited to the eastern provinces and that our assumption of close to zero smuggling in the west is a valid one.

[11] We re-run all specifications limiting the sample to only urban populations, and also including urban/rural controls. Our finding are robust to these alternate specifications.

Table 2
Means

	Mean	S.D.	Minimum	Maximum
Province and year data				
Cigarettes per capita	2118.8	813.18	817.82	4612.9
Real price	31.21	10.25	11.95	57.92
Real excise and sales tax	21.28	9.04	5.31	42.91
Unemployment rate	11.01	3.75	3.9	20.8
Real per capita income	15528.32	1911.41	10510.26	19641.91
FAMEX data				
Cigarette expenditures	552.91	934	0	10800
Percentage of with any cigarette expenditure	44.14	50.00	0	1
Mean cigarette expenditure if >0	1252.61	1048.75	1.84	10800
Real excise & sales tax	20.93	8.54	8.14	39.04
Real price	31.51	10	14.81	51.59
Maritime provinces	0.24	0.43	0	1
Quebec	0.17	0.38	0	1
Ontario	0.2	0.4	0	1
Praries	0.27	0.44	0	1
British Columbia	0.12	0.33	0	1
After-tax HH income	35714.42	22468.62	−122915	356228.4
Family size	2.65	1.39	1	15
Total family expenditure	42849.45	28182.89	57.09	356225.6

Note: source is National Clearinghouse on Tobacco and Health Program and 1982−1998 FAMEX. For regions the mean represents the proportion of the survey in each cell. All dollar amounts are in 1992 Canadian dollars.

3.3. Means

Means of our data sets are shown in Table 2. On average, Canadians consumed 2188.8 cigarettes on an annual basis at a per-carton real (1992) price of CAN$ 31.21, paying a tax of CAN$ 21.28. There is considerable variation in real taxes as the sample minimum and maximum are CAN$ 5.31 and 42.91, respectively. The sample mean of taxes as a share of price is 66.01%, with minimum and maximum values of 44.40 and 80.65%, respectively. In the FAMEX data, average cigarette expenditure was CAN$ 553 in 1992 dollars. Forty-four percent of households spent some amount on cigarettes in the past year and among smokers average expenditure was CAN$ 1253 (1992 dollars).

4. Empirical methodology

Our basic empirical methodology follows that used in the previous literature. We use the legal sales data to estimate models of the form:

$$\text{SALES}_{jt} = \alpha + \beta\text{PRICE}_{jt} + \delta_j + \tau_t + \delta_j\text{TIME} + \varepsilon \quad (1)$$

where SALES is cigarettes sold per capita in province j in year t; PRICE is the cigarette price; δ_j and τ_t are fixed effects for province and year, respectively; and TIME is a linear time trend. By including province fixed effects, we control for any fixed differences in

tastes for smoking across provinces. Likewise, by including fixed time effects, we control for any national changes in smoking behavior which may be correlated with, but causally unrelated to, tax changes. But the problem with those controls alone, when the panel is long, is that there may be slowly moving trends within provinces that are correlated with both smoking and cigarette prices; as Gruber and Koszegi (2000) discuss for the US, there is a very significant impact of such trends on price elasticity estimates. Thus, we include linear province-specific time trends in our models as well. Finally, we also control for provincial unemployment rates and real per capita income in order to proxy business-cycle effects. We estimate this model in levels; results from log–log models are quite similar.

One problem with this model is that price may be endogenous. That is, tobacco companies may set province-specific prices in reaction to province-specific shocks that affect the taste for smoking. We therefore estimate an instrumental variables version of Eq. (1), where we use province and year taxes as instruments for prices.

The major problem that remains with this framework, as highlighted above, is smuggling. If there is significant smuggling, then the elasticity we estimate with legal sales data will be biased, since part of the response to price increases is to exit the legal market. That is, suppose that true total consumption is:

$$\text{SMOKE}_{jt} = \text{SALES}_{jt} + \text{SMUGGLE}_{jt}$$

where SALES is legal sales, as above; SMUGGLE is smoking of smuggled cigarettes; and SMOKE is total smoking. Then the estimated elasticity of sales with respect to the price in those provinces with smuggling is:

$$\frac{\delta \text{SALES}}{\delta \text{PRICE}} = \frac{\delta \text{SMOKE}}{\delta \text{PRICE}} - \frac{\delta \text{SMUGGLE}}{\delta \text{PRICE}}$$

Since the first term on the right hand side is negative, and the second term is positive, the response of sales with respect to price will over state the true response of smoking with respect to price in those provinces where there is smuggling. How this upward bias will affect the elasticity estimate over all provinces (both those with and without smuggling) is not clear, a priori. If in the smuggling provinces the legal price of cigarettes is above the legal price in the non-smuggling provinces, then the estimated slope across all province will be steeper than the true slope. If the legal price in the smuggling provinces is below the average legal price, then the opposite will be true. If these prices are similar, then there should be no net bias across the set of smuggling and non-smuggling provinces. Indeed, this appears to be the case in our instance: the legal prices in the smuggling provinces were quite similar to those in the non-smuggling provinces prior to 1990 (CAN$ 31.29 versus CAN$ 31.83 per carton) and remained quite similar through 1993 (CAN$ 46.51 versus CAN$ 47.87).

How can one address this problem? There are three approaches. The first is to try to include a measure of smuggled consumption directly into the model, to control for this omitted factor. The problem is that the only measure that we have available is export data, but these are national data and there is no way to use them to derive a province-specific amount of smuggling.

The second approach is to estimate the elasticity over times and places where smuggling is not an issue. We have already presented evidence that the worst smuggling in Canada was in the eastern part of the country. In terms of the specific time period, we assume that

significant movement in contraband cigarettes from the US occurred during 1990–1994, which is consistent with previous research (Galbraith and Kaiserman, 1997). Therefore, we can re-estimate this model excluding observations from these eastern provinces over the 1990–1994 period.

But the disadvantage of this approach is that it is relatively crude. We cannot definitely define either the times or the places where smuggling was worst. And the broader the cut out of our data to account for this, the more true variation in prices we lose, since the 1990s was the period of the greatest movement in cigarette prices.

We therefore also rely on a third approach: using actual cigarette expenditure data. The advantage of cigarette expenditure data is that they provide a second source with which to verify our elasticity estimates when we exclude the smuggling provinces. However, the bias in the smuggling provinces will understate the elasticity within those provinces using expenditure data. This is because our regressions use the *legal* price of cigarettes, which overstates the *effective* price of consumption in the smuggling provinces. Thus, there is systematic measurement error in the price data that leads to a downwards bias to the estimated elasticity within the smuggling provinces to the degree that the extent of smuggling differs among the smuggling provinces. As noted above, this does not necessarily imply that the elasticity estimate for all provinces (including both smuggling and non-smuggling provinces) will be appreciably biased. Once again, since legal prices in the smuggling and non-smuggling provinces are quite similar, the overall bias when the model is estimated across all provinces may be small.

In the cigarette expenditure data, we run similar regressions to those above. The dependent variable is household cigarette expenditures (including zeros if there is no cigarette expenditure). We also show results below where we estimate separate models for any smoking and the conditional amount smoked. As above, we control for fixed effects for each region and for each year, as well as region-specific linear time trends. We also control for some of the household characteristics available in this micro-data: after tax household income, the square of after tax income, the sex of the household head and the family size.

5. Basic results

Our basic estimates from the legal sales data, with no attempt to correct for smuggling, are shown in the first column of Table 3, which shows a linear model which relates cigarette sales per capita to the price (instrumented by tax). We estimate that for every CAN$ 1 rise in (real) price, there is a 49.95 reduction in cigarette consumption per capita. The implied elasticity is −0.72. This estimate is somewhat larger than the elasticity estimates for the US; given that prices are so much higher in Canada, the presumption discussed above was that the elasticity would actually be lower. However, there is no correction for smuggling bias.

In column (2), we attempt our first correction: excluding the smuggling provinces (the eastern provinces during the 1990–1994 period). Doing so, we find a fall in the elasticity, which is now estimated to be −0.47. Thus, correcting for smuggling in this way does appear to have an important impact on the estimated elasticities. In particular, it moves them into the range estimated for the US.

Table 3
Part IV: estimates of price elasticity using legal sales data

	All provinces	Excluding smuggling provinces and years
Price coefficient	−4995.5 (701.58)	−3267.50 (703.68)
Elasticity	−0.72 (0.10)	−0.47 (0.09)
Unemployment rate	37.02 (16.39)	30.66 (18.22)
Per capita income	23.93 (4.78)	20.80 (4.89)
Number of observations	190	165

Note: source is National Clearinghouse on Tobacco and Health Program and Statistics Canada. Results contained in column (1) is based on a sample of all 10 Canadian provinces between 1981 and 1999. Column (2) consists of empirical estimates derived from British Columbia, Alberta, Saskatchewan, Manitoba, and Newfoundland between 1981 and 1999 and from Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island between 1981 and 1989 and from 1995 to 1998. S.E. are enclosed in parentheses. Cigarette price is instrumented using the cigarette excise and sales tax rate. Specifications include year and province dummies and province specific time trends. *F*-statistics for the first stage are 2186.21 for all provinces and 1167.27 excluding smuggling provinces.

We then turn, in Table 4, to comparable estimates using the FAMEX consumption data. Column (1) shows the estimated impact of price (instrumented by tax) on dollars of cigarette expenditure. The coefficient estimates show the impact of a CAN$ 1 price increase on expenditures; the standard errors are in parentheses. Below each estimate is the price elasticity of sales implied by this consumption response, at the mean price and quantity; this elasticity is computed as $\beta/\bar{C} - 1$, where β is the estimated coefficient and $\bar{C}$ is the sample mean of consumption. The implied elasticity will be an unbiased estimate of the true price elasticity in the absence of smuggling. In those provinces with smuggling, the true price paid is lower than the observed price and hence $\beta/\bar{C} - 1$ will be a biased estimate the true price elasticity.[12] However, as we explain further below, our estimates suggest that this bias is quite small. We estimate that each dollar price increase leads to an increase in annual cigarette expenditures of CAN$ 10, for an implied elasticity of −0.45.

Columns (2) and (3) decompose this response into its intensive and extensive margins. We do so by modeling separately a dummy for the presence of any tobacco expenditure in the household, and the level of spending conditional on there being any household spending (elasticities are almost identical if we use log of conditional spending). We find that there is only a small and insignificant effect of prices on the presence of any tobacco expenditure in the family. But there is a large elasticity of conditional expenditures of −0.41. Thus, it appears that almost all of the response of consumption to price changes occurs through reductions in consumption and not quitting smoking; this stands in contrast to the US evidence, which suggests that both margins are responsible in similar proportions for the sensitivity of smoking to price (e.g. Evans et al., 1999). However, it is important to note that our data report cigarette expenditure at the household level and cannot identify whether a family member quits smoking if there is actually more than one smoker in the household. In addition, if children in the household do not reveal the fact that they smoke to the household

[12] If the actual price paid by consumers, $P^* = P - j$ where P is the observed price and j is the discount (we assume that j is larger the higher the legal price of cigarettes) then our estimated price elasticity, $\beta/\bar{C} - 1 = (\delta C/\delta P)P/\bar{C} - (\delta j/\delta P) - (\delta C/\delta P)j/\bar{C}$. The second term is assumed to be positive and the third is negative, therefore the resulting bias in the estimate in the elasticity is ambiguous.

Table 4
Part IV: estimates of price elasticity using FAMEX data

	All provinces			Excluding smuggling provinces and years		
	Total spending	Any spending	Spending if >0	Total spending	Any spending	Spending if >0
Price	10.44 (2.01)	−0.00072 (0.00)	25.53 (3.42)	10.79 (3.03)	−0.0004 (0.00)	25.03 (4.98)
Elasticity	−0.45 (0.11)	−0.02 (0.03)	−0.41 (0.08)	−0.45 (0.16)	−0.01 (0.05)	−0.43 (0.11)
Quebec	52.88 (21.90)	0.063 (0.01)	−24.22 (33.18)	49.05 (21.76)	0.065 (0.01)	−32.17 (32.59)
Ontario	24.14 (20.97)	0.024 (0.01)	−2.50 (32.52)	4.60 (20.65)	0.018 (0.01)	−24.30 (31.72)
Prairie	−63.82 (23.34)	0.014 (0.01)	−159.37 (36.92)	−74.79 (24.93)	0.012 (0.01)	−171.70 (39.42)
BC	−147.91 (26.20)	−0.042 (0.01)	−238.62 (42.51)	−159.69 (26.65)	−0.044 (0.01)	−252.42 (42.76)
Male	7.47 (6.85)	0.0025 (0.00)	37.2 (11.30)	7.10 (6.91)	0.01 (0.00)	28.67 (11.26)
After-tax HH Inc.	8.20E−03 (3.71E−04)	9.36E−07 (2.06E−07)	1.90E−02 (6.90E−04)	7.55E−03 (3.73E−04)	6.96E−07 (2.12E−07)	1.83E−02 (6.90E−04)
HH Inc. squared	−5.58E−08 (2.98E−09)	−1.39E−11 (1.69E−12)	−1.13E−07 (5.94E−09)	−5.16E−08 (2.97E−09)	−1.24E−11 (1.69E−12)	−1.11E−07 (5.96E−09)
Family size	72.7 (2.66)	0.047 (0.00)	35.2 (4.29)	71.7 (2.67)	0.047 (0.00)	34.96 (4.26)
Number of observations	81479	81479	35965	72839	72839	32538

Notes: source is 1982–1998 Canadian Survey of Family Expenditure. Results contained in columns (1)–(3) are based on a sample of all 10 Canadian provinces between 1981 and 1999. Columns (4)–(6) consists of empirical estimates derived from British Columbia, Alberta, Saskatchewan, Manitoba, and Newfoundland between 1981 and 1999 and from Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island between 1981 and 1989 and from 1995 to 1998. S.E. are enclosed in parentheses. Cigarette price is instrumented using the cigarette excise and sales tax rate. Specifications include year and province dummies and province specific time trends. S.E. for the any spending regressions are robust. The *F*-statistics on the excluded instrument for the first stage regressions are 685.6 for all provinces and 819.77 excluding smuggling provinces.

head, then changes in smoking behavior by children may not be accurately reflected in the expenditure data.

In columns (4)–(6), we repeat these estimates, excluding once again the smuggling provinces and years. This change in sample, interestingly, has essentially no effect on the estimated elasticities. This suggests that the bias from using legal prices instead of illegal prices paid through smuggling is quite modest.

Putting these two sets of estimates together, we have a well defined range of price elasticities from −0.45 to −0.47. It is clear that the estimates obtained from the legal sales data, without any correction for smuggling, are too large. But, once the smuggling provinces and years are removed, the legal sales data estimates are comparable to those from the expenditure data. The similarity of the estimates using these two alternative approaches is comforting and suggests we are obtaining the "true" price elasticity that is not tainted by smuggling.

6. Estimates by income group

6.1. Motivation

A primary consideration in the policy debate over excise taxation is the potential regressivity of tobacco taxes. Lower income groups spend a much larger share of their incomes on cigarettes than do higher income groups. This is illustrated for Canada in Table 5. The first column of this table shows the distribution of cigarette expenditures as a share of after-tax income by after-tax income quartile in 1998. While the lowest income quartile spent 4% of after-tax income on cigarettes, the highest income quartile spent only 1% of after tax income.

Table 5
Part IV: estimates of elasticities by income/expenditure group in FAMEX data

	Income quartiles		Expenditure quartiles	
	Ex ante spending as percentage of income	Effect of US$ 1 price increase	Ex ante spending as percentage of expenditure	Effect of US$ 1 price increase
Quartile 1	4.14	0.07 (2.78) [−0.99] (0.247)	2.28	0.76 (2.69) [−0.92] (0.255)
Quartile 2	2.16	10.11 (3.78) [−0.45] (0.204)	1.82	4.84 (3.72) [−0.73] (0.202)
Quartile 3	1.72	15.96 (4.43) [−0.31] (0.190)	1.43	18.55 (4.36) [−0.20] (0.188)
Quartile 4	1.01	14.96 (4.64) [−0.36] (0.199)	0.93	15.24 (4.73) [−0.37] (0.194)

Notes: source is 1982−1998 Canadian Survey of Family Expenditure. Data are broken down into quartiles by after-tax income and expenditure. Regressions control for region, year, sex, income, income squared, family size and regional time trends. First and third column give distribution of cigarette spending as a percentage of family after-tax income; second and fourth columns show group-specific effects of a US$ 1 increase in cigarette prices. S.E. are in parentheses. Price elasticities in square brackets. Cigarette price is instrumented using the cigarette tax rate. *F*-statistics for the first stage by quartile (1–4) are 696.52, 713.21, 688.35, and 657.48.

This seeming inequity is much smaller than it appears when considered from the lifetime perspective, however. The lifetime burden of excise taxes is typically much smoother than the annual incidence, since income levels vary more over a lifetime than smoking levels (Poterba, 1989). The third column of Table 5 follows Poterba (1989) in using cigarette expenditures as a share of consumption expenditures (the appropriate proxy for lifetime income in the life cycle model). The distribution of expenditures is much smoother with the lowest expenditure quartile spending 2.3% on cigarettes and the highest quartile spending 0.9% on cigarettes.

These facts would suggest that a tax on cigarettes would be very regressive. But Gruber and Koszegi (2002) question this traditional approach to tax incidence. They note that this approach is only valid under the rational addiction model of Becker and Murphy (1988). This model presumes that agents decide to smoke in the same way they decide on other things: they trade off the long-term costs of smoking against the immediate pleasures, all the while taking into account the addictive properties of nicotine. In particular, Becker and Murphy model the act of smoking as the building of an addiction stock. The more cigarettes smoked today, the greater the addiction capital tomorrow. High addiction capital lowers *average* utility but raises the *marginal* utility to smoking. In this way, smoking lowers future utility but also increases the craving for another cigarette. The key feature of any addiction model is on how people deal with this intertemporal problem. In the original Becker–Murphy formulation individuals discounted the future *exponentially*, meaning that they discount k-periods forward by δ^k, where δ is the per-period time discount factor.

Gruber and Koszegi (2001, 2002) develop an alternative to the Becker and Murphy model which embeds within the Becker–Murphy stock addiction framework preferences that are *time inconsistent*, following Laibson (1997) and O'Donoghue and Rabin (1999). In this quasi-hyperbolic formulation, next period is discounted by $\beta\delta$, the following period by $\beta\delta^2$, and k-periods in the future by $\beta\delta^k$, where $\beta < 1$ is an extra discount factor that changes the discounting of this period relative to the entire future. The key feature of such a hyperbolic model is that individuals will have self-control problems. Specifically, a sophisticated hyperbolic individual (one who knows that he discounts hyperbolically) would like to smoke less in the future than he actually can. The problem arises because he is patient about the future (the relative discount rate between future periods is δ), but impatient about the present (the relative discount rate between today and tomorrow is $\beta\delta < \delta$). This means that when the future arrives he will end up making more impatient choices (i.e. smoke more) than he would like to from today's vantage point.

As Gruber and Koszegi show, the discounted utility of a sophisticated hyperbolic consumer can rise if a tax is imposed. The reason is that the tax serves as a self-commitment device. By forcing a reduction in the smoking in the future, the tax allows the sophisticated hyperbolic agent to do something they would not be otherwise be able to do. Gruber and Koszegi cite a variety of empirical evidence in favor of this alternative model of smoking, including the fact that smokers clearly do demand self-control devices as a means of quitting smoking, and the econometric findings of Gruber and Mullainathan (2002) that higher cigarette taxes increase the reported well-being of smokers.

Gruber and Koszegi (2002) show that, if smokers are time inconsistent, the standard measures of tax incidence are wrong. In particular, the incidence of a tax is no longer simply proportional to the ex ante distribution of expenditure shares. Rather, the self-control benefits

of the tax across income groups must be taken into account. If a tax provides self-control benefits, then the fact that the poor smoke more means that they derive a larger self-control benefit from a higher tax. That is, since the tax now serves a positive role in reducing unwanted smoking, the larger is the share of income spent on unwanted smoking, the larger is the benefit from taxation.

Moreover, the self-control benefits of taxation rise with the differences in price elasticity of demand across groups. Groups that are more price sensitive derive a larger self-control benefit from cigarette taxation, since higher taxes will more likely to cause them to quit. Thus, if lower income groups are more price sensitive, it mitigates the regressivity of the tax. In fact, in the US, where lower income groups are about three times as price elastic as higher income groups, Gruber and Koszegi (2002) find that cigarette taxes are actually *progressive* for many parameter values, and for all parameter values are much less regressive than traditionally thought. Thus, if we also find great differences in elasticities by income group in Canada, it suggests that parallel results may obtain in the Canadian context.[13]

6.2. Results

Table 5 shows estimates of the demand equation by after-tax income quartile, and consumption quartile, in our FAMEX data; we show the results for all years and provinces, as excluding the smuggling provinces does not appear to have much of an impact on our FAMEX estimates. In our data, as in the US, there is a much larger price elasticity of demand among the lowest income smokers. In the bottom income quartile, there is no effect of higher taxes on cigarette spending, with an estimated elasticity of demand close to -1. This elasticity falls to -0.45 in the second quartile, and then to -0.31 in the third quartile before rising again to -0.36 in the top quartile. The drop between the lowest income quartile and the other three quartiles is a statistically significant one, whereas the differences in elasticities within the top three quartiles are not statistically significant. Divided by consumption quartiles, the elasticity pattern is similar, except that the big drop-off is between the second and third quartiles (this drop is statistically significant), while the difference in elasticities between the first and second quartiles and the third and fourth quartiles are not statistically significant.

In either case, in Table 5 there is a pattern of much higher elasticities for the lowest income groups than for the highest income groups. These results are very consistent with those found in the US by Gruber and Koszegi; indeed, the fall in elasticities as income/expenditure rise in Canada is somewhat steeper than in the US. This suggests that the type of calibration results obtained by Gruber and Koszegi for the US might well hold in Canada as well, so that cigarette taxes are actually progressive (or not very regressive) under their alternative model of the smoking decision.

[13] The other outside factors used in these simulations are the damage done by smoking and the distribution of smoking across the life cycle; these are similar in the Canada and the US. Gruber and Koszegi find that taxes are progressive (or roughly proportional) for all values of β and δ so long as lives are worth equal amounts throughout the income distribution. For an income elasticity of the value of life of 1 (so that individuals with incomes half as large as others have a value of life that is also half as large), then taxes are progressive/proportional only for lower β (in the range of 0.6).

7. Effect on alcohol consumption

Another key issue that has not been explored in the Canadian context, and has also been relatively unexplored in the US context as well, is the substitutability or complementarity of cigarette and alcohol consumption. Ex ante, it is not clear if these activities will be complementary or substitutable. If there is a fixed demand for such "vice" activities, then when cigarette prices go up, individuals will substitute into drinking. But, if the activities are pursued together, or if individuals assign a fixed budget to such activities, then as cigarette prices go up, alcohol consumption may fall. In the US context, Dee (1999) finds that smoking and drinking are complementary for youth; we are aware of no studies for overall consumption. There is also no evidence on this point of which we are aware for Canada.

If these activities are substitutes/complements, then it suggests that (a) the large tax increases of the early 1990s increased/decreased consumption of alcohol and (b) the smuggling that resulted decreased/increased consumption of alcohol. To the extent that consumption of alcohol is a "bad", such as smoking, this could imply potentially important spillover effects on welfare from cigarette taxation.

We can investigate this issue directly in both our legal sales and expenditure data, by modeling alcohol consumption as a function of cigarette prices. One problem that we face in the legal sales data, however, is that, unlike cigarettes, alcohol is not a uniform product that can simply be aggregated; different products have very different alcoholic content. Thus, we rely specifically on beer consumption and prices, since this is a relatively homogenous good like cigarettes. Beer sales represent 80% of total alcohol sales, so that this should provide a good representation of the effects on alcohol consumption; our results are in fact quite similar if we use total volume of alcohol sales as well. Also, to the extent that any alcohol smuggling occurred in this period (reports from the Criminal Intelligence Service Canada (1999) suggest that alcohol smuggling began to be a problem post 1997 and hence after most of our sample period) it is mostly in hard liquor, and not in beer.

Our price measure is beer price per litre, which is computed by dividing the value of beer sales by the volume of sales, using data from CANSIM. Ideally, we would instrument beer prices with taxes as we do for cigarettes. Unfortunately, beer tax data are not available for our full sample period. Therefore, we present two sets of estimates, one instrumenting only for cigarette prices, and one instrumenting for both cigarette and beer prices for which we restrict our sample from 1986 onwards (the years for which we have beer taxes). The restricted sample somewhat reduces the cigarette price variation with which we identify our estimates. Our results for cigarette cross-price effects are insensitive to whether beer prices are included in the model.

When examining own price effects of cigarette prices on cigarette consumption, we expected (and found) an increase in the absolute value of the elasticity due to smuggling. But, for cross-price effects of cigarette prices on alcohol consumption, we expect a decrease in the absolute value of the elasticity from smuggling; a given price rise for cigarettes has less of an effect on alcohol consumption because its effects are muted by smuggling. Thus, if alcohol and cigarettes are substitutes, smuggling will reduce the positive effect of cigarette prices on alcohol consumption; if they are complements, smuggling will mitigate the negative effect from rising cigarette prices.

Table 6
Part IV: estimates of cross-price elasticities of alcohol sales and expenditures

	All provinces		Excluding smuggling provinces and years	
	Instrumenting for cigarette prices only	Instrumenting for cigarette and beer prices	Instrumenting for cigarette prices only	Instrumenting for cigarette and beer prices
Legal beer sales per capita				
Beer price coefficient	−6.53 (3.20)	7.32 (31.09)	−8.05 (3.81)	−22.11 (70.4)
Elasticity	−0.19 (0.09)	0.22 (0.92)	−0.22 (0.11)	−0.65 (2.07)
Cigarette price coefficient	−28.7 (14.0)	−21.94 (22.20)	−49.2 (23.0)	−30.75 (46.77)
Elasticity	−0.10 (0.05)	−0.08 (0.08)	−0.16 (0.07)	−0.10 (0.16)
F-statistic on excluded instruments				
Cigarette prices	2284.87	729.92	1246.36	414.13
Beer prices		1.78		0.72
Mean of beer sales per capita	90.75	87.12	91.58	87.53
FAMEX data on alcohol expenditures				
Beer price coefficient	−104.6 (48.7)	−205.69 (141.08)	−84.7 (56.1)	−352.9 (253.14)
Elasticity	−1.34 (0.16)	−1.67 (0.46)	−1.28 (0.18)	−2.15 (0.81)
Cigarette price coefficient	2.96 (2.35)	4.99 (5.12)	0.35 (3.42)	2.71 (7.46)
Elasticity	0.12 (0.10)	0.20 (0.21)	0.01 (0.13)	0.10 (0.29)
F-statistic on excluded instruments				
Cigarette prices	685.57	345.41	819.77	568.42
Beer prices		8.66		2.38
Mean of alcohol expenditures	630.6	585.3	629.5	577.1

Notes: sources as in previous tables. S.E. are in parentheses. Regressions include all additional covariates described in previous tables and footnotes to those tables. Beer prices are instrumented with beer taxes and cigarette prices are instrumented with cigarette taxes. Beer tax information is available from 1986 onwards and hence we exclude years prior to 1986 from the analysis in the second and fourth columns.

The results of this analysis for legal beer sales are presented in the top panel of Table 6. The regression framework is identical to Eq. (1), except that the dependent variable is now beer sales, and there are variables for both the cigarette and beer price. We find evidence here that cigarettes and alcohol are complements. The first column reports results instrumenting only for cigarette prices with cigarette taxes. There is a significant negative effect of cigarette prices on beer consumption, with a cross-price elasticity of −0.10. The own price elasticity, which admittedly is less well identified since beer prices are not instrumented for is roughly twice as large. In the next column we use the restricted sample to instrument for both beer and cigarette prices. The first stage *F*-statistics (presented in the Table 6) suggest that while taxes are a good instrument for cigarette prices, they do not perform well as instruments for beer prices. Consequently, our estimates of the effect of beer prices on beer sales are insignificant (and even the opposite sign). The cross-price elasticity is similar in magnitude but the standard error is now much larger.

In the third column, we once again exclude the smuggling provinces. And, as expected, there is a rise in absolute value of the estimated cross-price elasticity, which roughly doubles in magnitude when the smuggling provinces are excluded. This suggests that cigarettes and

alcohol are complements. Moreover, it suggests that smuggling significantly increased the sales of alcohol, by increasing sales of cigarettes. The final column once again instruments for both beer and cigarette prices. Again, the cross-price elasticity is similar in magnitude, but the standard error is considerably larger.

We next turn to an investigation of the impact of cigarette prices on alcohol in the FAMEX data. In FAMEX, unfortunately, we do not have beer expenditures, but rather only information on total alcohol expenditures. Once again, we follow an identical approach to that used earlier, with the exception of (a) changing the dependent variable to alcohol expenditures and (b) including a beer price regressor. The results are shown in the bottom panel of Table 6.

In this case, we do not find any evidence for complementarity between cigarettes and alcohol; there is a positive effect of cigarette prices on alcohol consumption, but it is highly insignificant, both with the smuggling provinces in and with them out. We find insignificant elasticities in all cases whether we instrument for cigarette prices only or instrument for both cigarette and beer prices. At the same time, we find a much larger own price elasticity of alcohol consumption. Instrumenting for beer prices as well as cigarette prices results in an even larger elasticity estimate, however once again the *F*-statistic on the beer price first stage when we exclude the smuggling provinces is not very strong.

It is unclear why we found consistent results across our data sets for own cigarette price effects and inconsistent results for cross-price effects. This may have something to do with the fact that we have beer consumption directly in the legal sales data, but only total alcohol expenditures in the FAMEX data; but, as noted above, our legal sales results are quite similar if we use total alcohol volumes. In any case, this leaves us unable to conclude that cigarettes and alcohol are complements. But we can conclude that these substances are not substitutes. This mitigates concerns that higher cigarette taxes will simply serve to drive up use of alcohol.

8. Conclusion

A central parameter for designing public policy towards smoking is the price elasticity of demand for cigarettes. While there are numerous credible attempts to estimate this parameter in the US, there is much less evidence for Canada. Partly this is because the key period of price variation in Canada is a period of significant smuggling.

We have presented two approaches to surmounting the bias to estimated elasticities from smuggling. The first is to use legal sales data, and exclude the regions and years where the smuggling problem was the worst. The second is to use micro-data on consumer cigarette expenditures as an alternate source of data. Our estimated elasticities from these two approaches are strikingly similar, in the range of -0.45 to -0.47. This suggests that a fairly reliable estimate of the elasticity of demand for cigarettes can be provided for Canada despite the large smuggling problem.

Further, we examine differences in the demand elasticities by income and consumption quartile. We find that demand elasticities are much higher for the lowest income or consumption quartile than for the higher quartiles, ranging from -1 for the lowest income quartile to -0.3 for the highest income quartiles. These estimates are consistent with those

found in the US literature. They suggest, under the alternative time inconsistent model of smoking developed by Gruber and Koszegi (2001, 2002), that taxes on cigarettes may not be very regressive, as more price sensitive lower income groups derive a greater self-control benefit from higher cigarette prices.

Finally, higher taxes on cigarettes do not appear to drive consumers into drinking as an alternative source of "pleasure". Depending on the data set, we either find limited evidence that cigarettes and alcohol are complements, or no strong evidence either way. Thus, smuggling may not have only served to raise cigarette consumption; it may have led to higher consumption of alternative "bads", such as alcohol, as well.

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