

**THE PROBABILITY OF HOUSEHOLDS PURCHASING TOBACCO IN
CANADA AND THE CHALLENGES ASSOCIATED WITH IDENTIFYING
PRICE EFFECT**

by

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Abstract

A logit specification is used to examine the Statistics Canada Survey of Household Spending cross sections collected within the 10 provinces across Canada. These cross sections are used to investigate the relationship between whether households purchase tobacco over an entire year and the price of tobacco. Unlike many published papers, and similar to some, the price parameter estimate is positive and statistically insignificant. This finding raises questions about how the likelihood of households purchasing tobacco products has been changing across provinces and calendar years. In order to examine these factors the price variable is replaced with province crossed with year indicator variables.

Finally in order to examine the stability of findings, 5 geographic regions and 4 time periods are each separately examined. These 20 region-time period findings are generally the same as other findings in terms of sign and magnitude. In contrast there is statistical evidence to reject the hypothesis that parameters are the same across the 20 region-time periods.

In summary of the findings, for particular provinces and years, the likelihood of purchasing tobacco increased along with the price and this holds even after statistically controlling for variation in other factors. One possible interpretation is that the role of the price of tobacco is challenging to identify. For each province the likelihood of purchasing tobacco generally drops over calendar time however there are some regions and time periods during which this time trend is offset. Across each set of estimates, higher income lowers the odds of purchasing tobacco and this change becomes smaller as income rises. Generally, when the household member that Statistics Canada surveys

is married, older, or the only individual in the household then the household is less likely to purchase tobacco.

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1. Introduction

Smoking is a potentially important health risk factor that may affect both smokers and individuals around them (Krueger et al., 2014, p.74). Furthermore, the smoking behaviour of parents, other members of a household and those who care for children are found to be significantly related to a child's passive smoke (Frijters et al. 2010, p.206). Frijters et al. (2010) estimate the effects of risk factors and in particular examines how much an increase in family income may offset the health effects of passive smoking on children. For example, increasing family income by £16,000 per year is predicted to offset the child health effects of two parents smoking 20 cigarettes a day along with one other household member smoking as well (Frijters et al., 2010, p.209). This raises questions concerning how household smoking has been changing in Canada across geographic regions and periods of time. Furthermore, tobacco sales are a source of government revenue (Gruber et al., 2003, p.821), and policy makers may be interested in how price changes are related to this revenue as well as people's health (Galbraith and Kaiserman, 1997, p.288).

This essay is on the probability of one or more people in a household smoking and this is related to publications on smoking in several ways. First, few published papers examine household information on smoking over an entire year and this may complement research on individual choices and on smoking information over other time spans. Furthermore, recent household data that has not been examined in published papers is available. Household information can be used to examine several factors one of which is the socioeconomic status of the individual surveyed which may reflect and be inter-related with choices made by other household members.

Since relatively large cross sections of household information are available, the stability of findings over geographic regions and periods of time can be examined. Findings that are different across regions and time spans may be related to peoples understanding and appreciation of the health effects of smoking, an aging population, smoking policies, tobacco taxes, and illegal markets. Most previous researches on smoking in Canada involve just one or two cross sections. The Survey of Household Spending (SHS) provides an opportunity to examine whether statistical findings are stable across geographic regions and time periods.

The probability of a household purchasing tobacco products is examined by analyzing thirteen SHS cross sections collected each year between 1997 and 2009. This SHS data is merged with a price variable that has just one value for each province and for each year which makes it difficult to disentangle the role of the price and other factors that are different across provinces and/or over calendar years. One main objective is to draw a general picture of smoking in Canada.

The following section reviews econometric functional forms that have been used to examine smoking and the estimated price effects on smoking in Canada. After this review, Section 3 presents the econometric specification estimated and Section 4 describes the dependent as well as explanatory variables. Next, Section 5.1 involves the following explanatory variables: tobacco price index, household income before tax, household size, province, calendar year, as well as the marital status and age of the one person in each household that Statistics Canada surveyed. The findings raise questions about how provincial differences in the likelihood of purchasing tobacco are changing over time. In order to examine this, in Section 5.2 the price variable is replaced with

province crossed with year covariates and all of the other covariates examined in Section 5.1 are included. In Section 5.2 Royal Canadian Mounted Police (RCMP) information on tobacco smuggling is also discussed and after this the provincial-year findings arrived at in this section are compared in detail with the findings in the previous section. Furthermore in order to examine the stability of findings across geographic regions and time periods in Section 5.3, 20 subsamples are each separately examined. The region subsamples examined are Atlantic Canada, Quebec, Ontario, Prairies, BC and for each of these regions the following time periods are separately examined: 1997-2000, 2001-2003, 2004-2006, 2007-2009. Finally Section 6 provides a summary and discusses future research.

2. Literature Review

A few published papers examine smoking in Canada and this literature review focuses on the econometric methods applied and price findings. In order to provide a general flavour of research into smoking across Canada two articles published in the *Journal of Health Economics*, one published in *Health Economics* and two others on smoking in Canada are reviewed. The two *Journal of Health Economics* publications are Galbraith and Kaiserman (1997), Gruber et al. (2003) and the *Health Economics* publication is Laporte et al. (2010). Furthermore Auld (2005) is published in the *Canadian Journal of Economics* and focuses on price sensitivity. Gospodinov and Irvine (2004) also examines Canadian data, is published in *Topics in Economic Analysis & Policy* and examines the relationship between price and smoking prevalence as well as quantity. Below each paper is discussed in detail, after which the specifications estimated and price findings are summarized.

Gospodinov and Irvine (2004) examine the Canadian Tobacco Use Monitoring Survey collected during the second half of 2000 and first half of 2001 and they estimate a two-part model. Smoking prevalence is examined by estimating a probit specification and quantity smoked is examined by applying ordinary least squares. Gospodinov and Irvine (2004) find that the price parameter estimate is statistically significant, and the findings suggest that price increases have played some role in both smoking prevalence and intensity (p.17).

Auld (2005) estimates a probit specification and examines the 1994 Youth Smoking Survey. Auld (2005) finds that in early adolescence, initiation decisions are more price sensitive than later decisions. This suggests that tax increases which raise the price of cigarettes may prevent adolescents from starting to smoke.

Gruber et al. (2003) apply ordinary least squares and analyze the Canadian Survey of Family Expenditure (FAMEX), as well as the SHS in order to examine cross sections of household tobacco expenditure. Gruber et al. (2003) separately examine three dependent variables. One is household spending, another indicates whether or not a household smokes, and the third involves just strictly positive household spending. Gruber et al. (2003) apply ordinary least squares for each part. Each cross section was collected across Canada during a year and the following years are examined: 1982, 1984, 1986, 1990, 1992, 1996, 1997 and 1998. Among them the first six cross sections are FAMEX, the final two are SHS and these two cross sections along with 11 more cross sections are examined below. Gruber et al. (2003) find a large price elasticity when examining strictly positive spending but only a small, negative and statistically insignificant price effect with regard to whether or not a household purchases tobacco

products. This suggests that “almost all of the response of consumption to price changes occurs through reductions in consumption and not quitting smoking” (p.833). Since cross sections are examined this finding could be related to quitting or to a lower likelihood of starting.

Galbraith and Kaiserman (1997) apply ordinary least squares and examine Canadian cigarette consumption and taxation from 1980 to 1994. Legal consumption and total consumption which includes contraband are separately examined. Galbraith and Kaiserman (1997) find that the price elasticity of demand for cigarettes tends to increase over time so that taxation is an increasingly strong instrument. However, due to untaxed sales such as contraband “the sensitivity of total cigarette sales to the taxation instrument is much lower than would otherwise appear, and has evidently fallen (but remains significantly non-zero)” (p.300).

Laporte et al. (2010) examine 4 cycles of the biennial longitudinal Canadian National Population Health Survey and these were collected between 2000 and 2007. Laporte et al. (2010) use quantile regression to examine people’s tendency to be forward looking at different cigarette consumption levels and price is one explanatory variable. Laporte et al. (2010) find that the price variable has a statistically insignificant and positive relationship with cigarette consumption. The reason for this result may be that Laporte et al. “were forced to assume that everyone living in one of Canada’s ten provinces in a given year faced the same price” (p.1071).

With regard to specification estimated most of the papers reviewed apply ordinary least squares and a few estimate a logit or probit specification. In particular Gospodinov and Irvine (2004) apply ordinary least squares in order to examine smoking

intensity and a probit specification in order to examine smoking prevalence. This is called a two-part specification. Auld (2005) applies a probit specification in order to examine smoking decisions. Like Gospodinov and Irvine (2004), Gruber et al. (2003) as well as Galbraith and Kaiserman (1997) use ordinary least squares and these two papers examine cigarette sales. Finally Laporte et al. (2010) apply quantile regression to examine cigarette consumption.

In summary of the price findings Gospodinov and Irvine (2004) find that a price variable has a statistically significant negative relationship with smoking prevalence (p.12). Similarly, Auld (2005) finds that price changes at age 14 have a statistically significant negative effect on early smoking initiation but “has smaller effects in late adolescence conditional on early smoking behaviour” (p.720). Gruber et al. (2003) find “there is only a small and insignificant effect of prices on the presence of any tobacco expenditure in the family” (p.833). The sign is also negative. Galbraith and Kaiserman (1997) find the price effect on national per capita cigarette sales to be statistically insignificant and negative (p.297). In contrast Laporte et al. (2010) find “the price variable had a persistent tendency to have the wrong sign and to be non-significant” (p.1071).

In summary, the papers reviewed point out that by using tax as an instrument, an increase in the price has played some role in smoking behaviour. However, price changes sometimes have rather low statistical significance and one of these publications finds a positive price effect. Among the papers reviewed Auld (2005) involves the Youth Smoking Survey and Gospodinov and Irvine (2004) involve the Canadian Tobacco Use Monitoring Survey. These two datasets provide detailed information on

individuals who smoke in Canada. The SHS provides an opportunity to examine smoking behaviour over a relatively wide time span and across Canada. Few papers examine the likelihood of anyone in a household smoking over an entire year.

3. Econometric Specification

When a dependent variable is equal to zero or one ordinary least squares can be applied. Alternatively, the dependent variable can be strictly constrained between zero and one by estimating a probit, Cauchy, complementary log-log or logit specification. A logit specification is applied below because it is well known and relatively simple to interpret.

The main topic is the likelihood of a household purchasing tobacco. Under a logit specification for household i , the log odds of purchasing tobacco is

$$\ln\left(\frac{pr_i}{1-pr_i}\right) = \beta_0 + \beta_1 X_{i,1} + \beta_2 X_{i,2} + \beta_3 X_{i,3} + \dots + \beta_j X_{i,j} + \dots + \beta_k X_{i,k}$$

Where pr_i is the probability of household i purchasing any tobacco during a year, $\frac{pr_i}{1-pr_i}$ is the odds of purchasing tobacco, $X_{i,1}, X_{i,2}, X_{i,3}, \dots, X_{i,k}$ are explanatory variables, and each beta is an unknown parameter.

Under this specification the odds of purchasing any tobacco is equal to

$$\exp(\beta_0 + \beta_1 X_{i,1} + \beta_2 X_{i,2} + \beta_3 X_{i,3} + \dots + \beta_j X_{i,j} + \dots + \beta_k X_{i,k}) \quad (1)$$

and when the j^{th} explanatory variable is increased by $\Delta X_{i,j}$ the odds become

$$\exp(\beta_0 + \beta_1 X_{i,1} + \beta_2 X_{i,2} + \beta_3 X_{i,3} + \dots + \beta_j (X_{i,j} + \Delta X_{i,j}) + \dots + \beta_k X_{i,k}) \quad (2)$$

Equation (2) divided by equation (1) is the odds ratio associated with a change in the j^{th} explanatory variable. When the level of each explanatory variable is the same in the numerator and the denominator this odds ratio is equal to $\exp(\beta_j \Delta X_{i,j})$. A one unit change in $X_{i,j}$ is typically considered and this odds ratio is relatively simple to interpret in part because it does not depend on the level at which each covariate is held constant.

This functional form also implies that the percentage change in odds due to change in $X_{i,j}$ is

$$\% \Delta \left(\frac{pr_i}{1 - pr_i} \right) = (\beta_j * 100) \Delta X_{i,j}$$

Finally when x_j is in natural logarithmic form the percentage change in odds due to a percentage change in x_j is equal to β_j .

4. Data, Dependent Variable and Explanatory Variables

4.1 Data

The SHS is a series of cross sections collected by Statistics Canada between the months of January and March. The SHS focuses on household spending during the past calendar year, as well as household characteristics, characteristics of the person surveyed (the reference person) and characteristics associated with other household members. Expenditures on tobacco products and smokers' supplies are recorded in the SHS. This study examines the relationship between the probability of purchasing tobacco and the characteristics of households. The cross sections examined are associated with 13 calendar years and there are 192,842 observations that each report information on a household.

There are 2,726 households who do not report their province or territory of residence and hence they are omitted, this is less than 2% of the sample. Data from the Yukon, Northwest and Nunavut territories was first collected in 1997 and again in 1998 and 1999, after which these territories were surveyed every second year. Analyses of smoking in these particular regions may lead to very different findings and this topic could be examined in the future. They are omitted in this research. Below 183,893 households are examined.

4.2 Dependent and Explanatory Variables

As mentioned above, expenditures on tobacco products and smokers' supplies are reported in the Statistics Canada data set. This variable does not report who smokes in each household and it does not identify households who smoke over short periods of time such as weeks or months and those who regularly smoke over an entire year. Furthermore misreporting may be associated with illegal markets for tobacco products. Households who just purchase illegal tobacco may claim to purchase none or they may not respond to Statistics Canada. In contrast households who purchase tobacco both legally and illegally may accurately convey purchasing some while miss-reporting the exact amount.

The dependent variable examined is equal to 1 when a household reports any expenditure on tobacco during a calendar year and is equal to zero otherwise. Compared with quantities, one advantage of this dependent variable is that households who do not purchase tobacco for an entire year will have a relatively small or no stock of addiction. Households who have not smoked for an entire year may have never done so for a much longer period of time and they may be unlikely to smoke in the future.

Price information is not reported in the SHS and hence Statistics Canada consumer price indices are used to construct this variable. The Appendix provides detail on how this was done. This price variable takes on one value for each province and each year. The real price of tobacco can abruptly change at any point in time and the price variable is one general measurement over an entire year. This price variable is merged with the sample using each household's province of residence when surveyed and the calendar year that the sample reports information on. The base for this price index is 100 and this is associated with Newfoundland in 2002.

Higher income is associated with more saving and consumption options. Furthermore, households with higher income may live in relatively wealthy neighborhoods or apartment buildings that forbid smoking. For these reasons people residing in wealthier neighborhoods may be less likely to smoke. Among the papers reviewed, Gospodinov and Irvine (2004) examine 5 income categories and Gruber et al. (2003) examine just one continuous income explanatory variable. In order to examine a slightly less flexible functional form than Gospodinov and Irvine (2004), and a slightly more flexible functional form than Gruber et al. (2003), income and income squared are included below. This income variable is constructed with a before tax income variable that is deflated by consumer price indexes. The base is associated with Newfoundland in 2002 and the income variable is measured in thousands of dollars.

Four indicators identify the number of people in each household. When there is just one member he or she might be more likely to take on smoking alone at home as people may choose activities with other household members over smoking, or smoker may find it more difficult to find a partner to live with. When there are two or more

household members the sample does not report any individual specific smoking information. Furthermore the member who conveys information to Statistic Canada may be unaware of smoking among other members, this may be particularly true for adolescents and such misinformation may be more likely among households with more members. Gospodinov and Irvine (2004) find fewer cigarettes are purchased per person and the probability of smoking is lower in larger households (p.13). In contrast, Gruber et al. (2003) find that larger households have higher smoking intensity and probability (p.834). Household size is examined with four indicators which are 1 household member, 2 household members, 3 household members and 4 or more household members.

Some provinces may have higher tobacco consumption than other provinces. Contraband tobacco products may be a more serious concern in certain provinces as they mainly enter Canada through such provinces. Also the RCMP may face more difficulties in seizing illegal tobacco in some provinces than others. Ten indicator variables identify each household's province of residence and the reference category is Newfoundland.

Smoking behaviour may change over years. Over calendar time the population may have become more aware of the health effects of smoking and hence smoke less. Furthermore a new policy/law in a particular year may reduce smoking. In addition to this, a large amount of tobacco expenditure may not be reported when smuggling is severe. Year indicators identify the year that a household is asked about, 1997 serves as a reference category, and each year is associated with one cross section.

Differences across provinces may be changing over time due to factors such as the density of shops that sell tobacco and laws that restrict smoking. As mentioned above heavy tobacco smuggling and/or new tobacco control policies may have taken place in particular provinces and during particular years. For these reasons provincial differences associated with each calendar year are examined and Newfoundland in 1997 serves as a reference category. When the province crossed with year covariates are included the price variable has to be dropped due to perfect collinearity. This means the province crossed with year covariates are associated with both the factors discussed above and the price variable.

Households whose reference person is married may have a different likelihood of smoking than households whose reference person is a single male or a single female. These three covariates are examined and married serves as a reference category. Households whose reference person is a single male might take on smoking due to advertising aimed particularly at them. Being married might reduce, stop or increase the likelihood of smoking due to cohabitation and interaction among household members meanwhile some might plan to give birth to children and worry about the effects of smoking. Furthermore respondents who are married might be more aware of, or more appreciate of, the potential harm from second hand smoke, as well as the specific risks among pregnant women, babies, and young children. Finally single male and single female indicators may simply reflect gender differences. Auld (2005), Krueger (2014) and Laporte et al. (2004) examine a gender covariate. Auld (2005) finds that at young age levels males and females initiated “at roughly the same rate, but males were 3.8 percentage points more likely to take up smoking in late adolescence if they did not

initiate early” (p.721). Krueger (2014) finds the cost associated tobacco smoking is higher for males than for females (p.75). Laporte et al. (2004) find that a male indicator is insignificant at the bottom quantiles but is significantly greater at higher quantiles of cigarette consumption (p.1069). Laporte et al. (2004) also examine a marital status covariate but do not discuss this finding.

Age is another factor that may be related to smoking behaviour and the age of the reference person is examined. People may start smoking when or before it is legal to smoke, and they may stop smoking when they experience the associated health effects that typically take place at older age levels. It is worth noting that Gospodinov and Irvine (2004) examine age as a potentially important factor and find that the effect of health warnings is the same among people who are aged 15-19, 20-64 and above 64 (p.17). Below several household respondent age categories are included in order to flexibly examine differences. According to the SHS questionnaire, individuals who are 14 years old or younger are not considered financially independent thus we assume that a reference person is older than this (e.g. Survey of Household Spending in 1997, p.54). The household respondent age categories examined are: 15 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, 65 to 74, and over 75 years old. The age group of 15 to 24 years old serves as a reference category.

4.3 Descriptive Analysis

The unweighted number and proportion of observations for each province and year are listed in Table 1. Descriptive statistics includes both unweighted and weighted numbers. Approximately 37% of the households purchased tobacco during the calendar year before they are surveyed and Table 3 reports the number of households that

purchase tobacco among every 200 for each year and province. The number of households per 200 is reported so that this information can be clearly plotted along with the price variable.

Table 1
Numbers of Observations

year	Canada	nfld	pei	ns	nb	que	ont	man	sask	alb	bc	
1997	16,971	1,580	628	1,768	1,586	2,515	2,301	1,429	1,182	2,019	1,963	9.23%
1998	14,442	1,100	644	1,162	1,167	2,155	2,103	1,372	1,416	1,641	1,682	7.85%
1999	16,219	1,477	600	1,526	1,417	2,030	2,214	1,609	1,441	1,873	2,032	8.82%
2000	14,563	1,314	654	1,321	1,298	1,886	1,898	1,485	1,303	1,562	1,842	7.92%
2001	15,899	1,422	641	1,541	1,481	2,045	2,129	1,489	1,463	1,717	1,971	8.65%
2002	14,534	1,251	622	1,351	1,224	1,974	1,966	1,419	1,483	1,477	1,767	7.90%
2003	16,303	1,360	572	1,404	1,321	3,450	1,961	1,416	1,403	1,595	1,821	8.87%
2004	13,999	1,344	575	1,314	1,236	1,902	1,754	1,398	1,399	1,438	1,639	7.61%
2005	14,202	1,330	638	1,300	1,241	1,935	1,776	1,406	1,385	1,465	1,726	7.72%
2006	14,430	1,310	603	1,393	1,300	1,868	2,119	1,454	1,418	1,356	1,609	7.85%
2007	13,013	1,236	578	1,178	1,223	1,661	1,706	1,304	1,309	1,292	1,526	7.08%
2008	9,493	943	531	893	848	1,229	1,311	860	960	834	1,084	5.16%
2009	9,825	978	492	897	927	1,275	1,486	830	938	926	1,076	5.34%
total	183,893	16,645	7,778	17,048	16,269	25,925	24,724	17,471	17,100	19,195	21,738	
		9.05%	4.23%	9.27%	8.85%	14.10%	13.44%	9.50%	9.30%	10.44%	11.82%	

Note: nfld = Newfoundland; pei = Prince Edward Island; ns = Nova Scotia; nb = New Brunswick; que = Quebec; ont = Ontario; man = Manitoba; sask = Saskatchewan; alb = Alberta; bc = British Columbia

The minimum of the price variable is 42.4 and this takes place in Ontario during 1997 as shown in Figure 1. In contrast the maximum is 153.4 and this takes place in Nova Scotia during 2009. The average of this tobacco price variable is about 5 units lower than the reference point of 100 which is associated with Newfoundland in 2002. Across provinces this price variable generally rises over time and the increases are relatively large in the early 2000s. All of the provinces have more or less the same shapes.

In Table 2, the real household income before taxes ranges from -\$14 thousand to \$728.6 thousand. The average is \$53.2 thousand. Income as well as income squared are

examined. The income odds ratio associated with a one thousand dollar increase is examined below.

As mentioned above there are three indicators for the number of household members. In the sample 25.6% of the households have one member, 34.9% have two members, 16% have 3 members and 23.6% have 4 or more members.

Among approximately 60% of the households the reference person is married, whereas 15% are single males and 25% are single females. As mentioned above the reference person age groups are 15 to 24 years old (8,872 observations), 25 to 34 years old (31,058 observations), 35 to 44 years old (42,058 observations), 45 to 54 years old (40,779 observations), 55 to 64 years old (29,559 observations), 65 to 74 years old (21,775 observations) and above 75 years old (18,741 observations).

Table 2 reports the mean, standard deviation, weighted mean, minimum and maximum for each variable. As mentioned above Table 3 reports the rounded number of households among every 200 that purchase tobacco for each year and province and below this is compared with multiple regression analysis findings. Figure 1 plots Table 3 along with the price variable. For each province the price variable consistently rises over time and the proportion of households who purchase tobacco is generally, but not always, falling.

Table 2
Descriptive Statistics

variable	mean	sd	Weighted		
			mean	min	max
1 if any household expenditure on tobacco, 0 otherwise	0.391	0.488	0.375	0	1
tobacco price index (2002 Newfoundland=100)	95.8	30.837	92.31	42.4	153.4
household income before tax in thousands	53.2	41.198	56.042	-14	728.6
1 household member (reference category)	0.256	0.436	0.266	0	1
2 household members	0.349	0.476	0.329	0	1
3 household members	0.160	0.367	0.144	0	1
4 or more household members	0.236	0.424	0.261	0	1
Newfoundland (reference category)	0.091	0.287	0.016	0	1
Prince Edward Island	0.042	0.201	0.004	0	1
Nove Scotia	0.093	0.29	0.03	0	1
New Brunswick	0.088	0.284	0.024	0	1
Quebec	0.141	0.348	0.258	0	1
Ontario	0.134	0.341	0.371	0	1
Manitoba	0.095	0.293	0.036	0	1
Saskatchewan	0.093	0.29	0.031	0	1
Alberta	0.104	0.306	0.097	0	1
British Columbia	0.118	0.323	0.133	0	1
year 1997 (reference category)	0.092	0.289	0.071	0	1
year 1998	0.079	0.269	0.071	0	1
year 1999	0.088	0.284	0.073	0	1
year 2000	0.079	0.27	0.074	0	1
year 2001	0.087	0.281	0.075	0	1
year 2002	0.079	0.27	0.076	0	1
year 2003	0.089	0.284	0.077	0	1
year 2004	0.076	0.265	0.078	0	1
year 2005	0.077	0.267	0.079	0	1
year 2006	0.079	0.269	0.08	0	1
year 2007	0.071	0.256	0.081	0	1
year 2008	0.052	0.221	0.082	0	1
year 2009	0.053	0.225	0.083	0	1
reference person information:					
married (reference category)	0.604	0.489	0.597	0	1
single male	0.148	0.353	0.165	0	1
single female	0.249	0.432	0.238	0	1
age 15-24 (reference category)	0.046	0.209	0.032	0	1
age 25-34	0.159	0.366	0.169	0	1
age 35-44	0.216	0.412	0.22	0	1
age45-54	0.211	0.408	0.224	0	1
age 55-64	0.154	0.361	0.155	0	1
age 65-74	0.115	0.319	0.111	0	1
age over 75	0.100	0.3	0.089	0	1

Note: Number of observations = 183,893. The base for each covariate measured in real dollars is Newfoundland and the year of 2002.

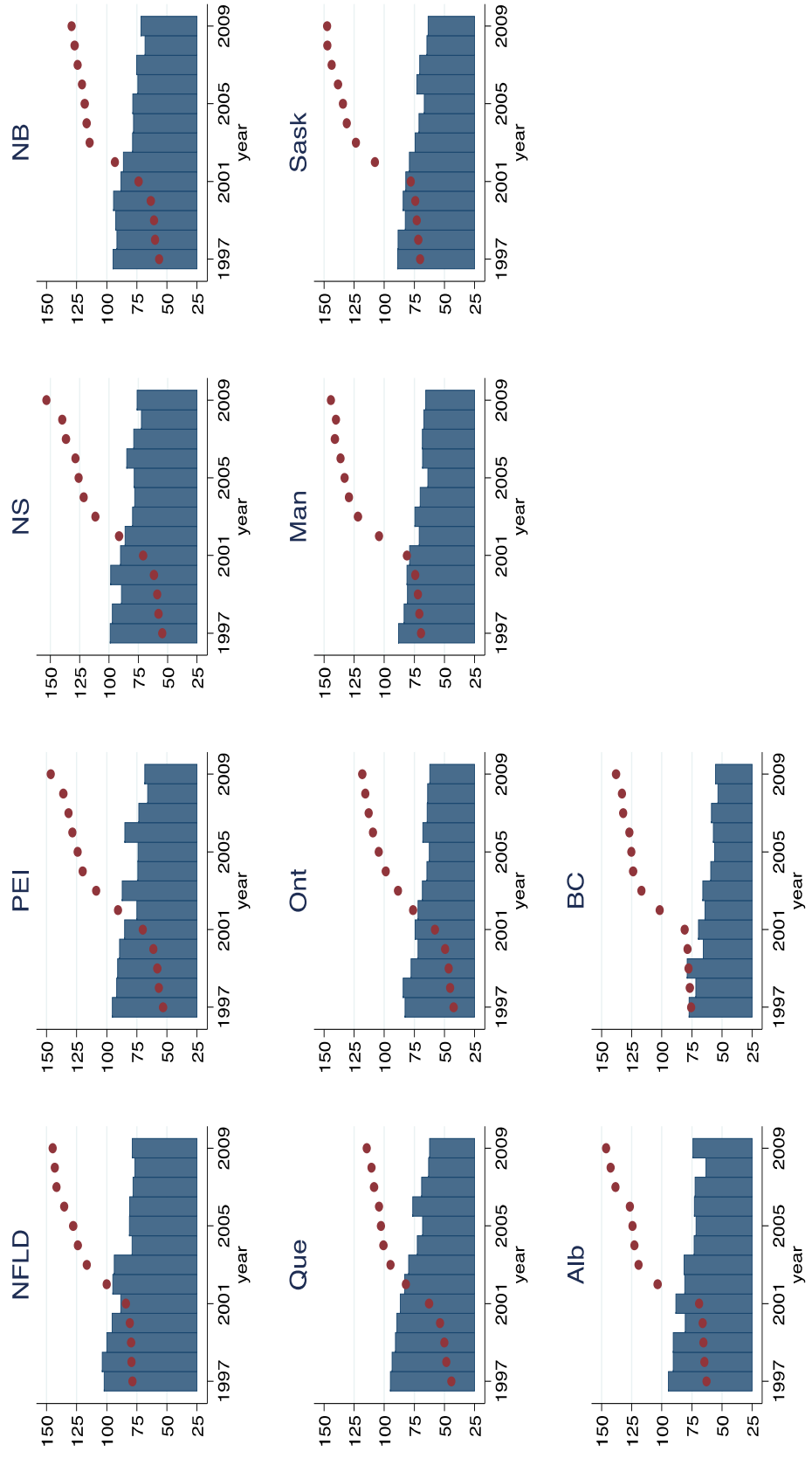
Table 3

Rounded Number of Households Among Every 200 that Purchase Tobacco for Each Year and Province

year	Canada	nfld	pei	ns	nb	que	ont	man	sask	alb	bc
1997	91	102	95	99	95	95	83	88	89	95	77
1998	89	104	92	97	92	93	84	84	89	91	72
1999	87	100	91	89	93	91	78	81	83	91	79
2000	84	96	89	99	94	90	72	81	84	80	65
2001	83	88	85	90	88	87	74	79	82	88	70
2002	79	95	75	86	86	83	72	71	79	81	64
2003	77	94	87	80	79	80	68	75	74	81	66
2004	71	79	74	78	78	72	65	70	71	73	59
2005	69	81	74	78	78	68	63	64	67	72	56
2006	73	81	85	85	74	76	68	68	73	73	57
2007	70	78	73	79	75	69	64	68	71	72	59
2008	65	77	66	72	68	63	64	67	65	63	53
2009	67	79	68	76	72	62	62	66	64	74	55

Note: nflld = Newfoundland; pei = Prince Edward Island; ns = Nova Scotia; nb = New Brunswick; que = Quebec; ont = Ontario; man = Manitoba; sask = Saskatchewan; alb = Alberta; bc = British Columbia

Figure 1
 Number of Households Who Purchase Tobacco Among Every 200, Tobacco Price Index.



Bar: Number of Household Who Purchase Tobacco Among Every 200;
 Dot: Tobacco Price Index

5 Results

5.1 Initial Set of Explanatory Variables

The entire sample is first examined with the following explanatory variables: price, income, number of household members, province, year, marital status and gender of the person surveyed, as well as the age of the person surveyed. Table 4 reports the parameter estimates and odds ratios.

The price odds ratio is slightly above one and the associated parameter estimate is statistically insignificant. This price finding is similar to Laporte et al. (2010, p.1071). For any given price level the predicted number of households who purchase tobacco among every 200 is equal to:

$$\frac{200}{1 + \exp(-\hat{\beta}_0 - \hat{\beta}_{price} \text{price}_{prov,year} - \hat{\beta}_{income} \text{income} - \hat{\beta}_{incomesq} (\text{income})^2 - \hat{\beta}_{2members} - \hat{\beta}_{year2000} - \hat{\beta}_{age35-44})}$$

This prediction is for a household who has: the mean level of income, two household members, resides in Newfoundland, is sampled in 2000, and whose reference person is married and between 35 and 44 years old. In Figure 2 each dot is a price level and each bar is the associated number of households per 200 predicted to purchase tobacco based on the price level and the equation above.

In Figure 2 the very first bar is associated with the price level observed in Newfoundland during 1997 and approximately 100 out of every 200 are predicted to purchase tobacco. This is very close to the proportion of households in Newfoundland who report purchasing tobacco in 1997 which is plotted in Figure 1. Figure 2 implies that with all covariates other than the price held constant a consistently rising price is associated with slight increases in the probability of households purchasing tobacco.

This raises questions about how the price variable may be associated with other factors that have been changing over time and across provinces.

The income parameter estimate is negative and the income squared parameter estimate is positive. Both covariates are relatively close to zero and statistically significant at one percent. The odds ratio associated with a particular level of household income before tax in thousands of dollars ($incbth$) and a change in this covariate ($\Delta incbth$) is equal to

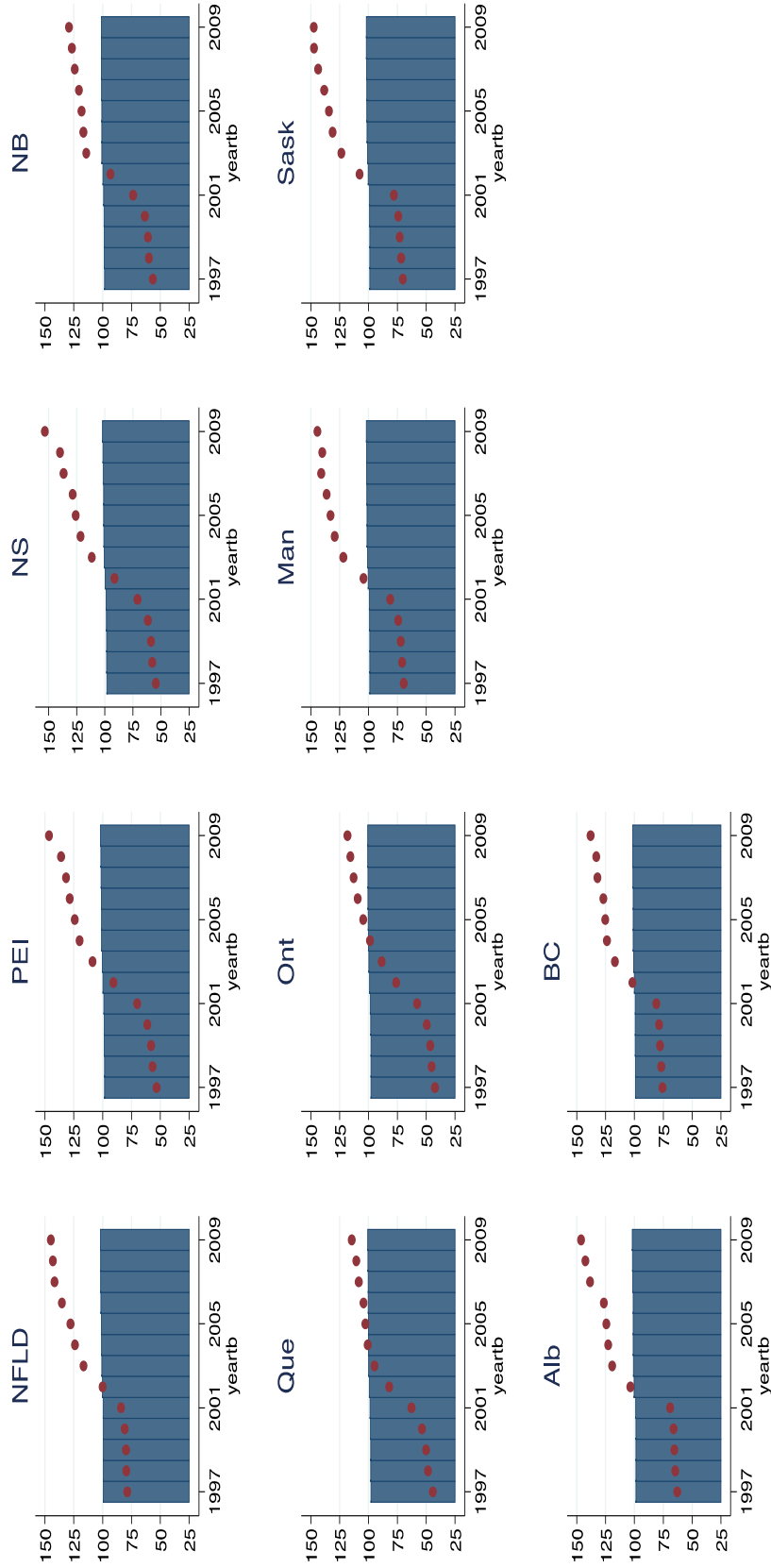
$$\exp(-0.00815 * (\Delta incbth) + 0.0000119 * (2 * incbth * \Delta incbth + (\Delta incbth)^2))$$

Furthermore the predicted percentage change in odds due to a one thousand dollar increase in household income before taxes is

$$-0.81381 + 2 * 0.00119 * incbth$$

The sample mean income in thousands is 53.2 hence 50 serves as a reference point. The lowest income from the sample is -14. Predictions associated with income levels from -10 thousand to 260 thousand are in Table 5.

Figure 2
 Number of Households Predicted to Purchase Tobacco Among Every 200 with All Other Covariates Held Constant, Tobacco Price Index, Price Variable Included



Bar: Number of households Predicted to Purchase Tobacco Among Every 200 with All Other Covariates Held Constant;
 Dot: Tobacco Price Index

Note: income is set equal to the mean level. Household size is set equal to 2. Indicator for Newfoundland is set equal to 1 and others 0. Year indicator for 2000 is set equal to 1 and others 0. Indicator for married reference person is set equal to 1. Indicators for single male and single female reference person are set equal to 0. Indicator for age group 35-44 is set equal to 1 and others 0.

Table 4
Initial Set of Explanatory Variables with Price Variable Included

	Parameter Estimate	Odds Ratio	z statistic
tobacco price index	0.000777	1.001	(0.59)
household income before tax in thousands	-0.00815***	0.992***	(-28.93)
household income before tax in thousands squared	0.0000119***	1.000***	(10.65)
1 household member	reference		
2 household members	0.601***	1.824***	(33.42)
3 household members	0.855***	2.351***	(41.25)
4 or more household members	0.752***	2.121***	(34.56)
Newfoundland	reference		
PEI	-0.0998***	0.905***	(-3.01)
Nova Scotia	-0.0158	0.984	(-0.59)
New Brunswick	-0.0786***	0.924***	(-2.67)
Quebec	-0.132***	0.876***	(-3.18)
Ontario	-0.320***	0.726***	(-7.38)
Manitoba	-0.211***	0.810***	(-9.08)
Saskatchewan	-0.137***	0.872***	(-5.88)
Alberta	-0.127***	0.881***	(-5.18)
British Columbia	-0.494***	0.610***	(-21.95)
year 1997	reference		
year 1998	-0.0412*	0.960*	(-1.73)
year 1999	-0.0754***	0.927***	(-3.22)
year 2000	-0.127***	0.881***	(-5.09)
year 2001	-0.149***	0.862***	(-5.30)
year 2002	-0.252***	0.777***	(-4.93)
year 2003	-0.287***	0.751***	(-4.07)
year 2004	-0.420***	0.657***	(-5.28)
year 2005	-0.449***	0.638***	(-5.38)
year 2006	-0.361***	0.697***	(-4.11)
year 2007	-0.375***	0.687***	(-3.94)
year 2008	-0.502***	0.606***	(-5.07)
year 2009	-0.466***	0.628***	(-4.46)
married	reference		
single male	0.612***	1.844***	(31.15)
single female	0.125***	1.133***	(7.81)
age 15-24	reference		
age 25-34	-0.186***	0.830***	(-7.25)
age 35-44	-0.192***	0.825***	(-7.56)
age 45-54	-0.136***	0.873***	(-5.35)
age 55-64	-0.411***	0.663***	(-15.75)
age 65-74	-0.970***	0.379***	(-35.06)
age over 75	-1.724***	0.178***	(-55.08)
intercept	0.0410***		(0.40)
number of observations	183,893		

* p < 0.10, ** p < 0.05, *** p < 0.01

Table 5
Household Income Results

household income before taxes in thousands of dollars	odds ratios	percentage change in odds
-10	1.726541026	-0.83761
0	1.548443139	-0.81381
10	1.398667503	-0.79001
20	1.272431962	-0.76621
30	1.165884469	-0.74241
40	1.075913427	-0.71861
50	1	-0.69481
60	0.936102781	-0.67101
70	0.882567505	-0.64721
80	0.838056297	-0.62341
90	0.801492231	-0.59961
100	0.772016003	-0.57581
110	0.748952287	-0.55201
120	0.73178392	-0.52821
130	0.72013254	-0.50441
140	0.71374466	-0.48061
150	0.712482449	-0.45681
160	0.716318771	-0.43301
170	0.725336205	-0.40921
180	0.739730018	-0.38541
190	0.759815225	-0.36161
200	0.786038111	-0.33781
210	0.818992789	-0.31401
220	0.859443665	-0.29021
230	0.908355007	-0.26641
240	0.966929202	-0.24261
250	1.036655846	-0.21881
260	1.119374447	-0.19501

Note: odds ratio equals to $\exp(-0.00815*(\Delta\text{incbth}) + 0.0000119*(2*50* \Delta\text{incbth}+(\Delta\text{incbth})^2))$ and percentage change in odds equals to $-0.81381 + 2*0.00119*\text{incbth}$

In Table 5 an income level of \$50,000 serves as a reference category for a number of different odds ratios. For example the odds among households with an income before taxes of \$10,000 is 1.4 times higher than the odds among households with an income before taxes of \$50,000. In contrast the odds ratio is the lowest one when comparing households with an income before taxes of \$150,000 to households with an income before taxes of \$50,000. After \$150,000 odds ratio starts to increase. This table also reports the percentage change in odds due to \$1,000 change in income. The general finding is that a higher income lowers the odds of purchasing tobacco and this change becomes smaller as income rises. Furthermore the odds of purchasing tobacco is higher

among low and high income households as compared with households whose income is in the middle range.

Compared with a household with only one member, a household with two members has 1.824 times higher odds, a household with three members has 2.351 times higher odds and a household with four or more members has 2.121 times higher odds of purchasing tobacco. It is notable that a household with four or more members has lower probability than one with three members. The reason may be that it is more common in larger households to have children and members are more aware of the potential harm from second hand smoke. Household size parameter estimates are each statistically significant at one percent.

With Newfoundland as a reference category there is little evidence to reject the hypothesis that the Nova Scotia parameter is equal to zero and all the other provincial parameter estimates are statistically significant at one percent. Households in Newfoundland and Nova Scotia are the most likely to purchase tobacco and among the other provinces the order from most likely to least is: New Brunswick, PEI, Alberta, Quebec, Saskatchewan, Manitoba, Ontario, and British Columbia.

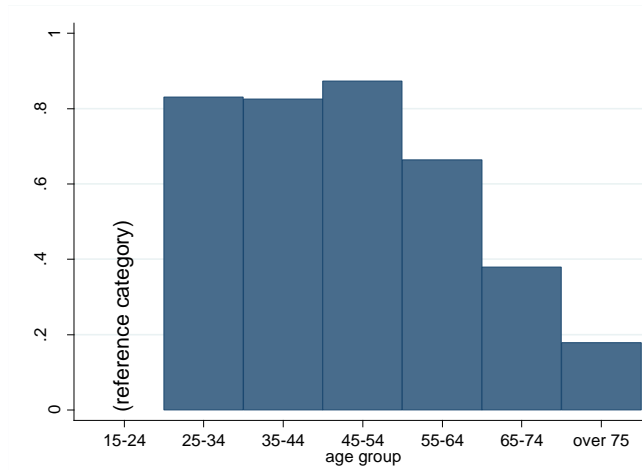
After statistically controlling for variation in other covariates, the probability of a household purchasing tobacco is generally declining across consecutive calendar years. The 1998 parameter estimate is statistically significant at ten percent and all others are statistically significant at one percent. Across years small increases in the likelihood of purchasing tobacco take place when going from 2005 to 2006 and from 2008 to 2009. The odds ratio for 2006 compared with 2005 is 1.09 and the odds ratio for 2009 compared with 2008 is 1.04. This raises questions about what was happening during

these years and whether these findings are associated with particular provinces during these years. The p-value associated with the hypothesis that the 2006 parameter is equal to the 2005 parameter is 0.0007, which provides evidence to reject this hypothesis. In contrast the hypothesis that the 2009 parameter is equal to 2008 parameter has a p-value of 0.2616.

When the person surveyed is a single male rather than married the odds is 1.844 times higher. Similarly when the person surveyed is a single female rather than married the odds is 1.133 times higher. Both single male and single female parameter estimates are statistically significant at one percent. Perhaps a married reference person is more likely to have children and as mentioned above, he/she may be more aware of the potential harm from second hand smoke.

The odds ratio for each age group is plotted in Figure 3. The odds of purchasing tobacco is highest when the head is between 15 and 24 years old, is relatively high for the 25 to 34, 35 to 44, and 45 to 54 age groups, and falls for each age category after this. Age parameter estimates are each statistically significant at one percent. People may stop smoking when they experience health effects associated with smoking in older age and this may be why the odds ratio drops greatly after 54 years old. This finding may also reflect that smokers tend to pass away at younger age levels.

Figure 3
Odds Ratio for Each Age Group (age 15-24 as reference category)



In summary, for the entire sample 78 households among every 200 purchase tobacco. Table 3 reports this same information across Canada for each year and the number of households among every 200 that purchase tobacco drops from 91 in 1997 to 67 in 2009. In contrast to this general downward trend, two slight increases take place over the years 2005 to 2006 and 2008 to 2009. This is similar to the multiple regression year findings in Table 4. With regard to the price finding in Table 4, Figure 2 plots the proportion of households predicted to purchase tobacco at each level of the price variable and with all other covariates held constant. Figure 2 shows that the price has been generally rising and after variation in other covariates is accounted for, the price parameter may be equal to zero, or the price variable may be correlated with missing information.

In Table 4 all of the parameter estimates are statistically significant at 1 percent except the price parameter estimate, one provincial parameter estimate and one year parameter estimate. The price parameter estimate is positive and this may reflect bias due to not accounting for variation in provincial differences over time. In order to

examine how provincial differences are changing over time, the province and year indicator variables are crossed and due to perfect collinearity, the price variable can not be included.

5.2 Province Crossed with Year Covariates

For reasons stated above the sample is examined with province crossed with year covariates, the price variable left out, and all other covariates included. Table 6 reports the parameter estimates and odds ratios.

The parameter estimates for income, household size, age, marital status and gender are all statistically significant and almost the same as in Table 4. Most of the province-year covariates are statistically significant at one percent. For each province the odds ratio generally drops across calendar years. The parameter estimates for the first few years in most of the provinces are statistically insignificant.

Table 6

Initial Set of Explanatory Variables and Province Crossed with Year Covariates Rather than the Price

	Parameter Estimate	Odds Ratio	z statistic
household income before tax in thousands	-0.00815***	0.992***	(-28.89)
household income before tax in thousands squared	0.0000119***	1.000***	(10.63)
1 household member	reference		
2 household members	0.602***	1.825***	(33.44)
3 household members	0.855***	2.352***	(41.23)
4 or more household members	0.753***	2.123***	(34.57)
Newfoundland#1997	reference		
Newfoundland#1998	0.0835	1.087	(1.03)
Newfoundland#1999	0.0155	1.016	(0.21)
Newfoundland#2000	-0.0667	0.935	(-0.86)
Newfoundland#2001	-0.180**	0.836**	(-2.37)
Newfoundland#2002	-0.0546	0.947	(-0.70)
Newfoundland#2003	-0.0792	0.924	(-1.04)
Newfoundland#2004	-0.351***	0.704***	(-4.53)
Newfoundland#2005	-0.295***	0.744***	(-3.81)
Newfoundland#2006	-0.288***	0.750***	(-3.70)
Newfoundland#2007	-0.285***	0.752***	(-3.59)
Newfoundland#2008	-0.347***	0.707***	(-4.01)
Newfoundland#2009	-0.280***	0.756***	(-3.28)
PEI#1997	-0.0163	0.984	(-0.17)
PEI#1998	-0.0826	0.921	(-0.85)
PEI#1999	-0.0925	0.912	(-0.93)
PEI#2000	-0.156	0.855	(-1.62)
PEI#2001	-0.203**	0.816**	(-2.08)
PEI#2002	-0.454***	0.635***	(-4.54)
PEI#2003	-0.155	0.857	(-1.52)
PEI#2004	-0.470***	0.625***	(-4.57)
PEI#2005	-0.428***	0.652***	(-4.31)
PEI#2006	-0.169*	0.845*	(-1.69)
PEI#2007	-0.374***	0.688***	(-3.62)
PEI#2008	-0.549***	0.577***	(-5.07)
PEI#2009	-0.460***	0.631***	(-4.13)
Nova Scotia#1997	0.0184	1.019	(0.26)
Nova Scotia#1998	-0.0210	0.979	(-0.26)
Nova Scotia#1999	-0.121	0.886	(-1.62)
Nova Scotia#2000	0.0621	1.064	(0.80)
Nova Scotia#2001	-0.0975	0.907	(-1.31)
Nova Scotia#2002	-0.193**	0.825**	(-2.50)
Nova Scotia#2003	-0.319***	0.727***	(-4.17)
Nova Scotia#2004	-0.342***	0.711***	(-4.37)
Nova Scotia#2005	-0.310***	0.734***	(-3.95)
Nova Scotia#2006	-0.185**	0.831**	(-2.41)
Nova Scotia#2007	-0.219***	0.803***	(-2.71)
Nova Scotia#2008	-0.411***	0.663***	(-4.63)
Nova Scotia#2009	-0.308***	0.735***	(-3.49)
New Brunswick#1997	-0.0640	0.938	(-0.87)
New Brunswick#1998	-0.111	0.895	(-1.39)
New Brunswick#1999	-0.0712	0.931	(-0.94)
New Brunswick#2000	-0.0263	0.974	(-0.34)

New Brunswick#2001	-0.156**	0.856**	(-2.08)
New Brunswick#2002	-0.189**	0.828**	(-2.38)
New Brunswick#2003	-0.357***	0.700***	(-4.58)
New Brunswick#2004	-0.387***	0.679***	(-4.87)
New Brunswick#2005	-0.354***	0.702***	(-4.47)
New Brunswick#2006	-0.407***	0.666***	(-5.16)
New Brunswick#2007	-0.315***	0.730***	(-3.92)
New Brunswick#2008	-0.480***	0.619***	(-5.27)
New Brunswick#2009	-0.415***	0.660***	(-4.73)
Quebec#1997	-0.0518	0.949	(-0.78)
Quebec#1998	-0.0732	0.929	(-1.07)
Quebec#1999	-0.134*	0.875*	(-1.93)
Quebec#2000	-0.145**	0.865**	(-2.06)
Quebec#2001	-0.200***	0.819***	(-2.88)
Quebec#2002	-0.263***	0.768***	(-3.76)
Quebec#2003	-0.341***	0.711***	(-5.40)
Quebec#2004	-0.464***	0.629***	(-6.48)
Quebec#2005	-0.563***	0.569***	(-7.85)
Quebec#2006	-0.356***	0.701***	(-4.97)
Quebec#2007	-0.460***	0.631***	(-6.17)
Quebec#2008	-0.607***	0.545***	(-7.40)
Quebec#2009	-0.637***	0.529***	(-7.83)
Ontario#1997	-0.291***	0.748***	(-4.29)
Ontario#1998	-0.269***	0.764***	(-3.89)
Ontario#1999	-0.378***	0.685***	(-5.51)
Ontario#2000	-0.482***	0.617***	(-6.73)
Ontario#2001	-0.428***	0.652***	(-6.16)
Ontario#2002	-0.476***	0.621***	(-6.70)
Ontario#2003	-0.540***	0.583***	(-7.56)
Ontario#2004	-0.617***	0.540***	(-8.35)
Ontario#2005	-0.665***	0.514***	(-8.98)
Ontario#2006	-0.553***	0.575***	(-7.87)
Ontario#2007	-0.595***	0.551***	(-7.98)
Ontario#2008	-0.636***	0.529***	(-7.94)
Ontario#2009	-0.658***	0.518***	(-8.46)
Manitoba#1997	-0.0701	0.932	(-0.92)
Manitoba#1998	-0.209***	0.811***	(-2.71)
Manitoba#1999	-0.245***	0.783***	(-3.30)
Manitoba#2000	-0.227***	0.797***	(-3.00)
Manitoba#2001	-0.284***	0.753***	(-3.75)
Manitoba#2002	-0.450***	0.638***	(-5.79)
Manitoba#2003	-0.336***	0.714***	(-4.35)
Manitoba#2004	-0.456***	0.634***	(-5.85)
Manitoba#2005	-0.630***	0.532***	(-8.01)
Manitoba#2006	-0.507***	0.603***	(-6.55)
Manitoba#2007	-0.459***	0.632***	(-5.75)
Manitoba#2008	-0.477***	0.621***	(-5.23)
Manitoba#2009	-0.537***	0.584***	(-5.81)
Saskatchewan#1997	-0.0534	0.948	(-0.67)
Saskatchewan#1998	-0.0944	0.910	(-1.24)
Saskatchewan#1999	-0.196**	0.822**	(-2.57)
Saskatchewan#2000	-0.144*	0.866*	(-1.84)
Saskatchewan#2001	-0.209***	0.811***	(-2.75)

Saskatchewan#2002	-0.274***	0.761***	(-3.60)
Saskatchewan#2003	-0.310***	0.733***	(-3.99)
Saskatchewan#2004	-0.432***	0.649***	(-5.54)
Saskatchewan#2005	-0.475***	0.622***	(-6.03)
Saskatchewan#2006	-0.379***	0.685***	(-4.89)
Saskatchewan#2007	-0.374***	0.688***	(-4.72)
Saskatchewan#2008	-0.484***	0.616***	(-5.47)
Saskatchewan#2009	-0.542***	0.582***	(-6.06)
Alberta#1997	-0.0229	0.977	(-0.33)
Alberta#1998	-0.113	0.893	(-1.55)
Alberta#1999	-0.120*	0.887*	(-1.69)
Alberta#2000	-0.301***	0.740***	(-4.04)
Alberta#2001	-0.0995	0.905	(-1.38)
Alberta#2002	-0.317***	0.728***	(-4.21)
Alberta#2003	-0.305***	0.737***	(-4.12)
Alberta#2004	-0.474***	0.622***	(-6.18)
Alberta#2005	-0.429***	0.651***	(-5.60)
Alberta#2006	-0.410***	0.663***	(-5.26)
Alberta#2007	-0.381***	0.683***	(-4.80)
Alberta#2008	-0.602***	0.548***	(-6.50)
Alberta#2009	-0.376***	0.687***	(-4.31)
British Columbia#1997	-0.423***	0.655***	(-5.99)
British Columbia#1998	-0.530***	0.589***	(-7.17)
British Columbia#1999	-0.387***	0.679***	(-5.54)
British Columbia#2000	-0.658***	0.518***	(-9.02)
British Columbia#2001	-0.556***	0.573***	(-7.80)
British Columbia#2002	-0.680***	0.507***	(-9.19)
British Columbia#2003	-0.630***	0.533***	(-8.62)
British Columbia#2004	-0.781***	0.458***	(-10.26)
British Columbia#2005	-0.818***	0.441***	(-10.80)
British Columbia#2006	-0.776***	0.460***	(-10.07)
British Columbia#2007	-0.722***	0.486***	(-9.27)
British Columbia#2008	-0.883***	0.414***	(-10.08)
British Columbia#2009	-0.811***	0.444***	(-9.29)
married	reference		
single male	0.613***	1.845***	(31.18)
single female	0.125***	1.133***	(7.81)
age 15-24	reference		
age 25-34	-0.187***	0.830***	(-7.27)
age 35-44	-0.193***	0.824***	(-7.60)
age 45-54	-0.136***	0.873***	(-5.38)
age 55-64	-0.412***	0.662***	(-15.80)
age 65-74	-0.972***	0.378***	(-35.10)
age over 75	-1.725***	0.178***	(-55.07)
intercept	0.0255***		
number of observations	183,893		

* p<0.10 ** p<0.05 *** p<0.01

The predicted number of households who purchase tobacco among every 200 given a particular province and a year is equal to:

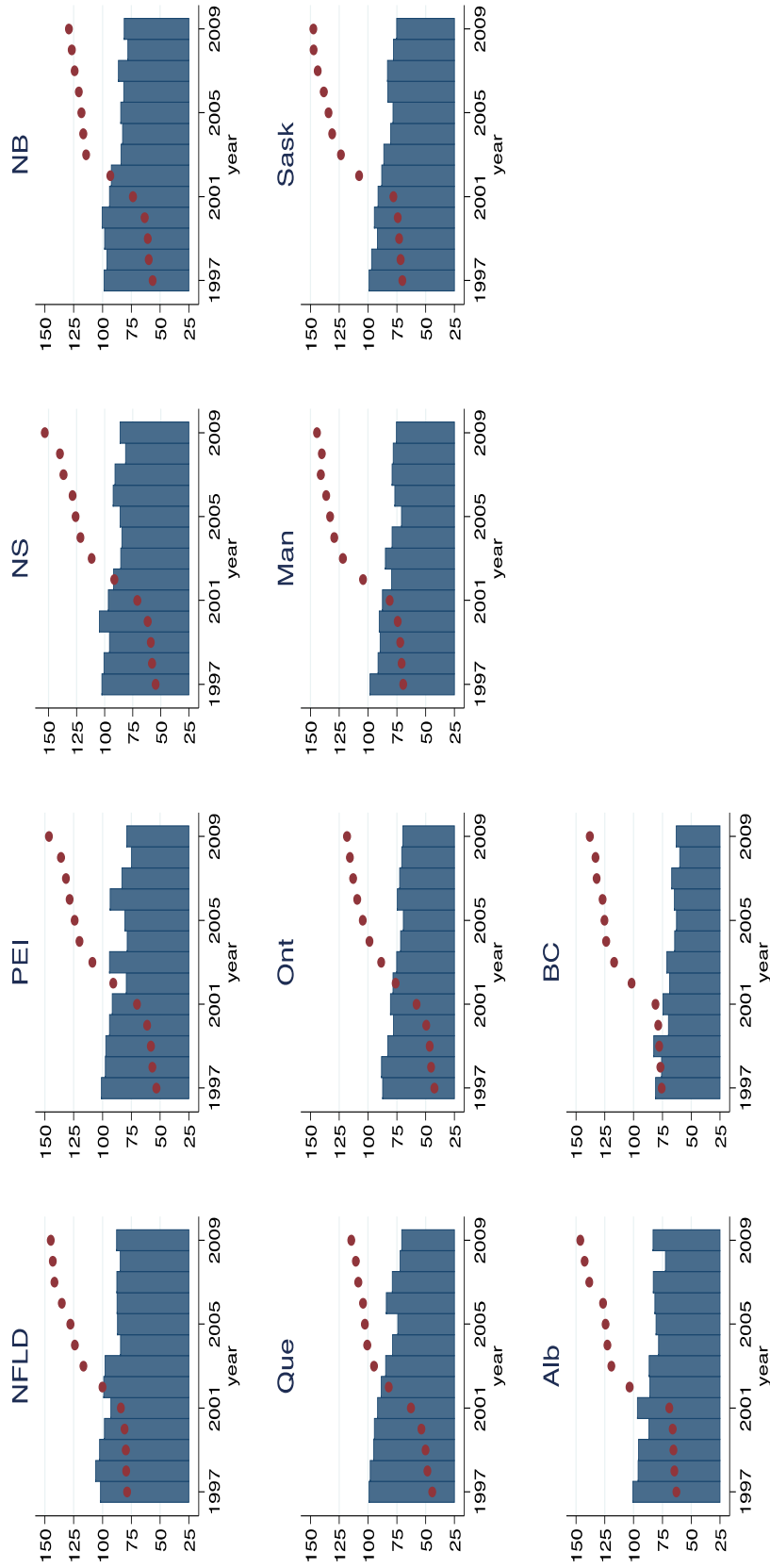
$$\frac{200}{1 + \exp(-\hat{\beta}_0 - \hat{\beta}_{income} \overline{income} - \hat{\beta}_{incomesq} (\overline{income})^2 - \hat{\beta}_{2members} - \hat{\beta}_{prov,year} - \hat{\beta}_{age35-44})}$$

This prediction is for a household who has: the mean level of income, two household members, and whose reference person is married and between 35 and 44 years old.

Apart from the province and year indicators these are the same circumstances associated with the price predictions plotted in Figure 2 on page 20. The province crossed with year variable may be associated with the price as well as other factors. In Figure 4 below each dot is a price level and each bar is the associated number of households per 200 predicted to purchase tobacco based on the equation above.

Overall for each province and year, the proportion of households predicted to purchase tobacco in Figure 4 is very similar to the proportions who report purchasing tobacco which is plotted in Figure 1. In Figure 2 the number of households predicted to purchase tobacco among every 200 is reported for each price level while the province, year and all other explanatory variables are held constant. In contrast to the slight increases in the likelihood of purchasing tobacco due to an increase in the price in Figure 2, in Figure 4 there is a general downward trend in the likelihood of purchasing tobacco. Furthermore there are two year findings that stand out.

Figure 4
 Number of Households Predicted to Purchase Tobacco Among Every 200 with All Other Covariates Held Constant, Tobacco Price Index, Province Crossed with Year Covariates



Bar: Number of Households Predicted to Purchase Tobacco Among Every 200 with All Other Covariates Held Constant;
 Dot: Tobacco Price Index

Note: income is set equal to the mean level. Household size is set equal to 2. Indicator for married reference person is set equal to 1. Indicators for single male and single female reference person are set equal to 0. Indicator for age group 35-44 is set equal to 1 and others 0.

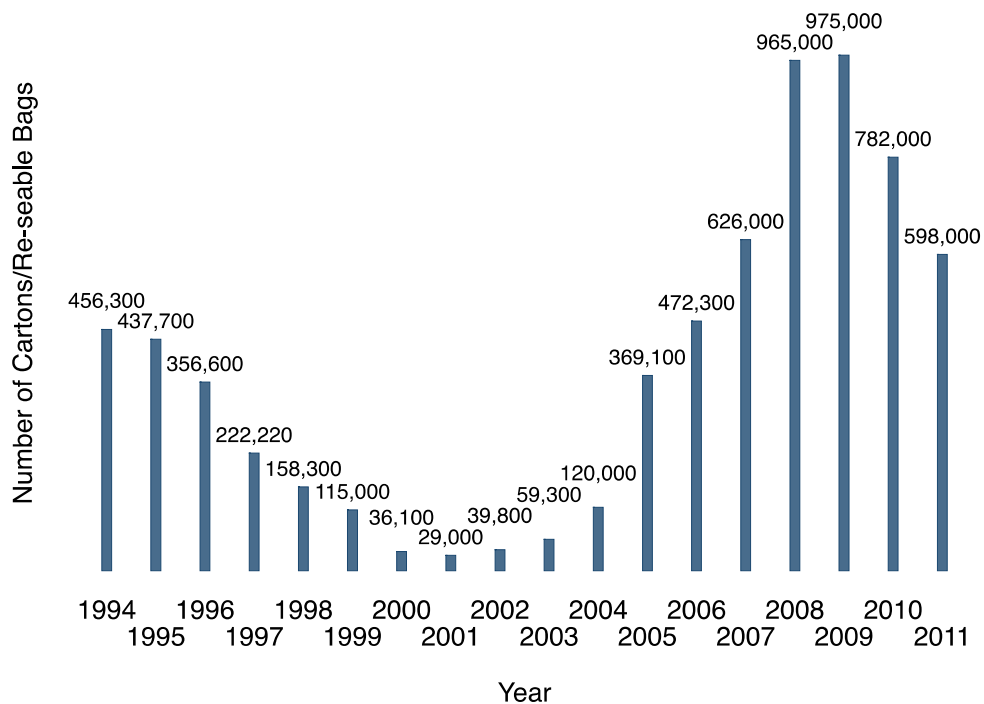
One of these findings takes place when the price of tobacco is rising relatively quickly in each province between 2001 and 2003. During these three years the number of households predicted to purchase tobacco among every 200 goes up for: Newfoundland 2002, Prince Edward Island 2003, Ontario 2001, Manitoba 2003, Alberta 2001, and British Columbia 2001. The other year finding that stands out is that the number of households predicted to purchase tobacco among 200 goes up in each province when changing from 2005 to 2006 and/or 2007. During these years the price of tobacco is relatively high across Canada.

These findings raise questions about the role price plays. Perhaps price has little or no effect on the likelihood of purchasing tobacco even when other factors that influence people's choices are held constant. It is also possible that price is correlated with other factors that are different across provinces and changing over time.

In general when a demand curve shifts to the right and a supply curve remains the same the equilibrium price and quantity both rise. Perhaps unreported factors have shifted the demand curve for tobacco products to the right in certain provinces and during particular years. If this is the case, it is likely that reverse causality or other endogeneity is causing the insignificant price results. One possibility to an exogenous increase in demand is an expanding market for contraband tobacco products. With regard to illegal tobacco sales the RCMP Contraband Tobacco Enforcement Strategy states that "[e]stimating the size of Canada's contraband tobacco market continues to be a challenge due to the complexity of the illicit tobacco environment and the lack of available data" (2010-2011, p.31). In order to further examine this RCMP cigarette seizures from 1994 to 2011 are plotted in Figure 5. The RCMP cigarette seizures

declined in the mid to late 1990s, reached a minimum in 2001, and continuously increased until 2009. Perhaps not long after 2001 and in particular provinces the market for illegal cigarettes was growing and furthermore the illegal market for tobacco products may have peaked across Canada during the few years after 2007. This may be associated with the increased number of households predicted to purchase tobacco during 2001 to 2003 and 2006 to 2007. Furthermore during these years there may be other unreported changes in tobacco control policies, public awareness of the health effects of tobacco, and/or changes in the tobacco products produced.

Figure 5
Royal Canadian Mounted Police Cigarette Seizures



Note: Each carton and re-sealable bag contains 200 cigarettes. For 1994 to 2010, “Contraband Tobacco Enforcement Strategy, Third Progress Report (2010-2011)”, p.6 and footnote 2 p.8. For 2011, Royal Canadian Mounted Police, Illicit Tobacco website <http://www.rcmp-grc.gc.ca/ce-da/tobac-tabac/index-eng.htm#a>.

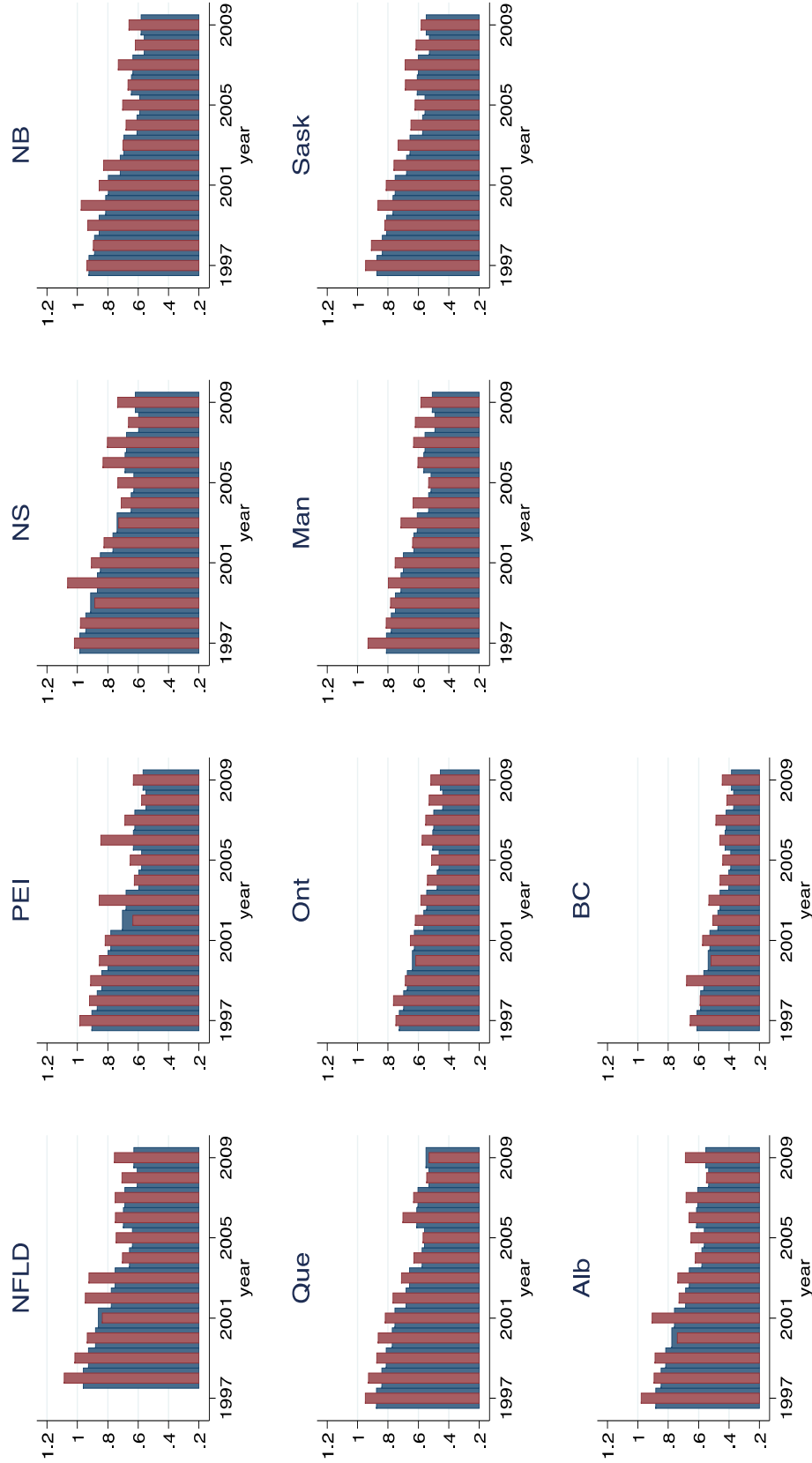
Before discussing the next set of estimates it is valuable to compare the year and province findings when province crossed with year covariates are included and the price is omitted (Table 6) to the year and province findings when the price is included along with province and year indicators that are not crossed (Table 4). In Figure 6 Newfoundland in 1997 is a reference category and each maroon bar is an odds ratio based on the province-year parameter estimates in Table 6. Behind each maroon bar is a wider navy bar that is based on the year and province parameter estimates in Table 4. Given the functional form associated with Table 4 the height of navy bars varies across provinces and for each province the general pattern of the navy bars is the same across years. In order to interpret Figure 6 consider Prince Edward Island in 1997. The maroon bar is close to one and implies that the odds of purchasing tobacco in Prince Edward Island in 1997 is almost the same as the odds in Newfoundland in 1997. Behind this maroon bar the wider navy bar is just slightly lower and hence has a similar interpretation. Figure 6 conveys that the findings in this section and the previous section both reflect a general downward trend in the likelihood of households purchasing tobacco across calendar years. The maroon bars reflect an increase in the likelihood of purchasing tobacco from the previous year to the next for: Newfoundland 2002, Prince Edward Island 2003, Ontario 2001, Manitoba 2003, Alberta 2001, and British Columbia 2001. In contrast the navy bars imply downward trends for these provinces and years. This difference is in part because the functional form associated with Table 4 does not allow provincial differences to change across years. The maroon bars also reflect increases in the likelihood of purchasing tobacco for each province when going from 2005 to 2006 and/or 2007 and the navy bars reflect this same finding.

In summary the price parameter estimate in Table 4 is positive and statistically insignificant and year estimates suggest a general downward trend in the likelihood of households purchasing tobacco. This general downward trend is somewhat offset by an upward trend from 2005 to 2006 and/or 2007. These same 2005 to 2006 and/or 2007 findings are arrived at when the price is omitted and province crossed with year covariates are examined. In contrast to when the price is included, the province crossed with year findings imply increases in the likelihood of purchasing tobacco for six of the ten provinces during the early 2000s. When the sample price variable is included province specific changes over time can not be identified. In the future it will be valuable to examine a price variable that varies across households within each province and across years.

Thus far the effects of changes in a number of covariates are assumed to be the same across provinces as well as over calendar time and the following subsection relaxes this assumption. In particular income effects, differences due to the number of household members, and differences associated with the marital status and gender, as well as age of the person surveyed may vary across regions and time periods. If these effects vary across provinces and over time then accounting for this may alter the predicted province-year findings. For example if households with a particular income level are more likely to illegally purchase tobacco products then income parameter estimates may vary across regions and periods of time and accounting for this may alter the province and/or calendar year findings. In the following subsection, provincial and calendar time subsamples are each separately examined and likelihood ratio tests are used to examine the stability of parameter estimates across regions and time periods.

After allowing for such flexibility with regard to the effects of each covariate it is informative to see if province-year findings are similar to the findings discussed above.

Figure 6
 Province-year Findings when Price Variable is Included, Province and Year are not Crossed and when Province Crossed with Year Covariates are Included, Price is Omitted



Navy Bar: Odds Ratio from Section 5.1 when One of or Both a Province Indicator and a Year Indicator are Equal to 1
 Maroon Bar: Odds Ratio from Section 5.2 when a Province Crossed with Year Indicator is Equal to 1

5.3 Stability of Findings Across Regions and Years

Each subsection above involves one set of parameter estimates. Another alternative to Section 5.2 is to group provinces and years into regions and time periods. In this subsection the following five regions are examined within four periods of time for a total of 20 sets of estimates. The regions are: Atlantic Canada, Quebec, Ontario, Prairies, BC, and for each of these regions the following time spans are examined: 1997-2000, 2001-2003, 2004-2006, 2007-2009. The same estimates can be arrived at by crossing 20 region-time period indicators with the other covariates and with these estimates likelihood ratio tests can be used to examine the stability of parameter estimates. The parameter estimates and odds ratios are in Table 7.

Income, household size, marital status and gender, as well as age parameter estimates are generally the same in terms of size and magnitude across these estimates. Most of them are statistically significant, some estimates in a certain province and period are greater than others and some estimates have a different sign than others. Similar to the findings in previous subsections all the income parameter estimates are negative. Furthermore the income squared parameter estimates are all very close to zero and just one has a different sign. When the respondent is a single male the household is more likely to purchase tobacco than when the respondent is married. Similarly when the respondent is a single female rather than married the household is generally more likely to purchase tobacco however this difference is smaller for single females than for single males. Furthermore for a few of the region-time periods households with a single female respondent are less likely to purchase tobacco than when the respondent is married. Overall most of these findings are similar to the estimates in Table 4 and 6. The

age parameter estimates have different signs and magnitudes and similar to Figure 3 the odds is highest when the respondent is between 45 and 54.

Table 7
Initial Set of Explanatory Variables Crossed with Region and Time Period Indicators and Province Crossed with Year Covariates Rather than the Price

	parameter estimates	odds ratio	z statistic		parameter estimates	odds ratio	z statistic
household income before tax in thousands				age over 75			
1997-2000 Atlantic Canada	-0.0168***	0.983***	(-12.08)	1997-2000 Atlantic Canada	-1.578***	0.206***	(-16.01)
2001-2003 Atlantic Canada	-0.0131***	0.987***	(-8.71)	2001-2003 Atlantic Canada	-1.556***	0.211***	(-13.84)
2004-2006 Atlantic Canada	-0.0168***	0.983***	(-12.07)	2004-2006 Atlantic Canada	-1.597***	0.203***	(-12.97)
2007-2009 Atlantic Canada	-0.0120***	0.988***	(-8.12)	2007-2009 Atlantic Canada	-1.613***	0.199***	(-10.83)
1997-2000 Quebec	-0.00742***	0.993***	(-5.27)	1997-2000 Quebec	-1.378***	0.252***	(-9.55)
2001-2003 Quebec	-0.00815***	0.992***	(-6.61)	2001-2003 Quebec	-1.887***	0.152***	(-12.08)
2004-2006 Quebec	-0.0116***	0.988***	(-6.61)	2004-2006 Quebec	-1.880***	0.153***	(-10.26)
2007-2009 Quebec	-0.00652***	0.994***	(-3.03)	2007-2009 Quebec	-2.078***	0.125***	(-9.50)
1997-2000 Ontario	-0.00707***	0.993***	(-5.27)	1997-2000 Ontario	-1.980***	0.138***	(-12.22)
2001-2003 Ontario	-0.00397***	0.996***	(-3.13)	2001-2003 Ontario	-1.833***	0.160***	(-9.28)
2004-2006 Ontario	-0.00698***	0.993***	(-5.20)	2004-2006 Ontario	-1.994***	0.136***	(-9.85)
2007-2009 Ontario	-0.00678***	0.993***	(-3.99)	2007-2009 Ontario	-1.576***	0.207***	(-6.81)
1997-2000 Prairies	-0.00606***	0.994***	(-5.87)	1997-2000 Prairies	-1.798***	0.166***	(-19.89)
2001-2003 Prairies	-0.00490***	0.995***	(-4.57)	2001-2003 Prairies	-1.887***	0.152***	(-17.89)
2004-2006 Prairies	-0.00599***	0.994***	(-6.04)	2004-2006 Prairies	-1.800***	0.165***	(-15.56)
2007-2009 Prairies	-0.00653***	0.993***	(-4.92)	2007-2009 Prairies	-1.941***	0.144***	(-13.71)
1997-2000 British Columbia	-0.00261	0.997	(-1.41)	1997-2000 British Columbia	-1.673***	0.188***	(-10.70)
2001-2003 British Columbia	-0.00709***	0.993***	(-3.60)	2001-2003 British Columbia	-1.818***	0.162***	(-9.54)
2004-2006 British Columbia	-0.00485***	0.995***	(-2.75)	2004-2006 British Columbia	-1.455***	0.233***	(-6.97)
2007-2009 British Columbia	-0.00811***	0.992***	(-3.56)	2007-2009 British Columbia	-1.470***	0.230***	(-5.77)
household income before tax in thousands squared				2 household members			
1997-2000 Atlantic Canada	0.0000488***	1.000***	(5.72)	1997-2000 Atlantic Canada	0.775***	2.171***	(13.40)
2001-2003 Atlantic Canada	0.0000268***	1.000***	(3.14)	2001-2003 Atlantic Canada	0.742***	2.100***	(11.16)
2004-2006 Atlantic Canada	0.0000448***	1.000***	(6.44)	2004-2006 Atlantic Canada	0.643***	1.901***	(9.41)
2007-2009 Atlantic Canada	0.0000165**	1.000**	(2.28)	2007-2009 Atlantic Canada	0.796***	2.217***	(10.38)
1997-2000 Quebec	0.00000881	1.000	(1.41)	1997-2000 Quebec	0.613***	1.847***	(7.76)
2001-2003 Quebec	0.00000956**	1.000**	(2.48)	2001-2003 Quebec	0.491***	1.633***	(5.88)
2004-2006 Quebec	0.0000176**	1.000**	(2.48)	2004-2006 Quebec	0.380***	1.462***	(3.83)
2007-2009 Quebec	0.00000533	1.000	(0.58)	2007-2009 Quebec	0.381***	1.464***	(3.20)
1997-2000 Ontario	0.00000598	1.000	(1.09)	1997-2000 Ontario	0.591***	1.806***	(6.91)
2001-2003 Ontario	0.00000264	1.000	(0.67)	2001-2003 Ontario	0.345***	1.412***	(3.36)
2004-2006 Ontario	0.0000115***	1.000***	(2.76)	2004-2006 Ontario	0.568***	1.765***	(5.30)
2007-2009 Ontario	0.0000144**	1.000**	(2.41)	2007-2009 Ontario	0.366***	1.443***	(3.20)
1997-2000 Prairies	0.00000876*	1.000*	(1.89)	1997-2000 Prairies	0.705***	2.024***	(12.42)
2001-2003 Prairies	0.00000418	1.000	(0.09)	2001-2003 Prairies	0.614***	1.848***	(9.29)
2004-2006 Prairies	0.00000871**	1.000**	(2.56)	2004-2006 Prairies	0.700***	2.015***	(10.14)
2007-2009 Prairies	0.0000100*	1.000*	(1.94)	2007-2009 Prairies	0.476***	1.610***	(5.92)
1997-2000 British Columbia	-0.0000105	1.000	(-1.03)	1997-2000 British Columbia	0.507***	1.661***	(5.92)
2001-2003 British Columbia	0.0000144	1.000	(1.46)	2001-2003 British Columbia	0.590***	1.803***	(5.84)
2004-2006 British Columbia	0.00000119	1.000	(0.17)	2004-2006 British Columbia	0.478***	1.612***	(4.27)
2007-2009 British Columbia	0.0000157	1.000	(1.59)	2007-2009 British Columbia	0.484***	1.622***	(3.80)
single male				3 household members			
1997-2000 Atlantic Canada	0.469***	1.598***	(7.25)	1997-2000 Atlantic Canada	1.143***	3.138***	(17.45)
2001-2003 Atlantic Canada	0.690***	1.994***	(9.23)	2001-2003 Atlantic Canada	1.151***	3.161***	(15.11)
2004-2006 Atlantic Canada	0.529***	1.697***	(6.85)	2004-2006 Atlantic Canada	1.053***	2.867***	(13.33)
2007-2009 Atlantic Canada	0.921***	2.512***	(10.66)	2007-2009 Atlantic Canada	1.215***	3.370***	(13.39)
1997-2000 Quebec	0.480***	1.616***	(5.40)	1997-2000 Quebec	0.922***	2.515***	(9.93)
2001-2003 Quebec	0.378***	1.459***	(4.07)	2001-2003 Quebec	0.731***	2.078***	(7.45)
2004-2006 Quebec	0.557***	1.746***	(5.17)	2004-2006 Quebec	0.620***	1.860***	(5.29)
2007-2009 Quebec	0.573***	1.774***	(4.40)	2007-2009 Quebec	0.572***	1.772***	(4.02)
1997-2000 Ontario	0.494***	1.638***	(5.36)	1997-2000 Ontario	0.797***	2.219***	(8.23)
2001-2003 Ontario	0.333***	1.395***	(2.99)	2001-2003 Ontario	0.426***	1.531***	(3.75)
2004-2006 Ontario	0.476***	1.610***	(4.04)	2004-2006 Ontario	0.563***	1.756***	(4.60)

2007-2009 Ontario	0.663***	1.940***	(5.42)	2007-2009 Ontario	0.628***	1.875***	(4.88)
1997-2000 Prairies	0.686***	1.985***	(11.26)	1997-2000 Prairies	0.969***	2.635***	(14.79)
2001-2003 Prairies	0.572***	1.771***	(8.00)	2001-2003 Prairies	0.805***	2.237***	(10.59)
2004-2006 Prairies	0.711***	2.037***	(9.58)	2004-2006 Prairies	0.896***	2.449***	(11.18)
2007-2009 Prairies	0.655***	1.926***	(7.67)	2007-2009 Prairies	0.714***	2.042***	(7.62)
1997-2000 British Columbia	0.646***	1.908***	(7.19)	1997-2000 British Columbia	0.668***	1.949***	(6.70)
2001-2003 British Columbia	0.616***	1.851***	(5.61)	2001-2003 British Columbia	0.499***	1.647***	(4.22)
2004-2006 British Columbia	0.897***	2.451***	(7.65)	2004-2006 British Columbia	0.479***	1.615***	(3.67)
2007-2009 British Columbia	0.736***	2.088***	(5.35)	2007-2009 British Columbia	0.602***	1.826***	(3.98)
single female				4 or more household members			
1997-2000 Atlantic Canada	0.0437	1.045	(0.90)	1997-2000 Atlantic Canada	1.128***	3.089***	(16.33)
2001-2003 Atlantic Canada	0.127**	1.135**	(2.22)	2001-2003 Atlantic Canada	1.075***	2.930***	(13.24)
2004-2006 Atlantic Canada	0.0631	1.065	(1.06)	2004-2006 Atlantic Canada	1.015***	2.761***	(12.03)
2007-2009 Atlantic Canada	0.345***	1.411***	(5.03)	2007-2009 Atlantic Canada	1.149***	3.155***	(11.67)
1997-2000 Quebec	0.102	1.108	(1.41)	1997-2000 Quebec	0.822***	2.275***	(8.34)
2001-2003 Quebec	-0.0638	0.938	(-0.83)	2001-2003 Quebec	0.674***	1.961***	(6.36)
2004-2006 Quebec	0.0676	1.070	(0.71)	2004-2006 Quebec	0.574***	1.776***	(4.52)
2007-2009 Quebec	-0.0560	0.946	(-0.49)	2007-2009 Quebec	0.315**	1.370**	(2.03)
1997-2000 Ontario	-0.0746	0.928	(-1.02)	1997-2000 Ontario	0.574***	1.775***	(5.79)
2001-2003 Ontario	-0.143	0.867	(-1.61)	2001-2003 Ontario	0.286**	1.331**	(2.39)
2004-2006 Ontario	0.0421	1.043	(0.46)	2004-2006 Ontario	0.439***	1.551***	(3.48)
2007-2009 Ontario	0.153	1.165	(1.48)	2007-2009 Ontario	0.250*	1.284*	(1.80)
1997-2000 Prairies	0.154***	1.167***	(3.05)	1997-2000 Prairies	0.839***	2.314***	(12.44)
2001-2003 Prairies	0.185***	1.203***	(3.10)	2001-2003 Prairies	0.758***	2.135***	(9.62)
2004-2006 Prairies	0.336***	1.400***	(5.36)	2004-2006 Prairies	0.796***	2.218***	(9.64)
2007-2009 Prairies	0.164**	1.178**	(2.20)	2007-2009 Prairies	0.564***	1.758***	(5.77)
1997-2000 British Columbia	0.201***	1.222***	(2.60)	1997-2000 British Columbia	0.458***	1.581***	(4.52)
2001-2003 British Columbia	0.209**	1.233**	(2.29)	2001-2003 British Columbia	0.585***	1.794***	(4.75)
2004-2006 British Columbia	0.189*	1.208*	(1.85)	2004-2006 British Columbia	0.440***	1.553***	(3.29)
2007-2009 British Columbia	0.244**	1.276**	(2.08)	2007-2009 British Columbia	0.209	1.232	(1.30)
age 25-34				Province crossed with year covariates with base levels of:			
1997-2000 Atlantic Canada	-0.0743	0.928	(-0.87)	Newfoundland 1997/2001/2004/2007			
2001-2003 Atlantic Canada	-0.349***	0.705***	(-3.47)	Quebec 1997/2001/2004/2007			
2004-2006 Atlantic Canada	-0.189*	0.827*	(-1.74)	Ontario 1997/2001/2004/2007			
2007-2009 Atlantic Canada	-0.00349	0.997	(-0.03)	Manitoba 1997/2001/2004/2007			
1997-2000 Quebec	-0.158	0.854	(-1.41)	British Columbia 1997/2001/2004/2007			
2001-2003 Quebec	-0.447***	0.639***	(-3.87)	Newfoundland 1998	0.0966	1.101	(1.18)
2004-2006 Quebec	-0.431***	0.650***	(-2.95)	Newfoundland 1999	0.0321	1.033	(0.42)
2007-2009 Quebec	-0.402**	0.669**	(-2.28)	Newfoundland 2000	-0.0425	0.958	(-0.54)
1997-2000 Ontario	-0.442***	0.643***	(-3.55)	Newfoundland 2002	0.132	1.141	(1.64)
2001-2003 Ontario	-0.484***	0.616***	(-2.92)	Newfoundland 2003	0.107	1.112	(1.35)
2004-2006 Ontario	-0.345**	0.708**	(-2.10)	Newfoundland 2005	0.0640	1.066	(0.78)
2007-2009 Ontario	0.0607	1.063	(0.31)	Newfoundland 2006	0.0920	1.096	(1.12)
1997-2000 Prairies	-0.0838	0.920	(-1.17)	Newfoundland 2008	-0.0635	0.939	(-0.68)
2001-2003 Prairies	-0.182**	0.833**	(-2.20)	Newfoundland 2009	0.0133	1.013	(0.14)
2004-2006 Prairies	-0.0256	0.975	(-0.30)	PEI 1997	0.0415	1.042	(0.42)
2007-2009 Prairies	-0.249**	0.779**	(-2.22)	PEI 1998	-0.0145	0.986	(-0.15)
1997-2000 British Columbia	-0.237*	0.789*	(-1.95)	PEI 1999	-0.0237	0.977	(-0.23)
2001-2003 British Columbia	0.00575	1.006	(0.04)	PEI 2000	-0.0991	0.906	(-1.01)
2004-2006 British Columbia	-0.0143	0.986	(-0.08)	PEI 2001	-0.00637	0.994	(-0.06)
2007-2009 British Columbia	-0.0817	0.922	(-0.37)	PEI 2002	-0.256**	0.774**	(-2.50)
age 35-44				PEI 2003	0.0458	1.047	(0.44)
1997-2000 Atlantic Canada	-0.0187	0.981	(-0.22)	PEI 2004	-0.0977	0.907	(-0.91)
2001-2003 Atlantic Canada	-0.298***	0.742***	(-3.02)	PEI 2005	-0.0394	0.961	(-0.38)
2004-2006 Atlantic Canada	-0.223**	0.800**	(-2.09)	PEI 2006	0.229**	1.257**	(2.21)
2007-2009 Atlantic Canada	-0.162	0.850	(-1.20)	PEI 2007	-0.0983	0.906	(-0.90)
1997-2000 Quebec	0.109	1.115	(0.97)	PEI 2008	-0.262**	0.769**	(-2.30)
2001-2003 Quebec	-0.222*	0.801*	(-1.95)	PEI 2009	-0.180	0.836	(-1.54)
2004-2006 Quebec	-0.304**	0.738**	(-2.10)	Nova Scotia 1997	0.0593	1.061	(0.82)
2007-2009 Quebec	-0.587***	0.556***	(-3.32)	Nova Scotia 1998	0.0303	1.031	(0.37)
1997-2000 Ontario	-0.348***	0.706***	(-2.82)	Nova Scotia 1999	-0.0505	0.951	(-0.67)
2001-2003 Ontario	-0.362**	0.696**	(-2.23)	Nova Scotia 2000	0.122	1.130	(1.56)
2004-2006 Ontario	-0.557***	0.573***	(-3.47)	Nova Scotia 2001	0.100	1.105	(1.30)

2007-2009 Ontario	-0.137	0.872	(-0.70)	Nova Scotia 2002	0.00150	1.002	(0.02)
1997-2000 Prairies	-0.0573	0.944	(-0.81)	Nova Scotia 2003	-0.122	0.885	(-1.54)
2001-2003 Prairies	-0.201**	0.818**	(-2.42)	Nova Scotia 2004	0.0369	1.038	(0.45)
2004-2006 Prairies	-0.154*	0.858*	(-1.77)	Nova Scotia 2005	0.0663	1.069	(0.80)
2007-2009 Prairies	-0.392***	0.676***	(-3.43)	Nova Scotia 2006	0.203**	1.225**	(2.50)
1997-2000 British Columbia	-0.311**	0.732**	(-2.57)	Nova Scotia 2007	0.0675	1.070	(0.77)
2001-2003 British Columbia	-0.0742	0.928	(-0.53)	Nova Scotia 2008	-0.127	0.881	(-1.34)
2004-2006 British Columbia	-0.0924	0.912	(-0.55)	Nova Scotia 2009	-0.0199	0.980	(-0.21)
2007-2009 British Columbia	-0.215	0.807	(-0.97)	New Brunswick 1997	-0.0170	0.983	(-0.23)
age 45-54				New Brunswick 1998	-0.0608	0.941	(-0.75)
1997-2000 Atlantic Canada	-0.150*	0.861*	(-1.77)	New Brunswick 1999	-0.0150	0.985	(-0.19)
2001-2003 Atlantic Canada	-0.210**	0.811**	(-2.14)	New Brunswick 2000	0.0354	1.036	(0.45)
2004-2006 Atlantic Canada	-0.112	0.894	(-1.06)	New Brunswick 2001	0.0440	1.045	(0.56)
2007-2009 Atlantic Canada	0.0597	1.062	(0.45)	New Brunswick 2002	0.0126	1.013	(0.15)
1997-2000 Quebec	0.185*	1.204*	(1.65)	New Brunswick 2003	-0.162**	0.851**	(-2.01)
2001-2003 Quebec	-0.209*	0.811*	(-1.85)	New Brunswick 2004	-0.0191	0.981	(-0.23)
2004-2006 Quebec	-0.207	0.813	(-1.45)	New Brunswick 2005	0.0336	1.034	(0.40)
2007-2009 Quebec	-0.320*	0.726*	(-1.86)	New Brunswick 2006	-0.0193	0.981	(-0.23)
1997-2000 Ontario	-0.263**	0.768**	(-2.11)	New Brunswick 2007	-0.0155	0.985	(-0.18)
2001-2003 Ontario	-0.362**	0.697**	(-2.22)	New Brunswick 2008	-0.187*	0.830*	(-1.92)
2004-2006 Ontario	-0.327**	0.721**	(-2.04)	New Brunswick 2009	-0.110	0.896	(-1.17)
2007-2009 Ontario	0.0809	1.084	(0.42)	Quebec 1998	-0.0211	0.979	(-0.35)
1997-2000 Prairies	-0.118	0.888	(-1.62)	Quebec 1999	-0.0778	0.925	(-1.26)
2001-2003 Prairies	-0.199**	0.819**	(-2.40)	Quebec 2000	-0.0926	0.912	(-1.47)
2004-2006 Prairies	-0.0946	0.910	(-1.10)	Quebec 2002	-0.0601	0.942	(-0.91)
2007-2009 Prairies	-0.188*	0.829*	(-1.70)	Quebec 2003	-0.136**	0.873**	(-2.32)
1997-2000 British Columbia	-0.299**	0.742**	(-2.42)	Quebec 2005	-0.102	0.903	(-1.46)
2001-2003 British Columbia	0.174	1.190	(1.26)	Quebec 2006	0.116*	1.123*	(1.66)
2004-2006 British Columbia	0.0385	1.039	(0.23)	Quebec 2008	-0.141*	0.868*	(-1.70)
2007-2009 British Columbia	-0.115	0.891	(-0.53)	Quebec 2009	-0.180**	0.836**	(-2.18)
age 55-64				Ontario 1998	0.0211	1.021	(0.33)
1997-2000 Atlantic Canada	-0.344***	0.709***	(-3.96)	Ontario 1999	-0.0929	0.911	(-1.48)
2001-2003 Atlantic Canada	-0.583***	0.558***	(-5.85)	Ontario 2000	-0.191***	0.826***	(-2.89)
2004-2006 Atlantic Canada	-0.505***	0.603***	(-4.77)	Ontario 2002	-0.0558	0.946	(-0.84)
2007-2009 Atlantic Canada	-0.283**	0.754**	(-2.13)	Ontario 2003	-0.121*	0.886*	(-1.81)
1997-2000 Quebec	-0.214*	0.807*	(-1.86)	Ontario 2005	-0.0607	0.941	(-0.81)
2001-2003 Quebec	-0.515***	0.598***	(-4.39)	Ontario 2006	0.0605	1.062	(0.86)
2004-2006 Quebec	-0.547***	0.579***	(-3.77)	Ontario 2008	-0.0433	0.958	(-0.53)
2007-2009 Quebec	-0.520***	0.595***	(-3.00)	Ontario 2009	-0.0702	0.932	(-0.89)
1997-2000 Ontario	-0.615***	0.541***	(-4.77)	Manitoba 1998	-0.143*	0.867*	(-1.78)
2001-2003 Ontario	-0.540***	0.582***	(-3.22)	Manitoba 1999	-0.175**	0.839**	(-2.27)
2004-2006 Ontario	-0.601***	0.548***	(-3.68)	Manitoba 2000	-0.157**	0.855**	(-1.99)
2007-2009 Ontario	-0.227	0.797	(-1.17)	Manitoba 2002	-0.165**	0.848**	(-2.07)
1997-2000 Prairies	-0.397***	0.672***	(-5.19)	Manitoba 2003	-0.0532	0.948	(-0.67)
2001-2003 Prairies	-0.415***	0.660***	(-4.72)	Manitoba 2005	-0.176**	0.838**	(-2.12)
2004-2006 Prairies	-0.345***	0.708***	(-3.86)	Manitoba 2006	-0.0630	0.939	(-0.77)
2007-2009 Prairies	-0.411***	0.663***	(-3.61)	Manitoba 2008	-0.0259	0.974	(-0.27)
1997-2000 British Columbia	-0.523***	0.593***	(-4.02)	Manitoba 2009	-0.0913	0.913	(-0.94)
2001-2003 British Columbia	-0.0697	0.933	(-0.48)	Saskatchewan 1997	0.0216	1.022	(0.26)
2004-2006 British Columbia	-0.235	0.790	(-1.37)	Saskatchewan 1998	-0.0229	0.977	(-0.29)
2007-2009 British Columbia	-0.256	0.774	(-1.16)	Saskatchewan 1999	-0.126	0.882	(-1.58)
age 65-74				Saskatchewan 2000	-0.0678	0.934	(-0.83)
1997-2000 Atlantic Canada	-0.992***	0.371***	(-11.01)	Saskatchewan 2001	0.0801	1.083	(1.02)
2001-2003 Atlantic Canada	-1.057***	0.347***	(-10.08)	Saskatchewan 2002	0.0169	1.017	(0.22)
2004-2006 Atlantic Canada	-1.052***	0.349***	(-9.41)	Saskatchewan 2003	-0.0199	0.980	(-0.25)
2007-2009 Atlantic Canada	-0.781***	0.458***	(-5.68)	Saskatchewan 2004	0.0270	1.027	(0.33)
1997-2000 Quebec	-0.711***	0.491***	(-5.90)	Saskatchewan 2005	-0.0185	0.982	(-0.22)
2001-2003 Quebec	-1.196***	0.302***	(-9.48)	Saskatchewan 2006	0.0673	1.070	(0.82)
2004-2006 Quebec	-1.229***	0.292***	(-7.71)	Saskatchewan 2007	0.0768	1.080	(0.90)
2007-2009 Quebec	-1.034***	0.356***	(-5.60)	Saskatchewan 2008	-0.0292	0.971	(-0.31)
1997-2000 Ontario	-1.131***	0.323***	(-8.41)	Saskatchewan 2009	-0.0984	0.906	(-1.04)
2001-2003 Ontario	-1.139***	0.320***	(-6.43)				
2004-2006 Ontario	-1.367***	0.255***	(-7.70)				
2007-2009 Ontario	-0.804***	0.448***	(-3.91)				

1997-2000 Prairies	-0.909***	0.403***	(-11.44)	Alberta 1997	0.0267	1.027	(0.37)
2001-2003 Prairies	-1.039***	0.354***	(-11.04)	Alberta 1998	-0.0682	0.934	(-0.89)
2004-2006 Prairies	-0.897***	0.408***	(-9.07)	Alberta 1999	-0.0729	0.930	(-0.98)
2007-2009 Prairies	-0.994***	0.370***	(-7.98)	Alberta 2000	-0.256***	0.774***	(-3.30)
1997-2000 British Columbia	-1.034***	0.356***	(-7.48)	Alberta 2001	0.170**	1.186**	(2.28)
2001-2003 British Columbia	-0.634***	0.530***	(-4.05)	Alberta 2002	-0.0500	0.951	(-0.64)
2004-2006 British Columbia	-0.557***	0.573***	(-3.05)	Alberta 2003	-0.0337	0.967	(-0.44)
2007-2009 British Columbia	-0.639***	0.528***	(-2.74)	Alberta 2004	-0.0387	0.962	(-0.48)
				Alberta 2005	0.00240	1.002	(0.03)
intercept for a region and time period				Alberta 2006	0.0147	1.015	(0.18)
1997-2000 Atlantic Canada	0.000158			Alberta 2007	0.0628	1.065	(0.74)
2001-2003 Atlantic Canada	-0.0867			Alberta 2008	-0.161	0.851	(-1.64)
2004-2006 Atlantic Canada	-0.115			Alberta 2009	0.0707	1.073	(0.76)
2007-2009 Atlantic Canada	-0.532***						
1997-2000 Quebec	-0.280**			British Columbia 1998	-0.112	0.894	(-1.58)
2001-2003 Quebec	0.112			British Columbia 1999	0.0321	1.033	(0.48)
2004-2006 Quebec	0.0341			British Columbia 2000	-0.239***	0.787***	(-3.42)
2007-2009 Quebec	-0.0414			British Columbia 2002	-0.126*	0.881*	(-1.76)
1997-2000 Ontario	0.00546			British Columbia 2003	-0.0862	0.917	(-1.22)
2001-2003 Ontario	-0.00453			British Columbia 2005	-0.0396	0.961	(-0.51)
2004-2006 Ontario	-0.218			British Columbia 2006	-0.0153	0.985	(-0.19)
2007-2009 Ontario	-0.599***			British Columbia 2008	-0.164*	0.848*	(-1.80)
1997-2000 Prairies	-0.296***			British Columbia 2009	-0.105	0.901	(-1.15)
2001-2003 Prairies	-0.358***						
2004-2006 Prairies	-0.712***						
2007-2009 Prairies	-0.348**						
1997-2000 British Columbia	-0.378**						
2001-2003 British Columbia	-0.722***						
2004-2006 British Columbia	-0.946***						
2007-2009 British Columbia	-0.658**						
number of observations	183,893						

* p<0.10 ** p<0.05 *** p<0.01"

Likelihood ratio tests are used to examine the stability of parameter estimates across the 20 region-time period categories. For example the hypothesis that the household income parameter is the same for each of the 20 region-year period categories is tested. A similar hypothesis is tested for the gender and marital status, age, and household size parameters. The p-value associated with each of these tests is very small which provides evidence to reject the hypothesis that parameter estimates are stable across the 20 region-time period categories. In the future it may be valuable to plot the odds for each of these covariates based on the parameter estimates in the previous subsection and compare them with similar graphs based on the parameter estimates in this subsection.

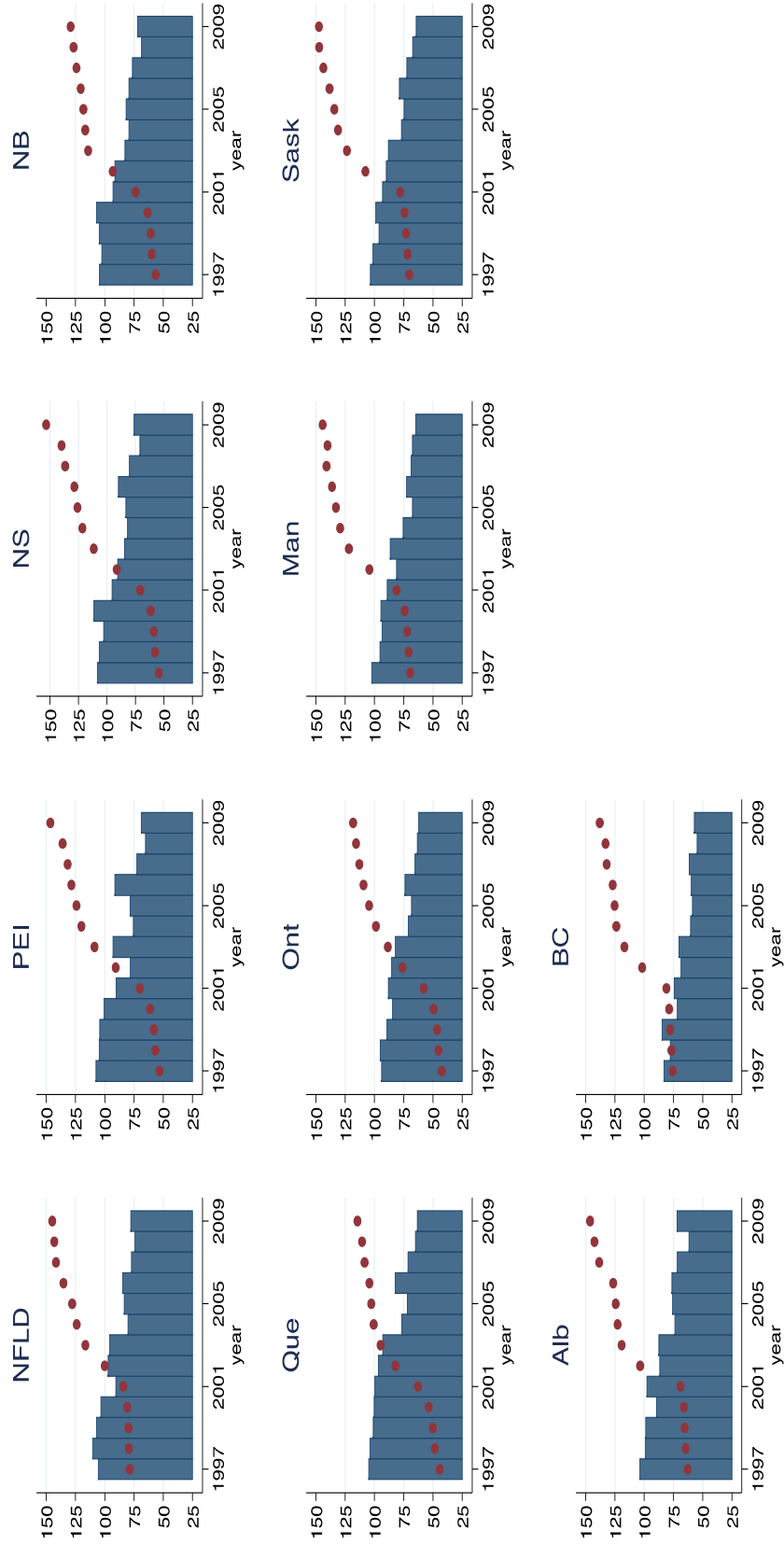
The predicted number of households who purchase tobacco every 200 given a particular province and a year is equal to:

$$\frac{200}{1 + \exp(-\hat{\beta}_{rp\#income} \overline{income} - \hat{\beta}_{rp\#incomesq} (\overline{income})^2 - \hat{\beta}_{rp\#2members} - \hat{\beta}_{prov,year} - \hat{\beta}_{rp\#age35-44} - \hat{\beta}_{rp})}$$

The term rp is associated with the 20 region-time period categories. This prediction is for a household who has: the mean level of income, two household members, and whose reference person is married and between 35 and 44 years old, which are same circumstances used for the price predictions in Section 5.2. In Figure 7 each dot is a price level and each bar is the associated number of households per 200 predicted to purchase tobacco based on the equations above.

Like in the previous subsection the odds rises for: Newfoundland 2002, Prince Edward Island 2003, Ontario 2001, Manitoba 2003, Alberta 2001, and British Columbia 2001. The odds also rises for all provinces 2006 and/or 2007. Figure 7 is very similar with Figure 4. The similar findings again indicate that it's possible that price has little or no effect and that unreported factors are changing over time and across provinces.

Figure 7
 Number of Households Predicted to Purchase Tobacco Among Every 200 with All Other Covariates Held Constant, Tobacco Price Index, Region-time Period Indicators Crossed



Bar: Number of Households Predicted to Purchase Tobacco Among Every 200 with All Other Covariates Held Constant;
 Dot: Tobacco Price Index

Note: income is set equal to the mean level. Household size is set equal to 2. Indicator for married reference person is set equal to 1. Indicators for single male and single female reference person are set equal to 0. Indicator for age group 35-44 is set equal to 1 and others 0.

6 Conclusions and Discussion

The relationship between whether households purchase tobacco over an entire year and the price of tobacco is estimated. This research applies logit specification on the 1997-2009 SHS which covers household information over 10 provinces in Canada.

The analysis consists of three parts which focus on the entire sample, province crossed with year covariates and finding robustness across geographic regions and periods of time. Despite the national 26.5% drop in household smoking rate and 146.6% rise in tobacco price index over the 13 years, the price parameter estimate is small and statistically insignificant in the first part. The sign is positive which is similar to Laport et al. (2010) and different from most of the smoking researches on price. After statistically controlling for variation in factors other than tobacco price, likelihood of purchasing tobacco increased along with price over calendar years. In the second and third parts, price variable is omitted due to perfect collinearity. In these parts, the results in the first part hold in particular provinces and years as the likelihood of purchasing tobacco increased along with price. There are two possible interpretations to this. Maybe the price parameter estimate equals to zero. It is also possible that the statistically insignificant and positive price parameter estimate may be related to unobserved factors that off-set price effects. For example, an exogenous increase in tobacco demand increases the price.

Factors other than price like household income, household size and reference person's gender, marital status and age are examined. The findings of these factors are generally the same in the three subsections in terms of sign and magnitude. A higher income lowers the odds of purchasing tobacco and this change becomes smaller as

income increases. The odds of purchasing tobacco is much higher for lower income households than high income households. Households with 2 or 3 members are more likely to purchase tobacco compared with households with only one member. However households with 4 or more members are less likely to purchase tobacco compared with households with 3 members. Compared with a household hold with a married reference person, a household with a single male or female reference person has higher probability of purchasing tobacco. The odds of purchasing tobacco is highest when the head is 15 to 24 years old, is relatively high for 25 to 34, 35 to 44 and 45 to 54 age groups. The odds of purchasing tobacco falls along with the head's age after 55 years old. Likelihood ratio tests for these factors indicate there is evidence to reject hypotheses that such parameter estimates are the same across the 20 region-time periods. Few papers consider whether effects on smoking probability in Canada stay constant province and year wise. Also, few researches attempt to disentangle price role in smoking probability and those who do only include a price variable.

From the policy point of view, with contraband and other factors exist, tax instrument that policy makers usually use to control smoking might not be effective as suggested in other researches on smoking. Raising price may not result in lower probability to purchase tobacco. The increased number of households predicted to purchase tobacco during 2001 to 2003 and 2006 to 2007 may be associated with the growing market for illegal cigarettes after 2001. Researchers, policy makers along with law enforcement collaboration in controlling smuggling may be an effective way to lower likelihood of purchasing tobacco.

As mentioned in Section 4.2, from the SHS we can only know if anyone in the household smokes. How many members smoke and whether a member quit during the surveyed year is unavailable. The household smoking indicator is not as accurate as individual smoking indicator. Furthermore, we are forced to assume each household from a province in a year faces the same price index. The role of price is difficult to disentangle. It is valuable to have more detailed household smoking information and more variability in price variable in future researches.

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Appendix

The Price Explanatory Variable

Unlike other explanatory variables, price information is not included in SHS. A few steps are taken to obtain price data:

The first step is to use Table 326-0021 (consumer price index, annual) provided by Statistics Canada. This table is used for deflations of household income. A part of the table on CPIs of all items is extracted as shown in Table A1.

Table A1

Part of Table 326-0021 Consumer Price Index, Annual (2002=100), on All Items

province	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
nfld	92.3	92.5	93.8	96.6	97.7	100	102.9	104.8	107.6	109.5	111.1	114.3	114.6
pei	90.5	90.1	91.2	94.9	97.4	100	103.5	105.8	109.1	111.6	113.6	117.5	117.3
ns	90	90.6	92.1	95.3	97.1	100	103.4	105.3	108.2	110.4	112.5	115.9	115.7
nb	90.1	90.6	92.1	95.1	96.8	100	103.4	104.9	107.4	109.2	111.3	113.2	113.5
que	90.8	92.1	93.5	95.8	98	100	102.5	104.5	106.9	108.7	110.4	112.7	113.4
ont	89.8	90.6	92.4	95.1	98	100	102.7	104.6	106.9	108.8	110.8	113.3	113.7
man	90.6	91.8	93.6	95.9	98.5	100	101.8	103.8	106.6	108.7	110.9	113.4	114.1
sask	89.2	90.4	92	94.4	97.2	100	102.3	104.6	106.9	109.1	112.2	115.9	117.1
alt	88.1	89.2	91.4	94.5	96.7	100	104.4	105.9	108.1	112.3	117.9	121.6	121.5
bc	93.1	93.4	94.4	96.1	97.7	100	102.2	104.2	106.3	108.1	110	112.3	112.3

Note: nfld = Newfoundland; pei = Prince Edward Island; ns = Nova Scotia; nb = New Brunswick; que = Quebec; ont = Ontario; man = Manitoba; sask = Saskatchewan; alt = Alberta; bc = British Columbia

Another part of this table provides details on tobacco CPIs is extracted as shown in

Table A2.

Table A2

Part of Table 326-0021 Consumer Price Index, Annual (2002=100), on Tobacco

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Canada	59	62.5	64	67.1	75.9	100	116.2	124.9	129	132.6	138.4	141.2	145.5
nfld	78.6	79.4	79.7	80.8	84	100	116.5	124	127.8	135.2	141.6	143.1	144.8
pei	58.7	62.6	64	67.6	77.3	100	120	132.4	137	141.8	145.3	150.1	161.6
ns	59.7	63.2	64.4	67.5	77.6	100	122.1	133	137.7	140.7	149.5	153	167.7
nb	60.6	64.2	65.2	68	78.9	100	122.6	125.2	126.9	129.3	133.3	135.9	138.6
que	53.9	59	61.1	65.4	76.5	100	115.6	122.7	125.2	127.1	132.2	134.8	139.6
ont	55.7	59.5	61.1	65	76.1	100	116.4	129.8	137.5	143.8	148.4	152.1	155.4
man	66.6	68	69.1	71.2	77.8	100	116.8	124	127.5	130.7	135.2	134.4	138.4
sask	65.2	66.6	67.8	68.9	72.4	100	114.7	121.8	124.7	128.5	133.4	136.7	136.9
alt	60.8	62.4	63.2	63.9	66.7	100	115.3	118.7	120.2	122.3	133.8	137.8	141.4
bc	74.4	75.4	76.4	77.3	79.6	100	114.9	121.7	123.1	124.8	129.8	130.8	135.6

Note: nfld = Newfoundland; pei = Prince Edward Island; ns = Nova Scotia; nb = New Brunswick; que = Quebec; ont = Ontario; man = Manitoba; sask = Saskatchewan; alt = Alberta; bc = British Columbia

However, one problem about this table is that it fails to report the differences among provinces since all CPIs in year 2002 in all provinces are rounded as 100. Furthermore, the two parts of the table are not able to compare with each other, which means we are not able to see the price differences among CPIs on tobacco and all items.

In order to compare across provinces, in the second step Table 326-0015 (Inter-city indexes of price differentials of consumer goods and services, annual) is also provided by Statistics Canada. A city from each province is chosen. Not only price differences on all items, price differences on tobacco are also available in this table. A part of Table 326-0015 is shown in Table A3.

Table A3

Part of Table 326-0015 Inter-city Indexes of Price Differentials of Consumer Goods and Services, Annual (Index, Combined City Average=100)

city	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
St. John's (nfld)	100	99	97	96	95	95	93	98	97	96
St. John's (nfld)	147	134	117	122	119	118	123	122	125	122
Charlottetown and Summerside (pei)	95	95	94	93	93	94	94	94	95	97
Charlottetown and Summerside (pei)	110	112	106	115	111	111	114	109	118	123
Halifax (ns)	100	99	100	97	98	98	99	99	99	98
Halifax (ns)	109	111	107	113	112	111	113	113	116	131
Saint John (nb)	95	93	94	92	93	93	92	96	95	96
Saint John (nb)	114	116	109	115	107	105	107	99	104	103
Montreal (que)	95	94	95	93	93	93	93	95	95	95
Montreal (que)	93	96	96	95	92	92	90	85	87	88
Toronto (ont)	109	110	110	110	110	110	109	107	107	107
Toronto (ont)	85	89	89	88	96	97	101	101	96	94
Winnipeg (man)	92	92	91	91	92	92	92	94	94	94
Winnipeg (man)	133	128	122	123	120	120	120	119	118	119
Regina (sask)	93	93	92	90	92	92	93	93	95	97
Regina (sask)	134	124	126	122	118	116	120	116	122	119
Edmonton (alt)	93	93	95	97	97	97	97	98	101	102
Edmonton (alt)	114	104	121	118	111	109	104	109	119	119
Vancouver (bc)	106	106	105	103	102	102	104	103	101	101
Vancouver (bc)	141	126	119	121	117	116	118	115	109	110

Note: Rows in grey are indexes of price differences on tobacco products and smokers' supplies, others on all items. nfld = Newfoundland; pei = Prince Edward Island; ns = Nova Scotia; nb = New Brunswick; que = Quebec; ont = Ontario; man = Manitoba; sask = Saskatchewan; alt = Alberta; bc = British Columbia

One defect of Table 326-0015 is that the earliest data collected is from year 2000 which is not able to cover this research (as early as year 1997). However, with this table it becomes able to compare price differences provincially.

Assume that the cites chosen in Table 326-0015 represents the province of each, extract year 2002 data from Table 326-0015, which are

	nfld	pei	ns	nb	que	ont	man	sask	alt	bc
2002	97	94	100	94	95	110	91	92	95	105

for all items and

	nfld	pei	ns	nb	que	ont	man	sask	alt	bc
2002	117	106	107	109	96	89	122	126	121	119

for tobacco products and smokers' supplies, as weights in order to create two new tables shown as Table A4 and Table A5.

Table A4

Price Differences on All Items (Newfoundland 2002=100) (Weighted Using 2002 Data from Table 326-0015)

	nfld	pei	ns	nb	que	ont	man	sask	alt	bc
1997	92.3	87.7	92.8	87.3	88.9	101.8	85.0	84.6	86.3	100.8
1998	92.5	87.3	93.4	87.8	90.2	102.7	86.1	85.7	87.4	101.1
1999	93.8	88.4	94.9	89.3	91.6	104.8	87.8	87.3	89.5	102.2
2000	96.6	92.0	98.2	92.2	93.8	107.8	90.0	89.5	92.6	104.0
2001	97.7	94.4	100.1	93.8	96.0	111.1	92.4	92.2	94.7	105.8
2002	100.0	96.9	103.1	96.9	97.9	113.4	93.8	94.8	97.9	108.2
2003	102.9	100.3	106.6	100.2	100.4	116.5	95.5	97.0	102.2	110.6
2004	104.8	102.5	108.6	101.7	102.3	118.6	97.4	99.2	103.7	112.8
2005	107.6	105.7	111.5	104.1	104.7	121.2	100.0	101.4	105.9	115.1
2006	109.5	108.1	113.8	105.8	106.5	123.4	102.0	103.5	110.0	117.0
2007	111.1	110.1	116.0	107.9	108.1	125.6	104.0	106.4	115.5	119.1
2008	114.3	113.9	119.5	109.7	110.4	128.5	106.4	109.9	119.1	121.6
2009	114.6	113.7	119.3	110.0	111.1	128.9	107.0	111.1	119.0	121.6

Note: nfld = Newfoundland; pei = Prince Edward Island; ns = Nova Scotia; nb = New Brunswick; que = Quebec; ont = Ontario; man = Manitoba; sask = Saskatchewan; alt = Alberta; bc = British Columbia

Table A5
Price Differences on Tobacco Products and Smokers' Supplies (Newfoundland 2002=100) (Weighted Using 2002 Data from Table 326-0015)

	nfld	pei	ns	nb	que	ont	man	sask	alt	bc
1997	78.6	53.2	54.6	56.5	44.2	42.4	69.4	70.2	62.9	75.7
1998	79.4	56.7	57.8	59.8	48.4	45.3	70.9	71.7	64.5	76.7
1999	79.7	58.0	58.9	60.7	50.1	46.5	72.1	73.0	65.4	77.7
2000	80.8	61.2	61.7	63.4	53.7	49.4	74.2	74.2	66.1	78.6
2001	84.0	70.0	71.0	73.5	62.8	57.9	81.1	78.0	69.0	81.0
2002	100.0	90.6	91.5	93.2	82.1	76.1	104.3	107.7	103.4	101.7
2003	116.5	108.7	111.7	114.2	94.9	88.5	121.8	123.5	119.2	116.9
2004	124.0	120.0	121.6	116.6	100.7	98.7	129.3	131.2	122.8	123.8
2005	127.8	124.1	125.9	118.2	102.7	104.6	132.9	134.3	124.3	125.2
2006	135.2	128.5	128.7	120.5	104.3	109.4	136.3	138.4	126.5	126.9
2007	141.6	131.6	136.7	124.2	108.5	112.9	141.0	143.7	138.4	132.0
2008	143.1	136.0	139.9	126.6	110.6	115.7	140.1	147.2	142.5	133.0
2009	144.8	146.4	153.4	129.1	114.5	118.2	144.3	147.4	146.2	137.9

Note: nfld = Newfoundland; pei = Prince Edward Island; ns = Nova Scotia; nb = New Brunswick; que = Quebec; ont = Ontario; man = Manitoba; sask = Saskatchewan; alt = Alberta; bc = British Columbia

Table A4 can be directly used to deflate household total income to offset price changes on all items through years. Table A5 has price differentials on tobacco products and smokers' supplies and is yearly and provincial. Values from Table A5 can be used in the price explanatory variable. Considering that Newfoundland comes first in the province variable values and is going to be the reference group, tobacco price of Newfoundland in year 2002 is set 100.

Curriculum Vitae

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