Europe Economics

Economic Analysis of the Ban on the Display of Tobacco Products

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Executive Summary

Europe Economics was commissioned by Japan Tobacco International to consider the data available in the public domain, internationally, and to test whether it suggests there is credible statistical evidence supporting claims that bans on the display of tobacco products have reduced the prevalence of smoking or consumption of cigarettes in countries where such restrictions have been introduced.

Specifically, we have identified data, suitable for the construction of relevant statistical models, in Canada, Australia and various European countries. We have been able to use those data to test for any statistical relationship between display bans and:

- smoking prevalence in Australia, amongst the general population aged 14 years and above;
- smoking prevalence and cigarette (or tobacco) consumption (average number of cigarettes smoked) in Canada amongst the general population (15 years and above) and amongst those aged 15 to 19;
- daily smokers in various European countries[1], amongst the general population aged 15 years and above.

Our key findings are as follows:

- In no country (neither Australia, Canada, nor our model including several European countries) do we find evidence that the introduction of display bans has been associated with reductions in smoking prevalence or smoking consumption, either amongst the general population or amongst those aged 15 to 19 (in the case of Canada).

Moreover:

- In Australia we find that display bans have been statistically significantly correlated with an *increase* (not decrease) in smoking prevalence for the general population aged 14 years and above.
- In Canada we find that display bans have been statistically significantly correlated with an *increase* (not decrease) in smoking prevalence for the 15 to 19 age group.

[1] Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Sweden, Switzerland, England, Scotland, Northern Ireland, Wales, Luxemburg, and the United Kingdom (Great Britain).

1 Introduction

Europe Economics was commissioned by Japan Tobacco International (JTI) to test if there is credible statistical evidence supporting claims that bans on the display of tobacco products have reduced the prevalence of smoking or consumption of cigarettes.

Bans on the display of tobacco products have been introduced in some countries at different points in time. As of now, it is in full effect in Australia (all states), British Virgin Islands, Canada (all provinces), Croatia, England, Finland, Iceland, Ireland, Kosovo, New Zealand, Northern Ireland, Norway, Russia, Scotland, Thailand[2], and Wales.

In previous reports for JTI, we tested this hypothesis (display bans reduced smoking prevalence) using data available from certain Canadian provinces, Iceland and Thailand. Our analysis of the available data in Thailand and Iceland in 2008 and 2010 reports found that display bans had no measurable impact upon the prevalence of smoking, either among the young or among the population as a whole. The data on Canadian provinces, explored in a series of reports, suggested that there was, as yet, no credible statistical evidence that the introduction of display bans had been associated with reduced smoking prevalence and although the presence of the display ban had had no statistical correlation with the extent of smoking prevalence for the general population in Canada, the display ban had been materially and statistically significantly correlated with increased prevalence amongst 15-19 year olds.[3]

As more data has become available, it has become possible to test the relationship, if any, between display ban and smoking prevalence for a number of additional countries such as Australia and the European countries where it has been introduced. Thus, in this report we use standard economic factor models as per our previous reports, to test whether display bans have been effective in reducing smoking prevalence or cigarette consumption in these countries. For a detailed description of the models used, please see Section 2 of this report.

As data is available at state / province level for Canada and Australia, we have estimated individual panel models for these two countries. For the European countries, we test the relationship using one panel data set consisting of EU-28 countries plus Norway, Switzerland and Iceland where data on smoking prevalence is available. For data sources used, please see the Appendix to this report.

1.1 When and where display bans have been introduced

By the term tobacco "display ban" or "ban on the display" of tobacco we refer to the prohibition on displaying tobacco products at the point of sale. The first tobacco display ban we are aware of was introduced in Iceland in 2001 with the main aim of deterring teenagers from buying tobacco products and hence reducing tobacco consumption in the population in general and teenagers in particular. Over the years, some other countries have also introduced display bans on tobacco products with the overarching aim of reducing tobacco consumption in the total population and particularly amongst teenagers.

The table below shows the dates of implementation of display ban in different countries. It should be noted that in Australia and Canada, display bans were introduced at different points in time in different states and provinces.

2 In Thailand there has been a de facto display ban in place since 2005, but formal legislation was passed only in March 2017 with full implementation in July 2017.

3 Paragraph 2.46(d) of the 2009 Report, reported at paragraph 2.51(d) of the 2010 Report.

Table 1.1: Countries with display ban on tobacco products

Country	Notes and date of implementation
Australia	Retail display ban now in all states and territories with the exception of specialist tobacconists
Canada	Display ban now in place for all provinces and territories with Saskatchewan being the first in 2005. The most recent legislation coming into force in Labrador and Newfoundland on 1 January 2010. Ontario banned the display of tobacco products from 31 May 2008 and Alberta and British Columbia in the summer of 2008
Croatia	Display of tobacco products banned from 1 July 2014
England	A retail display ban for large shops (over 280 sq. m) came into force on 6 April 2012 and for smaller shops on 6 April 2015.[7]
Finland	Display of tobacco products banned from 1 January 2012
Iceland	First country in the world to implement a shop display ban for tobacco in 2001
Ireland	First country in the EU to implement a display ban which came into effect on 1 July 2009
Kosovo	A retail display ban came into force on 24 June 2013
New Zealand	Tobacco display ban came into force on 23 July 2012
Northern Ireland	A retail display ban for large shops (over 280 sq. m) came into force on 31 October 2012 and for smaller shops on 6 April 2015
Norway	Since 1 January 2010 the display of tobacco products has been prohibited
Russia	Display of tobacco products banned from 1 July 2014
Scotland	A retail display ban for large shops (over 280 sq. m) came into force on 29 April 2013 and for smaller shops on 6 April 2015
Thailand	Display ban was in place as of 2005
Wales	A retail display ban for large shops (over 280 sq. m) came into force on 3 December 2012 and for smaller shops on 6 April 2015

2 Model specification

In order to estimate the impact of display bans on smoking prevalence and consumption in different countries, we have employed a standard demand model which relates the demand for tobacco (in terms of prevalence or average numbers of units) with the price of tobacco units and the average incomes of smokers (these account for standard economic substitution and income effects, respectively). Noting that in some cases the stated purpose of display bans has been to reduce smoking in teenagers, we also estimated the impact of display bans on the smoking prevalence amongst that cohort (where public domain data was available). No new surveys of either the general population or teenagers have been conducted as part of this research. All of our analysis uses public domain data and focuses upon those policy questions — prevalence and consumption amongst the general population and amongst teenagers (typically those 15-19, though the exact definition of the “youth” group varies between countries) — which policymakers introducing display ban had themselves identified as the main goals of the policy.

Following the standard approach followed in demand models, the prices of cigarettes are proxied by the relative tobacco Consumer Price Index (CPI) in each country and the income of consumers was defined in terms of real Gross Domestic Product (GDP) per capita of the respective country. To capture the effect of the display ban on smoking prevalence or average number of cigarettes smoked, we used a dummy variable “ban”, with a value of 1 in the year when ban was implemented and thereafter; and a value of 0 prior to the ban.

The estimation technique used to analyse the potential impact of the display ban is a first difference estimator with fixed effects. The rationale for choosing this model is explained in the section below and the general econometric methodology adopted for the quantitative analysis of the impact of the display ban in different countries in explained in the Appendix.

2.1 Rationale for choosing the first difference fixed effects model

Our models consider the impacts of a policy change (display bans) upon smoking prevalence and consumption, when the policy is introduced at different times in different regions within a country (in the cases of our Canadian and Australian models) or different countries (in the case of our European models). Smoking prevalence or consumption will have had different levels and different trends over time in different regions or countries. We need to take account of such differences, otherwise our models will give spurious results. For example, suppose that smoking prevalence was falling across some country, X, but falling more slowly in region A than in other regions, and then a display ban were introduced in region A but not elsewhere and had no effect whatever. If our model then considered how smoking prevalence fell, in country X, in regions that did have display bans relative to the region that did have a display ban, the answer would be that the region with the display ban had the slowest falls in prevalence. But it would be a mistake to conclude from this that display bans had slowed the pace of smoking prevalence reduction, because we had failed to control for the fact that prevalence was falling more slowly in A than elsewhere even before the display ban was introduced. Instead, before comparing average falls for display ban and non-display ban regions, we ought to control for any underlying trend that region has.

More generally, when there are many countries or regions, it is necessary to control for the ways unobserved features of a country or region might mean observations of the dependent variable have different levels or trends. If one region is believed to be very different from the others, it could be appropriate to use a dummy variable to reflect whether an observation comes from that region. But usually the standard approach is to have a dummy, for all but one region, that stays constant over time. This is called a “fixed effects” model. Indeed, as Woolridge (2010), puts it: “fixed effects is useful for policy analysis and program evaluation”.[4]

Models comparing the levels of two variables can often identify spurious correlations, because the levels shift together but without any genuine connection between them. So to test whether correlations reflect some genuine underlying connection, it is standard to compare variables in respect of their first differences.[5] As Woolridge (2010), puts it: “First differencing a structural equation with an unobserved effect is a simple yet powerful method of program evaluation”.[6]

We note, however, that precisely because tests in first differences are more demanding, the levels of statistical significance required can be more generous. So, whereas models based on levels will often require significance at the 5 per cent or even 1 per cent level before an association is deemed genuine, tests in first differences may (depending on the context) only require significance at the 10 per cent level.

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4 See Section 10.5, “Fixed Effects Methods” in Woolridge, J.M., *Econometric Analysis of cross section and panel data*, MIT Press, 2010.

5 See Harvey, A.C. (1980), “On Comparing Regression Models in Levels and First Differences”, International Economic Review, 21(3), pp707-720.

6 Woolridge, J.M., *op cit.,* Section 10.6.4.

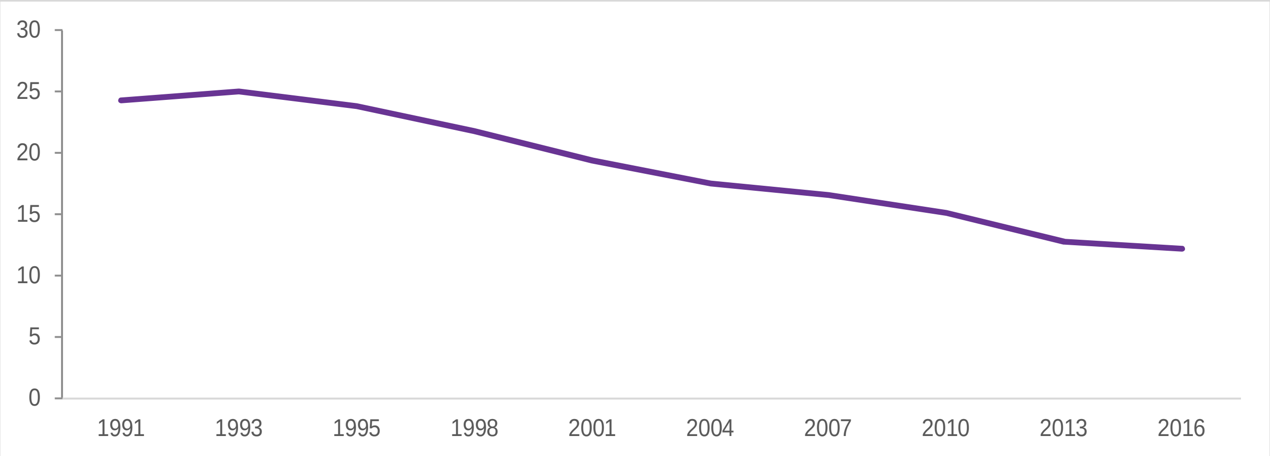
3 Economic analysis of the ban on the display of tobacco products

3.1 Australia

3.1.1 Dataset used

The data on smoking prevalence taken from the Australian Health Statistics ranged from 1998 to 2016 with 3 year intervals (detail provided in Appendix 4.1).

Figure 3.1: Daily smokers as percentage of the population aged 14 years and above



However the data disaggregated by state level was only available till 2013. As such, with eight Australian states, there were 48 data points, sufficient to estimate a panel data model.[7] The implementation dates of display bans in different states are shown in the table below.

[7] Panel data refers to multi-dimensional data measured over some period of time. A panel data set may typically involve data for the same group of units or entities (countries, regions) over several periods of time (months, years). Panel data regression methods exploit the information that is provided across the units and across time. This increases the researcher's degrees of freedom to include additional explanatory variables and allows exploring more complex relationships between the variables (including differences in the parameters across the different units or across time). Because such models typically incorporate more data points, they produce more efficient estimates (a large number of data points increases the degrees of freedom and reduces the collinearity among explanatory variables). Panel data models also allow controlling for omitted (unobserved or mismeasured) variables.

Table 3.1: Display ban implementation dates in different Australian states

State/Territory	Display ban implementation
New South Wales	For large retailers – 1 January 2010; Other retailers – 1 July 2010; Specialist tobacconists – 1 July 2013
Victoria	I January 2011
Queensland	18 November 2011
Western Australia	22 September 2010
South Australia	I January 2012
Tasmania	1 February 2011
Australian Capital Territory	For general retailers – 1 January 2010; For specialist tobacconists – 1 January 2011
Northern Territory	2 January 2011

Where display bans were implemented at different points in time for different retailers, the model assumes the earliest implementation date as the final implementation date and estimates the impact of display ban post implementation from there on. Thus, if a display ban was implemented for large retailers in January 2010 and for specialists tobacconists in July 2013 in New South Wales, the dummy variable ban takes the value of 1 from 2010 onwards.

As the data was available on a tri-annual basis (i.e. with data steps of three years between each new point) and the first implementation of display ban in Australia occurred on 1st Jan 2010, we tested whether display bans might have different effects depending upon how far through the three-year data step the measure was introduced. For this purpose, we constructed two other variables (other than the dummy variable ban): ban_month_12 and ban_month_36.

BAN_month_12 captured the number of months that had passed in that year since the introduction of the ban. It took a minimum value of 1/12 and a maximum value of 1 in the years the ban was in force. For instance if the ban was introduced on 1 July 2010, ban_month_12 took a value of 6/12 or 0.5 for the year 2010 and took a value of 1 for the year 2013. For years where the ban had not been introduced, ban_month_12 took a value of zero. By way of construction, it measured the relative impact of the display ban in the data step it was introduced depending on the date of introduction. The intuition behind this is that if the display ban was introduced at the end of the year, it is possible that its effect is less likely to have its full effect upon the average smoking prevalence statistic for that year.

BAN_month_36, on the other hand, took a minimum value of 1/36 (if introduced one month before the next data step began — 36 months passed between the end of one survey period, say 2010 and the next, say 2013) and a maximum value of 1. For instance, if the ban was introduced on 1 Jan 2012, ban_month_36 would take a value of 24/36 for 2013. For years prior to the ban, it took a value of zero.

The models were estimated using these three different ban variables, the findings of which are discussed in the next section. For detailed results, please see the Appendix to the report.

3.1.2 Summary of findings

We estimated the fixed effects panel data model in first differences while using the three ban variables. Display bans were statistically significantly correlated with an increase in smoking prevalence at the 10 percent significance level. Similarly, the BAN_month_36 variable was also statistically significantly correlated with an increase in smoking prevalence at the 10 per cent significance level. The coefficient of the BAN_month_12, by contrast, was statistically insignificant.

Price rises were correlated with a decline in smoking prevalence. This result is economically intuitive and was significant in all model specifications i.e. when tobacco prices rise, smoking prevalence declines. The income effect was very small and negative in all model specifications. This accords with the standard intuition that tobacco products are what economists term “inferior goods”, by which they mean that as incomes rise, people are less likely to smoke.

This evidence suggests that the hypothesis that display bans have reduced the prevalence of smoking in the general population in Australia can be rejected. If anything, the results indicate that display bans have been associated with increased smoking prevalence. While our model is robust to cross-checks, we do acknowledge that only a limited time period is available post display ban in most of the Australian states; and over the years as further data is collected the existing evidence on the relationship between display ban and smoking prevalence may change.

3.2 Canada

The evolution of smoking prevalence in Canada, over time, is illustrated in the figure below.

Figure 3.2: Percentage who smoke daily or occasionally, by sex, household population aged 12 or older, Canada, 2001 to 2014, percent

Dr Andrew Lilico’s previous reports analysing the data then available found that display bans had not been associated with reductions in smoking prevalence in Canada, either among the 15-19 age group or among the population as a whole.

In particular, in his 2010 report, Dr Lilico concluded that as yet:

- there is no credible statistical evidence that the introduction of display bans has been associated with reduced smoking prevalence, and in particular, no evidence of such an effect in respect of those aged 15-19;[8] and
- although the presence of the display ban has had no statistical correlation with the extent of smoking prevalence for the general population in Canada, the display ban was materially and statistically significantly correlated with increased prevalence amongst 15-19 year olds.[9]

Since that time, additional data has become available on smoking prevalence in Canadian provinces and in this report we again test the hypothesis that display bans have been associated with reduced smoking prevalence among the population as a whole or the 15-19 aged group using the latest available data.

3.2.1 Dataset used

Consistent with the approach taken in these previous reports, we have updated the standard economic factors models using four different panels:

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8 Paragraph 2.46(c) of the 2009 Report, reported at paragraph 2.51(c) of the 2010 Report.

9 Paragraph 2.46(d) of the 2009 Report, reported at paragraph 2.51(d) of the 2010 Report.

- Smoking prevalence and average number of cigarettes smoked (per person per day for the general population and for those aged 15-19, as available from Health Canada);
- Cigarette prices (obtained by combining the Consumer Price Index of cigarettes, as available from Statistics Canada, with information on the price levels of cigarettes in each province, as provided by the Smoking and Health Action Foundation);
- GDP per capita (obtained by combining historic data on GDP and population for each province available from Statistics Canada); and
- The display ban (for each province considered, the presence of the display ban was accounted for by using a dummy variable which takes value 1 if the display ban is in place and value 0 otherwise).

The table below shows when display bans were introduced in different Canadian provinces.

Table 3.2: Introduction of display bans in Canada

Province	Year of display ban enactment
Newfoundland and Labrador	2010
Prince Edward Island	2006
Nova Scotia	2007
New Brunswick	2009
Quebec	2008
Ontario	2008
Manitoba	2005
Saskatchewan	2005
Alberta	2008
British Columbia	2008

3.2.2 Summary of findings

Our models identify no statistically significant association of the presence of display bans with reductions in smoking prevalence or in the average number of cigarettes smoked in the general population in all model specifications (first differences).

There is also no statistically significant association of display bans with changes in the average number of cigarettes smoked amongst youth. However, the coefficient of the variable “BAN” is positive and statistically significant at a 10 per cent significance level in the model where we are testing for the prevalence of smoking amongst youth. This suggests that displays bans increased smoking prevalence amongst the Canadian youth. This result is in line with Dr Lilico’s findings in the previous reports where he reported that the display ban was materially and statistically significantly correlated with increased prevalence amongst 15-19 year olds.

The persistence of this result (correlating the display ban with increased prevalence amongst 15-19 year olds) even as extra years of data have been added suggests it is increasingly unlikely to have arisen from some statistical quirk. However, we have not sought to investigate this further in this report, and would remind the reader that this exercise investigates only correlation, not causality.

In the Appendix to this report we set out further details on estimated model results and the coefficients for other variables (such as prices and incomes). There we also analyse secondary issues such as whether there was a temporary impact of the display ban in the period it was introduced. Our main models set out there find no statistically significant effect on prevalence or on average number of cigarettes smoked, even temporarily in the year of introduction. We subject the findings of our main models to a number of cross-checks with less-favoured models. In one cross-check model the average number of cigarettes falls in the year the display ban was introduced. Accordingly, we do not claim to have robust results on the impacts of the display ban in the year it was introduced — although there is no impact in our preferred models, that result is not robust to all cross-checks.

3.3 European countries

3.3.1 Dataset used

As mentioned above, display bans have been introduced in a number of European countries (Iceland, Ireland, Finland, UK, Norway and Croatia). To estimate the impact of the display bans on smoking prevalence in these countries, we have run a panel model on a subset of the “EU28 plus Norway, Switzerland and Iceland” group of countries for which data is available on smoking prevalence. For more detail on the data available, please see Appendix 4.1 to the report.

The most consistent database for smoking prevalence was from the Organisation for the Economic Economic Co-operation (OECD). We have supplemented this database with figures from national statistics offices where possible. The OECD smoking variable captured the percentage of daily smokers in the population who are 15 years and over.

The relative price of cigarettes and individuals’ incomes have been proxied by the relative CPI of tobacco products and the GDP per capita of each country respectively. This data comes from Eurostat and was available from 1995-2015.

3.3.2 Summary of findings

We estimated the model in first differences using fixed effects panel regression. The results showed no statistically significant association between the display ban and smoking prevalence. This held true for all the models where we tested the presence of display ban, the presence of the display ban with a one year delay and the introduction of the display ban.

Given this, we conclude that there is no evidence from these data that display bans have been statistically associated with a reduction in smoking prevalence in the general population in European countries.

Again, further details and details on price and income effects can be found in the Appendix.

4 Appendix

This Appendix presents the technical details of the empirical analysis underpinning the findings set out in this report. The Appendix is structured as follows:

- Summary of data sources.
- Rationale for choosing the first difference fixed effect model.
- Econometric methodology and estimation results.
- Robustness analysis.

4.1 Summary of data sources

4.1.1 Australia

We provide below a brief description of the data sources on which the analysis of smoking prevalence in Australia has been based:

- National Drug Strategy Household Survey detailed report, 2013 gives the daily tobacco smokers, people aged 14 years and older, by state/territory from1998 to 2013 (per cent).[10]
- CPI of tobacco and CPI of all products by state was taken from Australian Bureau of Statistics. It should be noted here that the CPI is not measured at state level. We are using the CPI for the capital city in each state as a proxy for state level CPI.
- Real GDP per capita by state was taken from Australian Bureau of Statistics.

4.1.2 Canada

We provide below a brief description of the data sources on which the analysis of smoking prevalence and consumption in Canada has been based:

- Canadian Tobacco Use Monitoring Surveys (CTUMS), 1999-2012 and Canadian Tobacco, Alcohol and Drugs Survey (CTADS), (2013)[11] (as available from Health Canada at http://www.hc-sc.gc.ca/hc-ps/tobac-tabac/research-recherche/stat/index-eng.php), which provides yearly data on:
  - Percentage of smokers by age group and by province for the period 1999-2013.[12]
  - Average number of cigarettes smoked per person by age group and by province for the period 1999-2012.[13]
- Statistics Canada (available at http://www.statcan.gc.ca/start-debut-eng.html) provides the following information:
  - CPI for cigarettes by province for the period 1999-2013.[14]

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10 http://www.aihw.gov.au/publication-detail/?id=60129549469&tab=3

11 CTUMS and CTAD ask the same questions regarding tobacco use among the population.

12 Historical prevalence data for the period 1999-2012 is available at http://www.hc-sc.gc.ca/hc-ps/tobac-tabac/research-recherche/stat/_ctums-esutc_2012/ann-histo-eng.php.

13 Historical data on the average number of cigarettes consumed by province for the period 1999-2008 was retrieved from Health Canada in August 2009. Updates of this data for 2009 and 2010 were obtained from Health Canada in September 2010, and September 2011. Additional data for 2011 and 2012 are available at http://www.hc-sc.gc.ca/hc-ps/tobac-tabac/research-recherche/stat/ctums-esutc_2011-eng.php, and http://www.hc-sc.gc.ca/hc-ps/tobac-tabac/research-recherche/stat/_ctums-esutc_2012/ann-eng.php.

14 http://www5.statcan.gc.ca/cansim/a05?searchTypeByValue=1&lang=eng&id=3260020&pattern=3260020

- § Real GDP by province for the period 1999-2013.[15]
- § Population by Canadian province for the period 2009-2013.[16]

- The Smoking and Health Action Foundation provides:
  - § Average price level of 200 cigarettes by province as of 2013.[17]

4.1.3 European countries

We provide below a brief description of the data sources on which the analysis of smoking prevalence and consumption in Canada has been based:

- Data on smoking prevalence in EU countries was mainly taken from OECD[18] and was further supplemented by National Statistics Offices to fill the gaps where possible.
- Data on Tobacco CPI and all product CPI was taken from Eurostat[19]
- Data on real GDP per capita was taken from Eurostat.

4.2 Econometric methodology and estimation results Australia

4.2.1 The variables

The empirical analysis is based on panel with tri annual data covering the period 1998-2013 for the following eight Australian states.

New South Wales (NSW), Victoria (Vic) Queensland (Qld), Western Australia (WA), Southern Australia (SA), Tasmania (Tas), Australian Capital territory (ACT).

The dependent variable used in the model is smoking prevalence in people aged 14 years and over, GPREV.

The explanatory variables include:

- GDPC = real GDP per capita
- CPI_rel = CPI of Tobacco divided by CPI of all products

The variables capturing the statistical impact[20] of display bans are as follows:

- BAN = a dummy variable which takes value one if the display ban is in place and value zero otherwise
- D(BAN) = the first difference transformation of the variable BAN, i.e. a dummy variable which takes value one in the introduction year of the display ban, and value zero otherwise.
- BAN_month_12= the number of months that have passed in the year the ban was introduced divided by 12. Hence, it can take a minimum value of 1/12 and a maximum value of 1 in the years the ban was in force and zero otherwise

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15 http://www5.statcan.gc.ca/cansim/a46?lang=eng&childId=3840038&CORId=3764&viewId=3#customizeTab. We note that the historical GDP series used in the previous Reports and the 2010 Update Analysis (which corresponded to CANSIM table 384-0002) was terminated by Statistics Canada in November 2012. GDP data is now released on CANSIM table 384-0038, reflecting a revision to international accounting methods. The analysis here is therefore based on the revised GDP series.

16 http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0510001&tabMode=dataTable&srchLan=-1&p1=-1&p2=9.

17 https://www.nsra-adnf.ca/cms/file/files/130417_map_and_table.pdf

18 https://data.oecd.org/healthrisk/daily-smokers.htm.

19 http://ec.europa.eu/eurostat/statistics-explained/index.php/Consumer_prices_-_inflation_and_comparative_price_levels#Database.

20 We repeat, as noted in the main body of the report, that our models explore only statistical correlation, not substantive in-the-world causation. Thus the term “impact” should be understood in statistical terms as identifying modelling correlations (an “explanatory variable” has an “impact” on a “dependent variable” if its coefficient is non-zero and statistically significant). Hereafter in this appendix we shall use the term “impact” in that narrow sense.

- BAN_month_36= the total number of months that have passed since the introduction of the ban divided by 36. It can take a minimum value of 1/36 (as 36 months have passed between the end of one survey period, 2010 and the next i.e. 2013) and a maximum value of 1 in the years ban was in force and zero otherwise.

In general, D(.) denoted the first difference transformation of a given variable, and C denotes a constant.

4.2.2 The model specification

Formally, the first difference fixed effect model is represented by the following equation:

$$D(GPREV)_{i,t} = \gamma_i + \beta_1 D(CPI\_rel)_{i,t} + \beta_2 D(GDPC)_{i,t} + \beta_3 (BAN)_{i,t} + \varepsilon_{i,t}$$

where:

- $i = \{NSW, \dots, ACT\}$ indicates the states
- $t = \{1998, \dots, 2013\}$ indicates the year
- γ_i are the state-specific fixed effects, $\beta_1, \beta_2, \beta_3$ are the coefficients to be estimated, and $\varepsilon_{i,t}$ is the error term.

4.2.3 The estimation results for Australia

We report below the estimation results concerning the impact of the display ban on the prevalence of smoking in the general population. (C denotes the common co-efficient, and for notational simplicity state specific fixed-effects are not reported).

The first table indicates that the presence of the display ban is associated with an increase in the prevalence of smoking in the general population. We have re-estimated the models replacing the variable BAN with BAN_months_12, BAN_months_36 and D(BAN). We obtained similar results with the variable BAN_months_12 whereas the model with variable BAN_months_36 showed that there is no impact of the display ban on the smoking prevalence in the general population.

The impact of the introduction of display ban (as captured by D(BAN) variable) is also insignificant showing that the introduction of display ban did not have any effect on the smoking prevalence in the general population whatsoever.

Table 4.1: The impact of the presence of a display ban on smoking prevalence in the general population

Dependent Variable: D(GPREV)
Method: Panel Least squares cross section fixed (dummy variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BAN	1.571026	0.7963067	1.97	0.058
D(PRICE)	-20.18303	5.868473	-3.44	0.002
D(GDPC)	-0.0004694	0.00019	-2.47	0.02
C	1.372993	1.064272	1.29	0.207
R-squared	0.348089			
Adjusted R-squared	0.123292			
Observations	40			

Table 4.2: The impact of the presence of a display ban on smoking prevalence in the general population

Dependent Variable: D(GPREV)
Method: Panel Least squares cross section fixed (dummy variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BAN_month_12	1.243991	0.8304935	1.5	0.145
D(PRICE)	-18.99106	6.135069	-3.1	0.004
D(GDPC)	-0.0005066	0.0001937	-2.62	0.014
C	1.488748	1.101785	1.35	0.187
R-squared	0.31369			
Adjusted R-squared	0.077032			
Observations	40			

Table 4.3: The impact of the presence of a display ban overtime on smoking prevalence in the general population

Dependent Variable: D(GPREV)
Method: Panel Least squares cross section fixed (dummy variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BAN_month_36	1.854996	0.9112138	2.04	0.051
D(PRICE)	-21.09502	6.059191	-3.48	0.002
D(GDPC)	-0.0005502	0.0001889	-2.91	0.007
C	1.804191	1.09296	1.65	0.11
R-squared	0.353045			
Adjusted R-squared	0.129957			
Observations	40			

Table 4.4: The impact of introduction of a display ban on smoking prevalence in the general population

Dependent Variable: D(GPREV)
Method: Panel Least squares cross section fixed (dummy variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BAN)	0.8471167	0.777539	1.09	0.285
D(PRICE)	-15.29937	5.266557	-2.91	0.007
D(GDPC)	-0.0004566	0.0002035	-2.24	0.033
C	1.077818	1.120044	0.96	0.344
R-squared	0.289666			
Adjusted R-squared	0.044723			
Observations	40			

4.2.4 Robustness analysis

We have estimated models using least squares panel fixed effects regression as shown in the section above. To double check for the potential presence of cross-section heteroscedasticity and for the sake of consistency with the Canadian and the European countries model, we also estimated our Australian models using a Generalised Least Square (GLS) with cross section weights estimator, and employed Panel Corrected Standard Error (PCSE) methodology to estimate errors and covariance that are robust to cross-section heteroscedasticity. The results concerning the impact of the display ban on smoking prevalence are robust to other estimation and error correction techniques. However, we do note here that there is not sufficient data on Australian states to warrant estimation by GLS, and as such the cross checks results are likely to be spurious.

4.3 Econometric methodology and estimation results Canada

4.3.1 The variables

The empirical analysis is based on a panel with yearly data covering the period 1999-2013 for the following ten provinces (acronyms in brackets):

Alberta (ALB), British Columbia (BC), Manitoba (MAN), New Brunswick (NB), Newfoundland and Labrador (NFLD), Nova Scotia (NS), Ontario (ONT), Prince Edward Island (PEI), Québec (QUE), Saskatchewan (SASK).

The dependent variables used in the model are the following:

- GPREV = smoking prevalence of the general population (15+ years old)
- YPREV = smoking prevalence of the 15-19 year-old age group
- GCONS = average number of cigarettes smoked among the general population (15+ years old)
- YCONS = average number of cigarettes smoked among the general age group (15+ years old)

The explanatory variables are:

- PRICE = price of cigarettes which is calculated by using the average price of 200 cigarettes in 2013 in each Canadian province and deflating it using the relative tobacco CPI of each province in respective years[21].
- CPI_rel = CPI of tobacco divided by CPI of all products by state.
- GDPC = real GDP per capita

Since it is unclear over precisely what time period the display ban is intended to reach maturity in its effects, we have tested for:

- continuing effects produced by the presence of a display ban;
- immediate effects of a display ban; and
- effects that do not begin until one year after the introduction of the display ban.

The distinction between the continued presence of the display ban, the introduction of the display ban, and the presence of the display ban with a one year delay, is accounted for by measuring the display ban through the following variables:

- BAN = a dummy variable which takes value one if the display ban is in place and value zero otherwise
- D(BAN) = the first difference transformation of the variable BAN, i.e. a dummy variable which takes value one in the introduction year of the display ban, and value zero otherwise.
- BAN_DELAY = a dummy variable which takes value one if the display ban is in place for at least one year, and value zero otherwise

In general, D(.) denoted the first difference transformation of a given variable, and C denotes a constant.

4.3.2 The model specification

Formally, the first difference fixed effect model is represented by the following equation[22]:

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[21] Note that the models discussed in the next section have been estimated using both price and CPI_rel as independent variables. The results we report were robust to both price specifications.

$$D(YPREV)_{i,t} = \gamma_i + \beta_1 D(PRICE)_{i,t} + \beta_2 D(GDPC)_{i,t} + \beta_3 (BAN)_{i,t} + \varepsilon_{i,t}$$

where:

- $i = \{ALB, \dots, SASK\}$ indicates the province
- $t = \{1999, \dots, 2013\}$ indicates the year
- γ_i are the province-specific fixed effects, $\beta_1, \beta_2, \beta_3$ are the coefficients to be estimated, and $\varepsilon_{i,t}$ is the error term.

4.3.3 The estimation results for Canada

The tables below provide the results concerning the impact of the presence of a display ban on smoking prevalence among the general population (15+) and among those 15-19 years old (C denotes the common co-efficient, and for notational simplicity province specific fixed-effects are not reported). The tables indicate that, although the presence of the display ban has no statistical correlation with the extent of smoking prevalence for the general population, the display ban is materially and statistically significantly correlated (at the 90 per cent confidence level) with increased prevalence amongst 15-19 year olds.

Table 4.5: The impact of the presence of a display ban on smoking prevalence (15+)

Dependent Variable: D(GPREV)
Method: Panel Least squares cross section fixed (dummy variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BAN	0.0452	0.3374	0.1340	0.893
D(PRICE)	-0.0608	0.0343	-1.7684	0.079
D(GDPC)	-4.98E-05	0.0001	-0.4572	0.648
C	-0.4428	0.2841	-1.5582	0.121
R-squared	0.038838			
Adjusted R-squared	-0.05198			
Observations	140			

Table 4.6: The impact of the presence of a display ban on smoking prevalence (15-19)

Dependent Variable: D(YPREV)
Method: Panel Least squares cross section fixed (dummy variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BAN	0.9722	0.5552	1.7508	0.082
D(PRICE)	0.0270	0.0565	0.4789	0.632
D(GDPC)	-9.67E-05	0.0001	-0.5397	0.590
C	-1.6995	0.4676	-3.6343	0.000
R-squared	0.034794			
Adjusted R-squared	-0.05641			
Observations	140			

[22] The specification in the equation refers to the model that explains smoking prevalence among those aged 15-19. The same specification has been used also for the other dependent variables.

We have re-estimated the model for those aged 15-19 by replacing BAN with BAN_DELAY and the presence of the display ban ceases to be significant. Similarly, if we replace BAN with D(BAN) (that is to say, we assess the impact of the introduction of the display ban rather than the presence of the display ban) the significance also ceases to exist (see the table below).

Table 4.7: The impact of the introduction of the display ban on smoking prevalence (15-19)

Dependent Variable: D(YPREV)
Method: Panel Least squares cross section fixed (dummy variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BAN)	1.3083	0.9712	1.35	0.18
D(PRICE)	0.0009	0.0533	0.02	0.985
D(GDPC)	-0.0001	0.0001	-0.82	0.413
C	-1.2214	0.3282	-3.72	0
R-squared	0.0197			
Observations	140			

We report below the estimation results concerning the impact of the display ban on the average number of cigarettes smoked by the general population and those 15-19 years old. The first table indicates that the presence of the display ban is not associated with changes in the average number of cigarettes smoked by those 15-19 years old. We have re-estimated the models replacing the variable BAN with BAN_DELAY (i.e. a ban with delay) and obtained similar results.

Table 4.8: The impact of the presence of a display ban on the average number of cigarettes smoked (15-19)

Dependent Variable: D(YCONS)
Method: Panel Least squares cross section fixed (dummy variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BAN	0.4402	0.3623	1.2149	0.227
D(PRICE)	-0.0303	0.0335	-0.9064	0.3667
D(GDPC)	0.0001	0.0001	1.2351	0.2194
C	-0.1735	0.2784	-0.6231	0.5345
R-squared	0.050331			
Adjusted R-squared	-0.054219			
Observations	122			

The next tables indicate that the presence of the display ban is not associated with changes in the average number of cigarettes smoked by the general population. When we replaced BAN with D(BAN) we found that the introduction of the display ban was not correlated with a reduction in cigarette consumption for the 15+ population.

Table 4.9: The impact of the presence of a display ban on the average number of cigarettes smoked (15+)

Dependent Variable: D(GCONS)
Method: Panel Least squares cross section fixed (dummy variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BAN	-0.0939	0.1939	-0.4842	0.629
D(PRICE)	-0.0081	0.0197	-0.4123	0.6808
D(GDPC)	-6.18E-05	6.26E-05	-0.9877	0.3252
C	-0.1084	0.1633	-0.6640	0.5079
R-squared	0.013509			
Adjusted R-squared	-0.079703			
Obesrvations	140			

Table 4.10: The impact of the introduction of a display ban on the average number of cigarettes smoked (15+)

Dependent Variable: D(GCONS)
Method: Panel Least squares cross section fixed (dummy variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BAN)	-0.4577	0.3355	-1.36	0.175
D(PRICE)	-0.0084	0.0184	-0.46	0.647
D(GDPC)	-5.9E-05	6.13E-05	-0.95	0.342
C	-0.1212	0.1134	-1.07	0.287
R-squared	0.025961			
Adjusted R-squared	-0.06607			
Observations	140			

4.3.4 Robustness analysis

We have estimated our models using least squares panel fixed effects regression. To double check for the potential presence of cross-section heteroscedasticity, we also estimated our models using a Generalised Least Square (GLS) with cross section weights estimator, and employed Panel Corrected Standard Error (PCSE) methodology to estimate errors and covariance that are robust to cross-section heteroscedasticity.

The results concerning the impact of the display ban on smoking prevalence and average number of cigarettes smoked are robust to other estimation and error correction techniques apart from two cases. These are analysed in the next sub-heading.

4.3.5 Ambiguous results

We estimated first differences models using least squares panel fixed effects regression and GLS with cross section weights estimator, and Panel Corrected Standard Error (PCSE). All our models were robust when using these different estimation techniques, except in the following cases:

- In the prevalence model (YPREV) estimated with GLS, the introduction of display ban was associated with *increased* smoking prevalence amongst 15-19 year olds at a 10 per cent level of significance (not statistically significant in the previous model).
- In the consumption model (GCONS) estimated with GLS, the introduction of display ban was associated with a one-year *reduction* in the consumption of cigarettes in the general population at the

10 per cent level of significance (in our previous panel model the variable was not statistically significant).

Table 4.11: Impact of display ban on smoking prevalence in youth using fixed effects and GLS

Dependent Variable: D(YPREV)
Method: Panel Least squares cross section fixed (dummy variables) and Panel EGLS (Cross-section weights)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BAN)	1.6193	0.8786	1.8429	0.067
D(PRICE)	-0.0044	0.0497	-0.0893	0.928
D(GDPC)	-0.0001	0.0001	-0.7515	0.453
C	-1.2127	0.2958	-4.0995	0.0001
R-squared	0.029942			
Adjusted R-squared	0.008544			
Observations	140			

Table 4.12: Impact of display ban on general consumption of cigarettes using fixed effects and GLS

Dependent Variable: D(GCONS)
Method: Panel Least squares cross section fixed (dummy variables) and Panel EGLS (Cross-section weights)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BAN)	-0.5621	0.3087	-1.8209	0.070
D(PRICE)	-0.0062	0.0163	-0.3823	0.702
D(GDPC)	-4.45E-05	5.61E-05	-0.7935	0.428
C	-0.1203	0.1042	-1.1538	0.250
R-squared	0.027871			
Adjusted R-squared	0.006427			
Observations	140			

4.4 Econometric methodology and estimation results European Countries

4.4.1 The variables

The empirical analysis is based on a panel with yearly data covering the period 1995-2015 for the following countries. The data set is an unbalanced panel consisting of 24 countries and 240 observations in total. The table below shows the countries and the data available.

Table 4.13: Data available on smoking prevalence in various European countries

Country	Time	Data source
Austria	1986, 1997, 2006, 2014	OECD and national statistics
Belgium	1997, 2001, 2004, 2008, 2014	OECD
Bulgaria	No data available	
Cyprus	No data available	
Czech Republic	1993, 1996, 1999, 2003-2014	OECD
Denmark	1983-2015	OECD
Estonia	1990-2014 every two years	OECD
Finland	1993-2013 (every two years with larger gaps in some places) from the national statistics; From OECD the data is very detailed starting from 1983 to 2014 on annual basis	National statistics and OECD
France	1988-2014	OECD
Germany	2009, 2010, 2012 from national statistics; 1989-2013 (every three years from OECD)	National statistics and OECD
Greece	1998-2014 (every two or three years)	OECD
Hungary	1994-2014 (every 3 or 4 years)	OECD
Iceland	1987-2015	National statistics and OECD
Ireland	2002, 2007, 2015 form OECD;	National statistics and OECD
Italy	1983-1990 (every 3 years); 1993-2015	OECD
Latvia	2008, 2014	OECD, Eurostat
Liechtenstein	No data available	
Lithuania	2000, 2004, 2006, 2008, 2010, 2012, 2013, 2014	OECD
Malta	No data available	
Netherlands	2010-2013 (National statistics); 1985-2015 from OECD	National statistics and OECD
Norway	1983-2015	National statistics and OECD
Poland	2000, 2010, 2013 from national statistics; 1996-2014 (every 5 years from OECD)	National statistics and OECD
Portugal	1987, 1996, 1999, 2016, 2014	OECD
Romania	No data available	
Slovak Republic	2003, 2009, 2014	OECD
Slovenia	No data available	
Sweden	2008-2009, 2010-2011, 2012-2013, 2014-2015 (from national statistics); 1984-2014 from OECD	National statistics and OECD

Switzerland	1992, 1997, 2002, 2007, 2012, 2014	OECD and Eurostat
England	1982-2014 (young people 11-15 from ONS); All (Vaping database, 2007 onwards)	ONS
Scotland	2003, 2008, 2009-2015	Scotland statistics
Northern Ireland	1983-2015 (every 2 years in the 80s and 90s)	Source: Continuous Household Survey 1983-2009/10, Health Survey Northern Ireland 2010/11-2014/15
Wales	2003-2015	National statistics
Luxemburg	2001-2015	OECD
UK (Great Britain)	1996-2000 (every two years), 2001-2013 every year; ONS has data for 2014	OECD; ONS

The dependent variables used in the model are the following:

- GPREV = smoking prevalence of the general population (15+ years old)

The explanatory variables are:

- CPI_rel = CPI of tobacco products/ CPI of all products
- GDPC = real GDP per capita

Since it is unclear over precisely what time period the display ban is intended to reach maturity in its effects, we have tested for:

- continuing effects produced by the presence of a display ban;
- immediate effects of a display ban; and
- effects that do not begin until one year after the introduction of the display ban.

The distinction between the continued presence of the display ban, the introduction of the display ban, and the presence of the display ban with a one year delay, is accounted for by measuring the display ban through the following variables:

- BAN = a dummy variable which takes value one if the display ban is in place and value zero otherwise
- D(BAN) = the first difference transformation of the variable BAN, i.e. a dummy variable which takes the value of one in the introduction year of the display ban, and a value of zero otherwise.
- BAN_DELAY = a dummy variable which takes value one if the display ban is in place for at least one year, and value zero otherwise

In general, D(.) denoted the first difference transformation of a given variable, and C denotes a constant.

4.4.2 The model specification

Formally, the first difference fixed effect model is represented by the following equation:

$$D(YPREV)_{i,t} = \gamma_i + \beta_1 D(CPI\_rel)_{i,t} + \beta_2 D(GDPC)_{i,t} + \beta_3 (BAN)_{i,t} + \varepsilon_{i,t}$$

where:

- $i = \{Austria, Belgium, \dots, UK\}$ indicates the countries in Europe

- t = {1996, … ,2015} indicates the year[23]
- γ_i are the province-specific fixed effects, $\beta_1, \beta_2, \beta_3$ are the coefficients to be estimated, and $\varepsilon_{i,t}$ is the error term.

4.4.3 The estimation results for European Countries

In the tables below, we show the results for impact of display ban on smoking prevalence in European countries. The coefficients of the variable BAN, BAN_delay and D(BAN) are all insignificant showing that display bans did not have any impact on smoking prevalence.

Table 4.14: The impact of the presence of a display ban on smoking prevalence (15+)

Dependent Variable: D(GPREV)
Method: Panel Least squares cross section fixed (dummy variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BAN	0.018616	0.392975	0.047373	0.9623
D(PRICE)	-4.90987	1.562584	-3.14215	0.0019
D(GDPC)	-7.68E-05	9.07E-05	-0.8473	0.3978
C	-0.60038	0.152948	-3.92538	0.0001
R-squared	0.166686			
Adjusted R-squared	0.062522			
Obesrvations	235			

Table 4.15: The impact of the presence of a delay in display ban on smoking prevalence (15+)

Dependent Variable: D(GPREV)
Method: Panel Least squares cross section fixed (dummy variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BAN_DELAY	-0.01788	0.405999	-0.04405	0.9649
D(PRICE)	-4.90698	1.562015	-3.14144	0.0019
D(GDPC)	-7.81E-05	8.97E-05	-0.87038	0.3851
C	-0.59483	0.149245	-3.98558	0.0001
R-squared	0.166685			
Adjusted R-squared	0.062521			
Observations	235			

[23] Though data smoking prevalence data is available for some countries pre 1996, the model only uses data from 1996 onwards as the tobacco CPI is only available post 1996 from Eurostat.

Table 4.16: The impact of introduction of display ban on smoking prevalence (15+)

Dependent Variable: D(GPREV)
Method: Panel Least squares cross section fixed (dummy variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BAN)	0.120515	0.725326	0.166153	0.8682
D(PRICE)	-4.91666	1.562755	-3.14615	0.0019
D(GDPC)	-7.56E-05	8.99E-05	-0.84135	0.4011
C	-0.60068	0.139851	-4.29512	0
R-squared	0.166788			
Adjusted R-squared	0.062636			
Observations	235			

4.4.4 Robustness analysis

We have estimated our models using least squares panel fixed effects regression as shown in the section above. To double check for the potential presence of cross-section heteroscedasticity, we also estimated models using a Generalised Least Square (GLS) with cross section weights estimator, and employed Panel Corrected Standard Error (PCSE) methodology to estimate errors and covariance that are robust to cross-section heteroscedasticity. The results concerning the impact of the display ban on smoking prevalence are robust to other estimation and error correction techniques.