of random observations over time that do not follow a trend), and consequently accept the alternative hypothesis of a stationary process, where we observe a time series value that moves around the mean over the period.

These analyses suggest that tobacco consumption in the two countries is co-integrated and comparable, meaning that there is (or was, prior to the implementation of Plain Packaging) a stable relationship between consumption in Australia and consumption in New Zealand.

New Zealand is also considered as a good comparator for Australia due to its GHW requirements which remained the same as the warnings required in Australia prior to December 2012 throughout the observation period. *The New Zealand Smoke–free Environments Regulations 2007* provided for GHWs that covered at least 30% of the total area of the front face of packs and at least 90% of the total area of the back face (as also prescribed in Australia until 2012) until 14 March 2018. This regulation was amended in New Zealand by regulation 64 of the Smoke-free Environments Regulations 2017, which enlarged the GHWs to cover at least 75% of the front of tobacco packs in New Zealand from 14 March 2018.[35]

### *8.2 Results of "before and after" analysis*

"Before and after" analysis attempts to mimic an experimental research design using observational study data by studying the differential effect of a treatment on a "treatment group" versus a "control group" in a natural experiment. It calculates the effect of a treatment on an outcome (tobacco consumption in our case) by comparing its average value before and after a critical event (Plain Packaging in our case). In our case the treatment group is represented by Australia (due to the introduction of Plain Packaging) and the control group is represented by New Zealand (which had not introduced Plain Packaging during the relevant period and which has been selected as comparable country after the comparability analysis).

Once we determined that New Zealand was a good comparator for Australia, we carried out a "before and after" analysis to assess the impact of the introduction of Plain

[35] An additional six weeks was allowed for old stock to be distributed and a further six weeks for that old stock to be sold. Therefore, the new warnings were fully implemented from 6 June 2018.

Packaging on consumption, comparing the average consumption of tobacco (both FMC and RYO) before and after the introduction of Plain Packaging ("market clean").

As reported in Figure 2, evidence for Australia suggests that in the year after December 2012, average cigarette consumption was 1.374 bln/sticks/month, which is slightly higher than the average cigarette consumption of 1.371 bln/sticks/month in the year before December 2012 (delta equal to 0.2%).

As reported in Figure 3, results show an average RYO consumption of 0.163 bln/sticks/month in the year after December 2012, which is higher than the average RYO consumption in the year before December 2012 at 0.157 bln/sticks/month (delta equal to 3.9%).

Figure 4 reports results relative to average total consumption one year before and after December 2012. One year after the introduction of Plain Packaging, results show an average total consumption of 1.536 bln/sticks/month, which is higher than the average total consumption in the year before the introduction of Plain Packaging of 1.527 bln/sticks/month (delta equal to 0.6%).

**Figure 2. Australia – One-year comparison between cigarette consumption pre/post December 2012**

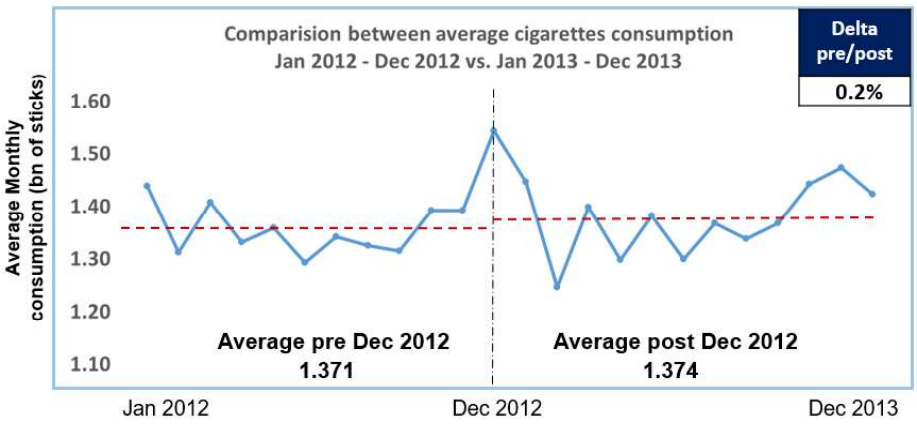


**Figure 3. Australia – One-year comparison between RYO consumption pre/post December 2012**

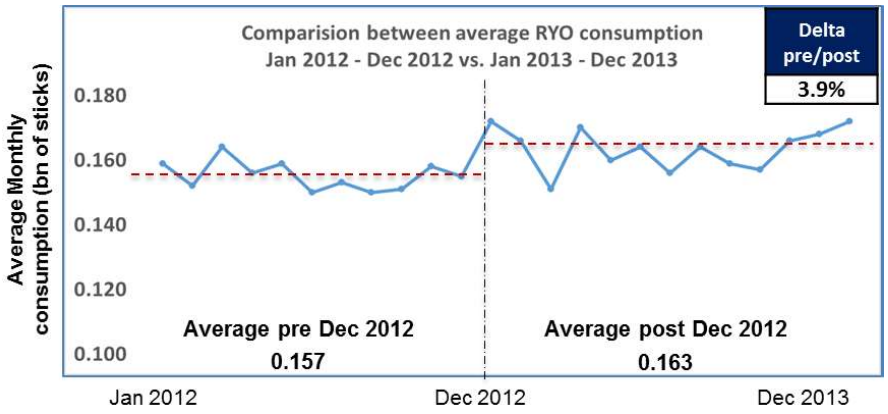
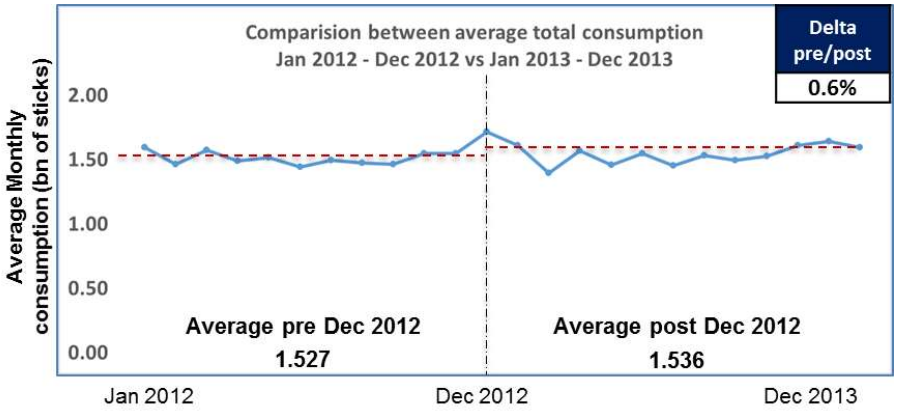



**Figure 4. Australia – One-year comparison between total consumption pre/post December 2012**




In the case of New Zealand, cigarette consumption in the year after December 2012 was 0.069 bln/sticks/month compared to 0.072 bln/sticks/month in the year before December 2012, with a decrease of -3.8% (Figure 5). RYO consumption was 0.021 bln/sticks/month in the year after December 2012, and 0.022 bln/sticks/month in the year before December 2012, with a decrease of -1.0% (Figure 6). As a result, average total consumption (Figure 7) in the year after December 2012 was lower than the average total consumption in the year before December 2012 (delta equal to -3.2%).

**Figure 5. New Zealand – One-year comparison between cigarette consumption pre/post December 2012**

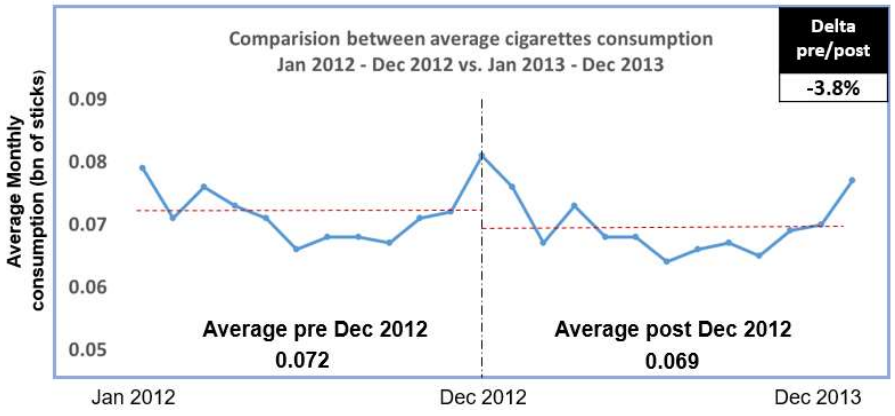



**Figure 6. New Zealand – One-year comparison between RYO consumption pre/post December 2012**

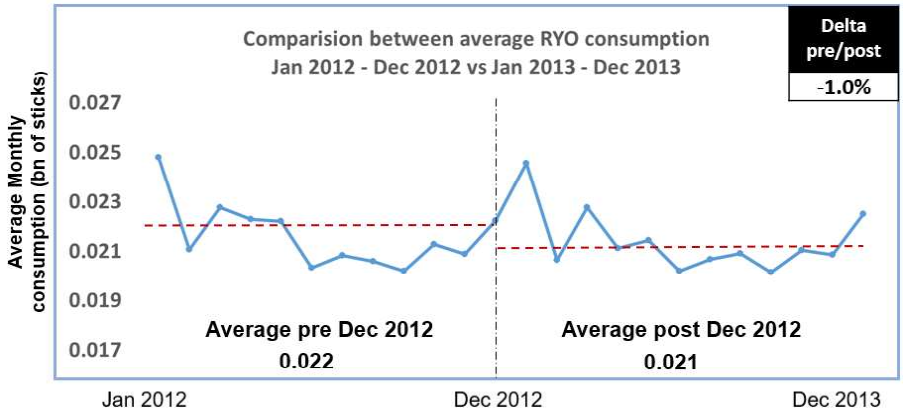
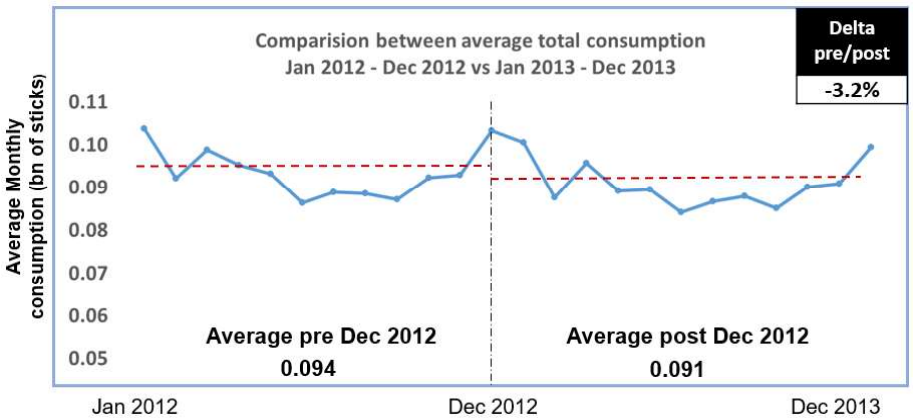



**Figure 7. New Zealand – One-year comparison between total consumption pre/post December 2012**



In conclusion, Australia shows an increase in total consumption in the year after the introduction of Plain Packaging, while New Zealand (where Plain Packaging was not implemented) shows a decrease in total consumption in the same period. These results suggest that Plain Packaging has not had any significant impact on reducing total legal tobacco consumption in Australia.

As a robustness check, we also extended our analysis to longer observation periods, including two, three, four and five years before and after the introduction of Plain Packaging. We note, however, that when we extend the observation period, the results of the before and after analysis become less reliable, as they are more likely to be affected by other confounding factors, such as price variations, that are not related to the focal event (i.e. Plain Packaging).[36]

In the following tables (from Table 2 to Table 4), we report a summary of the results of the robustness tests we conducted using longer time periods which are recorded in Appendix 2. As shown in Table 4, our robustness tests confirm the one-year comparison results for total tobacco consumption. After December 2012, total tobacco consumption decreased faster in New Zealand (where Plain Packaging had not been implemented) as compared to Australia (where Plain Packaging had been implemented) for all the time periods we consider. This evidence suggests that the ongoing decline in total legal tobacco consumption in Australia after 2012 cannot be attributed to Plain Packaging.

We note that when we extend the analysis to the fifth year after the implementation of Plain Packaging the reduction of cigarette consumption is only slightly higher for Australia, even though the values are still very similar. However, this result could be caused by other events occurring after the introduction of Plain Packaging, for example price increases. For this reason, in the econometric analysis that we report in section 9, we control for price when assessing the impact of Plain Packaging on tobacco consumption in Australia.

[36] See McWilliams and Siegel (1997) for a discussion on this point.

**Table 2: Delta cigarette consumption two, three, four and five years, before/after the adoption of Plain Packaging in Australia**

| | Delta cigarettes consumption | | | |
|---|---|---|---|---|
| | Two years | Three years | Four years | Five years |
| Australia | -1.87% | -3.54% | -6.21% | -9.04% |
| New Zealand | -5.88% | -6.89% | -8.10% | -8.83% |

**Table 3: Delta RYO consumption two, three, four and five years before/after the adoption of Plain Packaging in Australia**

| | Delta RYO consumption | | | |
|---|---|---|---|---|
| | Two years | Three years | Four years | Five years |
| Australia | 8.18% | 12.00% | 17.31% | 24.03% |
| New Zealand | -7.10% | -13.95% | -19.45% | -24.32% |

**Table 4: Delta Total consumption two, three, four and five years before/after the adoption of Plain Packaging in Australia**

| | Delta Total consumption | | | |
|---|---|---|---|---|
| | Two years | Three years | Four years | Five years |
| Australia | -0.86% | -1.99% | -3.94% | -5.95% |
| New Zealand | -6.16% | -8.64% | -10.98% | -12.90% |

## 9. Analysis of cigarette consumption: structural break and regression analysis

We next perform a test for any major change in the demand for cigarettes (FMC) in Australia. In particular, we study whether any major structural changes (or structural breaks)[37] in the consumption data are related to the implementation of Plain Packaging. This enables us to detect whether an exogenous shock (such as the implementation of Plain Packaging) affected the structural relationship between the explanatory variables and the dependent variable (i.e. cigarette consumption). In addition, we estimate a regression model to assess the impact of Plain Packaging after controlling for other alternative explanations. For this analysis, we analyse the dynamics of aggregate consumption of cigarettes (FMC) in Australia.[38]

[37] As noted above, in statistics, a structural break is an unexpected shift in a time series (i.e. cigarette consumption).

[38] For the regression model reported in section 9.2 we also provide as a robustness check, an analysis for total consumption (FMC and RYO) in Appendix A2.5.

The testing methodology we use is as follows:

- Firstly, we use a test for detecting a structural break in the consumption trend after the introduction of Plain Packaging (Section 9.1) using a purely autoregressive model as a preliminary analysis.
- Secondly, we estimate a regression model including the introduction of Plain Packaging, price and other control variables (Section 9.2).[39]
- Finally, following the previous work of Dryden (2017), we estimate a difference in differences regression model including New Zealand as a comparator (Section 9.3).[40]

The details of the model estimated and further robustness checks are presented in the Appendix A2.3.

### *9.1 Structural break analysis*

The presence of a potential structural shock due to the introduction of Plain Packaging is investigated through the evolution of the Chow statistics over the sample,[41] which may detect whether a structural exogenous break has occurred at some date. The rationale behind this statistics is that if differences in the results of the estimation model[42] before and after the shock are not statistically significant, then we can conclude that there was no break at the specified date. By also analysing parameter stability, we can check whether the structural economic relations in the model are stable or if they change after the implementation of Plain Packaging.[43]

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39 This model is defined as "structural" because we implicitly treat the economic relationships within a specific structure. In particular we estimate the relationship between demand (consumption) and price. The model allows us to test the structural shock considering other factors significantly affecting consumption, such as price.

40 For this analysis we only analyse FMC data, replicating the approach in Dryden (2017).

41 The Chow test, proposed by Gregory Chow (1960), is the most commonly used tool in time series analysis to test for the presence of a structural break.

42 The Chow test examines whether differences between results from the same model (i.e. the same explanatory variables) fitting different observations (i.e. using different samples, namely observations before and after the hypothesised shock) are statistically different.

43 We estimate the model with very few observations. Then we estimate the model again by adding one observation, and so on. We ultimately get a recursive estimation path for all the parameters. If the estimated parameters do not suffer major oscillations or apparent non-stationarity, it suggests that the structural relationship is strong.

### *9.1.1 Recursive Chow test*

In order to understand whether a break occurred at the date of implementation of Plain Packaging or later, we performed a recursive Chow test[44] by using a simple autoregressive model.

One approach to identify a potential date for the shock is to run sequential Chow tests for any possible date using the whole set of observations for each iteration. The date with the highest test statistics is a viable candidate for the shock identification.[45]

The graphical outcome for such an experiment is shown in Figure 8. The sample used for estimates spans from January 2009 until December 2017. In general, the higher the value of the test statistics, the higher the probability that a structural break has occurred on that date. We observe that the statistics does not exhibit clear peaks, especially from 2011 onwards.

The evolution of the statistics suggests that there is no likely date for a shock in the considered sample.[46] Since Plain Packaging was fully implemented in 2012, it is likely that Plain Packaging is not related to any particular shock. In fact, a break is more likely to have been induced by the annual increases in the excise duties starting in December 2013. In order to test this hypothesis further, we estimate a regression model where all the different potential effects are controlled for (see Sections 9.2 and 9.3).

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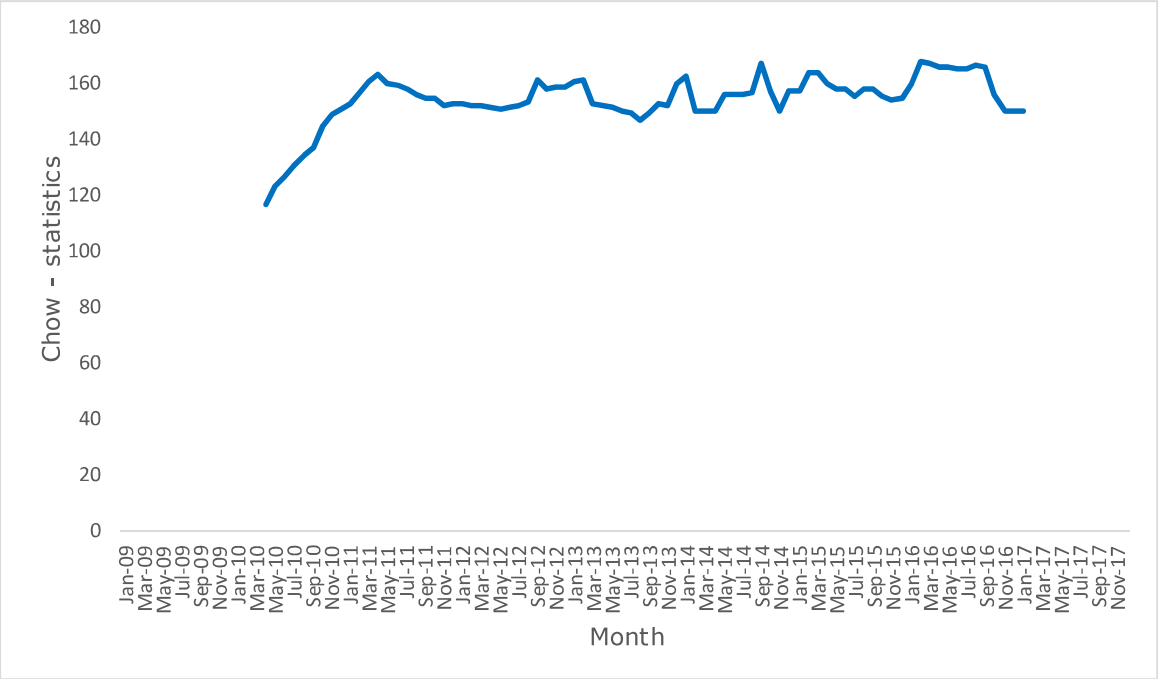
44 The recursive form of the Chow test is also known as supremum Wald statistics.

45 Because the experiment consists in finding the supremum of the test statistics, the critical value is non-parametric and unobtainable *ex-ante*, as shown in Andrews (1993) and Andrews and Ploberger (1994), where simulation-based critical values for this type of test are provided.

46 We note that the fact that the test statistics is 0 at the beginning and at the end of the observation period is due to the construction of the test, where, for each month *t*, separates the whole sample in two subsamples, one before and the other after month *t*. Thus, the test statistics cannot be estimated when the number of observations in one of the two subsamples is too low, which happens when *t* is at the beginning or the end of the observation period.

**Figure 8: Recursive Chow statistics[47] (observations: January 2009 – December 2017)**




### *9.1.2 Parameters stability*

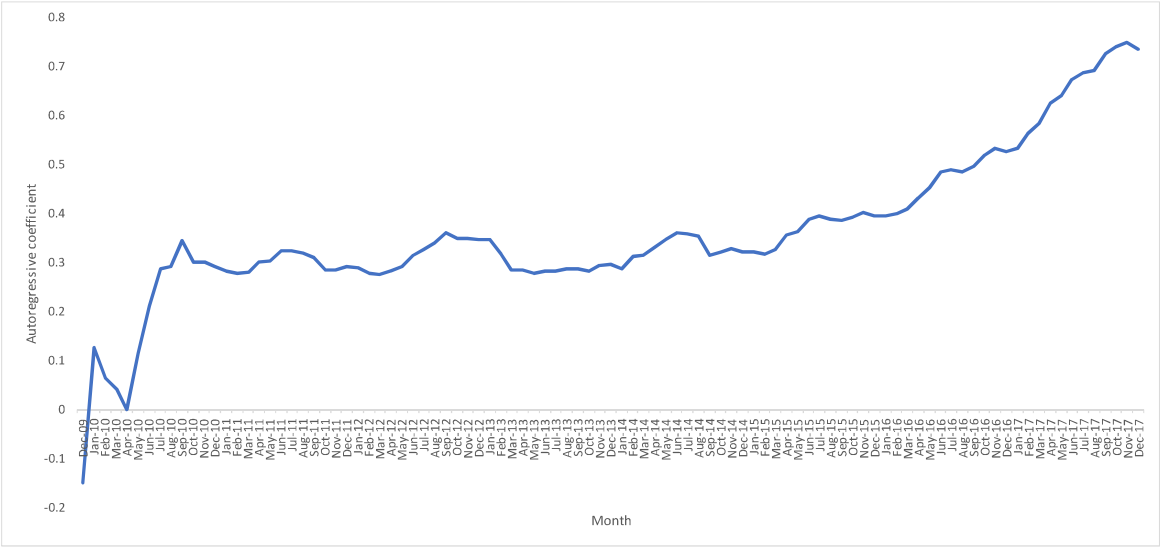
A parameter stability test provides further evidence that a shock occurred significantly later than the implementation of Plain Packaging. A parameters stability test is obtained by running recursive estimations of the model. Distinct from standard estimations, in this case, the estimation is made on a recursive basis (i.e. by running multiple sequential regressions and adding one observation at each regression). If the model is well specified, the estimates should be quite stable. A large deviation from the average values of the estimated parameter suggests a structural change in the underlying economic relationships.

The results of this simulation are shown in Figures 9 and 10. It can be observed that the estimated parameters are stable (excluding the initial variations due to small sample issues) until late 2014. From that date on the size of the autoregressive coefficient starts increasing, whereas the constant term starts decreasing. Therefore,

[47] The figure shows the evolution of the Chow statistics on a recursive basis, i.e. by running multiple sequential regressions and adding one observation at each regression. The Chow test has been computed on the autoregressive model in the period January 2009 to December 2017. The parameters cannot be estimated if the number of observation is too small. This is why the parameters are only available from December 2009.

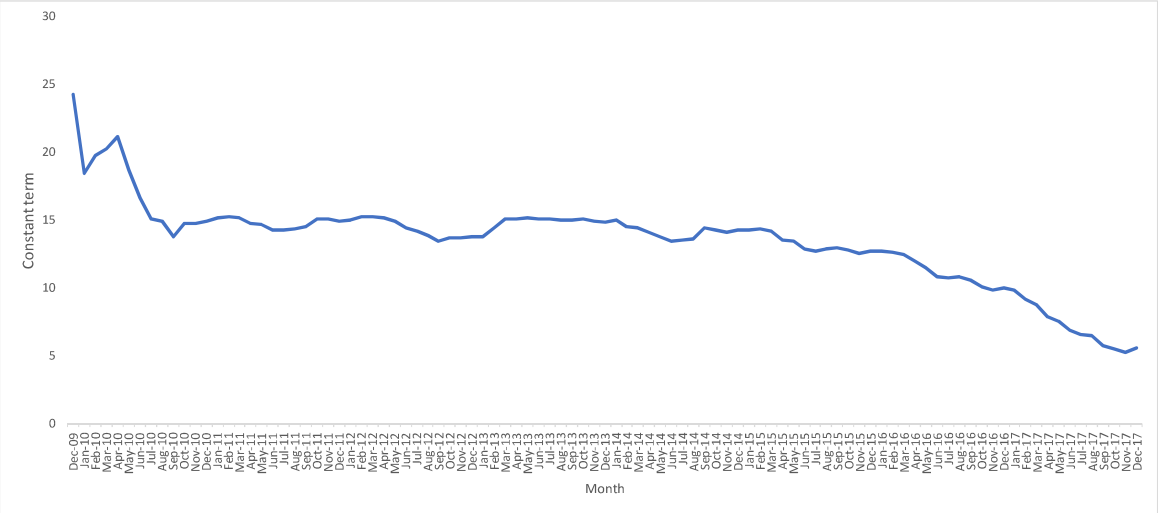
the autoregressive model is apparently stable until 2015, implying that a plausible date for a structural shock is after 2015, thus excluding a direct connection with Plain Packaging and suggesting a more likely association with the staged excise increases of 12.5% which began in December 2013. Again, in order to test this hypothesis further, we estimate a structural model where all the different potential effects are controlled for (see Section 9.2).

**Figure 9: Dynamics of the autoregressive parameter in the baseline autoregressive model as the sample size increases[48] (observations: January 2009 – December 2017)**




48 The figure shows the evolution of the autoregressive coefficient estimated on a recursive basis, i.e. by running multiple sequential regressions and adding one observation at each regression. The parameters cannot be estimated if the number of observation is too small. This is why the parameters are only available from December 2009.

**Figure 10: Dynamics of the constant term in the baseline autoregressive model as the sample size increases[49] (observations: January 2009 – December 2017)**




*9.2 Regression model estimation*

In this section we report the results of a regression model estimation where cigarette consumption is regressed on a set of covariates including an indicator variable for Plain Packaging Regulation. A regression analysis allows us to detect how the dependent variable (cigarettes consumption) is jointly affected by a number of explanatory variables, including Plain Packaging and other standard control variables, such as a time trend and price. In this way we are able to check whether Plain Packaging has had an effect on cigarettes consumption, after accounting for the other alternative explanations.

The lack of statistical significance of the effect of the Plain Packaging implementation is confirmed when we include the Plain Packaging dummy into the regression model. The variables are the same as in the model in the previous subsection, but with an added Plain Packaging variable.

The Plain Packaging variable is a Plain Packaging dummy, equal to 0 before the implementation of Plain Packaging and 1 for all the months after the implementation of Plain Packaging, capturing the effect of Plain Packaging on FMC consumption.

[49] The figure shows the evolution of the constant coefficient estimated on a recursive basis, i.e. by running multiple sequential regressions and adding one observation at each regression. The parameters cannot be estimated if the number of observation is too small. This is why the parameters are only available from December 2009.

**Table 5: Results of the regression analysis (observations: Jan 2009 – December 2017)**

| Variable | Coefficient | p-value |
|---|---|---|
| **FMC consumption Lag 1** | 0.538*** | 0.000 |
| **FMC consumption Lag 2** | 0.178* | 0.030 |
| **FMC consumption Lag 3** | -0.047 | 0.603 |
| **FMC consumption Lag 4** | 0.087 | 0.417 |
| **FMC consumption Lag 5** | 0.156 | 0.100 |
| **FMC consumption Lag 6** | 0.138 | 0.149 |
| **Price change** | -0.998*** | 0.000 |
| **1.m** | -0.103*** | 0.000 |
| **2.m** | -0.143*** | 0.000 |
| **3.m** | -0.037* | 0.032 |
| **4.m** | -0.144*** | 0.000 |
| **5.m** | -0.099*** | 0.000 |
| **6.m** | -0.143*** | 0.000 |
| **7.m** | -0.073*** | 0.000 |
| **8.m** | -0.028 | 0.144 |
| **9.m** | -0.121*** | 0.000 |
| **10.m** | -0.048** | 0.010 |
| **11.m** | -0.049** | 0.009 |
| **Plain Packaging** | 0.001 | 0.857 |
| **Constant term** | -0.986 | 0.271 |

*Level of confidence ***0.001 **0.01 *0.05 +0.1*

As shown in Table 5, the estimated coefficient attached to the Plain Packaging dummy is not significantly different from zero (p-value of 0.857), whereas the coefficient attached to price change is highly significant and has the expected negative sign (meaning that an increase in price reduces cigarette consumption). Monthly dummies are generally significant with the exception of August.

According to the analysis in this section, total consumed FMC depends on price changes, lagged consumption levels (six lags capturing consumption habits) and monthly patterns. Plain Packaging does not statistically affect FMC consumption. Therefore, according to the results of the regression model estimation, Plain Packaging has not affected FMC consumption.

### *9.3 Difference-in-differences regression model estimation*

In this section we extend the difference-in-differences analysis conducted in Dryden (2017) on per capita cigarettes consumption up to December 2017. The analysis in

Dryden (2017) implements a difference-in-differences regression methodology in order to infer the impact of Plain Packaging in Australia using New Zealand as a benchmark comparator. The impact of Plain Packaging is then assessed through a comparison between the factual consumption (in Australia) and the counterfactual consumption that would have occurred without Plain Packaging (estimated by means of New Zealand data on cigarettes consumption) after controlling for price, excise, per capita GDP and seasonality (through monthly and year dummies). The analysis conducted in Dryden (2017) used data up to December 2016. We use the same dataset used in Dryden (2017), but extend the data by one further year to December 2017. In Model 1, we present the results obtained through Ordinary Least Squares (OLS), while in Model 2 we estimate a 2 Stage Least Squares - Instrument Variable Regression where we simultaneously control for the determinants of price[50]. The complete details of the model are provided in Appendix A.2.6.[51]

Below in Table 6, we provide the estimation results for the parameter of interest, i.e. AUS*PP, which represents the coefficient for the effect of Plain Packaging on consumption in Australia. The sign of the coefficient is positive, as in the work of Dryden (2017), and is statistically significant to the standard 10% level. Thus, the model suggests that Plain Packaging is associated with an increase in consumption with respect to the counterfactual (i.e. New Zealand consumption) of 2.1% to 2.6%..

**Table 6: OLS estimation and IV regression on log volume per capita (observations: Jan 2009 – December 2017)**

| VARIABLES | (1) OLS - Dec - Nominal log_volume_pc | (2) IV - Dec - Nominal log_volume_pc |
|---|---|---|
| **AUS*PP** | 0.026$^{+}$ | 0.021$^{+}$ |
| **p-value** | (0.070) | (0.084) |
| | *Level of confidence* | ***0.001 **0.01 *0.05 $^{+}$0.1 |

[50] We run a 2SLS – IV regression in addition to a basic OLS regression to control for the potential endogeneity of the price.

[51] We have estimated all the models presented in Dryden (2017). However, for the sake of space we do not report those that use PPP data and where we use a different start date for the implementation of Plain Packaging, but the results of these models are in line with those presented here.

## 10. Main findings and conclusion

The objective of this Report was to test the impact of the introduction of Plain Packaging regulation in Australia in December 2012 on smoking prevalence and tobacco consumption using data up to December 2017 (i.e. 5 years post-implementation).

Plain packaging has not had a statistically significant impact on smoking prevalence.

With regard to smoking prevalence, we perform a regression analysis replicating the study of Chipty (2016), but using a longer time series (providing an additional two years and three months of post implementation data to Chipty (2016)) and including price and a quadratic trend among the independent variables. The inclusion of price among the control variables is particularly important because it is a main determinant of smoking behaviour and, as seen in Section 3 above, price has significantly increased in Australia after 2012 due to large increases in excise duties introduced from December 2013. We find that when we control for price, which has a significant negative effect as expected, we do not find any statistically significant impact of Plain Packaging on smoking prevalence. The result obtained by Chipty (2016) is most likely due to the lack of a robust control for the effect of price.

Plain packaging has not had a statistically significant impact on tobacco consumption and there is evidence suggesting that it has led to an increase in cigarette consumption.

With respect to tobacco consumption, we performed several analyses. We started with a comparative "before and after" analysis where New Zealand was identified as a statistically meaningful comparator to Australia. Our before and after analysis shows that after the full implementation of Plain Packaging in Australia ("market clean") in December 2012, the reduction of total legal tobacco consumption (FMC and RYO) decreased faster in New Zealand (where Plain Packaging had not been implemented) as compared to Australia (where Plain Packaging had been implemented). These results suggest that Plain Packaging has not had any significant impact on reducing total legal tobacco consumption in Australia.

After that, we performed an analysis of the eventual existence of structural breaks in cigarette consumption trends after the introduction of Plain Packaging. This analysis highlights that there has not been any specific structural break in the cigarette consumption trend in Australia as a result of the introduction of Plain Packaging. The

structural breaks, instead, are more likely to be connected with the staged increases in the excise duties in Australia starting in December 2013. Next, we run a regression model estimation where cigarette consumption is regressed on a set of covariates including Plain Packaging. The estimation of the regression model shows that after controlling for alternative explanations (especially price), Plain Packaging has no statistically significant impact on cigarette consumption in Australia.

Finally, we estimate a difference-in-differences regression including New Zealand which shows that plain packaging is associated with a statistically significant increase in per capita cigarettes consumption (relative to the counterfactual and up to December 2017) of 2.1% to 2.6%.

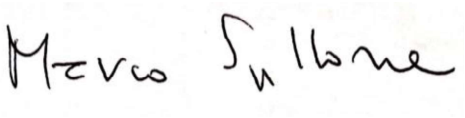
Taken together, these analyses suggest that there is no evidence to support any significant impact of the introduction of Plain Packaging on the reduction of legal tobacco consumption in Australia and, in the case of the difference-in-differences regression, we find that Plain Packaging in Australia is associated with an increase of per-capita cigarette consumption. We note that the period of analysis (i.e. 5 years post-implementation) is in line or even longer than that considered in other studies assessing policy effects on tobacco consumption (see for example Hu et al. (1994), (1995); Sung et al. 2005) and, to our knowledge, is the longest period of analysis used in published post-implementation reviews of Plain Packaging to date.

Our analysis does not include illegal tobacco consumption. However, two main sources of data on illicit tobacco consumption in Australia (Oxford Economics (2018) and KPMG (2019)) report an increase of the incidence of illicit trade on total tobacco consumption in Australia after 2012, which would likely reinforce the above conclusion that there is no significant impact of Plain Packaging on tobacco consumption. Our analysis also does not include potential shifts to the consumption of e-cigarettes, the use of which has grown in Australia notwithstanding that they are legally prohibited.[52]

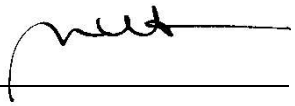
[52] Australian Institute of Health and Welfare 2017. National Drug Strategy Household Survey 2016: detailed findings. Drug Statistics series no. 31. Cat. no. PHE 214. Canberra: AIHW.

In conclusion, we can state that the results presented in this Report confirm that the data available from Australia up to December 2017 provides no evidence to support the effectiveness of Plain Packaging as a policy to reduce smoking prevalence or tobacco consumption and there is some evidence to suggest that Plain Packaging has had a counterproductive effect, resulting in an increase in cigarette consumption rather than a decrease.

Professor Raffaele Oriani



Professor Marco Spallone



Dr. Marco Vulpiani

8 November 2019

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## A1. Regulatory framework

### *A1.1 Plain Packaging requirements in Australia*

In this section we set out the detailed requirements of the TPP Act.

The second Chapter of the TPP Act provides the "*Requirements for plain packaging and appearance of tobacco products*". Section 18 specifies requirements for the physical features of the retail packaging of tobacco products. The TPP Act specifies requirements for the retail packaging of all tobacco products, referring in particular to the outer surfaces of packages. Section 19 specifies the requirements for the colour and finish of retail packaging. The last two sections to which we pay attention are section 20 and section 21 that prescribe the way in which trademarks and brand names can appear on packages  We describe these requirements in more detail below.

Section 18 of the TPP Act provides that the retail packaging of all tobacco products must comply with the following requirements:

a. outer surfaces must have no decorative ridges, no irregularities of shape or texture, and no other embellishment other than as permitted by regulations; and
b. any adhesive used in manufacturing the package must be transparent.

Additionally, section 18 sets out specific requirements for cigarette packs:

a. the pack must be rigid and made of cardboard;
b. when the pack is closed, each outer surface must be rectangular;
c. all edges of the pack must be rigid, straight and not rounded;
d. dimensions of the pack must comply with the requirements prescribed by regulations; and
e. the only opening to the pack must be a flip-top lid, which must be hinged only at the back of the pack and must have straight edges.

Section 19 sets out requirements for the colour and the finish of retail packaging. All outer surfaces of retail packaging of tobacco products:

a. must have a matt finish;
b. if regulations prescribe a particular colour, it must be adopted, otherwise, it must be a drab dark brown (Pantone 448C); and
c. health warnings, the text of other relevant legislative requirements and the text of brand, company name, or variant name are not required to be the abovementioned colour.

Section 20 states that the only permitted trademarks to appear on retail packaging of tobacco products are:

a. the brand name, company name and any variant name for tobacco products;
b. relevant legislative requirements; and
c. any other trademark or mark permitted by regulations.

Section 21 provides the requirements for brand, company or variant names and relevant legislative requirements. They must not:

a. obscure any relevant legislative requirement; and
b. appear more than once on any of the following outer surfaces: front, top and bottom.

Additional requirements include that:

a. the brand or company name must appear on the front outer surface of a cigarette pack horizontally, below and in the same orientation as the health warning, in the centre of the space remaining;
b. the brand or company name must appear on any outer surface (other than a front outer surface) of a cigarette pack horizontally and in the centre of the outer surface of the pack; and
c. the variant name must appear on any outer surface of a cigarette pack horizontally and immediately below the brand name, in the same orientation as the brand name.

### *A1.2 Calculation of excise duties in Australia*

Before analysing the method of calculation of excise duties in Australia, we briefly illustrate how the Australian government increased duty rates between 2010 and 2017.

In April 2010, the Australian government implemented a 25% increase in tobacco excise. Following that, the Government implemented a series of 12.5% increases in tobacco excise and excise-equivalent customs duty on tobacco and tobacco-related products. The staged increases occurred on 1 December 2013, 1 September 2014, 1 September 2015, 1 September 2016 and 1 September 2017.[53] Figure 11 shows the increase in excise and customs duty applicable to cigarettes and other tobacco products from February 2008 to March 2018. The annual increase in excise duties in Australia

[53] For further detail, see Thomas, M. (2016), available at: https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/BudgetReview201617/Tobacco.

has led to a gradual increase in the price of cigarettes, which are currently the most expensive in the world, as reported in Figure 12.

**Figure 11. Excise and customs duty applicable to cigarettes and other tobacco products from February 2008 to March 2018, Australia.**

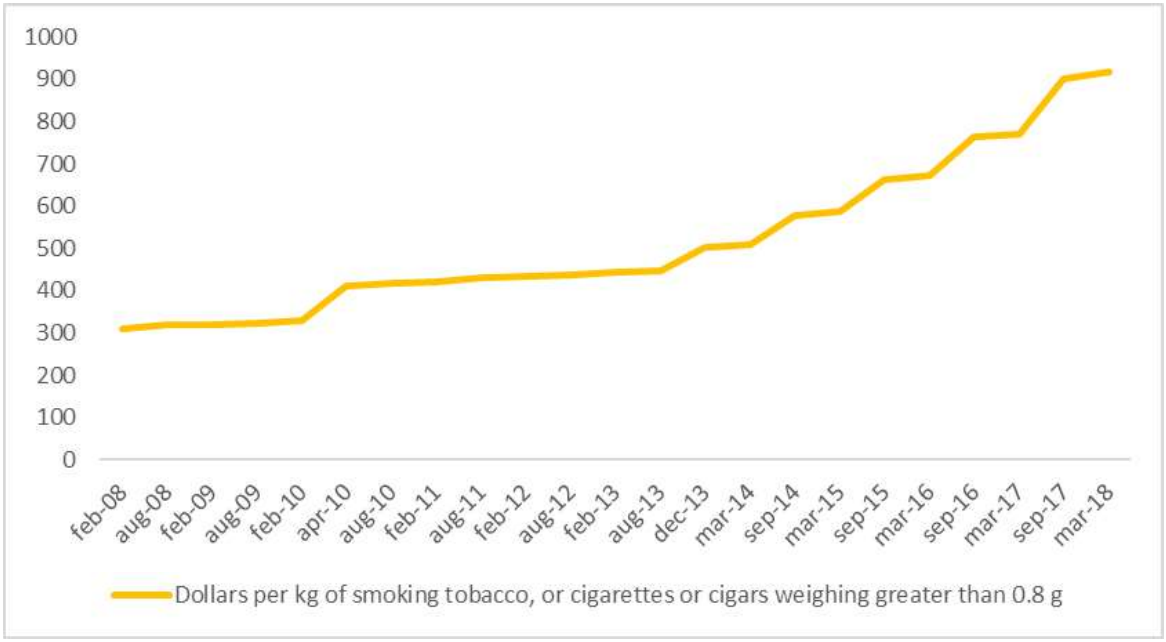
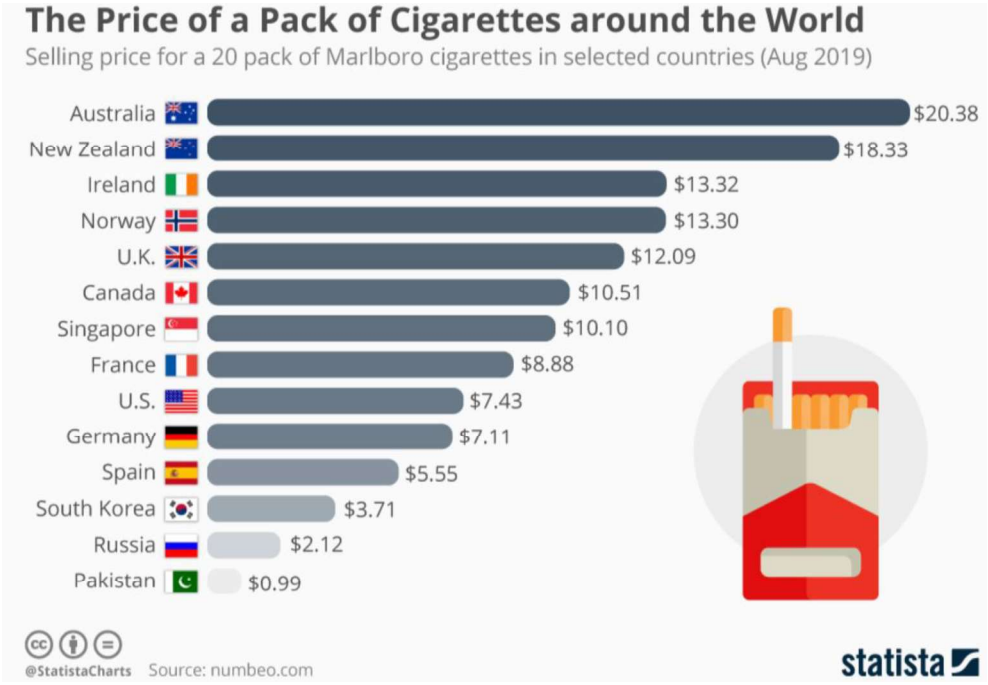



**Figure 12. Price (in US$/pack) of 20 pack of cigarettes around the world[54]**




[54] For further detail, see Wagner (2019), available at: https://www.statista.com/chart/15293/price-for-cigarettes-per-country/.

In order to calculate excise duties in Australia, we first need the relevant weight conversion factors:[55]

- 1st September 2017 – 0.000775 kg;
- 1st September 2018 – 0.00075 kg;
- 1st September 2019 – 0.000725 kg;
- 1st September 2020 and onwards – 0.0007 kg.

Before the amendments brought by the Excise Tariff Amendment Bill 2017 ("**ETA Bill 2017**") and the Customs Tariff Amendment Bill 2017 ("**CTA Bill 2017**"), the excise duty rate for other tobacco products was specified as a dollar amount per kilogram of tobacco and indexed to average weekly ordinary times earnings ("**AWOTE**") on a six monthly basis.

The new law states that the excise duty rate for other tobacco products is determined by dividing the (indexed) stick form duty rate by the weight conversion factor. In other words, the ETA Bill 2017 and the CTA Bill 2017 remove the fixed amount of excise duties on other tobacco products under the Excise Tariff Act 1921 and the Custom Tariff Act 1995. The duty rate is replaced with a formula that links the per kilogram rate of other tobacco duty to the stick form tobacco duty rate from 1 September 2017.

The formula used to determine the excise duty rate for other tobacco is:

$$\textit{Duty rate for other tobacco} = \frac{In\ stick\ form\ rate}{Weight\ conversion\ factor}$$

First, we have to determine the indexation factor for the indexation day (or, now, AWOTE indexation factor):

$$\textit{Indexation factor for the indexation day} = \frac{Most\ recent\ AWOTE}{Highest\ AWOTE\ for\ a\ previous\ June\ or\ December\ not\ preceding\ 2012\ Dec\ Quarter}$$

Then, we can determine the (indexed) in stick form tobacco duty rate:

[55] Weight conversion factor is the quantity of tobacco that in stick form tobacco products is contained, expressed in kilograms.

*(Indexed) In stick form duty rate =*

| | | | | |
|---|---|---|---|---|
| ***Tobacco duty rate on the day before the indexation day*** | * | ***Indexation factor for the indexation day*** | * | ***Additional factor for the indexation day*** |

The additional factor for an indexation day is:

a) 1.125, if the indexation day is 1 September 2014, 1 September 2015, 1 September 2016, 1 September 2017, 1 September 2018, 1 September 2019 or 1 September 2020; or

b) 1, for each other indexation day.[56]

## A2. Estimation methods and robustness checks

### *A2.1 Probit model for smoking prevalence*

The observed variable $\pi_t$ is one if a smoker, zero if a non-smoker. The latent variable $\pi_t^*$ underlying the observable is a linear function of the listed variables such that:

$$\pi^* = \boldsymbol{x}'\beta + u$$

Where x is a matrix of the listed observables and $\beta$ is a vector of coefficients.

In addition to the estimation of the coefficients of baseline model reported in Table 1, we report here in Table 7 also the marginal effects of each variable. The marginal effects explain how much each variable affects the probability of being a smoker.

**Table 7. Probit model for prevalence (observations: January 2001 – December 2017)**

| Variable | Coefficient | p-value |
|---|---|---|
| PP | -0.00156 | 0.475 |
| Price | -0.00029* | 0.012 |
| Trend | -0,00001 | 0.850 |

[56] The Parliament of the Commonwealth of Australia, House of Representatives, Excise Tariff Amendment Bill 2017, Customs Tariff Amendment Bill 2017, Explanatory Memorandum; Department of Immigration and Border Protection Notice No. 2017/25, Biannual Indexation of Certain Customs Duty Rates for Tobacco Products – 1 September 2017; Custom Tariff Act 1995, Compilation date 31 August 2017.

| | | |
|---|---|---|
| Quadratic Trend | -0,00000050 | 0.350 |
| Married | -0.1143*** | 0.000 |
| Female | -0.03354*** | 0.000 |
| Foreign | -0.01023*** | 0.000 |
| Age | -0.00324*** | 0.000 |
| Education level | -0.01205*** | 0.000 |
| Full-time job | 0.1135*** | 0.000 |
| Part-time job | 0.0751*** | 0.000 |
| Home duties | 0.1439*** | 0.000 |
| Unemployed | 0.1929*** | 0.000 |
| Income | -0.00018*** | 0.000 |
| Victoria Region | -0.00235* | 0.021 |
| South Australia Region | -0.00300+ | 0.055 |
| West Australia Region | -0.00879*** | 0.000 |
| Tasmania Region | 0.02063*** | 0.000 |
| Northern Territory Region | 0.04578*** | 0.000 |
| New South Wales | -0.00412 | 0.152 |

*Level of confidence ***0.001 **0.01 *0.05 +0.1*

In this Appendix we also report the results of several robustness checks. In Tables 8 and 9, a GHW variable is included in the regression. This variable is equal to 1 after the introduction of GHW and 0 before.

In Table 8, the model includes both GHW and PP. Table 9 provides model estimates of GHW only, thus excluding PP. The coefficient of PP is still statistically insignificant in Table 8, as well as the coefficient attached to GHW in both Table 8 and 9. A Wald test performed on model specifications in Tables 8 and 9 suggest that price and quadratic trend are jointly significant with a p-value close to zero.

**Table 8. Probit regression – results for smoking prevalence: PP and GHW (observations: January 2000 – December 2017)**

| Variable | Coefficient | p-value |
|---|---|---|
| Trend | -0.00002 | 0.922 |
| Quadratic trend | -0.0000018 | 0.372 |
| Married | -0.431*** | 0.000 |
| Female | -0.1265*** | 0.000 |
| Foreign | -0.0386*** | 0.000 |
| Age | -0.0122*** | 0.000 |

| | | |
|---|---|---|
| Education level | -0.0454*** | 0.000 |
| Full-time job | 0.4278*** | 0.000 |
| Part-time job | 0.2831*** | 0.000 |
| Home duties | 0.5427*** | 0.000 |
| Unemployed | 0.7275*** | 0.000 |
| Income | -0.0007*** | 0.000 |
| Victoria region | -0.0089* | 0.021 |
| South Australia Region | -0.0113$^{+}$ | 0.055 |
| West Australia Region | -0.0332*** | 0.000 |
| Tasmania Region | 0.0778*** | 0.000 |
| Northern Territory Region | 0.1726*** | 0.000 |
| New South Wales Region | -0.0158 | 0.148 |
| PP | -0.0062 | 0.458 |
| GHW | -0.0016 | 0.835 |
| Price | -0.0011* | 0.014 |
| Constant term | 0.2557** | 0.050 |

*Level of confidence ***0.001 **0.01 *0.05 $^{+}$0.1*

**Table 9. Probit regression 2 – results for smoking prevalence: GHW effect only and quadratic trend (observations: January 2000 – December 2017)**

| Variable | Coefficient | p-value |
|---|---|---|
| Trend | -0.00004 | 0.870 |
| Quadratic trend | -0.000003 | 0.181 |
| Married | -0.4210*** | 0.000 |
| Female | -0.1265*** | 0.000 |
| Foreign | -0.0386*** | 0.000 |
| Age | -0.0122*** | 0.000 |
| Education level | -0.0454*** | 0.000 |
| Full-time job | 0.4278*** | 0.000 |
| Part-time job | 0.2831*** | 0.000 |
| Home duties | 0.5427*** | 0.000 |
| Unemployed | 0.7275*** | 0.000 |
| Income | -0.0007*** | 0.000 |
| Victoria region | -0.0089* | 0.021 |
| South Australia Region | -0.014$^{+}$ | 0.054 |
| West Australia Region | -0.0332*** | 0.000 |
| Tasmania Region | 0.0777*** | 0.000 |
| Northern Territory Region | 0.1725*** | 0.000 |
| New South Wales Region | -0.0172 | 0.108 |
| GHW | 0.0004 | 0.960 |
| Price | -0.0010** | 0.019 |
| Constant term | 0.2865* | 0.021 |

*Level of confidence ***0.001 **0.01 *0.05 $^{+}$0.1*

Table 10 shows results from the probit regression for minors under the age of 18. If we exclude people that are 18 years old (and older), the price of FMC fails to be significant and the effect of PP is still statistically insignificant.

**Table 10: Probit regression 3 – Minors with a quadratic term (observations: January 2000 – December 2017)**

| Variable | Coefficient | p-value |
|---|---|---|
| Trend | -0.0012 | 0.276 |
| Quadratic trend | -0.000011 | 0.317 |
| Married | -0.1050 | 0.696 |
| Female | 0.1313*** | 0.000 |
| Foreign | -0.3239*** | 0.000 |
| Age | 0.5792*** | 0.000 |
| Education level | -0.0155** | 0.002 |
| Full-time job | 0.4582*** | 0.000 |
| Part-time job | -0.0970*** | 0.000 |
| Home duties | 1.0768*** | 0.000 |
| Unemployed | 0.5994*** | 0.000 |
| Income | 0.0159*** | 0.000 |
| Victoria region | -0.0093 | 0.661 |
| South Australia Region | -0.0275 | 0.425 |
| West Australia Region | -0.1390*** | 0.000 |
| Tasmania Region | 0.2188*** | 0.000 |
| Northern Territory Region | -0.0123 | 0.869 |
| New South Wales Region | -0.0068 | 0.924 |
| PP | -0.0347 | 0.491 |
| Price | 0.0018 | 0.469 |
| Constant term | 1.7382** | 0.007 |

*Level of confidence ***0.001 **0.01 *0.05 +0.1*

*A2.2 Before-and-after analysis*

The following graphs show the results of the robustness test on before-and-after analysis, conducted for the 2, 3, 4 and 5 years before and after December 2012 for Australia.

Figure 13 shows that the average cigarette consumption in Australia in the two years before December 2012 was 1.38 bln/sticks/month, and in the two years after December 2012 it was equal to 1.35 bln/sticks/month (delta equal to -1.9%).

Figure 14 shows that the average cigarette consumption in Australia in the three years before December was 1.38 bln/sticks/month, and in the three years after December 2012 it was equal to 1.34 bln/sticks/month (delta equal to -3.5%).

Figure 15 shows that the average cigarette consumption in Australia in the four years before December 2012 was 1.40 bln/sticks/month, and in the four years after December 2012 it was equal to 1.32 bln/sticks/month (delta equal to -6.2%).

As reported in Figure 16, the average consumption of cigarettes in Australia in the five years before the introduction of Plain Packaging was 1.41 bln/sticks/month, and in the five years after December 2012 it was equal to 1.28 bln/sticks/month (delta equal to -9.0%).

**Figure 13. Australia – Two year comparison of cigarette consumption pre/post December 2012 (period: January 2011 – December 2014)**

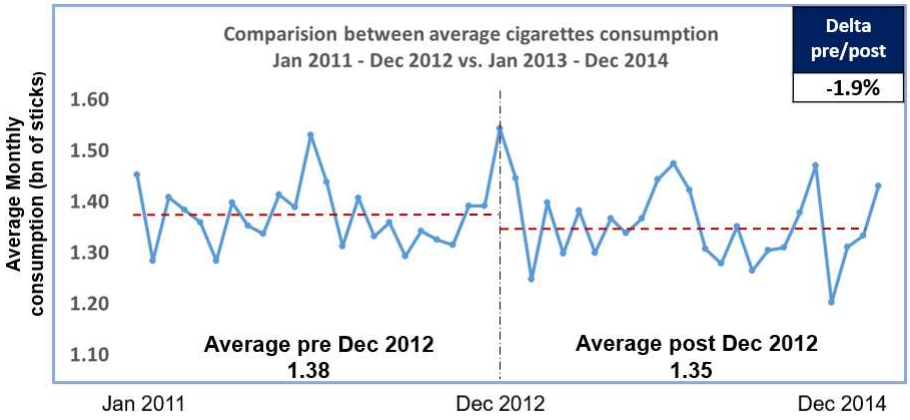


**Figure 14. Australia – Three year comparison of cigarette consumption pre/post December 2012 (period: January 2010 – December 2015)**

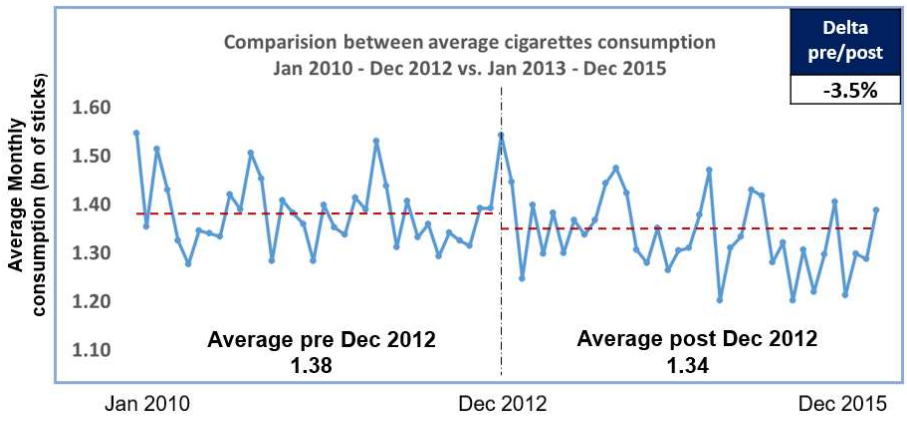



**Figure 15. Australia – Four year comparison of cigarette consumption pre/post December 2012 (period: January 2009 – December 2016)**

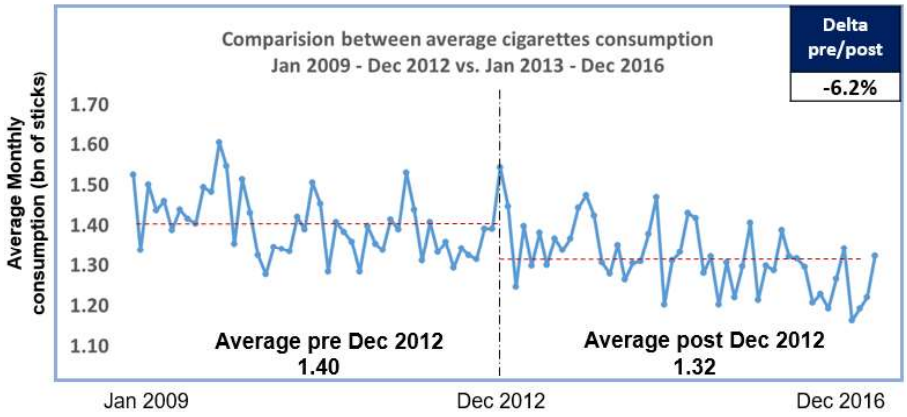


**Figure 16. Australia – Five year comparison of cigarette consumption pre/post December 2012 (period: January 2008 – December 2017)**

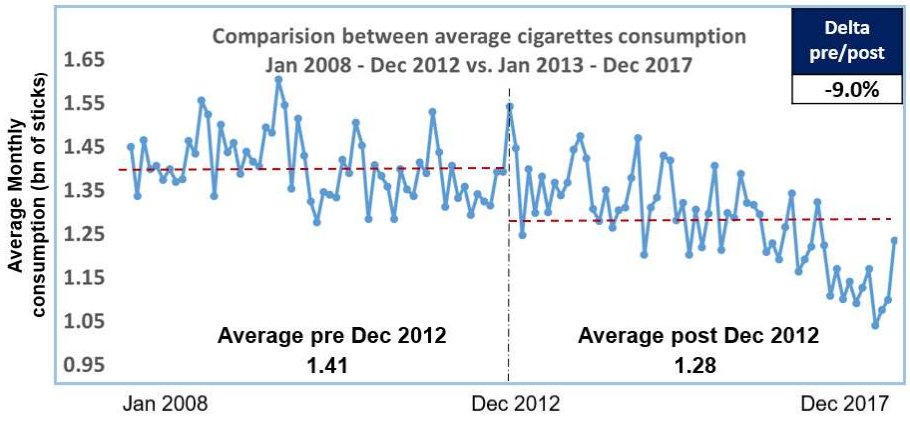



Figure 17 shows that the average RYO consumption in Australia in the two years before December 2012 was 0.15 bln/sticks/month, and in the two years after December 2012 it was equal to 0.17 bln/sticks/month (delta equal to 8.2%).

Figure 18 shows that the average RYO consumption in Australia in the three years before December 2012 was 0.153 bln/sticks/month, and in the three years after December 2012 it was equal to 0.171 bln/sticks/month (delta equal to 12%).

Figure 19 shows that the average RYO consumption in Australia in the four years before December 2012 was 0.15 bln/sticks/month, and in the four years after December 2012 it was equal to 0.18 bln/sticks/month (delta equal to 17.3%).

Figure 20 shows that the average RYO consumption in Australia in the five years before December 2012 was 0.14 bln/sticks/month, and in the five years after December 2012 it was equal to 0.18 bln/sticks/month (delta equal to 24%).

**Figure 17. Australia – Two year comparison on RYO consumption pre/post December 2012 (period: January 2011 – December 2014)**

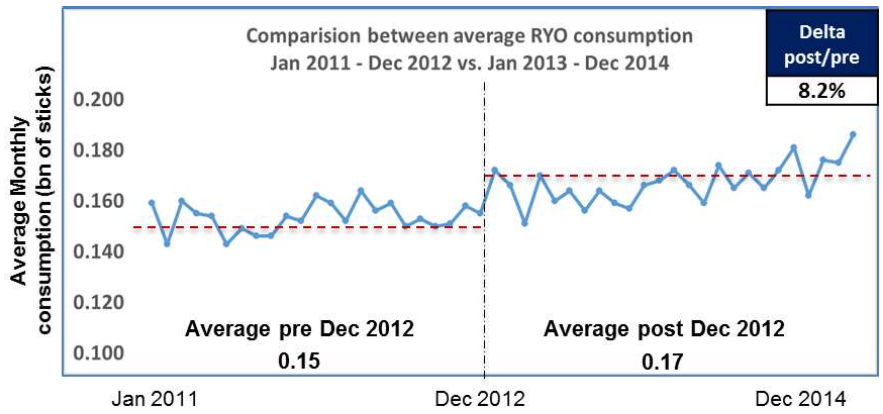



**Figure 18. Australia – Three year comparison of RYO consumption pre/post December 2012 (period: January 2010 – December 2015)**

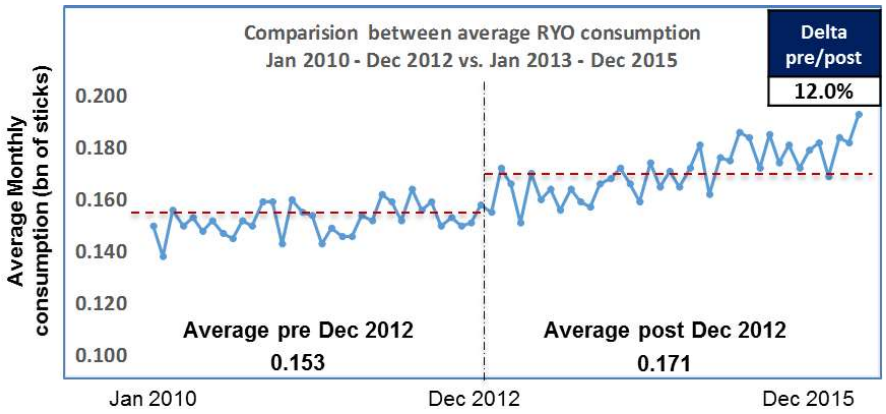


**Figure 19. Australia – Four year comparison of RYO consumption pre/post December 2012 (period: January 2009 – December 2016)**

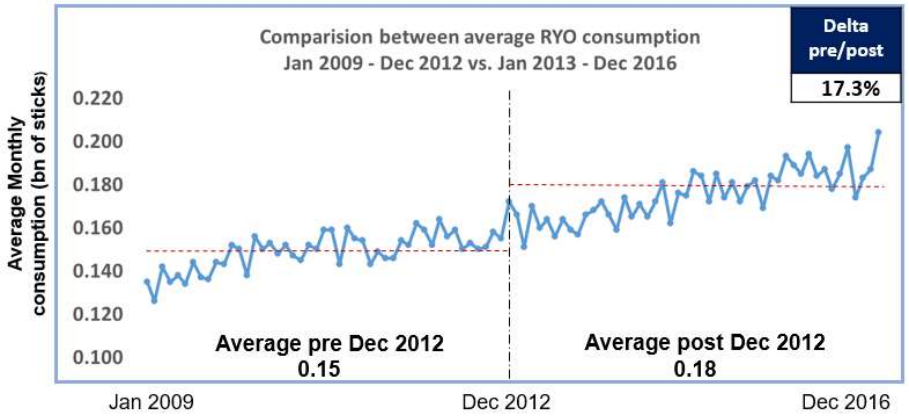



**Figure 20. Australia – Five year comparison of RYO consumption pre/post December 2012 (period: January 2008 – December 2017)**

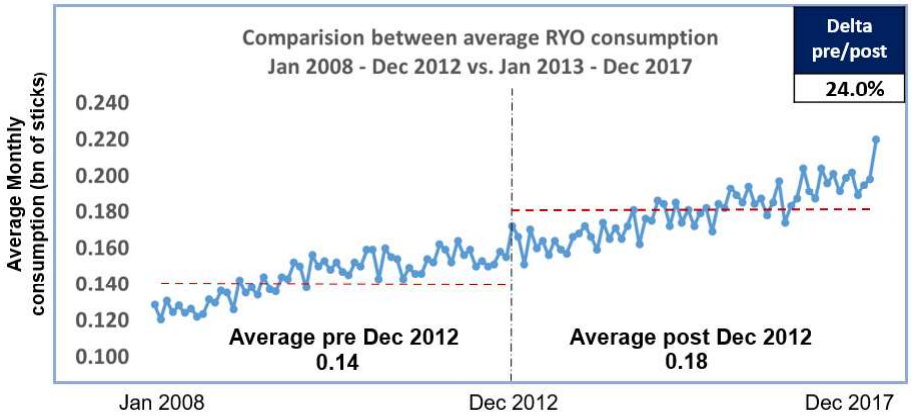



Figure 21 shows that the average total tobacco consumption in the two years before December 2012 was equal to 1.53 bln/sticks/month, and in the two years after December 2012 it was equal to 1.52 bln/sticks/month (delta equal to -0.9%).

Figure 22 shows that the average total tobacco consumption in the three years before December 2012 was equal to 1.54 bln/sticks/month, and in the three years after December 2012 it was equal to 1.51 bln/sticks/month (delta equal to -2.0%).

Figure 23 shows that the average total tobacco consumption in the four years before December 2012 was equal to 1.55 bln/sticks/month, and in the four years after December 2012 it was equal to 1.49 bln/sticks/month (delta equal to -3.9%).

Figure 24 shows that the average total tobacco consumption in the five years before December 2012 was equal to 1.55 bln/sticks/month, and in the five years after December 2012 it was equal to 1.46 bln/sticks/month (delta equal to -6.0%).

**Figure 21. Australia – Two year comparison of total consumption pre/post December 2012 (period: January 2011 – December 2014)**

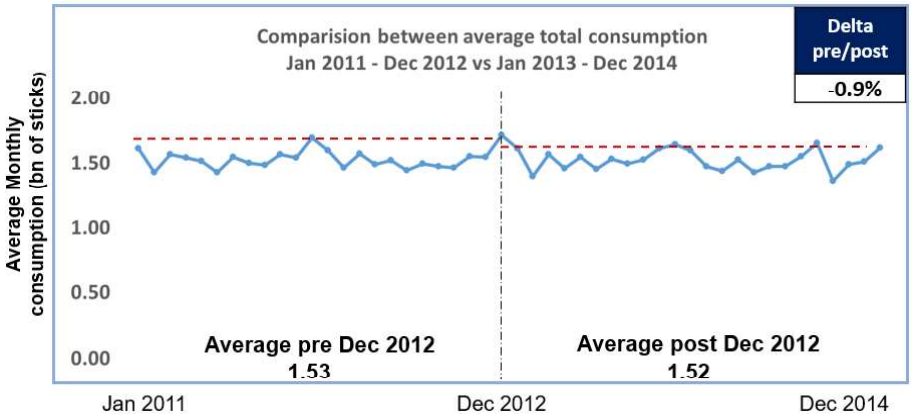



**Figure 22. Australia – Three year comparison of total consumption pre/post December 2012 (period: January 2010 – December 2015)**

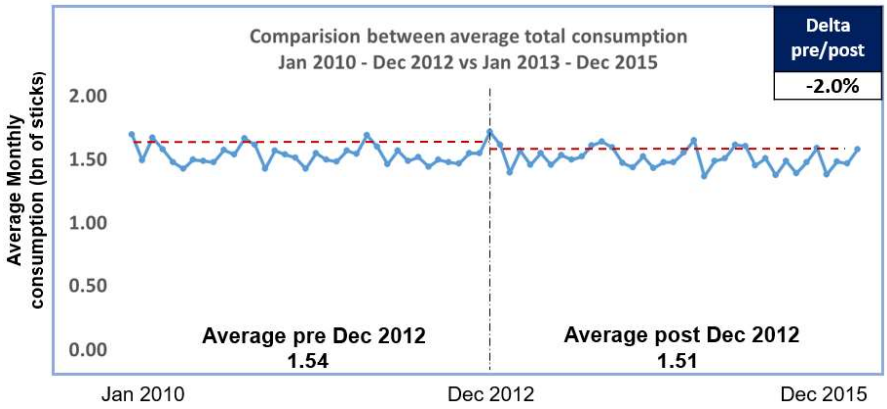


**Figure 23. Australia – Four year comparison of total consumption pre/post December 2012 (period: January 2009 – December 2016)**

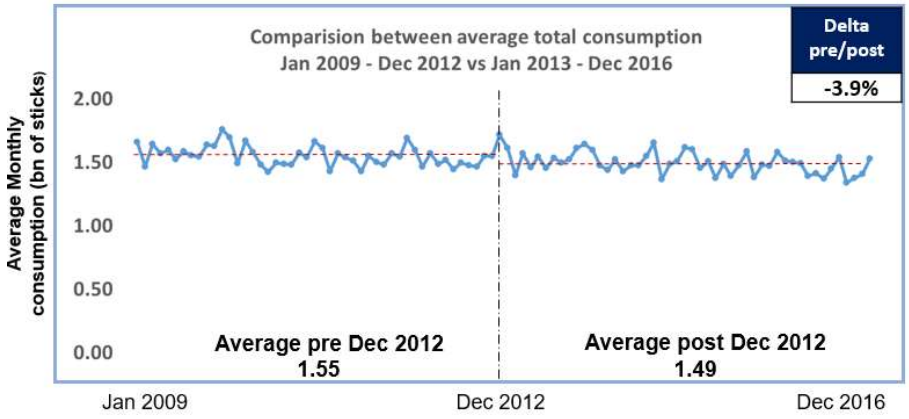
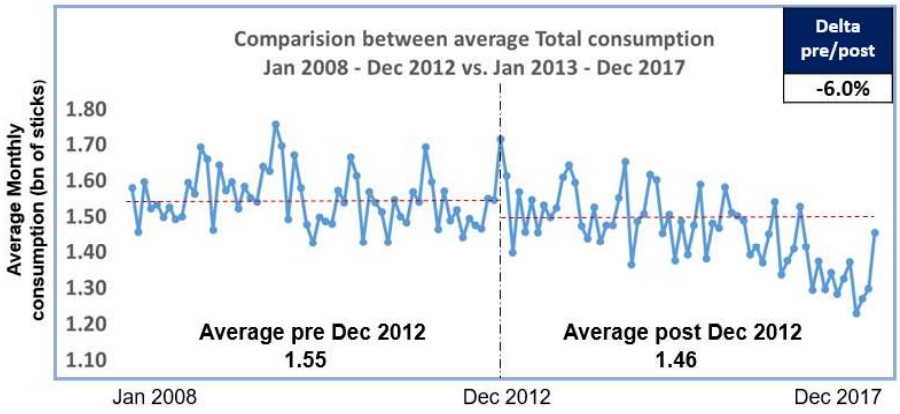



**Figure 24. Australia – Five year comparison of total consumption pre/post December 2012 (period: January 2008 – December 2017)**




The following graphs show the results of the robustness test on before and after analysis, respectively conducted for the 2, 3, 4 and 5 years before and after December 2012 for New Zealand.

Figure 25 reports that the average cigarette consumption in New Zealand in the two years before December 2012 was equal to 0.074 bln/sticks/month, and in the two years after December 2012 it was equal to 0.069 bln/sticks/month (delta equal to -5.9%).

Figure 26 shows that the average cigarette consumption in New Zealand in the three years before December 2012 was equal to 0.075 bln/sticks/month, and in the three years after December 2012 it was equal to 0.069 bln/sticks/month (delta equal to -6.9%).

Figure 27 shows that average cigarette consumption in the four years before December 2012 was equal to 0.075 bln/sticks/month and in the four years after December 2012 it was equal to 0.069 bln/sticks/month (delta equal to -8.1%).

Figure 28 shows that average cigarette consumption in the five years before December 2012 was equal to 0.074 bln/sticks/month and in the five years after December 2012 it was equal to 0.067 bln/sticks/month (delta equal to -8.8%).

**Figure 25. New Zealand – Two year comparison of cigarette consumption pre/post December 2012 (period: January 2011 – December 2014)**

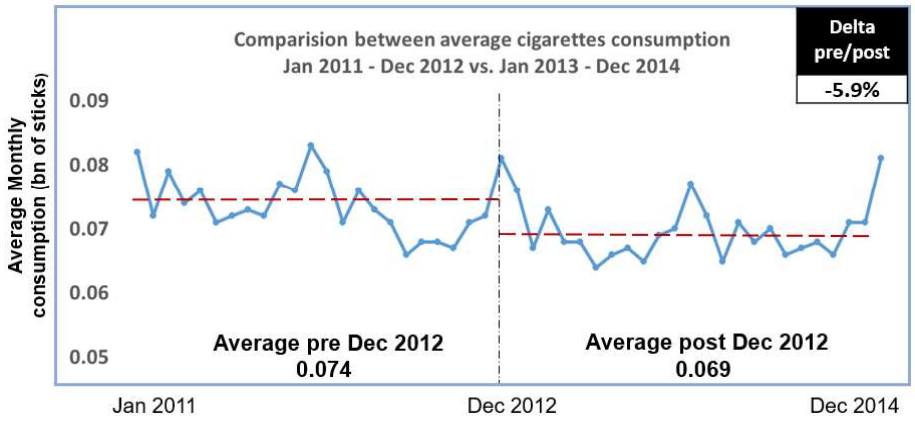



**Figure 26. New Zealand – Three year comparison of cigarette consumption pre/post December 2012 (period: January 2010 – December 2015)**

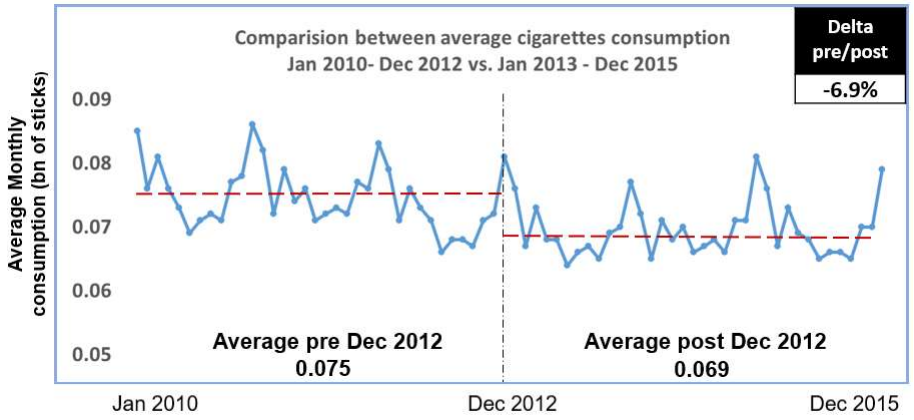


**Figure 27. New Zealand – Four year comparison of cigarette consumption pre/post December 2012 (period: January 2009 – December 2016)**

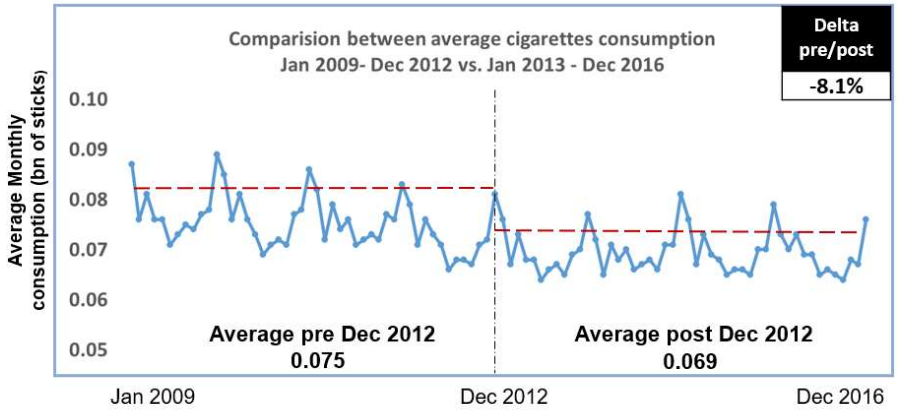



**Figure 28. New Zealand – Five year comparison of cigarette consumption pre/post December 2012 (period: January 2008 – December 2017)**

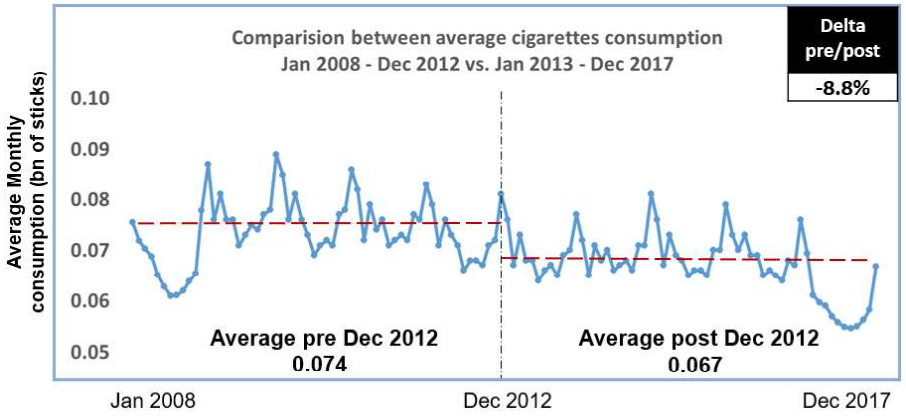



Figure 29 shows that the average RYO consumption in New Zealand in the two years before December 2012 was equal to 0.023 bln/sticks/month and in the two years after December 2012 it was equal to 0.021 bln/sticks/month (delta equal to -7.1%).

Figure 30 shows that the average RYO consumption in the three years before December 2012 was 0.025 bln/sticks/month and in the three years after December 2012 it was equal to 0.021 bln/sticks/month (delta equal to -13.9%).

Figure 31 shows that the average RYO consumption in the four years before December 2012 was 0.026 bln/sticks/month and in the four years after December 2012 it was equal to 0.021 bln/sticks/month (delta equal to -19.4%).

Figure 32 shows that the average RYO consumption five years before December 2012 was equal to 0.026 bln/sticks/month, and the average RYO consumption five years after December 2012 was equal to 0.020 bln/sticks/month (delta equal to -24.3%).

**Figure 29. New Zealand – Two year comparison of RYO consumption pre/post December 2012 (period: January 2011 – December 2014)**

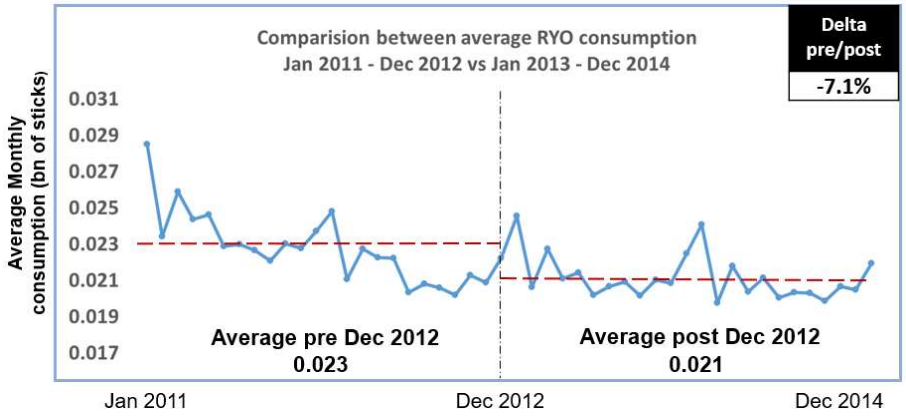



**Figure 30. New Zealand – Three year comparison of RYO consumption pre/post December 2012 (period: January 2010 – December 2015)**

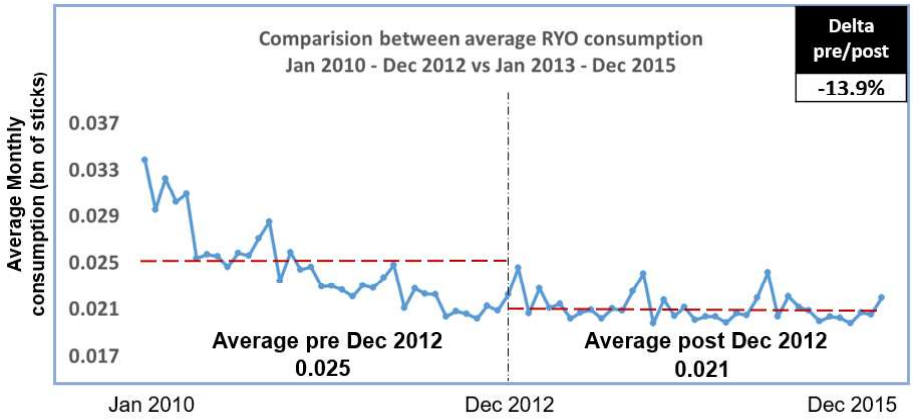


**Figure 31. New Zealand – Four year comparison of RYO consumption pre/post December 2012 (period: January 2009 – December 2016)**

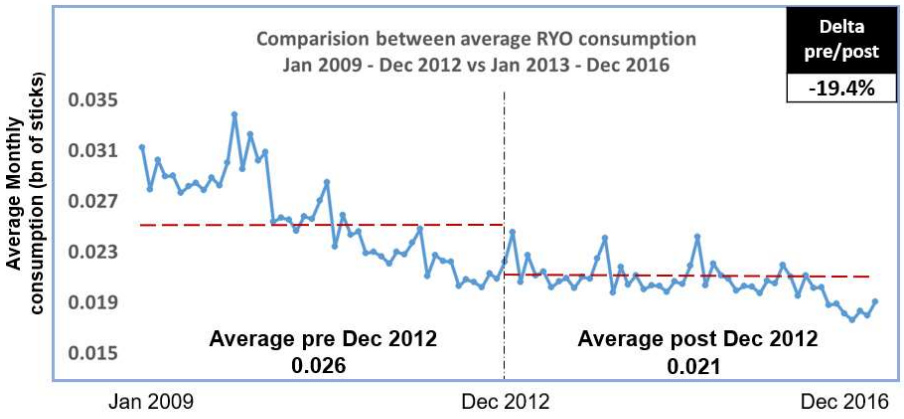



**Figure 32. New Zealand – Five year comparison of RYO consumption pre/post December 2012 (period: January 2008 – December 2017)**

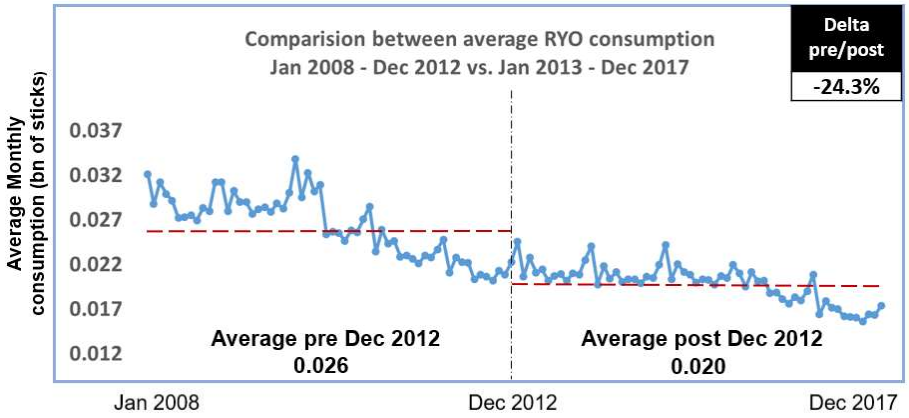



Figure 33 shows that the average total tobacco consumption in New Zealand in the two years before December 2012 was equal to 0.097 bln/sticks/month and in the two years after December 2012 it was equal to 0.091 bln/sticks/month (delta equal to -6.2%).

Figure 34 shows that the average total tobacco consumption in the three years before December 2012 was 0.099 bln/sticks/month and in the three years after December 2012 it was equal to 0.091 bln/sticks/month (delta equal to -8.6%).

Figure 35 shows that the average total tobacco consumption in the four years before December 2012 was equal to 0.101 bln/sticks/month, and in the four years after December 2012 it was equal to 0.090 bln/sticks/month (delta equal to -11.0%).

Figure 36 shows that the average total tobacco consumption for the five years before December 2012 was 0.100 bln/sticks/month, and in the five years after December 2012 it was equal to 0.087 bln/sticks/month (delta equal to -12.9%).

**Figure 33. New Zealand – Two year comparison of total consumption pre/post December 2012 (period: January 2011 – December 2014)**

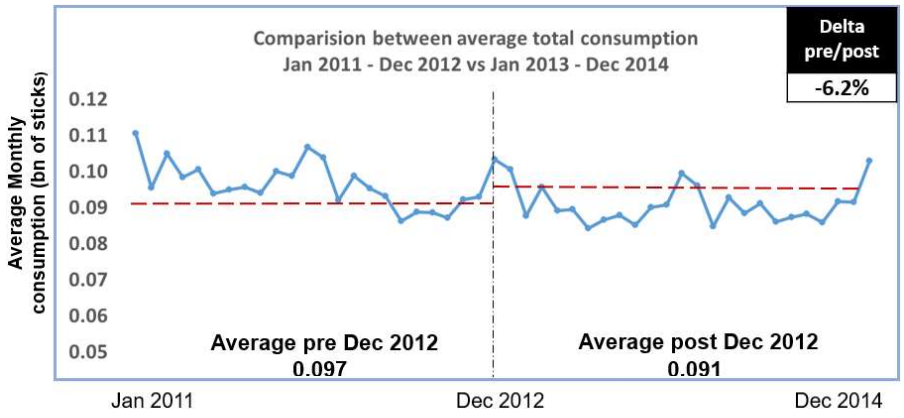



**Figure 34. New Zealand – Three year comparison of total consumption pre/post December 2012 (period: January 2010 – December 2015)**

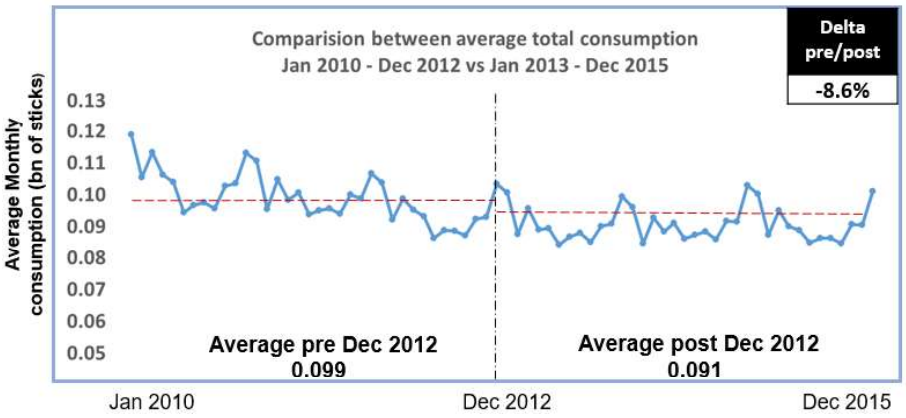


**Figure 35. New Zealand – Four year comparison of total consumption pre/post December 2012 (period: January 2009 – December 2016)**

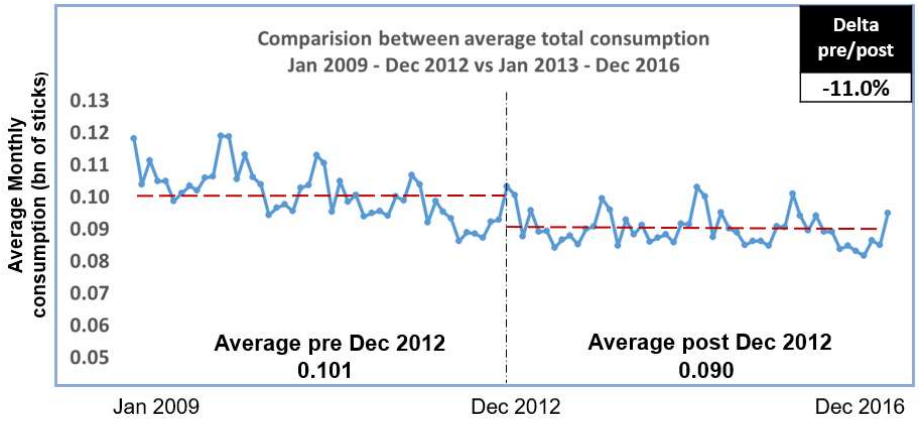
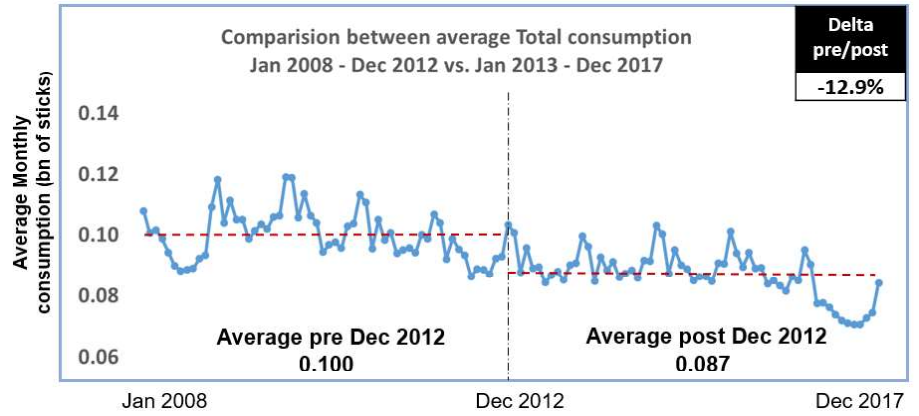



**Figure 36. New Zealand – Five year comparison of total consumption pre/post December 2012 (period: January 2008 – December 2017)**



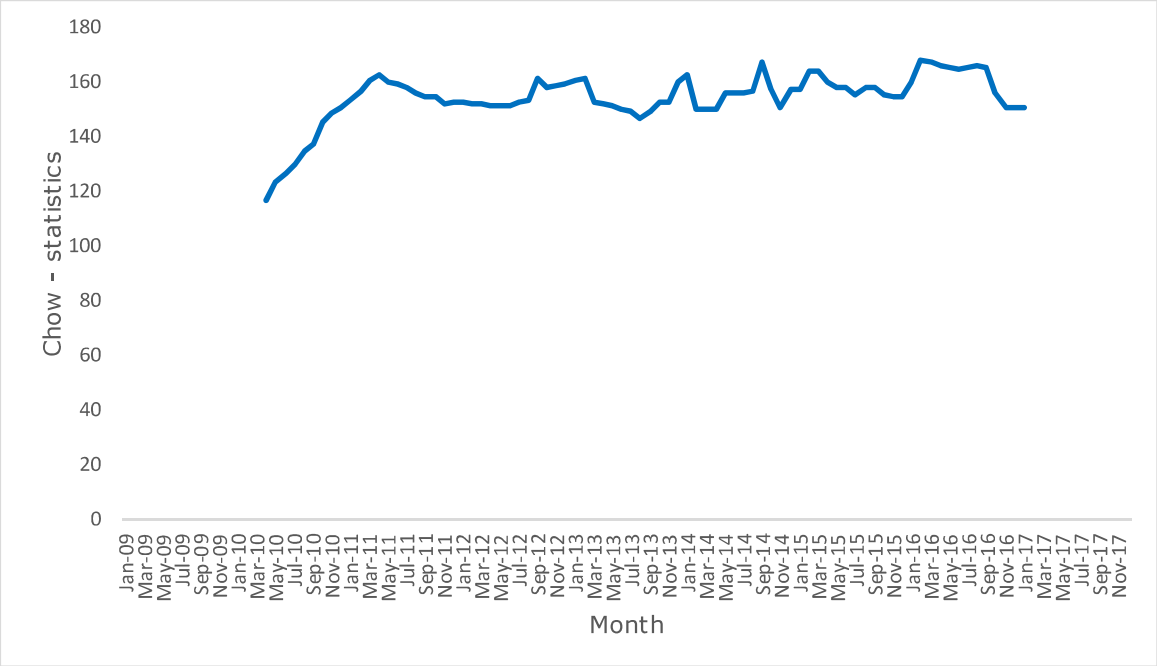
*A2.3 Analysis of structural breaks*

The analysis of structural breaks is based on the following autoregressive AR(1) model:

$$y_t = \alpha + \beta y_{t-1} + \epsilon_t$$

Observations are available from January 2009 until December 2017. The model is fitted to depict the supremum Chow statistics shown in Figure 37, reported below for convenience.

**Figure 37. Chow statistics on AR(1) model (observations: January 2009 – December 2017)**




**Robustness checks**

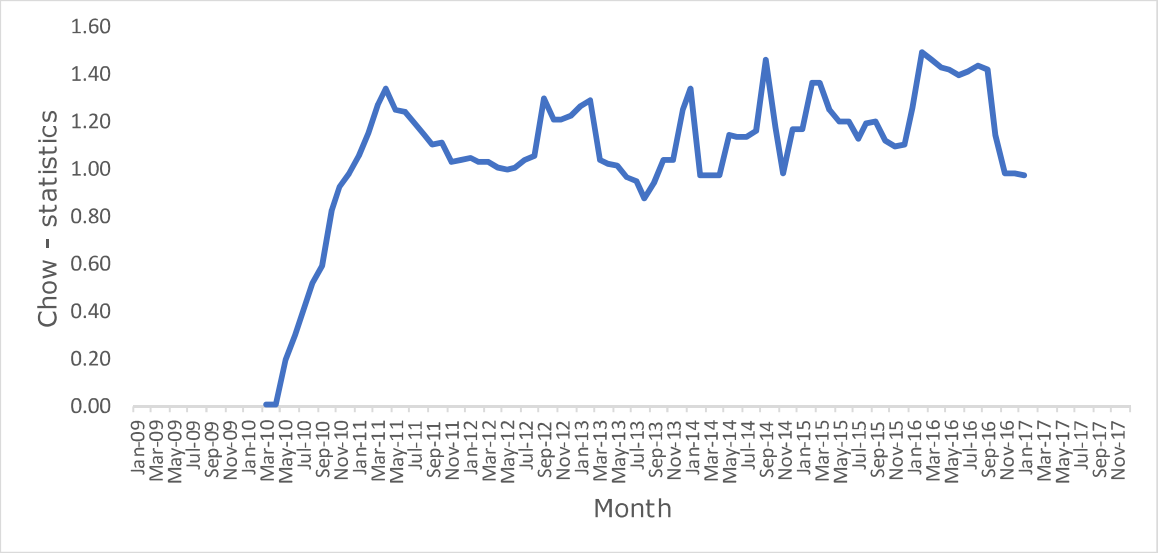
*AR(12) + linear trend*

In order to tackle stationarity issues, the supremum test is performed on a higher order specification of the model including lags until the 12th and a deterministic linear trend as follows.

$$y_t = \alpha + \sum^{12} \beta_i y_{t-i} + t + \epsilon_t$$

According to a residuals' normality portmanteau Q test, residuals do not depart significantly from a white noise process. The Chow statistic is shown in Figure 38. It can be observed that there is no clear peak, and the beginning of 2013 (i.e. after the full implementation of Plain Packaging) does not exhibit any apparent structural break.

**Figure 38. Chow statistics on AR(12) model with linear trend (observations: January 2009 – December 2017)**



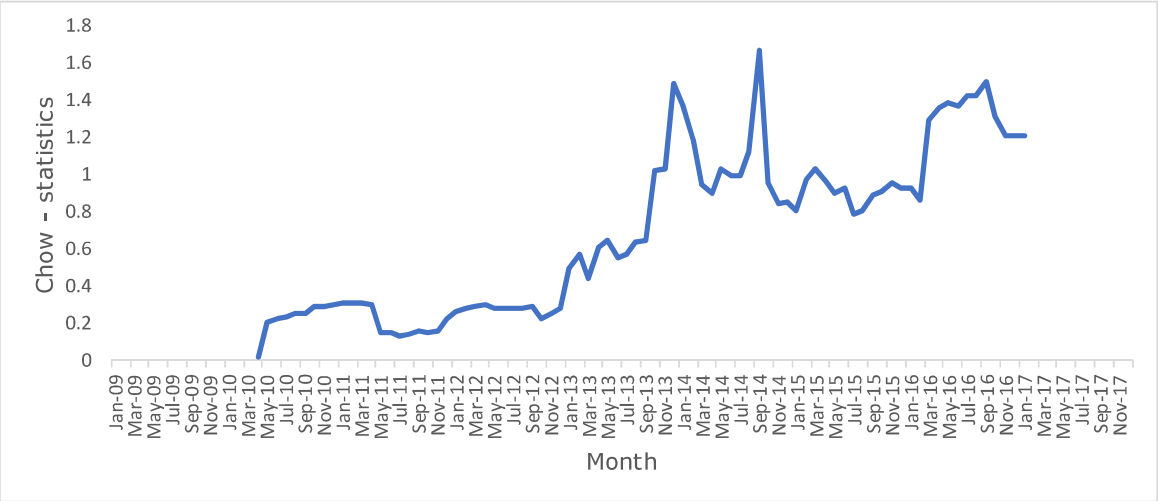

*Differenced AR(12)*

An additional specification of the AR(12) model is fitted in terms of differences, as shown in the equation below, in order to account for unit root issues:

$$dy_t = \alpha + \sum^{12} \beta_i dy_{t-i} + \epsilon_t$$

Where *dy* stands for log-differences of the dependent variable, i.e. FMC consumption. Figure 39 reports the results of the tests.

**Figure 39. Chow statistics on Differenced AR(12) model (observations: January 2009 – December 2017)**




In this case, the peak is after September 2014, more than one year after the implementation of Plain Packaging (Figure 39). Further shocks are similarly likely on January 2014 and on September 2016. As for this specification of the model we provide below the results from formal tests for various supremum statistics. Such tests are meant as alternative tests for Chow test and are performed in order to detect potential dates of structural breaks. The shown statistics are the highest value in a recursive sample estimation and is accompanied by a p-value that indicates the significance of the distance from the null hypothesis of no structural break. It can be observed that within the sample 2011m5 to 2016m10 (Table 11) mixed results are obtained. No break is detected at a statistically significant level from the Likelihood Ratio (LR) tests, while the Wald test detects a structural break. The test is performed for any potential date, and the date of the most likely potential shock, as detected by the test, is September 2016.

*Tests for a structural break: Unknown break date*

*Number of observations: 95*

*Full sample: 2010m2 – 2017m12*

*Trimmed sample: 2011m5 – 2016m10*

*Ho: No structural break*

**Table 11: Tests for a structural break**

| Test | Statistic | p-value |
|---|---|---|
| Supremum Wald Test | 68.035*** | 0.0000 |
| Average Wald Test | 20.0397* | 0.0329 |
| Exponential Wald Test | 29.9702*** | 0.0000 |
| Supremum LR | 25.9721 | 0.2197 |
| Average LR | 12.4059 | 0.5240 |
| Exponential LR | 9.848 | 0.2167 |

*Level of confidence ***0.001 **0.01 *0.05 +0.1*

Assuming that the break date is January 2013, the Wald test for a structural break with known break date does not reject the null hypothesis of no structural break with a p-value of 0.5267. This means that, according to this market model, the assumption that a structural break hit the market on January 2013 is not plausible.

### *A2.4 Regression model*

The regression model is a standard model of myopic addiction in consumption. Consumption of FMC is assumed to depend on six lags of consumption ($y$) and on change of a current time-weighted average price of FMC ($dp$). The deterministic monthly pattern is accounted for by eleven monthly dummy variables (MD). The remaining exogenous regressor is the Plain Packaging regulation dummy variable, which is equal to one from January 2013 on, and zero elsewhere.

$$y_t = \alpha + \sum_{i=1}^{6} \gamma_i y_{t-i} + \beta dp_t + MD_t + PP_t + \epsilon_t$$

**Table 12: Regression model (observations: Jan 2009 – December 2017)**

| Variable | Coefficient | p-value |
|---|---|---|
| **FMC consumption Lag 1** | 0.538*** | 0.000 |
| **FMC consumption Lag 2** | 0.178* | 0.030 |
| **FMC consumption Lag 3** | -0.047 | 0.603 |
| **FMC consumption Lag 4** | 0.087 | 0.417 |
| **FMC consumption Lag 5** | 0.156$^{+}$ | 0.100 |
| **FMC consumption Lag 6** | 0.138 | 0.149 |
| **Price change** | -0.998*** | 0.000 |
| **1.m** | -0.103*** | 0.000 |
| **2.m** | -0.143*** | 0.000 |
| **3.m** | -0.037* | 0.032 |
| **4.m** | -0.144*** | 0.000 |
| **5.m** | -0.099*** | 0.000 |
| **6.m** | -0.143*** | 0.000 |
| **7.m** | -0.073*** | 0.000 |
| **8.m** | -0.028 | 0.144 |
| **9.m** | -0.121*** | 0.000 |
| **10.m** | -0.048** | 0.010 |
| **11.m** | -0.049** | 0.009 |
| **Plain Packaging** | 0.001*** | 0.857 |
| **Constant term** | -0.986 | 0.271 |

*Level of confidence ***0.001 **0.01 *0.05 $^{+}$0.1*

The Durbin's alternative statistics is a formal test to detect first order autocorrelation of the regression residuals. It is constructed to test the null hypothesis of no serial correlation. The test yields a statistic equal to 2.690, implying that the null is not rejected with a p-value of 0.1010 suggesting that autocorrelation is not a concern for the estimation.

A Breusch-Pagan/Cook-Weisberg test for heteroskedasticity (i.e. the presence of changing variance of the residuals along time) is performed as well. It tests the plausibility of the hypothesis of constant residuals variance. The formal test does not reject the null hypothesis of constant variance of residuals with a p-value of 0.6927. Therefore, heteroskedasticity is not an issue for the estimation.

The Portmanteau white noise test is meant to test the plausibility of the hypothesis of normally distributed residuals. The formal test does not reject the null hypothesis of a

normal distribution of residuals by a p-value of 0.5232. Therefore, the hypothesis of white-noise residuals is not violated.

**Robustness checks**

*Instrumental Variables (IV) model (levels)*

In order to account for endogeneity issues, i.e. the potential influence of consumption on price (and not only of price on consumption) the regression model is estimated by GMM through instrumentation of price by the current excise on cigarettes.

$$y_t = \alpha + \sum_{i=1}^{6} \gamma_i y_{t-i} + \beta dp_t + MD_t + PP_t + \epsilon_t$$

The instrument is exogenous by definition, since it evolves accordingly to the regulators' political will. It is highly correlated with price as well (correlation is 0.996).

Estimated coefficients are reported below in Table 13 and do not differ significantly from the values estimated through ordinary least squares, i.e. the estimators used in the baseline regression.

**Table 13: IV model (levels) (observations: January 2009 – December 2017)**

| Variable | Coefficient | pvalue |
|---|---|---|
| **Price change** | -1.884*** | 0.000 |
| **FMC consumption Lag 1** | 0.585*** | 0.000 |
| **FMC consumption Lag 2** | 0.250*** | 0.000 |
| **FMC consumption Lag 3** | -0.010 | 0.884 |
| **FMC consumption Lag 4** | -0.031 | 0.713 |
| **FMC consumption Lag 5** | 0.179** | 0.003 |
| **FMC consumption Lag 6** | 0.060 | 0.424 |
| **PP** | 0.017** | 0.062 |
| **1.m** | -0.126*** | 0.000 |
| **2.m** | -0.152*** | 0.000 |
| **3.m** | -0.039** | 0.002 |
| **4.m** | -0.158*** | 0.000 |
| **5.m** | -0.101*** | 0.000 |
| **6.m** | -0.148*** | 0.000 |
| **7.m** | -0.073*** | 0.000 |
| **8.m** | -0.026 | 0.116 |
| **9.m** | -0.087*** | 0.000 |
| **10.m** | -0.051*** | 0.000 |
| **11.m** | -0.056*** | 0.000 |
| **Constant term** | -0.621 | 0.434 |

*Level of confidence ***0.001 **0.01 *0.05 +0.1*

The Portmanteau test is performed to check that residuals are white noise. The test does not reject the null hypothesis of white noise residuals with a p-value of 0.881. The Hansen's J test is performed to check for over-identifying restriction and is meant to check whether the instruments are invalid or the regression equation is not correctly specified. Since the formal test does not reject the null (p-value = 0.6428), both options can be plausibly excluded, supporting the validity of the results of the regression model.

*Instrumental Variables (IV) model (differences)*

The IV estimation is also performed to fit a differenced model as shown below.

$$dy_t = \alpha + \sum_{i=1}^{6} \gamma_i dy_{t-i} + \beta dp_t + MD_t + PP_t + \epsilon_t$$

As shown in Table 14, the results do not significantly change, as price variation still has a negative significant effect on the rate of change of consumption and Plain Packaging does not significantly affect the rate of change of consumption.

**Table 14: Regression IV model (differences) (observations: January 2009 – December 2017)**

| | Coefficient | p-value |
|---|---|---|
| **Price change** | -1.917*** | 0.000 |
| **FMC consumption change Lag 1** | -0.382*** | 0.000 |
| **FMC consumption change Lag 2** | -0.117$^{+}$ | 0.089 |
| **FMC consumption change Lag 3** | -0.121 | 0.168 |
| **FMC consumption change Lag 4** | -0.167* | 0.025 |
| **FMC consumption change Lag 5** | 0.011 | 0.901 |
| **FMC consumption change Lag 6** | 0.068 | 0.410 |
| **PP** | 0.015$^{+}$ | 0.082 |
| **1.m** | -0.132*** | 0.000 |
| **2.m** | -0.152*** | 0.000 |
| **3.m** | -0.034** | 0.007 |
| **4.m** | -0.159*** | 0.000 |
| **5.m** | -0.097*** | 0.000 |
| **6.m** | -0.144*** | 0.000 |
| **7.m** | -0.065*** | 0.000 |
| **8.m** | -0.022 | 0.166 |
| **9.m** | -0.089*** | 0.000 |
| **10.m** | -0.049*** | 0.000 |
| **11.m** | -0.059*** | 0.000 |
| **Constant term** | 0.077*** | 0.000 |

*Level of confidence ***0.001 **0.01 *0.05 $^{+}$0.1*

The Portmanteau test for white noise residuals does not rejected the null hypothesis with a p-value of 0.9046. The Hansen's J Test of over-identifying restriction, which is meant to check whether the instruments are invalid, or the regression equation is not correctly specified, yields a value of 1.147, such that the null cannot be rejected with p-value equal to 0.5635 and both the options of invalid instrument or incorrectly specified equation can be plausibly excluded, again supporting the reliability of the results.

### *A2.5 Structural break and regression analyses on total consumption*

In this section we provide a re-estimation of the econometric model in section 9.1 using total consumption (i.e. FMC + RYO) as a dependent variable.

This analysis shows no evidence of a structural break related to Plain Packaging. Moreover, a Plain Packaging dummy is not statistically significant in a regression where prices of FMC and RYO are included as explanatory variables.

We estimated the following autoregressive model through OLS:

$$q_t = \alpha + \beta_1 q_{t-1} + \beta_2 q_{t-2} + \beta_3 q_{t-3} + t + \epsilon_t$$

where $q_t$ stands for logarithm of total consumption (FMC + RYO) in period t, $\alpha$ is a constant, $t$ is a linear trend and $\epsilon_t$ is a white noise process.

According to our analyses an important regressor (i.e. price) is omitted, which may lead to biased estimation. Therefore, further investigation including price is necessary. Nevertheless, given the pure autoregressive nature of this model, it can provide reliable insights assuming that residuals are uncorrelated and heteroskedastic. The number of lags (three lags are included as explanatory variables) has been chosen in order to get uncorrelated and homoskedastic residuals (Durbin's alternative test has a p-value equal to 0.723, and the Breusch-Pagan test shows a p-value equal to 0.804).

The Wald supremum test for breaks at unknown date finds a potential structural break on December 2016, but the p-value is only 0.0875. Therefore, no evidence supports a structural break in 2013 related to Plain Packaging Regulation. The behavior of the Wald statistics is depicted in Figure 40 and shows no evidence of a structural break.

The dynamics of the estimated parameters in a rolling window recursive estimation (with the sample increasing at each iteration) is depicted in Figure 41, and does not provide any evidence of a structural break.

We estimated a model including price differences as an explanatory variable, as well:

$$q_t = \alpha + \beta_1 q_{t-1} + \beta_2 q_{t-2} + \beta_3 q_{t-3} + \gamma \Delta p_t + MD_t + t + \epsilon_t$$

where $\Delta p_t$ stands for price change in percentage terms and $MD_t$ stands for monthly indicator variables. Such a model exhibits white noise residuals since a Portmanteau Q test delivers a p-value equal to 0.317 (i.e. the null hypothesis of white noise residuals cannot be plausibly rejected).

By adding a Plain packaging indicator variable, estimated coefficients do not change significantly and the Plain packaging indicator variable itself is not statistically significant (see the estimated coefficients in Table 15 and in Table 16).

Different specifications have been estimated of the same model, including the price of RYO[57]. However, Plain Packaging regulation does not exhibit a significant impact in any of them.

$$q_t = \alpha + \beta_1 q_{t-1} + \beta_2 q_{t-2} + \beta_3 q_{t-3} + \gamma \Delta avp_t + MD_t + t + \epsilon_t$$

Where $\Delta avp_t$ is the variation in the weighted average price of FMC and RYO. Results are shown in Table 17. The p-value in the residuals test for normality is 0.16, which does not reject the null of normality.

The last model includes a variation of RYO price as a separate explanatory variable:

$$q_t = \alpha + \beta_1 q_{t-1} + \beta_2 q_{t-2} + \beta_3 q_{t-3} + \gamma_1 \Delta p_t + \gamma_1 \Delta p_t^{RYO} + MD_t + t + \epsilon_t$$

Where $p_t^{RYO}$ stands for the RYO price. Results are shown in Table 18. The p-value in the residuals test for normality is 0.01, which does reject the null of normality.

The results of the estimation are reported in Tables 15, 16, 17 and 18.

[57] As data on the price of RYO is not available before May 2012, the period of observation is May 2012 to December 2017. Given the lower number of observations, only three time lags are included in the regression models.

**Figure 40. Wald supremum statistics (sample: January 2009 – December 2017)**

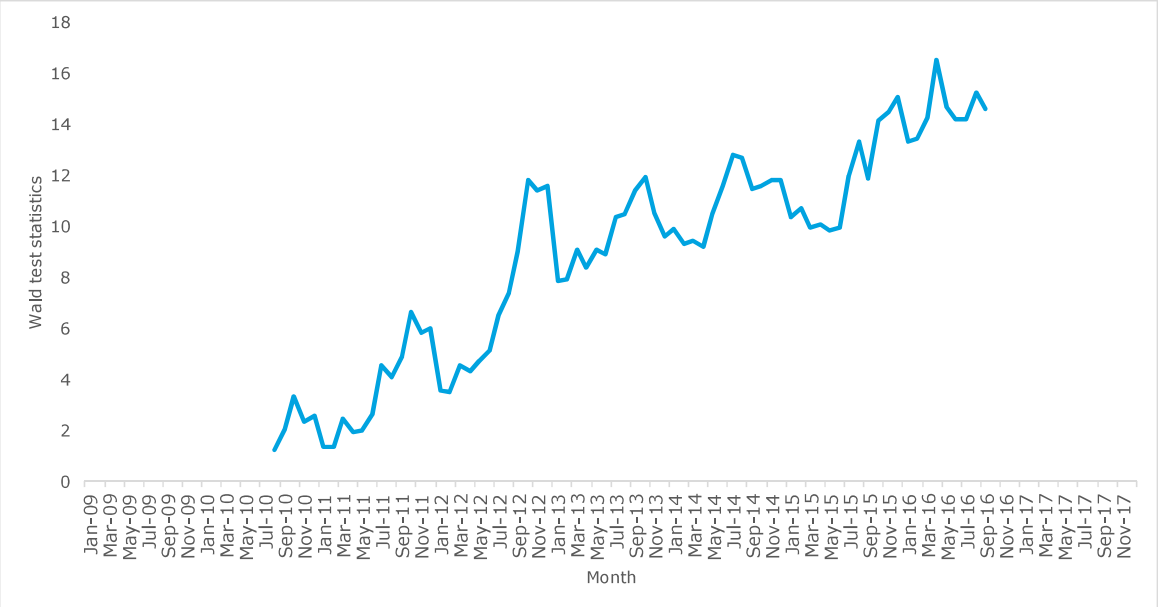



**Figure 41. Dynamics of parameter estimates in a rolling window recursive estimation of the AR model**

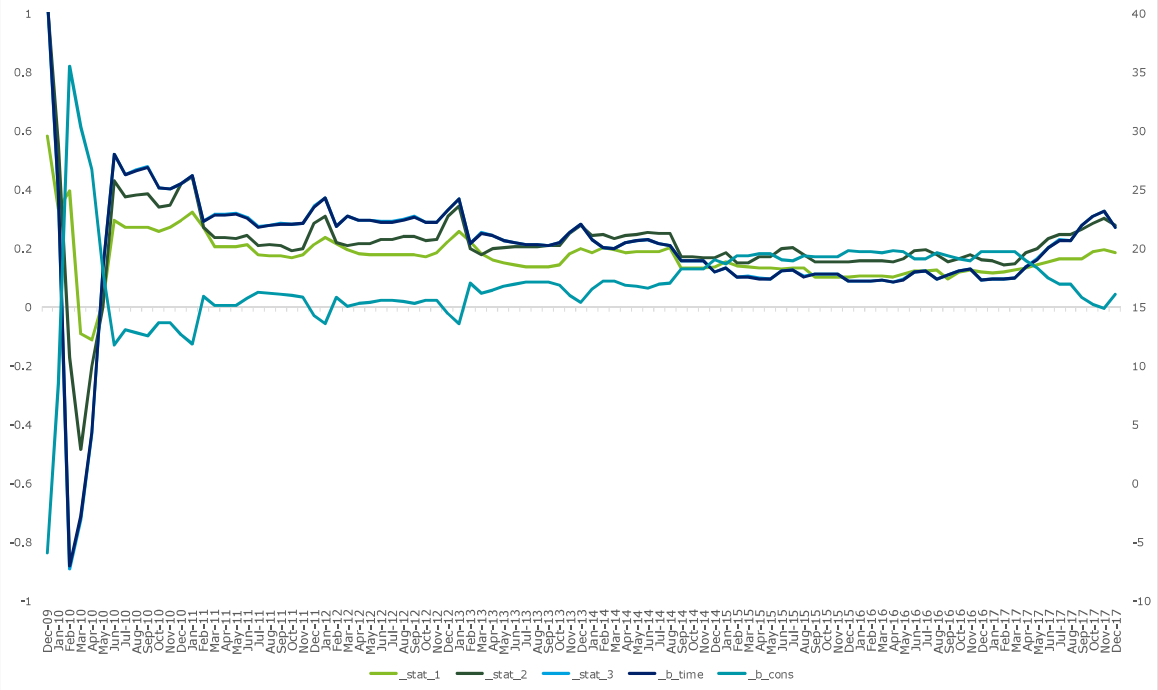


**Table 15: Estimation results. Model with price (sample: May 2012 - December 2017)**

| Variable | Coefficient | Standard Error | t | pvalue |
|---|---|---|---|---|
| **L.totalconsumption** | 0.458 | 0.141 | 3.247 | 0.002 |
| **L2.totalconsumption** | 0.138 | 0.113 | 1.217 | 0.230 |
| **L3.totalconsumption** | -0.026 | 0.113 | -0.230 | 0.819 |
| **D.p_tot** | -0.749 | 0.270 | -2.770 | 0.008 |
| **time** | -0.001 | 0.001 | -1.998 | 0.051 |
| **1.m** | -0.072 | 0.027 | -2.649 | 0.011 |
| **2.m** | -0.130 | 0.031 | -4.249 | 0.000 |
| **3.m** | -0.042 | 0.026 | -1.634 | 0.109 |
| **4.m** | -0.130 | 0.023 | -5.699 | 0.000 |
| **5.m** | -0.059 | 0.017 | -3.371 | 0.001 |
| **6.m** | -0.110 | 0.022 | -5.074 | 0.000 |
| **7.m** | -0.053 | 0.017 | -3.205 | 0.002 |
| **8.m** | -0.036 | 0.028 | -1.291 | 0.203 |
| **9.m** | -0.115 | 0.029 | -4.005 | 0.000 |
| **10.m** | -0.058 | 0.023 | -2.485 | 0.017 |
| **11.m** | -0.054 | 0.025 | -2.154 | 0.036 |
| **12b.m** | 0.000 | | | |
| **_cons** | 9.919 | 5.313 | 1.867 | 0.068 |

**Table 16: Estimation results. Model with price and PP dummy (sample: May 2012 - December 2017)**

| Variable | Coefficient | Standard Error | t | pvalue |
|---|---|---|---|---|
| **L.totalconsumption** | 0.413 | 0.130 | 3.179 | 0.003 |
| **L2.totalconsumption** | 0.107 | 0.107 | 0.995 | 0.325 |
| **L3.totalconsumption** | -0.078 | 0.111 | -0.707 | 0.483 |
| **D.p_tot** | -0.741 | 0.271 | -2.737 | 0.009 |
| **time** | -0.002 | 0.001 | -2.702 | 0.010 |
| **1.m** | -0.070 | 0.028 | -2.516 | 0.015 |
| **2.m** | -0.128 | 0.032 | -3.996 | 0.000 |
| **3.m** | -0.040 | 0.026 | -1.582 | 0.120 |
| **4.m** | -0.131 | 0.023 | -5.719 | 0.000 |
| **5.m** | -0.064 | 0.017 | -3.746 | 0.000 |
| **6.m** | -0.113 | 0.021 | -5.294 | 0.000 |
| **7.m** | -0.059 | 0.017 | -3.540 | 0.001 |
| **8.m** | -0.036 | 0.028 | -1.314 | 0.195 |
| **9.m** | -0.114 | 0.029 | -3.987 | 0.000 |
| **10.m** | -0.057 | 0.024 | -2.405 | 0.020 |
| **11.m** | -0.052 | 0.024 | -2.157 | 0.036 |

| | | | | |
|---|---|---|---|---|
| **12b.m** | 0.000 | | | |
| **PP** | 0.025 | 0.023 | 1.093 | 0.280 |
| **_cons** | 12.921 | 5.336 | 2.422 | 0.019 |

**Table 17: Model including the average of FMC and RYO price**

| Variable | Coefficient | Standard Error | t | pvalue |
|---|---|---|---|---|
| **L.totalconsumption** | 0.445 | 0.123 | 3.617 | 0.001 |
| **L2.totalconsumption** | 0.118 | 0.102 | 1.162 | 0.251 |
| **L3.totalconsumption** | -0.079 | 0.104 | -0.758 | 0.452 |
| **D.avp** | -0.921 | 0.265 | -3.477 | 0.001 |
| **time** | -0.002 | 0.001 | -2.659 | 0.011 |
| **1.m** | -0.073 | 0.027 | -2.721 | 0.009 |
| **2.m** | -0.129 | 0.030 | -4.244 | 0.000 |
| **3.m** | -0.039 | 0.025 | -1.587 | 0.119 |
| **4.m** | -0.133 | 0.022 | -6.069 | 0.000 |
| **5.m** | -0.064 | 0.017 | -3.784 | 0.000 |
| **6.m** | -0.113 | 0.021 | -5.463 | 0.000 |
| **7.m** | -0.060 | 0.016 | -3.688 | 0.001 |
| **8.m** | -0.035 | 0.027 | -1.336 | 0.188 |
| **9.m** | -0.105 | 0.026 | -4.027 | 0.000 |
| **10.m** | -0.056 | 0.023 | -2.471 | 0.017 |
| **11.m** | -0.052 | 0.023 | -2.265 | 0.028 |
| **12b.m** | 0.000 | | | |
| **PP** | 0.026 | 0.022 | 1.154 | 0.254 |
| **_cons** | 11.915 | 5.007 | 2.380 | 0.021 |

**Table 18: Model including RYO price as a separate explanatory variable**

| Variable | Coefficient | Standard Error | t | pvalue |
|---|---|---|---|---|
| **L.totalconsumption** | 0.6273 | 0.1077 | 5.8234 | 0.0000 |
| **L2.totalconsumption** | 0.0997 | 0.0765 | 1.3044 | 0.1986 |
| **L3.totalconsumption** | -0.1081 | 0.0739 | -1.4618 | 0.1506 |
| **D.p_tot** | -0.3889 | 0.1568 | -2.4801 | 0.0169 |
| **D.p_ryo** | -1.1586 | 0.1423 | -8.1430 | 0.0000 |
| **time** | -0.0011 | 0.0004 | -2.4207 | 0.0195 |
| **1.m** | -0.1073 | 0.0177 | -6.0770 | 0.0000 |
| **2.m** | -0.1417 | 0.0200 | -7.0926 | 0.0000 |
| **3.m** | -0.0244 | 0.0181 | -1.3506 | 0.1834 |
| **4.m** | -0.1471 | 0.0117 | -12.5653 | 0.0000 |
| **5.m** | -0.0675 | 0.0141 | -4.7831 | 0.0000 |
| **6.m** | -0.1259 | 0.0139 | -9.0308 | 0.0000 |

| | | | | |
|---|---|---|---|---|
| **7.m** | -0.0704 | 0.0122 | -5.7762 | 0.0000 |
| **8.m** | -0.0378 | 0.0183 | -2.0687 | 0.0442 |
| **9.m** | -0.0806 | 0.0136 | -5.9039 | 0.0000 |
| **10.m** | -0.0471 | 0.0147 | -3.1916 | 0.0026 |
| **11.m** | -0.0626 | 0.0143 | -4.3774 | 0.0001 |
| **12b.m** | 0.0000 | | | |
| **PP** | 0.0267 | 0.0175 | 1.5271 | 0.1336 |
| **_cons** | 8.8053 | 3.1037 | 2.8370 | 0.0068 |

### *A2.6 Difference-in-difference regression model*

The difference-in-difference analysis we carry out follows the analysis in Dryden (2017) and estimates the following model:

$$y_{cjk} = \alpha + \beta_1 AUS_c + \beta_2 PP_{jk} + \beta_3 AUS_c * PP_{jk} + \sum_j \beta_{4,j} year_j + \sum_k \beta_{5,k} month_k +$$
$$+ \sum_h \beta_{6,h} control^h_{cjk} + \sum_h \beta_{7,h} control^h_{cjk} * AUS_c + \varepsilon_{cjk}$$

where y stands for per capita cigarettes consumption and c, j and k refer, respectively, to country, year and month. AUS is a dummy for Australia and PP, as usual, is a dummy for Plain Packaging Regulation. Therefore, the interaction AUS*PP represents the coefficient for the effect of Australian Plain Packaging Regulation on consumption. The year and month variables are respectively year-based and month-based dummies. The model also include a set of control variables for price, excise, per capita GDP and time effects. In Model 1, we control for the effect of excise taxes on consumption per capita, and in Model 2 we control for the indirect effects of taxes on consumption via prices.

The model above has been estimated through OLS (Model 1) and 2SLS - IV (Model 2). In Model 2 the logarithm of price has been instrumented, being estimated as a function of the logarithm of excise taxes, quarterly inflation (in levels and in squares), and respective interactions with a AUS dummy. In Table 19 we can observe that the interaction AUS*PP is significant at the standard 10% level.

**Table 19. Difference-in-difference regression model. P-values in brackets**

| VARIABLES | (1) OLS - Dec - Nominal log_volume_pc | (2) IV - Dec - Nominal log_volume_pc |
|---|---|---|
| **d_AUS** | 1.226*** | 2.166*** |
| | (0.005) | (0.000) |
| **d_PP_Dec** | 0.007 | 0.006 |
| | (0.712) | (0.746) |
| **d_AUS*PP_Dec** | 0.026+ | 0.021+ |
| | (0.070) | (0.084) |
| **log_Excise** | -0.219*** | |
| | (0.000) | |
| **log_Excise_AUS** | -0.081** | |
| | (0.039) | |
| **log_gdp_pc** | 0.346*** | 0.400*** |
| | (0.000) | (0.000) |
| **log_gdp_pc_AUS** | 0.046 | 0.286*** |
| | (0.675) | (0.007) |
| **_Imonth_2** | -0.101*** | -0.098*** |
| | (0.000) | (0.000) |
| **_Imonth_3** | -0.029*** | -0.020*** |
| | (0.001) | (0.007) |
| **_Imonth_4** | -0.097*** | -0.092*** |
| | (0.000) | (0.000) |
| **_Imonth_5** | -0.087*** | -0.084*** |
| | (0.000) | (0.000) |
| **_Imonth_6** | -0.137*** | -0.136*** |
| | (0.000) | (0.000) |
| **_Imonth_7** | -0.101*** | -0.098*** |
| | (0.000) | (0.000) |
| **_Imonth_8** | -0.091*** | -0.086*** |
| | (0.000) | (0.000) |
| **_Imonth_9** | -0.124*** | -0.115*** |
| | (0.000) | (0.000) |
| **_Imonth_10** | -0.097*** | -0.098*** |
| | (0.000) | (0.000) |
| **_Imonth_11** | -0.093*** | -0.094*** |
| | (0.000) | (0.000) |
| **_Imonth_12** | 0.002 | 0.003 |
| | (0.853) | (0.797) |
| **_Iyear_2010** | -0.037*** | -0.013 |
| | (0.000) | (0.204) |
| **_Iyear_2011** | -0.040*** | -0.001 |
| | (0.006) | (0.967) |
| **_Iyear_2012** | -0.073*** | -0.016 |
| | (0.000) | (0.493) |
| **_Iyear_2013** | -0.120*** | -0.039 |

| | | |
|---|---|---|
| | (0.000) | (0.277) |
| **_Iyear_2014** | -0.127*** | -0.034 |
| | (0.000) | (0.420) |
| **_Iyear_2015** | -0.132*** | -0.013 |
| | (0.000) | (0.799) |
| **_Iyear_2016** | -0.158*** | -0.026 |
| | (0.000) | (0.643) |
| **_Iyear_2017** | -0.266*** | -0.109* |
| | (0.000) | (0.090) |
| **log_price** | | -0.438*** |
| | | (0.000) |
| **log_price_AUS** | | -0.167*** |
| | | (0.000) |
| **Constant** | 4.605*** | 4.819*** |
| | (0.000) | (0.000] |
| | | |
| **Observations** | 216 | 216 |
| **R-squared** | | 0.999 |
| **Adjusted R-squared** | 0.998 | 0.998 |

*Level of confidence ***0.001 **0.01 *0.05 +0.1*

## B. About The Authors

**Raffaele Oriani** is an Full Professor of Corporate Finance at the Department of Business and Management of Luiss Guido Carli University of Rome. He is the MBA Director and Associate Dean for post-graduate programmes at Luiss Business School. He obtained a Ph.D. in Management from the University Bologna and he has been visiting scholar at the Department of Economics of the University of California at Berkeley. He has several publications on the topics of economics, finance and management in primary international academic journals, including Strategic Management Journal, Organization Science, Industrial and Corporate Change, Advances in Strategic Management, International Journal of Industrial Organization, Research Policy, Quarterly Review of Economics and Finance and Scientometrics.

**Marco Spallone** is an Associate Professor of Economics at the University of Chieti and Pescara, with teaching and research appointments at Luiss Guido Carli University and Temple University. He is the Deputy Director of CASMEF (Arcelli Centre for Monetary and Financial Studies) at Luiss Guido Carli University. He obtained a Ph.D. in Economics at NYU. He is in charge of several research projects in the field of banking, taxation, and regulated markets, both at national and international level. He has several publications in economics, banking, finance and taxation in primary international academic journals, including Theory and Decision, Journal of Behavioral and Experimental Economics, European Journal of Law and Economics, and North American Journal of Economics and Finance.

**Marco Vulpiani** holds a Ph.D. in Business Administration from the University of Rome "Tor Vergata" a Master of Science in Business Administration from the University of Rome "Tor Vergata" and a Master's Degree in Aeronautical Engineering from the University of Rome "La Sapienza". He has over 25 years of professional experience mainly in Business Valuation. As a Senior Partner of Deloitte, he is the Firm's Head of the "Valuation, Modelling and Economics" service line in Italy. He serves on the Deloitte Global Valuation Executive Committee and is a member of the Management Board of the Italian valuation standard setter "Organismo Italiano di Valutazione" (OIV). Marco is also an Adjunct Professor of "Business Valuation" at Luiss Guido Carli University of Rome and Adjunct Professor in the MBA, Master in Corporate Finance and Executive Master in Finance at Luiss Business School. He is author of several articles and publications (among which includes the book "Special Cases of Business Valuation", McGraw-Hill).

Prof. Stefano Nasini

(with the support of Prof. Mikayel Vardanyan)

Dept. of Economics and Quantitative Methods

IÉSEG School of Management

External review of

# Analysis of the impact of Plain Packaging on smoking prevalence and tobacco consumption in Australia

# 1. Summary description

The research report "Analysis of the impact of Plain Packaging on smoking prevalence and tobacco consumption in Australia" presents a comprehensive econometric analysis of the impact of the introduction of Plain Packaging regulation in Australia on smoking prevalence and legal tobacco consumption. After conducting a detailed review of the research project and the analysis, I outline below a final opinion on the appropriateness of the applied methodology and correctness of the reported results in the report.

# 2. Is the methodology appropriate for the analysis of the problems investigated and correctly applied?

The research report describes the different types of econometric analysis adopted to test the impact of the introduction of Plain Packaging on both smoking prevalence and tobacco consumption. The following list summarizes the different methodologies and statistical assessment, pointing out the appropriateness of their usage.

a. As regards smoking prevalence, a probit regression model has been applied to study the smoking status component of the Roy Morgan Single Source ("RMSS") survey – a cross-sectional survey of a nationally representative sample of Australian individuals aged 14 and over – covering the period from 2001 to December 2017. The dependent variable takes the value of zero if the respondent does not smoke and one if the respondent smokes. The usage of a probit model is appropriate for this type of survey data and the set of explanatory variables employed in the model are appropriate for this type of analysis; and the methodology has been correctly applied.

b. As regards legal tobacco consumption, a number of methods are employed to assess the impact of Plain Packaging using retail audit sales data covering the period from January 2008 to December 2017:

i. Firstly, a non-parametric approach has been used to carry out a before-and-after evaluation of the smoking prevalence and tobacco consumption,

using New Zealand as a comparative case (control group), which has not been subject to the introduction of the Plain Packaging (treatment). The methodology that is applied is useful for providing a preliminary assessment of the separate effects of the implementation of Plain Packaging from other characteristics that could affect tobacco consumption, and it has been correctly applied.

ii. Secondly, a structural break analysis has been implemented to assess the moment in which a break in the cigarette consumption time series happens. The usage of the Chow test is appropriate and has been correctly applied to assess whether there is a structural exogenous break in the consumption pattern at a given date. The results reveals that there has not been any specific change in the cigarette consumption trend in Australia as a result of the introduction of Plain Packaging.

iii. Thirdly, a regression analysis has been performed taking the cigarette consumption as a dependent variable and Plain Packaging with a set of other explanatory variables as independent variables. The inclusion of the Plain Packaging as a dummy variable into the structural model is suitable to test the impact of Plain Packaging, and the set of explanatory variables employed in the model are appropriate for this type of analysis; and the methodology has been correctly applied.

iv. Finally a difference-in-differences regression model has been performed on per capita cigarettes consumption up to December 2017, including also New Zealand as a comparator. This is in line with the study of Dryden (2017) and suggests that plain packaging is associated with a statistically significant (to the 10% level) increase in per capita cigarettes consumption.

## 3. Are the results correctly reported?

The research report has been competently written and includes a sufficiently large amount of technical details, to explain the adopted methodology and obtained results. The results have been correctly reported and interpreted, providing a clear understanding of the impact of Plain Packaging regulation in Australia on smoking prevalence and tobacco consumption.

## 4. Does the analysis meets the standard and rigor needed for publication in an academic journal?

The empirical research presented in the report constitutes an extensive and rigorous econometric study to analyse the underlying patterns of smoking prevalence and tobacco consumption and to assess the impact of the introduction of Plain Packaging.

This research makes use of inclusive data sets, which facilitate the application of a large battery of statistical approaches. As examined in the previous subsections, the applied methodologies cover the main aspects of the analysed phenomenon and have been appropriately applied to the described empirical setting, in line with the state-of-the-art contributions in this field.

The inclusion of supplementary appendixes provides a comprehensive assessment of the robustness of applied methodologies, and an explanation of the technical aspects which are relevant to support the correctness of the obtained results.

Professor Stefano Nasini

8 November 2019

**W. KIP VISCUSI**

# AN ASSESSMENT OF THE EFFECT OF AUSTRALIAN PLAIN PACKAGING REGULATION: ANALYSIS OF ROY MORGAN RESEARCH DATA, CITTS DATA, AND NTPPTS DATA:

**2 JANUARY 2018**

## I. INTRODUCTION

1. I am the University Distinguished Professor of Law, Economics, and Management at Vanderbilt University. I hold a Bachelor's degree in Economics, two master's degrees, and a Ph.D. in economics, all from Harvard University. I have published more than 350 articles and 20 books dealing primarily with health and safety risks, and I have been ranked among the top 25 economists in the world based on citations in economics journals. I worked extensively with the U.S. Environmental Protection Agency ("EPA") on a continuous basis from 1983 to 2012, where much of my work was focused on the development of guidelines for hazard warnings for dangerous pesticides and chemicals. I also have extensive professional experience evaluating regulatory impact analyses and the economic methodology used in benefit-cost analysis, including being the Deputy Director of the President's Council on Wage and Price Stability from 1979–1980, which was responsible for White House oversight of all new federal regulations during that period as well as executive branch review of all regulatory impact analyses. Further details of my educational background and professional experience are set out in Appendix D of this report.

2. I have been asked to provide a report that examines empirical data from Australia to see what effect, if any, plain packaging of tobacco products[1] ("Plain Packaging" or "PP") has had on smoking behaviors in Australia following its implementation.[2]

3. In particular I have been requested to:

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[1] Plain packaging, also known as standardized packaging, generally refers to regulation that requires the removal of all branding (colors, imagery, corporate logos and trademarks) from product packaging, permitting manufacturers to print only the brand name in a mandated size, font, and place on the pack, in addition to the health warnings and any other legally mandated information. The appearance of all tobacco packs is also standardized, including the color of the pack.

[2] Plain Packaging was introduced in Australia under the Tobacco Plain Packaging Act 2011, No. 148, 2011 with all tobacco products sold in Australia required to comply with the requirements from December 1, 2012.

a. Review the following datasets:

i. Roy Morgan Single Source Survey ("RMSS") data: a nationally representative, repeated cross-sectional survey of Australians aged 14 and above covering the period from January 2001 to December 2016.

ii. The Australian National Tobacco Plain Packaging Tracking Survey ("NTPPTS") data: A continuous survey of Australian smokers and recent ex-smokers commissioned by the Australian Government's Department of Health and Ageing to evaluate the impact of changes in the packaging of tobacco products in Australia for the period from 9 April 2012 to 30 March 2014.[3]

iii. The Cancer Institute New South Wales (NSW) Tobacco Tracking Survey ("CITTS") data: a serial, weekly cross-sectional survey of adult smokers and recent quitters in New South Wales, Australia, for the period from February 2009 to June 2016.[4]

b. Review and comment on the following publications in relation to the above datasets:

i. Analysis of the Australian RMSS data presented in:

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[3] The data collected in the National Tobacco Plain Packaging Tracking Survey is available on request from the Australian Department of Health, see http://www.health.gov.au/internet/main/publishing.nsf/content/tobacco-plain-packaging-evaluation, accessed 29 June 2017. See also the Australian National Tobacco Plain Packaging Tracking Survey: Technical Report, available at http://tobaccocontrol.bmj.com/content/suppl/2015/02/16/tobaccocontrol-2014-052050.DC1/tobaccocontrol-2014-052050supp.pdf, accessed 29 June 2017.

[4] I have previously addressed the CITTS data and NTPPTS data in reports that I submitted for British American Tobacco in October 2015 in UK legal proceedings in which PP was being challenged, and in November 2015 in relation to the Australian Government Department of Health Post-Implementation Review of the Tobacco Plain Packaging Act 2011 (Aus). My current report provides a more extensive analysis of these data including detailed multivariate controls, an empirical assessment of additional CITTS data, and a longer time period for the CITTS data, and also examines aspects of the cohort component of the NTPPTS data that I did not consider previously. In addition, this report also includes an analysis of the RMSS data, which I have not considered previously.

- The report of Dr. Tasneem Chipty entitled "Study of the Impact of the Tobacco Plain Packaging Measure on Smoking Prevalence in Australia" (January 24, 2016), which was commissioned by the Australian Department of Health and is the only econometric analysis of data that is relied on in the Australian Government's Post Implementation Review Report of the Australian Tobacco Plain Packaging Act 2011 ("TPP Act") published in February 2016.[5]
- Diethelm and Farley (2015) "Refuting tobacco-industry funded research: empirical data shows a decline in smoking prevalence following the introduction of plain packaging in Australia."[6]

ii. Analysis of the Australian NTPPTS data presented in several papers published in *Tobacco Control*, (April 2015), Volume 24, Suppl. 2, titled "Implementation and evaluation of the Australian tobacco Plain Packaging policy,"[7] which papers are also relied on in the Australian Post Implementation Review Report;[8] and

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5 The Australian Post Implementation Review Report and its appendices, including Dr. Chipty's report are available on the Australian Government Office of Best Practice Regulation website at http://ris.dpmc.gov.au/2016/02/26/tobacco-plain-packaging/, accessed 29 June 2017. Some program codes and data files relating to Dr. Chipty's report are also available on request from the Australian Department of Health at http://www.health.gov.au/internet/main/publishing.nsf/Content/foi-disc-log-2015-16, accessed 29 June 2107.

6 Pascal A Diethelm, Timothy M Farley, "Refuting tobacco-industry funded research: empirical data shows a decline in smoking prevalence following the introduction of plain packaging in Australia," Tob. Prev. Cessation 2015;1(November):6 http://dx.doi.org/10.18332/tpc/60650.

7 Available at http://tobaccocontrol.bmj.com/content/24/Suppl_2.toc. The papers in this publication that analyze the Australian NTPPTS data are:

- Melanie Wakefield, Kerri Coomber, Meghan Zacher, Sarah Durkin, Emily Brennan, and Michelle Scollo, "Australian Adult Smokers' Responses to Plain Packaging with Larger Graphic Health Warnings 1 Year after Implementation: Results from a National Cross-Sectional Tracking Survey," Tobacco Control 2015;24:ii17-ii25. doi:10.1136/tobaccocontrol- 2014-052050;

iii. Analysis of the New South Wales CITTS data presented in Dunlop et al (2014) "Impact of Australia's Introduction of Tobacco Plain Packs on Adult Smokers' Pack-Related Perceptions and Responses: Results from a Continuous Tracking Survey,"[9] which is also relied on in the Australian Post Implementation Review Report.

c. Review the Australian Government's Post Implementation Review Report of TPP Act published in February 2016 (the "PIR"),[10] and comment on the validity of the conclusions expressed in the report regarding the impact of Plain Packaging on smoking behaviors.

4. To the best of my knowledge, the analysis of Australian data that I provide in this report is the most up to date and comprehensive analysis of the data that has been provided to date. In particular:

a. My analysis of the RMSS data extends through December 2016, thus providing 15 more months of data in the post-PP period than analyzed in the report of Dr.

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- Sarah Durkin, Emily Brennan, Kerri Coomber, Meghan Zacher, Michelle Scollo, and Melanie Wakefield, "Short-Term Changes in Quitting-Related Cognitions and Behaviours after the Implementation of Plain Packaging with Larger Health Warnings: Findings from a National Cohort Study with Australian Adult Smokers," Tobacco Control 2015;24:ii26-ii32. doi:10.1136/tobaccocontrol-2014-052058;
- Emily Brennan, Sarah Durkin, Kerri Coomber, Meghan Zacher, Michelle Scollo, and Melanie Wakefield, "Are Quitting-Related Cognitions and Behaviours Predicted by Proximal Responses to Plain Packaging with Larger Health Warnings? Findings from a National Cohort Study with Australian Adult Smokers," Tobacco Control 2015;24:ii33-ii41. doi:10. 1136/tobaccocontrol-2014-052057; and
- Michelle Scollo, Meghan Zacher, Kerri Coomber, Megan Bayly, and Melanie Wakefield, "Changes in Use of Types of Tobacco Products by Pack Sizes and Price Segments, Prices Paid and Consumption Following the Introduction of Plain Packaging in Australia," Tobacco Control 2015;24:ii66-ii75.

[8] Supra at footnote 5.

[9] Sally M. Dunlop, Timothy Dobbins, Jane M. Young, Donna Perez, and David C. Currow, "Impact of Australia's Introduction of Tobacco Plain Packs on Adult Smokers' Pack-Related Perceptions and Responses: Results from a Continuous Tracking Survey," *BMJ Open* 2014; 4(12): e005836, Available at http://bmjopen.bmj.com/content/bmjopen/4/12/e005836.full.pdf.

[10] Supra at footnote 5.

Chipty and 3 additional years of data in the post-PP period than in Diethelm and Farley (2015);

b. My analysis of the Australian NTPPTS data and the New South Wales CITTS data includes an analysis of all of the survey outcomes, rather than a selection of the outcomes as presented in the published papers on these data. Also, unlike the the Australian Government's Australian Post Implementation Review Report which simply relies on the conclusions from the published papers on these data, I also undertake a review of the papers and analyze the underlying data; and

c. My analysis of the CITTS data includes a longer time period than in any published study as it extends through June 2016, which includes an additional 37 months of data from that considered by Dunlop et al. (2014) in their analysis of the CITTS data.

5. As noted in the report of Dr. Chipty, at the same time that Australia introduced tobacco Plain Packaging it also introduced updated and enlarged graphic health warnings on tobacco product packaging under the Competition and Consumer (Tobacco) Information Standard 2011 (which included expanding the size of the warning on the front of the pack from 30% to 75%). Given the timing of these changes, it is not possible to separately identify the effects of tobacco Plain Packaging from those of the updated and enlarged graphic health warnings without making restrictive assumptions. As such, my discussion of the effects of Plain Packaging encompasses the effects from both of these changes, which I refer to collectively as the "2012 Packaging Changes" (as is also the case with Dr Chipty's analysis in her report).

## II. EXECUTIVE SUMMARY

6. In this report I provide a comprehensive analysis of three key datasets from Australia, namely: 4 years of post-implementation RMSS data; 3 ½ years of post-implementation CITTS data; and the Australian Government commissioned NTPPTS data. My use of a longer post-implementation time frame for my analysis than in any previous study provides a stronger test of the impact of the 2012 Packaging Changes if, as some have suggested, the effect of the policy change would increase over time. Each of these datasets provides somewhat different perspectives, and no single dataset is complete in terms of addressing both smoking prevalence and various attitudinal responses to plain packs, or what are sometimes referred to as intermediate metrics. However, despite the different perspectives provided by these data, the implication of my analysis of the three datasets yields a consistent conclusion that there is no evidence of the 2012 Packaging Changes having any impact on reducing smoking prevalence rates or consumption amongst current smokers. There is also consistent evidence that the policy is associated with counterproductive effects on some of the intermediate or secondary measures that are relied upon in the Australian Government's Australian Post Implementation Review Report and by other proponents to promote Plain Packaging.[11] Chief among these potentially counterproductive effects is that there has been an increase in the belief that the warnings exaggerate the risks. Other impacts, such as the effects on quitting behavior and smoking rates, are more mixed. On balance, these results undermine any conclusion that the 2012 Packaging Changes have had a net beneficial effect. In particular:

[11] See e.g. World Health Organization, Regional Office for Europe, (2014) "Evidence Brief Plain packaging of tobacco products: measures to decrease smoking initiation and increase cessation"; and McNeill A, Gravely S , Hitchman SC, Bauld L, Hammond D, Hartmann-Boyce J. "Tobacco packaging design for reducing tobacco use". Cochrane Database of Systematic Reviews 2017, Issue 4. Art. No.: CD011244. DOI: 10.1002/14651858.CD011244.pub2 .

a. My analysis of the RMSS data, which includes 15 additional months of data in the post-2012 Packaging Changes period than was considered in the report of Dr. Chipty, and 3 years of additional data in the post-2012 Packaging Changes period than was addressed in Diethelm and Farley (2015), found that the estimated statistical association of the 2012 Packaging Changes with smoking prevalence rates is zero. Instead, my analysis of the RMSS data found that the decline in smoking prevalence rates in Australia is a continuation of past nonlinear time trends, overall economic trends such as the general Australian consumer price index, and influences such as rising cigarette prices, and is not significantly related to the adoption of the 2012 Packaging Changes. The only sound conclusion based on this evidence is that the 2012 Packaging Changes are not associated with any change in smoking prevalence rates.

b. An evaluation of the CITTS and NTPPTS data relating to actual cigarette consumption behavior in Australia indicates that the 2012 Packaging Changes have not been associated with a decrease in smoking behaviors amongst current smokers. The results for the CITTS sample are mixed, with no clear cut evidence of efficacy. The number of cigarettes smoked per day experienced a statistically significant increase of about one cigarette. There has also been a change in the distribution of smoking activity. More respondents report that they smoke daily, fewer report that they smoke at least weekly (not daily), fewer report that they smoke less often than weekly, and a statistically insignificant larger number report that they currently smoke not at all, though they did smoke in the last year. Within the NTPPTS sample, there is no statistically significant change in the

number of cigarettes smoked per day.[12] My analysis of the CITTS data includes a longer time period than in any published study as it extends through June 2016, which includes an additional 37 months of data beyond that considered in Dunlop et al. (2014).[13]

c. There is also consistent evidence from the CITTS and NTPPTS data indicating an unfavorable association of the 2012 Packaging Changes with a number of so called intermediary metrics (e.g., increasing the efficacy of health warnings) even setting aside issues pertaining to the efficacy of these intermediate variables in predicting actual smoking behaviors. For example, my analysis of the CITTS data shows that after the implementation of 2012 Packaging Changes in Australia:

i. respondents rate it significantly more difficult to quit both in terms of how difficult it would be to quit and how difficult they thought it would be to quit, and respondents are significantly less confident that they can quit, which is an impact that could arise if the policy made consumers think that quitting would be a more formidable challenge; and

ii. there is a statistically significant 16% increase in whether respondents believe that the graphic warning labels policy exaggerate the risk of smoking, a statistically significant 7% increase in beliefs that the government pesters people too much about smoking risks, a statistically

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[12] I note that consistent with my analysis, Scollo et al. (2015), which is the only published study of the NTPPTS data that discusses the data on actual consumption behavior, also found that the 2012 Packaging Changes had no impact on consumption: see Michelle Scollo, Meghan Zacher, Kerri Coomber, Megan Bayly, and Melanie Wakefield, "Changes in Use of Types of Tobacco Products by Pack Sizes and Price Segments, Prices Paid and Consumption Following the Introduction of Plain Packaging in Australia," *Tobacco Control* 2015;24:ii66-ii75.

[13] Sally M. Dunlop, Timothy Dobbins, Jane M. Young, Donna Perez, and David C. Currow, "Impact of Australia's Introduction of Tobacco Plain Packs on Adult Smokers' Pack-Related Perceptions and Responses: Results from a Continuous Tracking Survey", *BMJ Open* 2014; 4(12): e005836;

significant 5% increase in beliefs that the health effects are exaggerated, and a statistically significant 3% increase in the belief that smoking is only harmful to heavy smokers. These result could arise from defensive processes and increased reactance activated by the the 2012 Packaging Changes, leading to an increased degree of rejection of the graphic warnings message.

d. My analysis of the NTPPTS data also shows that after the implementation of the 2012 Packaging Changes in Australia:

i. respondents were less likely to think about quitting either once or once every few days over the previous week, less likely to stub out many times after the policy, and were less likely to stop many times upon having the urge to smoke;

ii. there was a decrease in the number of respondents who intend to quit smoking in the next month, and a decrease in the number of respondents who stub out their cigarette many times after thinking about the harms of smoking; and

iii. there is no statistically significant impact on beliefs regarding the harmfulness of cigarettes; zero effects with respect to all categories of responses regarding whether the person thinks about the money spent on cigarettes; and an increase in the agreement that the dangers are exaggerated.

7. The evidence of a lack of impact of the of the 2012 Packaging Changes in Australia and of a number of potentially counterproductive effects is not unexpected given that

consumers are informed of the risks of smoking and the 2012 Packaging Changes do not provide any new information to consumers. An assumption that making the warnings larger and more prominent will increase their effectiveness is misplaced. There is no empirical evidence that "shouting" works in increasing behavioral compliance in this context where no new information is being provided. The evidence of negative outcomes is also consistent with research that demonstrates that fear-based warnings may in fact elicit responses that are the opposite of their intended effect.

8. In this report, I also evaluate and provide a critique of previous analysis of the Australian RMSS data presented in the report by Dr. Tasneem Chipty and in Diethelm and Farley (2015):

   a. The report by Dr. Tasneem Chipty was commissioned by the Australian Department of Health to assess the impact of Plain Packaging on smoking prevalence in Australia, and is the only econometric analysis of data that seeks to identify the actual effect of the 2012 Packaging Changes on smoking that is relied on in the Australian Post Implementation Report. As explained below, I have identified several flaws in in Dr. Chipty's approach that render it unreliable, namely:

      i. the use of overlapping indicator variables which create confounding effects, meaning that any conclusions drawn from Dr. Chipty's analysis are highly speculative;

      ii. the use of a linear time trend when the time trend is nonlinear. Dr. Chipty's procedure violates basic principles of statistical analysis since she reported no statistical tests of the use of a linear trend as opposed to a

nonlinear trend. Capturing any nonlinear relationship with a linear trend line, as Dr. Chipty does, leads to an unexplained "policy impact" that is spurious, as it is not an effect of the policy but instead reflects an underlying nonlinear trend; and

iii. the use of indicator variables only for the major tax increases that occurred in Australia, which fails to recognize the continuous nature of excise tax levels and generates a source of error in the treatment of taxes; and

iv. the failure to include a cigarette price variable in her model which is the most important variable in models of the economic demand for any consumer product.

As a result of these shortcomings, the report of Dr Chipty provides no sound evidence in support of the efficacy of plain packs policies**. The two most important flaws in her study were the failure to consider the nonlinearity of the temporal trend in smoking prevalence rates and the omission of cigarette prices from the model.**

v. Three principal results from the RMSS data analysis are apparent in both the analysis of the extended dataset that I used, as well as in my analysis of the shorter time period considered in Dr. Chipty's report:

- Properly recognizing that the temporal trend is nonlinear rather than linear (as Dr. Chipty wrongly assumes) alone accounts for the downward trend in smoking rates;
- Even with only a linear trend, reasonable specifications of the model using either overall consumer prices or continuous measures

of the recommended retail price of cigarettes rather than the crude excise tax indicator variables approach used by Chipty eliminates the statistical significance of the 2012 Packaging Changes variable. It is only by ignoring both the nonlinearity of the smoking prevalence time trend and the role of prices, as Dr. Chipty does, that it is possible to generate non-zero statistically significant estimates of the 2012 Packaging Changes variable; and

- Third, even if there were a purported association of the 2012 Packaging Changes with smoking prevalence based on Dr. Chipty's analysis, one should be skeptical of the import of these results given that her statistical analysis includes four overlapping indictor variables for the 2010 to 2015 period. Given her statistical format, it is difficult to disentangle the effect of the multiple policy shifts that occurred around the 2012 period. Attributing the lower smoking prevalence rates to the 2012 Packaging Changes as opposed to the excise tax increases both before and after the advent of the 2012 Packaging Changes policy is not warranted.

vi. Properly specified multivariate regression analyses that corrects for the flaws in Dr. Chipty's analysis demonstrates that the estimated effect of the 2012 Packaging Changes on the smoking prevalence rate cannot be distinguished statistically from zero. As noted above, I also extended Dr. Chipty's data period with an additional 15 months of data through to December 2016 and found that the impact of the 2012 Packaging Changes

on smoking prevalence rates cannot be distinguished statistically from zero for this longer time period as well.

b. The article by Diethelm and Farley (2015) is identified as the only published study that assesses the impact of Plain Packaging on smoking prevalence, in a recent Cochrane review of the plain packing literature that was published in April 2017 (the "Cochrane Review").[14] However, as I explain below, the article lacks scientific validity for several reasons:

i. The authors had no original data, but instead relied on estimates of monthly averages inferred from a figure in a working paper by Kaul and Wolf.[15] As a result, their sample size for their analysis only included 156 imputed monthly average figures, not the more than 700.000 individual observations in the Kaul & Wolf sample.[16] While the authors express concern about the possible error in imputing data based on the chart in Kaul and Wolf, the more important limitation is that the aggregation of the data by month reduces the informational content of the data and prevents the ability to match any data to particular respondents;

ii. Because of this reliance on monthly average data the authors have no information by individual respondent and consequently their analysis includes no controls in the model for individual characteristics such as

[14] McNeill, A., Gravely, S., Hitchman, S.C., Bauld, L., Hammond, D., and Hartmann-Boyce, J., "Tobacco Packaging Design for Reducing Tobacco Use," Cochrane Database of Systematic Reviews 2017, Issue 4, Art. No.: CD011244.

[15] Kaul, A. and Wolf, M. "The (Possible) Effect of Plain Packaging on Smoking Prevalence in Australia: A Trend Analysis," University of Zurich Department of Economics Working Paper, June 2014.

[16] I note that the Diethelm and Farley (2015) sample size is wrongly listed as 700,000 on p. 4 of the Cochrane Review.

age, gender, education, income level, and region, and changes in the sample composition that may have occurred over time.

iii. In addition to ignoring all demographic variables, the Diethelm and Farley (2015) article also omitted other key determinants of smoking prevalence rates. Cigarette prices are not included in the model. Excise tax rates are ignored except in terms of a single tax shift. Also, the nonlinear nature of the smoking prevalence rates before the advent of plain packaging is not taken into account.[17]

iv. The net impact of these flaws is that this study lacks any scientific credibility. The deficiencies I cited are not minor limitations nor matters of a difference of opinion, but are fundamental problems that make it inappropriate to rely on their study.

v. I note that the Cochrane Review graded the quality of the Diethelm and Farley (2015) paper as "low" (p.4), which is an assessment I believe nevertheless actually overstates the quality of the paper for the reasons stated above. Had the Cochrane Review also taken into account the factors I cite above, the article's value would be below the rating of "low," as it should not be regarded as having any scientific merit at all.

9. My examination of the outputs of each of the CITTS and NTPPTS datasets also indicates that the published articles analyzing these data are disturbing from the standpoint of academic integrity and are highly misleading. Rather than provide an unbiased assessment of the survey results, the studies present selected findings that purport to

[17] Diethelm and Farley (2015) faulted the study by Kaul and Wolf, which discarded the first 42 months of observations because they were not consistent with a linear trend. However, Diethelm and Farley (2015) do not present any statistical tests supporting the validity of a linear trend.

demonstrate the efficacy of the 2012 Packaging Changes policy which a more thorough analysis of the data shows is misleading. In particular, these studies have ignored substantial evidence from the same Australian datasets they purport to analyze; which evidence is consistent with a lack of efficacy of the 2012 Packaging Changes and underscores the point that the post-implementation publications analyzing these data have selectively and misleadingly presented the results they do present. Viewed in their entirety, the datasets consistently indicate that the 2012 Packaging Changes are not associated with any reduction in smoking behaviors. Empirical assessments are biased if a researcher only cites the results that portray a policy in a positive light and fails to report the evidence that indicates not only a lack of a favorable impact, but also rather important counterproductive effects. A comprehensive analysis of a broader set of questions in the CITTS and NTPPTS datasets leads to the conclusion that on balance the 2012 Packaging Changes policy is not working.

10. The fact that these articles are peer reviewed does not provide any assurance that the analyses and conclusions of the papers are valid. I have served for three decades as the founding editor of a peer-reviewed journal and have been on the editorial boards of 20 other peer-reviewed journals. Peer review only means that one or more persons in the field has reviewed the article and has recommended publication of it. The peer reviewers do not generally have access to the data used in the article to replicate the study. Reviewers typically only read the article to assess whether the methodology and findings appear to be sound and novel contributions. Other researchers who have access to the original data often can undertake a more thorough analysis than in a peer review, as I have done with the data that I have reviewed.

11. Similar to my review of the data, the only consistent evidence that the recent Cochrane Review of the Plain Packaging literature found was that Plain Packaging was associated with a decrease in the appeal of the pack. However, the responses to these questions could be a result of the increase in the size of the warning to 75% that result in the packs being dominated by graphic health warnings, rather than Plain Packaging. Indeed the Cochrane Review highlights the high risk of confounding in these studies given that Plain Packaging was introduced alongside enhanced health warnings in Australia making it difficult to isolate the effects of Plain Packaging. For studies that focused on the effects of Plain Packaging on actual behavioral outcomes, including smoking prevalence and consumption, the Cochrane Review concluded that the confidence in the findings was "limited, due to the nature of the evidence available" and that the evidence was "mixed." The Cochrane Review also noted that: "[n]o studies assessed uptake, cessation, or relapse prevention"(p. 2). The results of many of the studies on other intermediate outcomes were also limited and mixed so that there is no consistent evidence of Plain Packaging being effective across a large number of variables. The Cochrane Review concludes that "[t]he available evidence suggests that standardised packaging may reduce smoking prevalence" (p. 2), which itself doesn't demonstrate the efficacy of Plain Packaging. In addition, based on my review of the actual data emanating from Australia and critical analysis of the published papers on this data, which the Cochrane Review did not undertake, the overwhelming evidence across all the datasets is not consistent with the 2012 Packaging Changes being effective in reducing smoking, while there is also evidence consistent with the policy being counterproductive on many of the intermediate or secondary measures that are relied upon to promote Plain Packaging.

12. The Australian Government Post-Implementation Review Tobacco Plain Packaging 2016 report (the "PIR") provided an inadequate and incorrect assessment of the effect of the 2012 Packaging Changes on smoking. The PIR's only statistical evidence of the effect of the 2012 Packaging Changes is based on the flawed report by Dr. Chipty. What is also striking is that the PIR did not review the implications of the NTPPTS and CITTS data with respect to smoking prevalence and consumption. The PIR merely relies on published papers without any critique or review of those papers. Based on my review of the papers and the underlying NTPPTS and CITTS datasets, I conclude that they cannot be relied upon. There is not a sound basis for the PIR's conclusion (p. 4): "[i]n light of all this evidence, the PIR concludes that tobacco plain packaging is achieving its aim of improving public health in Australia and is expected to have substantial public health outcomes in the future." The PIR's reference to "all this evidence" is especially inappropriate because the cited studies did not report all the evidence from the NTPPTS and CITTS datasets, but only the selected results that provide the most favorable perspective on the performance of plain packs. In addition, as noted above my extended analysis of the RMSS data and the CITTS data which is the most extensive data analysis undertaken to date (and includes 15 months of additional data to the analysis undertaken by Dr Chipty) confirms that Plain Packaging has not been effective, as the statistical association of the 2012 Packaging Changes with smoking prevalence rates cannot be distinguished from zero. This result further demonstrates that the conclusion reached in the PIR is unjustified.

## III. ROY MORGAN RESEARCH DATA

13. The most extensive set of individual survey data on smoking prevalence in Australia are the RMSS data from Roy Morgan Research. This independent firm employs a large nationally representative Australian sample using cross-sectional surveys to generate survey data on individuals aged 14 and over regarding their smoking status, where interviewers are dispatched weekly and all areas are covered monthly.[18] The data have been used in previous peer-reviewed published research to obtain estimates of smoking prevalence in Australia.[19]

14. Previous reports have provided analyses of the effect of Plain Packaging on smoking prevalence in Australia using the RMSS data, including:

    a. A non-peer-reviewed report prepared for the Australian Department of Health by Dr. Tasneem Chipty, which analyzed the RMSS data from January 2001 to September 2015, and concluded based on a regression analysis that during the period after the implementation of the 2012 Packaging Changes in Australia through to September 2015, smoking prevalence rates declined by 0.55 percentage points relative to what the prevalence would have been without the 2012 Packaging Changes;[20] and

    b. Diethelm and Farley (2015) which assessed the effect of Plain Packaging on smoking prevalence in Australia using the RMSS data for adults (aged 18+) for

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[18] For details of how Roy Morgan Research collects the RMSS data see Roy Morgan Research. "How we collect and process Single Source data in Australia". Available from: http://www.roymorgan.com/products/single-source/single-source-fact-sheets, accessed 2 May 2017.

[19] See Wakefield MA, Durkin S, Spittal MJ, Siahpush M, Scollo M, Simpson JA, et al. "Impact of tobacco control policies and mass media campaigns on monthly adult smoking prevalence" Am J Public Health. 2008;98:1443-50. doi: 10.2105/AJPH.2007.128991; and Wakefield MA, Coomber K, Durkin SJ, Scollo M, et al. "Time series analysis of the impact of tobacco control policies on smoking prevalence among Australian adults," 2001-2011. Bull World Health Organ 2014; 92:413-422 doi: 10.2471/BLT.13.118448.

[20] Dr. Tasneem Chipty, "Study of the Impact of the Tobacco Plain Packaging Measure on Smoking Prevalence in Australia," Report of Dr. Tasneem Chipty, January 24, 2016, supra at footnote 5.

the period from January 2001 to December 2013 (one year after mandatory full implementation of PP in Australia) and found a statistically significant reduction of smoking prevalence of 3.7% following the introduction of Plain Packaging in Australia. I note that the recently published Cochrane Review of the Plain Packaging literature notes that this paper is the only peer-reviewed published paper that assesses the impact of Plain Packaging on smoking prevalence in Australia.[21]

15. In this report I present an analysis of a larger Roy Morgan Research sample that includes a longer post-2012 Packaging Changes time period than that provided in Diethelm and Farley (2015), and in the report of Dr. Chipty. I also present analysis of the time period considered in Dr. Chipty's report to facilitate a comparison of the results. The starting date for my Roy Morgan Research data is January 2001, which is the same as that of Diethelm and Farley (2015) and Dr. Chipty's report. However, the data I analyze extend through December 2016, thus providing 3 years of additional data in the post-2012 Packaging Changes period than was addressed in Diethelm and Farley (2015) and 15 additional months of data in the post-2012 Packaging Changes period than was considered in the report of Dr. Chipty, making my analysis the most up to date available. According to Dr. Chipty, the inclusion of the new data should lead to even larger estimates of the effect of plain packs as she hypothesizes, "the benefits of the Packaging Changes will likely grow over time."[22]

A. Analysis of RMSS Data

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[21] McNeill A, Gravely S , Hitchman SC, Bauld L, Hammond D, Hartmann-Boyce J. "Tobacco packaging design for reducing tobacco use". Cochrane Database of Systematic Reviews 2017, Issue 4. Art. No.: CD011244. DOI: 10.1002/14651858.CD011244.pub2.

[22] Chipty Report, p. 3.

16. Here I provide a detailed analysis of the RMSS data on smoking prevalence rates. The principal matter of interest is the effect of the 2012 Packaging Changes in Australia on smoking prevalence rates based on a regression analysis of whether the respondent is a smoker as a function of pertinent demographic and policy variables. My assessment of the RMSS data is patterned generally after that in the report of Dr Chipty. The table below lists the extensive set of demographic and locational variables from the RMSS data that I include in my multivariate regression analysis for which the detailed estimates appear in Appendix A. My variables address the same range of demographic influences as in Dr. Chipty's report, though there are a few minor differences. For example, I use continuous measures of age and income rather than a large series of categorical variables for different age and income categories.

Explanatory Variables Used in Regressions

| **Variable** | **Mean** | **Std. Dev.** |
|---|---|---|
| Female | 0.5181 | 0.4997 |
| Marital status, single | 0.2422 | 0.4284 |
| Marital status, divorced | 0.0818 | 0.2741 |
| Marital status, widowed | 0.0781 | 0.2683 |
| Marital status, separated | 0.0370 | 0.1887 |
| Student | 0.0238 | 0.1525 |
| Years of education | 12.34 | 3.18 |
| Age | 47.46 | 19.30 |
| Non-adults (14-17) | 0.0575 | 0.2328 |
| Employed full time | 0.5524 | 0.4972 |
| Retired | 0.0111 | 0.1048 |
| Income (thousands) | 47.63 | 40.93 |
| Income, multiple household members | 0.4162 | 0.4929 |
| Bread winner | 0.6502 | 0.4769 |

| | | |
|---|---|---|
| Household size | 2.7263 | 1.3806 |
| Home owner | 0.6812 | 0.4660 |
| Victoria | 0.2300 | 0.4208 |
| Queensland | 0.1985 | 0.3988 |
| South Australia | 0.0780 | 0.2681 |
| Western Australia | 0.0950 | 0.2932 |
| Tasmania | 0.0481 | 0.2139 |
| Darwin-Alice Springs | 0.0101 | 0.1001 |
| Lives in capital city | 0.5812 | 0.4934 |

17. The principal differences between my analysis and Dr. Chipty's, as I discuss below, are with respect to the following matters. First, I include different measures of cigarette prices in the equation to account for the important economic dependence of smoking behavior on the cost of cigarettes. Second, my analysis accounts for the nonlinear trend in smoking prevalence rates and includes a statistical test of the importance of nonlinearity, whereas Dr Chipty assumes without any testing that the trend is linear. Thirdly, my analysis also accounts for the continuous changes in cigarette excise tax rates rather than focusing on the major increases alone. As I discuss below, if the analysis correctly includes either a measure of cigarette prices or a nonlinear trend, or both of these influences, then the estimated statistical association of the 2012 Packaging Changes with smoking prevalence rates is zero. The only sound conclusion based on this evidence is that the 2012 Packaging Changes are not associated with any change in smoking prevalence rates.

18. I begin with an analysis of the RMSS data time period used in Dr. Chipty's report and excluding October and November 2012 from the sample. As noted above, my variables address the same range of demographic influences as do Dr. Chipty's, with only a few

minor differences. In addition to these variables, I have constructed a series of policy-related variables based on the different time periods relating to the policies noted above. These include indicator variables for the 2006 graphic warnings policy and the 2012 Packaging Changes as well as measures of consumer prices and the recommended retail price of cigarettes. I capture the effect of the cost of cigarettes in several separate ways. First, I use indicator variables for the major excise tax eras indicated in the table above. However, as I discuss further below in my critique of the report of Dr. Chipty, this formulation ignores the continuous nature of excise tax changes and also ignores the level of the taxes. Second, instead of these indicator variables I include a variable for the level of excise taxes per pack, in real inflation-adjusted terms. This measure accounts for both the excise tax level embodied in the major excise tax increases and also recognizes the periodic updates of the excise taxes during the year. Third, as a measure of the cost of cigarettes I have used two different measures of the total cigarette prices, not simply the excise tax component. The first cost variable is the overall consumer price index (CPI), which is a measure of general price trends in the economy, not just the cost of cigarettes. I also use a more cigarette-specific price measure, which is the recommended retail price per pack for Craven Cork Tip 20s cigarettes. This data is provided in Scollo, and Winstanley, "Tobacco in Australia: Facts and Issues," where the authors explain that Craven is a longstanding brand in Australia and one of a handful of brands available in 1940 that is still available in 2016.[23] Scollo, and Winstanley also provide recommended

[23] See table 13.3.1 in Section 13.3 in Scollo, MM and Winstanley, MH. "Tobacco in Australia: Facts and issues". Melbourne: Cancer Council Victoria; 2016. Available from www.TobaccoInAustralia.org.au. I recognize that the actual cost per pack may be different due to the influence of discounting. However, if discounting policies are consistent across time, the retail price will differ from the discounted price by a multiplicative constant, leaving the statistical significance of the estimated impact of prices unaffected. Even if discounting policies change over time, recommended retail prices will be strongly correlated with actual prices as evidenced by the negative effect of prices on smoking prevalence rates.

retail price data for Winfield 25s which they state is a popular Australian brand, and I obtained similar results using these data in results which are not reported here.

19. For simplicity I report here only the estimates for the 2012 Packaging Changes policy variable. Representative regression results for my full sample appear in Appendix A. The table below summarizes 10 different ways in which the model could be formulated—whether the model includes a linear or nonlinear trend and the formulation of the cigarette cost variables using indicator variables, the excise tax level, the overall consumer price index, the retail price per pack for Craven 20 cigarettes, and an instrumental variables (IV) version of the Craven 20 measure to account for the possible mutual dependence of cigarette prices and smoking prevalence.[24] In 8 of the 10 estimates reported below, it is not possible to reject the hypothesis that the coefficient for the 2012 Packaging Changes in the smoking prevalence rate equation is zero. The estimated coefficient is statistically indistinguishable from zero for all models including a nonlinear time trend or either a linear or nonlinear time trend but also including the consumer price index, the Craven 20 price level, or the IV version of the Craven 20 prices. It is only by ignoring both the nonlinearity of the smoking prevalence trend and the role of prices, as Dr. Chipty does, that it is possible to generate non-zero statistically significant 2012 Packaging Changes coefficient. Given the strong correlation of the nonlinear trend variable and the nonlinear trend in cigarette prices, including both these variables is not needed to eliminate the statistical significance of the 2012 Packaging Changes. Thus, the only two estimates below that can be distinguished from zero assume a linear time trend and use either indicator variables or the cigarette excise tax as a proxy for cigarette prices, which as explained below is unjustified.

[24] The instruments used to predict the Craven 20 price are the consumer price index and the excise tax levels.

| Estimates of the 2012 Packaging Changes Coefficient for Equations Using the Chipty Sample | | |
|---|---|---|
| | 2012 Packaging Changes Variable | |
| Equation characteristics | Coefficient | Standard Error |
| Tax policy indicators and linear time trend | –0.0062 *** | 0.0021 |
| Tax policy indicators and nonlinear time trend | –0.0029 | 0.0026 |
| Cigarette tax levels and linear time trend | –0.0050 *** | 0.0015 |
| Cigarette tax levels and nonlinear time trend | –0.0012 | 0.0024 |
| Consumer price index and linear time trend | –0.0026 | 0.0022 |
| Consumer price index and nonlinear time trend | –0.0004 | 0.0023 |
| Cost per pack and linear time trend | –0.0027 | 0.0021 |
| Cost per pack and nonlinear time trend | –0.0006 | 0.0023 |
| IV cost per pack and linear time trend | –0.0024 | 0.0022 |
| IV cost per pack and nonlinear time trend | –0.0006 | 0.0023 |

*Notes*: Significance levels: *0.10, **0.05, ***0.01

20. Similar results are found for the entire RMSS data time period extending through December 2016. The Roy Morgan Research sample that I use includes 857,355 observations from January 2001 through December 2016. Here I report results not excluding October and November 2016 from the sample and using December 2012 as the 2012 Packaging Changes starting date. As indicated in Appendix A, the results are similar when using October 1 as the starting date, December 1 as the starting date, or December 1 as the starting date but discarding the October and November 2012 data. As with the results above, the 2012 Packaging Changes variable is negative and statistically significant in only 2 of the 10 equations. However, in the other specifications, the 2012 Packaging Changes coefficient is substantially reduced and is never statistically significant. The estimated effect of the 2012 Packaging Changes is always indistinguishable from zero if the model includes a nonlinear trend term or includes a cost

measure based on the overall CPI, the recommended retail price of Craven 20 cigarettes, or an IV version of the Craven 20 variable.

Estimate of the 2012 Packaging Changes Coefficient for Equations Using the Full Sample

| | 2012 Packaging Changes Variable | |
|---|---|---|
| Equation characteristics | Coefficient | Standard Error |
| Tax policy indicators and linear time trend | –0.0061*** | (0.0021) |
| Tax policy indicators and nonlinear time trend | –0.0030 | (0.0026) |
| Cigarette tax levels and linear time trend | –0.0058*** | (0.0018) |
| Cigarette tax levels and nonlinear time trend | –0.0019 | (0.0023) |
| Consumer price index and linear time trend | –0.0029 | (0.0021) |
| Consumer price index and nonlinear time trend | –0.0013 | (0.0022) |
| Cost per pack and linear time trend | –0.0032 | (0.0021) |
| Cost per pack and nonlinear time trend | –0.0015 | (0.0022) |
| IV cost per pack and linear time trend | –0.0029 | (0.0021) |
| IV cost per pack and nonlinear time trend | –0.0015 | (0.0022) |

*Notes*: Significance levels: *0.10, **0.05, ***0.01

21. Using a Roy Morgan Research RMSS dataset that includes an additional 15 months of data not included in Dr. Chipty's report should have led to larger estimates of the effect of 2012 Packaging Changes if the impact of the policy is increasing over time, as Dr. Chipty hypothesizes. What I find instead is that the estimated effect is not distinguishable from zero if one correctly recognizes either the nonlinear nature of the time trend or the impact of cigarette prices on smoking prevalence rates.

B. Critique of Previous Analyses of RMSS Data

i. Report of Dr. Tasneem Chipty entitled "Study of the Impact of the Tobacco Plain Packaging Measure on Smoking Prevalence in Australia" (24 January 2016).

22. The report of Dr. Chipty was commissioned by the Australian Department of Health and is the only econometric analysis of data that is relied on in the Australian Government's Post Implementation Review Report. I also understand that it has been cited by a number of other regulators and proponents of Plain Packaging to support claims that the policy has been successful in reducing smoking.[25]

23. The report focuses on the effect of policy changes in Australia on the probability that members of the RMSS sample report are smokers. As noted above, Dr. Chipty acknowledges that it is not possible to separately identify the effects of tobacco plain packaging from those of the updated and enlarged graphic health warnings which Australia implemented at the same time. As such, Dr. Chipty's analysis, as well as the analysis in my report, encompasses the estimated effects of Plain Packaging and the updated and enlarged graphic health warnings (which Dr. Chipty also refers to as the 2012 Packaging Changes). Dr. Chipty's multivariate regression analysis controls for demographic factors, a linear time trend, and various tax increases and other policy shifts.

24. The principal matter of interest for this analysis is the estimated effect of the 2012 Packaging Changes. Dr. Chipty's model captures this influence with an indicator variable that takes on a value of 1 from December 1, 2012 through 2015, and a value of zero otherwise. Her particular 2012 Packaging Changes variable excludes the transition period

[25] See e.g. U.S. National Cancer Institute and World Health Organization. *The Economics of Tobacco and Tobacco Control.* National Cancer Institute Tobacco Control Monograph 21. NIH Publication No. 16-CA-8029A. Bethesda, MD: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute; and Geneva, CH: World Health Organization; 2016.

of October and November 2012 during which plain packs began to appear in the Australian market, so that the variable has a value of 0 through September 2012, with a value of 1 starting in December and the months of October and November excluded from the analysis. In Appendix A, I report representative parallel results using an October 1 start date, a December 1 start date, or a December 1 start date but excluding the October and November transition period from the analysis altogether, as does Dr. Chipty. The results are similar in all these cases. Dr. Chipty's indicator variable for the 2012 Packaging Changes is intended to capture shifts in smoking rates with the advent of the 2012 Packaging Changes. Smoking behavior will, of course, also be affected by other factors such as the cost of cigarettes. Dr. Chipty's analysis seeks to isolate the effect of the 2012 Packaging Changes on smoking prevalence rates by including indicator variables for different excise tax eras, notably the increases in excise taxes in 2010, 2013, and 2014. Similar to the indicator variable for the 2012 Packaging Changes, these variables take on a value of 0 in the years before the excise tax increase and 1 in those years and thereafter. In my analysis above, I also present models that avoid this undesirable variable overlap by using continuous measures of prices and taxes.

25. The following table lists the different policy events affecting smoking. In Dr. Chipty's analysis each of the events leads to an indicator variable with a value of 0 before the event and 1 after the policy event. For Dr. Chipty's report, that ends with data from September 2015, the analysis includes four overlapping 0-1 indicator variables beginning in 2010: from 2010 through 2015 for excise taxes, from 2012 through 2015 for the 2012 Packaging Changes, from 2013 through 2015 for excise taxes, and from 2014 through 2015 for excise taxes. Given the overlapping nature of the construction of her variables

that fall just short of having an indicator for every year, any conclusions drawn from her analysis are highly speculative. Dr. Chipty's procedure is not wrong from a statistical analysis standpoint, but the use of multiple time period indicators provides very limited insight into the separate effects of the 2012 Packaging Changes policy. In particular, there is only a single year in which the 2012 Packaging Changes indicator variable's effect is not also confounded with other policy shifts. Moreover, any lag time in behavioral responses to policy changes due, for example, to the difficulty of quitting cigarettes, will tend to lead to smoking prevalence shifts from the earlier excise tax increases that extend over multiple periods, thus contaminating the purported effect associated with subsequent time period indicators.

Relevant Policy Changes During Period of Dr. Chipty's Analysis

| Year | Policy |
|---|---|
| 2006 | Graphic warning labels on cigarette packages (Jan. 1) |
| 2010 | Tax increase, 25% per pack (May) |
| 2012 | Plain packaging of cigarette packs and increase in graphic health warnings from 30% to 75% of the front of pack (Oct. 1 begin / Dec. 1 full) |
| 2013 | Tax increase, 12.5% per pack (Dec.) |
| 2014 | Tax increase, 12.5% per pack (Sept.) |

26. The policy change summary above and the chart below indicate the year overlaps and the difficulties they create. Excise tax increases in 2010 may have an impact in reducing smoking cessation rates in 2012, creating a confounded effect along with any impact of the 2012 Packaging Changes and the possibility of attributing an association with the 2012 Packaging Changes where there isn't one. Similarly, the influence of the 2012 Packaging Changes that is captured with an indicator variable starting in December 2012

spans a period that includes subsequent cigarette excise tax increases. The only year in which the 2012 Packaging Changes are introduced but no new excise tax measure is introduced is 2012.[26] The overlapping nature of Dr Chipty's indicator variables leads to results that suggest statistically that the analysis may be capturing general time trends due to the impact of excise taxes rather than effects correlated with the role of the 2012 Packaging Changes.

| Dr. Chipty's Indicator Variables Specification | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Year | | | | | | |
| Policy | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| Excise Tax 2010 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2012 Packaging Changes | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| Excise Tax 2013 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| Excise Tax 2014 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |

27. Dr. Chipty's use of indicator variables for the major tax increases is also a crude empirical approach that generates a source of error in the treatment of taxes. The reliance on the indicator variables fails to recognize the continuous nature of excise tax levels, which are updated periodically for inflation. From 2001 through September 2015 (the period of Dr Chipty's analysis), cigarette excise tax levels in Australia had 32 different values.[27] My excise tax variable accounts for the level of excise taxes throughout my

[26] More specifically, if the full implementation of the 2012 Packaging Changes was in December 2012, and the 2013 excise tax was introduced in December 2013, the time period in which the 2012 Packaging Changes alone is the incremental change is from December 2012 to November 2013. My analysis accounts for the monthly policy changes, but for simplicity, the chart above focuses on years.

[27] See table 13.2.3 of Scollo, M, Bayly, M. 13.2 "Tobacco taxes in Australia". In Scollo, MM and Winstanley, MH [editors]. "Tobacco in Australia: Facts and issues". Melbourne: Cancer Council Victoria; 2016.

estimation period, more accurately characterizes the tax rate than simply identifying the major tax increase periods, and avoids the use of overlapping indicator variables.

28. The chart below also indicates the nature of Dr. Chipty's analysis and its fundamental shortcomings with respect to her analysis of temporal factors. As illustrated, there is a pronounced decline over time in smoking prevalence rates. Smoking prevalence rates over time may be affected by factors other than those explicitly captured by variables in a regression model. Progressive changes in public space smoking restrictions, differences across different population cohorts in attitudes toward smoking, and the rising role of vaping as an alternative to smoking are among the time-related variables that may not be accounted for in a regression model. To incorporate the role of omitted temporal factors, researchers may include variables reflecting the time period. However, there is no theoretical basis for assuming a particular temporal relationship as Dr. Chipty has done, as it might be linear or nonlinear. The proper form is an empirical question which Dr. Chipty doesn't consider. In estimates reported in Appendix A, I report multivariate regression equations including both time and time squared in the analysis.[28] The statistically significant coefficient on the time squared variable is the statistical test that shows that the temporal trend in smoking prevalence rates is consistent with the time trend being nonlinear. Contrary to Dr. Chipty's analysis, one can reject the hypothesis that the trend is linear.

29. Using data from the pre-2012 Packaging Changes period, I have fitted a nonlinear temporal relationship to the data indicated by the gray curve, focusing solely on the relationship between smoking propensities and time as well as time squared. The curve

[28] Thus, for example, for the first month of data in the RMSS sample the value of Time would be 1, in the second month it would be 2, the third month would be 3, etc. The value of Time squared is just the square of this value, or 1, 4, 9, etc.

fitting the pre-2012 Packaging Changes data generates the illustrated post-2012 Packaging Changes projections that track the overall trend nicely.[29] Thus, there is no discontinuous shift in the trajectory of smoking prevalence rates once one takes into account the nonlinear trend in smoking prevalence rates that already existed before the advent of the plain packs policy. My conclusion that there is no discontinuous shift in smoking prevalence rates that took place in 2012 is also consistent with findings by other researchers using a different statistical approach.[30]

30. A graphical analysis indicates the mistaken conclusions that will be generated by assuming that an underlying nonlinear trend is linear. Imposition of a linearity assumption when the underlying trend is nonlinear will always result in the projected values of smoking rates exceeding the actual future levels. This phenomenon can be illustrated using a variety of different time periods which, according to Dr. Chipty's logic, would indicate a shift in smoking prevalence rates, whereas in fact no shift has occurred, only a continuation of the underlying nonlinear trend.

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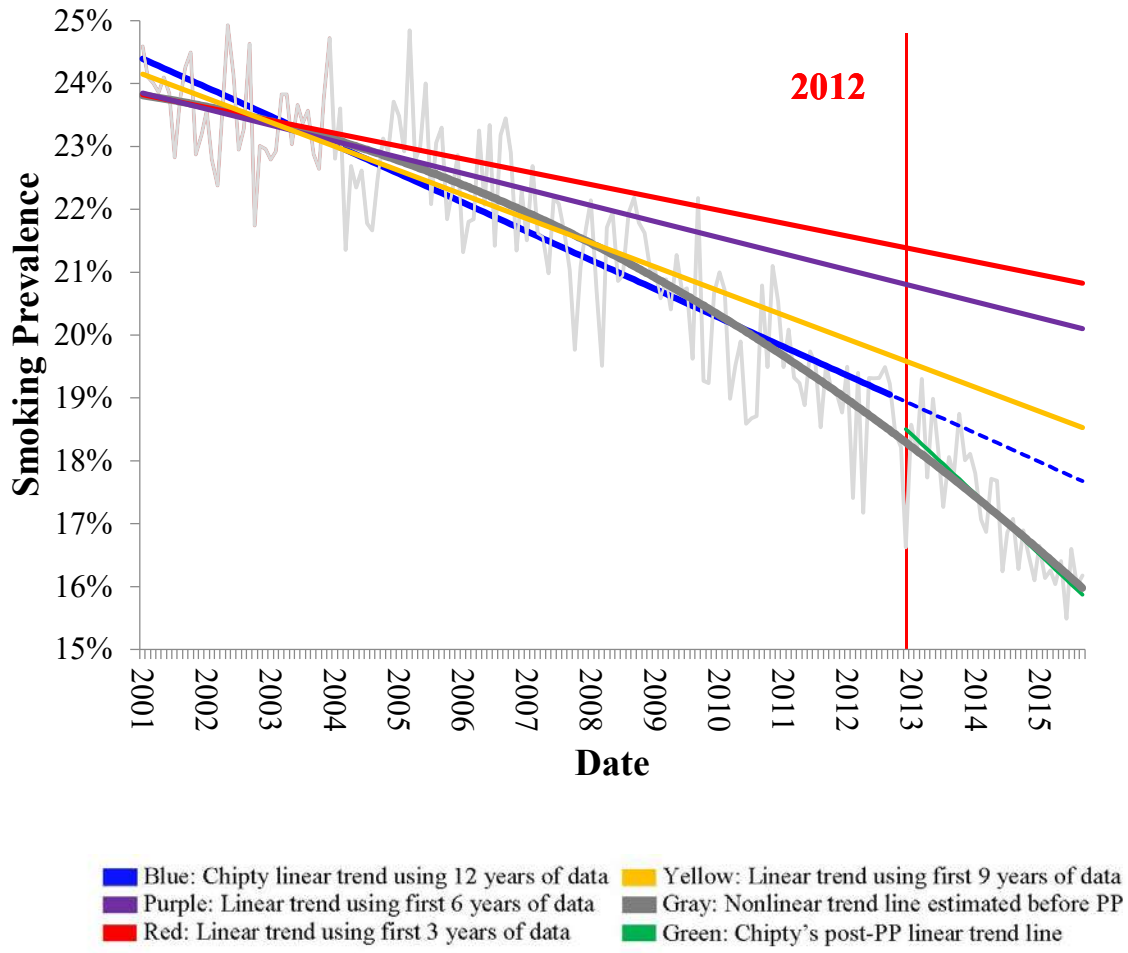
[29] The equation is a regression of the 0-1 smoking prevalence variable on a constant term, time in months, and time squared in months, where the smoking probability = 0.24 – 1.32E-4 time – 1.76E-6 time squared, where all coefficients are statistically significant at the 0.05 level or better.

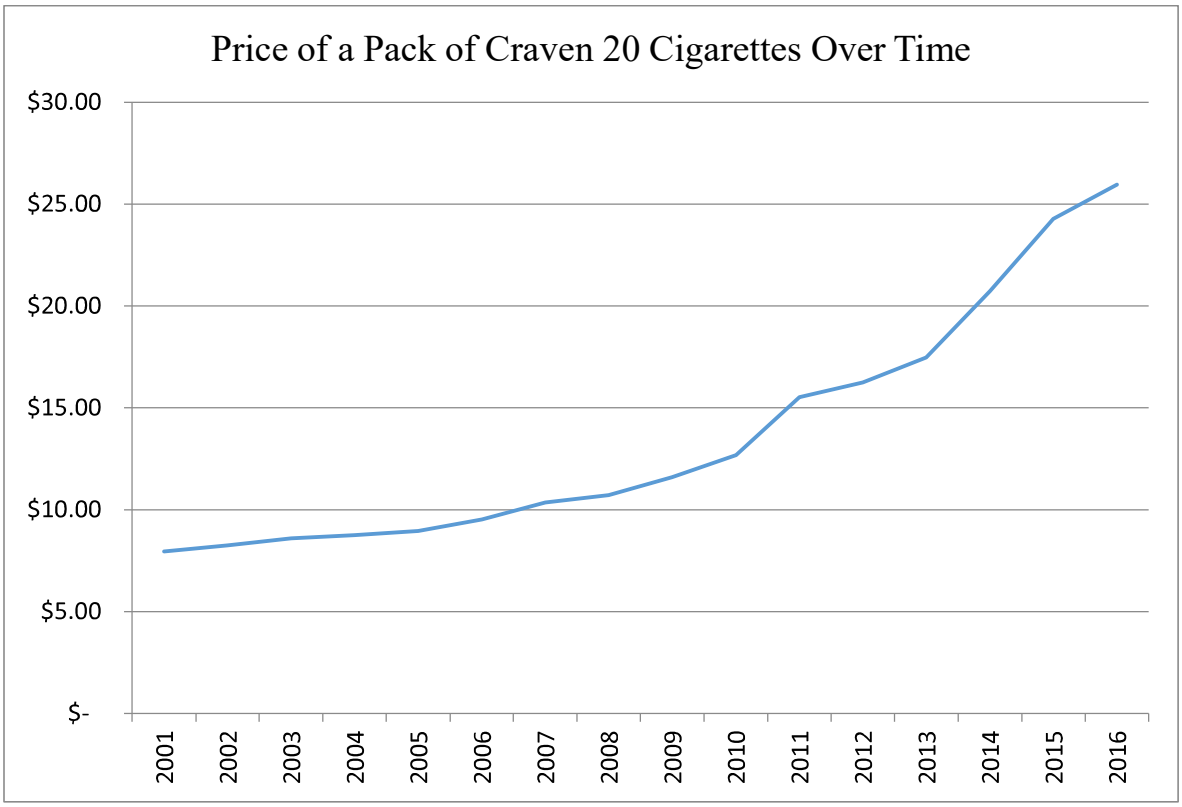
[30] Lilico, A. (2016). "Analysis of the Chipty Report's Conclusions Regarding Packaging Changes and Smoking Prevalence in Australia", August 30, 2016, available at http://www.jti.com/about-tobacco/key-regulatory-submissions/.




31. Dr. Chipty's analysis assumes a linear trend indicated by the blue line in the chart, which she estimated for the time period up to the 2012 Packaging Changes. As her analysis points out, this linear trend line does not predict the post- 2012 Packaging Changes trend, which exhibits an additional drop after the advent of the 2012 Packaging Changes. She then attributes the unexplained drop in smoking prevalence rates to the impact of the 2012 Packaging Changes. That there is a shift if one assumes that trends must be linear is illustrated by the green line, which is Dr. Chipty's linear trend line using only post-2012 Packaging Changes data. The blue line and the green line have clearly different slopes, indicating a purported drop in smoking prevalence rates associated with the 2012 Packaging Changes. However, one can generate other possible purported policy effects

for any time period in the chart since the underlying trend is nonlinear. Similar linear trend lines such as the red trend line based on the first 3 years of data indicate an unpredicted drop in smoking prevalence rates thereafter, as does the purple linear trend line based on the first 6 years of data, and the 9-year trend line in yellow. The "unexplained" departures from the trend lines occur because a linear trend line does not properly capture the nonlinear trend. Capturing any nonlinear relationship with a linear trend line as Dr. Chipty does, will lead to an unexplained subsequent apparent "policy impact" that is spurious, as it is not an effect associated with the policy but instead reflects an underlying nonlinear trend.

32. While there are multiple factors that could contribute to such a nonlinear trend such as progressive restrictions on public smoking and cohort effects as the population changes over time, an additional influence is the rising cost of cigarettes. The figure below indicates the recommended retail price trajectory for Craven 20 cigarettes, which has undergone a steep nonlinear increase, reflecting in part the influence of multiple boosts in the excise tax rate. The nonlinear nature of the price hikes is consistent with the nonlinear decline of smoking prevalence rates. Any increases in the non-monetary costs of smoking, such as the convenience costs arising from smoking restrictions, would reinforce such influences.




33. Three principal results from the RMSS data analysis are apparent in both the analysis of the extended dataset that I used as well as in my analysis of the shorter time period considered in Dr. Chipty's report. First, if one properly recognizes that the temporal trend is nonlinear rather than linear (i.e., by including a quadratic time trend term), that reformulation alone accounts for the downward trend in smoking rates without there being any additional downward shift associated with the 2012 Packaging Changes. Second, even with only a linear trend, reasonable specifications of the model using either overall consumer prices or continuous measures of the recommended retail price of cigarettes rather than the excise tax indicator variables approach used by Dr. Chipty eliminates the statistical significance of the 2012 Packaging Changes variable. Third, even if there were a purported association of the 2012 Packaging Changes with the

decline in smoking prevalence rates based on Dr. Chipty's analysis, one should be skeptical of the import of these results. Her statistical analysis ignores the multiple changes in excise tax rates and includes four overlapping indicator variables for the 2010 to 2015 period in which there is only a single year in which the 2012 Packaging Changes are introduced without any other new smoking policies also being introduced. Attributing the decline in smoking prevalence rates to the 2012 Packaging Changes as opposed to the excise tax increases, both before and after the advent of the 2012 Packaging Changes policy, is not warranted. While the final concern may reflect a difference in statistical approaches, the first two shortcomings are fundamental. Dr. Chipty's failure to consider the pivotal role of prices on smoking behavior and the underlying nonlinear trend in smoking prevalence rates have generated the mistaken conclusion that the 2012 Packaging Changes are associated with an unexplained drop in smoking prevalence rates.

ii. Diethelm and Farley (2015)[31]

34. The article by Diethelm and Farley (2015) analyzed the average monthly smoking prevalence rates in the RMSS data which they derive from a research paper by Kaul and Wolf.[32] They did not use any original RMSS data but instead relied on visual inspection of the figure in Kaul and Wolf to impute 156 monthly smoking prevalence rates. Because they have no individual respondent data, their analysis includes no demographic variables. As a result, changes in sample composition over time, such as the age and income level of respondents, are ignored. Similarly, there are no controls for different

[31] Pascal A Diethelm, Timothy M Farley, "Refuting tobacco-industry funded research: empirical data shows a decline in smoking prevalence following the introduction of plain packaging in Australia," Tob. Prev. Cessation 2015;1(November):6 http://dx.doi.org/10.18332/tpc/60650.

[32] Kaul, A. and Wolf, M. "The (Possible) Effect of Plain Packaging on Smoking Prevalence in Australia: A Trend Analysis" University of Zurich Department of Economics Working Paper, June 2014.

Australian state territories so that the mix of the sample across states and any state-specific smoking-related policies are not taken into account and may be incorrectly attributed to the 2012 Packaging Changes. The only explanatory variables included in the regression analysis reported in the paper are a linear time trend, an indicator variable for the 2010 excise tax increase, an indicator variable for smoke-free policies, and a plain packaging indicator variable. Even setting aside the omitted demographic and regional variables, the equation is a very 'bare-bones' specification. The many other excise tax changes, cigarette prices, and the nonlinear smoking prevalence trend are all omitted. The recent Cochrane Review notes the nonlinearity in the smoking prevalence trend but claims that the "additional covariates" in Diethelm and Farley (2015) address the nonlinearity. This claim is simply not true since their specification includes only two policy indicator variables and no variables that capture the evident nonlinearity in the trend apart from these shifts.

35. The impact of the limitations and flaws in the Diethelm and Farley (2015) paper is that this study lacks any scientific credibility. The deficiencies I cite above are not minor limitations or matters of a difference of opinion, but are fundamental problems that make it inappropriate to rely on their study. The paper has no scientific merit at all.

## IV. IMPLICATIONS OF THE CITTS DATA

### A. Overview of the CITTS Data

36. The CITTS data that I analyze consists of cross-sectional telephone data utilizing a sample of 17,468 adult smokers and recent quitters (people who quit smoking in the past 12 months). The CITTS data (and the NTPPTS data) only include smokers and recent quitters, so they cannot be used to assess the effect of the 2012 Packaging Changes on smoking prevalence. However, these data provide valuable insights into smoking-related behaviors of smokers and recent quitters, which is clearly an important target group of the policy. The survey also includes a number of variables relating to the perceptions of the 2012 Packaging Changes by this group even setting aside issues pertaining to the efficacy of these 'intermediate' variables in predicting actual smoking behaviors. The CITTS is undertaken in New South Wales, which is the most populous state in Australia. Further details of this survey are provided in the paper by Dunlop et al. (2014).[33] The sample analyzed by Dunlop et al. focused on smokers interviewed between April 2006 and May 2013, which includes only six months of data post the implementation of PP in Australia. My sample through June 2016 adds an additional 37 months and 2,045 observations to the sample, which takes it through June 2016 (i.e., 3 1/2 years of data post the implementation of the 2012 Packaging Changes in Australia).[34] Accordingly, the analysis I present here is the most up to date analysis of this dataset.

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[33] Sally M. Dunlop, Timothy Dobbins, Jane M. Young, Donna Perez, and David C. Currow, "Impact of Australia's Introduction of Tobacco Plain Packs on Adult Smokers' Pack-Related Perceptions and Responses: Results from a Continuous Tracking Survey," *BMJ Open* 2014; 4(12): e005836;

[34] As noted above, I have previously addressed the CITTS data in reports that I submitted for British American Tobacco in October 2015 in UK legal proceedings in which the 2012 packaging change regulation was being challenged, and in November 2015 in relation to the Australian Government Department of Health Post-Implementation Review (PIR) of the Tobacco Plain Packaging Act 2011 (TPP). In this report, in addition to using a larger sample, I also undertake new analyses using more detailed

37. The 2012 Packaging Changes took full effect in Australia on December 1, 2012. October and November of that year were a transition period in which some packs began to conform to the 2012 packaging change format. To streamline the exposition below, I only report results in the main body of the report using the December 1, 2012 starting date for the 2012 Packaging Changes. Results reported in Appendix B indicate that the results are stable using other policy starting dates.

38. The sampling procedure for the CITTS survey changed in 2013, as recruitment of respondents changed to include mobile phone users instead of only landline users.[35] As a result, my analysis of the CITTS data draws on the findings using multiple regression analyses in which there is a statistical control for the mobile phone recruitments in the sample as well as detailed set of demographic variables.

39. Many of the CITTS data questions are in the form of qualitative Likert rating scales in which some measures are rated on a scale from 1 to 5 (strongly disagree, somewhat disagree, neither, somewhat agree, strongly agree), where 1 equals strongly disagree and 5 equals strongly agree. These qualitative scales do not provide a basis that permits a comparison either within or across people since the cut-off between these categories will vary across individuals and across questions so that the distinctions are not very meaningful. For example, there is no way of knowing whether person A's score of a 4 for pack attractiveness implies a lower or higher level of attractiveness than person B's score of 3. Similarly, we cannot tell if a drop of a score from 4 to 2 is twice the size as a decrease from 4 to 3. Accordingly, focusing on only one set of extreme responses, such as shifts in the "strongly agree" category, will distort the assessment of the implications

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controls than in my previous assessments. In my previous reports I controlled for cell phone usage and time trends, but the current report also includes controls for a detailed demographic variables.

[35] Cancer Institute NSW's Tobacco Tracking Survey (CITTS) Research Plan 2013-2014 at page 11.