

Has FCTC decreased per capita cigarette consumption? A new look at Hoffman et al results

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Assessing the impact of global health treaties, such as the WHO Framework Convention on Tobacco Control (FCTC), requires not only appropriate data but also correct methodological strategies. While several studies have found positive effects of the FCTC on smoking outcome variables (1-3), some, most notably Hoffman et al. (2019) (4), have reported null or inconclusive results. In this short report, we revisit that study and demonstrate how specific methodological choices likely led to an underestimation of the treaty's impact. Using the same dataset,(5) we compare those findings with alternative specifications, and show that with appropriate modelling and design, statistically significant effects of the FCTC on per capita cigarette consumption emerge robustly across different models.

Why did Hoffman et al. (2019) find null results? A re-analysis with improved specifications

We believe that the null results of Hoffman et al. (2019) on the FCTC's impact on per capita cigarette consumption are due to several factors. One of the main ones is the inclusion of countries that never ratified the FCTC (7 out of the 71 countries considered). This inclusion is not as a control group (they do not have a control group in their main analyses), but they are pooled with the per capita consumption of countries that ratified the FCTC. The issue is far from negligible, as by 2003 (the year Hoffman et al. use as the intervention point), these non-ratifying countries accounted for approximately 12% of the total population and 14% of all smokers in the sample. Therefore, their conclusion that FCTC did not change the pre-FCTC trend of per capita consumption is partially affected by countries that should not have experienced any change if the null hypothesis holds.

In addition to that, there are several methodological mistakes, which extend beyond the choice of dataset and outcome variable. As mentioned before, we re-analyse the Hoffman et al data,⁽⁴⁾ presenting the original results and adding five intuitive and straightforward adjustments to their model (Table 1). The first row (Model 1) reproduces their result using linear Interrupted Time Series Analyses (ITSA) with the first difference of the per capita cigarette consumption as the dependent variable for the “world” (a pool of 71 countries that do not have observations for all years -a considerable problem as the composition of countries in each year may affect the results), including China. In their main specification, the year of “intervention” they chose is 2003 (FCTC entered into force in 2005), and they use data from 1970 onwards. Unsurprisingly, they found no statistically significant evidence to support that FCTC had an impact on decreasing smoking around the world.

The second row (Model 2) reproduces Hoffman et al.’s result, also with the first difference of per capita cigarette consumption as the outcome, using 2003 as the intervention year and data from 1970 onwards. However, it excludes China. They report a statistically non-significant decline of 2% in the pre- and post-intervention years. As explained elsewhere, excluding China to test for the robustness of the results is a good idea, given China's significant share of global cigarette consumption and the fact that a State monopoly is in charge of the production and sale of cigarettes in China.⁽⁶⁾

If only countries that ratified FCTC (excluding China) are considered (Model 3 in Table 1), changes in trend post 2003 are (marginally) non-significant. The substantial change in results comes not from selecting a particular group of countries but from a reasonable change in the model specification. In their model specification, Hoffman et al. use the first difference in per capita cigarette consumption, as their dependent variable. The first difference measures the change in consumption between time

periods t and $t-1$. In a regression context, its use implies assuming that the statistical impact of the change in per capita consumption from, for example, 90 to 80 cigarettes is equivalent to the change from 50 to 40 cigarettes. Basic economic theory and common sense suggest that the marginal reduction in consumption becomes more challenging at lower levels. In other words, it is harder to decrease one unit of consumption when the base level is, for instance, 50 than when it is 90.

Therefore, we replace Hoffman et al.'s first-difference assumption with the logarithm of per capita consumption (a robust measure of relative change, independent of the starting level) as the outcome (Model 4 in the Table). This demonstrates that the FCTC accelerated the decline in per capita cigarette consumption by an additional 2% per year compared to the pre-FCTC trend, and that this acceleration was statistically significant.

A second reasonable change is to choose the intervention year correctly, which Hoffman et al. set uniformly as 2003 (the year of FCTC adoption) in their main specification. However, 73% of the countries ratified the FCTC from 2005 onwards. Ratification implies that the FCTC becomes legally binding, with a commitment to adapt national legislation. In Model 5, we present the logarithm of the per capita consumption using each country's ratification year as the intervention point. This yields an accelerated drop in per capita cigarette consumption by an additional 6% per year relative to the pre-ratification trend.

Next, we correct Hoffman's use of pre-intervention years, which extend back to 1970. It is very unlikely that smoking trends from the 1970s would affect trends in the 2000s when contemporary tobacco control began implementing interventions. Therefore, Model 6 trims the pre-ratification period to a decade before and after the ratification of FCTC in each country, as done in previous analyses.⁽¹⁾ This yields an accelerated

drop in per capita cigarette consumption by an additional 7% per year relative to the pre-ratification trend.

Then, Model 7 presents results for the countries that increased tobacco taxes by 10 percentage points or more after ratifying the FCTC (a subgroup of countries used in Model 6). For this group, the ratification of FCTC would have implied an accelerated drop in per capita cigarette consumption of an additional 18% per year relative to the pre-ratification trend (Figure 1).

Finally, Model 8 addresses a fundamental issue in Hoffman et al.'s analysis, specifically the use of an unbalanced sample of countries with varying years of data availability. In their approach, the number and composition of countries contributing to the estimates vary over time, which may bias the results if, for instance, countries with more complete data exhibit systematically different smoking trends or policy adoption. To correct for this, we restrict the sample to countries that have at least eight years of data before and after their FCTC ratification year, ensuring a balanced panel across time. Although based on fewer countries, this approach improves the comparability between the pre- and post-intervention periods. This model indicates a statistically significant 3% decline in per capita consumption at the time of ratification, accompanied by an additional 2% annual decrease in the post-ratification trend compared to the pre-ratification trend.

Table 1: Alternative specifications of Interrupted Time Series Analyses using the Hoffman et al. dataset (5)

Model	Outcome variable	Treatment period	Period covered	Data*	Pre-trend (95% CI)	Change in level (95% CI)	Change in trend (95% CI)
1	1st Difference in per capita consumption	2003	Since 1970	Global	-1.7 (-2.5, -0.9)	23.7 (0.2, 47.2)	1.7 (-3.0, 6.5)
2	1st Difference in per capita consumption	2003	Since 1970	Global (excluding China)	-1.4 (-2.7, -0.2)	24.5 (-4.2, 53.2)	-2.1 (-6.3, 2)
3	1st Difference in per capita consumption	2003	Since 1970	Only ratifying countries (excluding China)	-1.0 (-2.0, 0.1)	13.7 (-10.8, 38.1)	-2.9 (-5.8, 0.3)
4	Logarithm of per capita consumption	2003	Since 1970	Global (excluding China)	-0.02 (-0.02, -0.01)	0.03 (-0.02, 0.07)	-0.02 (-0.03, -0.01)
5	Logarithm of per capita consumption	Each country's ratification year	Since 1970	Global (excluding China)	-0.01 (-0.01, -0.01)	0.04 (-0.08, 0.17)	-0.06 (-0.09, -0.02)
6	Logarithm of per capita consumption	Each country's ratification year	Ten years before/after ratification	Global (excluding China)	-0.01 (-0.01, -0.00)	0.08 (-0.06, 0.22)	-0.07 (-0.11, -0.04)
7	Logarithm of per capita consumption	Each country's ratification year	Ten years before/after ratification	High tax change	0.04 (0.02, 0.05)	0.20 (-0.09, 0.48)	-0.18 (-0.24, -0.13)
8	Logarithm of per capita consumption	Each country's ratification year	Eight years before/after ratification	Global Balanced (excluding China)	-0.01 (-0.02, -0.01)	-0.03 (-0.05, -0.01)	-0.02 (-0.03, -0.01)

Note: Bolded cells represent statistically significant findings ($p < 0.05$). *Global and high-tax change excludes China, which accounts for about a third of all global tobacco consumption and which has complex taxation and regulatory patterns on the mostly domestic cigarette market. **Balanced means that in every year there is the same number and composition of countries.

Final considerations

Smoking remains the leading preventable cause of death worldwide, accounting for more deaths than obesity and heavy alcohol consumption, with smoking on track to cause one billion deaths this century.(7) The FCTC promised to reduce this avoidable toll through evidence-based interventions, the most important of which is the implementation of higher excise taxes.(8-10) The FCTC has effectively reduced the number of smokers, particularly among younger individuals;(6) accelerated the rate of decline in per capita cigarette consumption; and promoted smoking cessation.(6) Countries that decisively increased tobacco taxes were more successful in achieving these results.(2, 6) Results presented here also show that FCTC ratification is associated with a significant decrease in per capita cigarette consumption.

These findings are particularly relevant as progress on taxes has slowed.(11) Without large increases in excise taxes in many countries and a decisive push to fend off the tobacco industry interference, the world can expect, for several decades at least, 125,000 deaths a week from smoking.(12) Tobacco taxes remain underused and have the potential to expedite the decrease in tobacco use. Countries that ratified the FCTC but did not substantially increase taxes could have more than doubled the reduction in young smokers (ages 10-24) had they raised taxes even modestly by 10 percentage points.(6)

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