Statistical method

Description

We use difference-in-differences (DID) estimators of intertemporal treatment effects to assess the effect of SSB tax and Dutch PPP policy on the average sugar content of new SSBs in France, the United Kingdom or the Netherlands (our outcome).[1] Specifically, these estimators compare the outcome evolution in France, the United Kingdom or the Netherlands that has announced/implemented the tax/PPP policy (the treated country) to that of countries that have not (the countries control group), i.e. Germany, Italy and Spain, from the last year before the tax/PPP policy has been announced/implemented to the lth year after that announcement/implementation. We estimate the effect of having announced/implemented the tax/PPP policy for the first time l years ago; the year of announcement/implementation of the tax/PPP policy ($l = 0$) and in later years ($l \geq 1$).

Policy effects on the average sugar content of all new SSBs combined and by SSB category, when their number is large enough, are estimated. The effects of the policy on flavoured water category were not estimated given the limited number of new flavoured waters marketed in Spain (9, 11, 5 ,13 and 11 in 2015, 2016, 2017, 2018 and 2019, respectively) and Italy (0, 3, 2 ,3 and 5 in 2015, 2016, 2017, 2018 and 2019, respectively).

Below, we only present the method for tax evaluation to facilitate the reading. The method to evaluate the effects of the Dutch PPP policy is the same and only the notations need to be adapted.

We apply de chaisemartin and D'Hautefeuille (2022) estimator to our sharp (treatment does not vary within country c and year t) and staggerred treatment adoption design (countries have maintained the tax after they have announced/implemented for the first time in year $t - l$). The estimator proposed is valid even if there are heterogeneity in the effects of the tax over time,[1,2] contrary to the estimator computed in the commonly-used dynamic two-way fixed effects regression: a regression of $Y_{i,c,t}$, the outcome of SSB i in country c at year t (e.g. the SSB sugar content sugar content in grams per 100 mL) on country fixed effects, period fixed effects, and relative-time indicators equal to one if a country *c* started receiving the treatment (e.g. announcement/implementation of the tax) l periods ago.

We first set the following notations. For any $l \in \{0, \ldots, 7\}$ and $t \in \{2012 + l, \ldots, 2019\}$, let $N^1_{c,t,l} = \sum_{i \in c, F_{c,1} = t-l} N_{i,c,t}$ denote the number of new SSBs *i* taxed in France or the United Kingdom (c=FR, UK) for the first time at year *t*- l, where for any country *c*, $F_{c,1} = min\{t: Tax_{c,t} = 1\}$ denotes the first year at which country *c* has announced/implemented the SSB tax, $Tax_{c,t} = 1$. In our setting, $F_{UK,1}$=2016 and $F_{FR,1} = 2012\ or\ 2018$ for the United Kingdom and France, respectively. It results that $N^1_{UK,t,l} > 0$ for $(t, l) \in \mathcal{T}^{UK} = \{(2016{,}0), (2017{,}1), (2018{,}2), (2019{,}3)\}$, and $N^1_{UK,t,l} = 0$ otherwise. For the 2012 French tax, we have $N^1_{FR,t,l} > 0$ for $(t, l) \in \mathcal{T}^{FR} = \{(2012{,}0), (2013{,}1), (2014{,}2), (2015{,}3)\}$, and $N^1_{FR,t,l} = 0$ otherwise. For the 2018 French tax, $N^1_{FR,t,l} > 0$ for $(t, l) \in \mathcal{T}^{FR} = \{(2018{,}0), (2019{,}1)\}$, and $N^1_{FR,t,l} = 0$ otherwise. We have the convention that $F_{c,1} = 2020$ if country *c* has not announced/implemented the tax, $Tax_{c,t} = 0$. Let $N^{nt}_t = \sum_{c: F_{c,1} > t} N_{c,t}$ denote the number of untaxed new SSBs in countries control group from period 2010 to *t*, where $N_{c,t}$ is the number of new SSBs in country c at period t. In our setting, N_t^{nt} is always strictly positive since no national tax was enacted in Germany, Italy or Spain. Finally, let $Y_{c,t} = 1/N_{c,t} \sum_{i \in c,t} Y_{i,c,t}$ denote the observed average sugar content in grams per 100 mL of new SSBs in country c at period t, our outcome variable.

We define the estimate of the SSB tax effect on the average sugar content of new SSBs in treated country, $treated = UK, FR$, in t of having announced/implemented the tax for the first time l years ago, as:

$$DID_{treated,t,l} = \begin{cases} \left(Y_{treated,t} - Y_{treated,t-l-1}\right) - \sum_{c:F_{c,1>t}} \frac{N_{c,t}}{N_t^{nt}} \left(Y_{c,t} - Y_{c,t-l-1}\right), & for\ (t,l) \in \mathcal{T}^{treated} \\ 0, & otherwise \end{cases}$$

$DID_{treated,t,l}$ is the DID estimator comparing the $t-l-1$-to-t evolution of the average sugar content in grams per 100 mL of new SSBs in France or the United Kingdom and in countries belonging to the countries control group from 2010 to year t. $DID_{treated,t,l}$ is the effect of having announced/implemented the tax rather than not for $l+1$ years. In our setting for all $(t,l) \in \mathcal{T}^{treated}$, $Y_{UK,t-l-1} = Y_{UK,2015}$ for the SDIL; $Y_{FR,t-l-1} = Y_{FR,2011}$ for 2012 French tax; and $Y_{FR,t-l-1} = Y_{FR,2017}$ for 2018 French tax. To illustrate, $DID_{UK,t=20\ \ ,l=3}$ is the DID estimator comparing the evolution of the average sugar content in grams per 100 mL of new SSBs from 2015 to 2019 in the United Kingdom, that announced the tax in 2016 and in Germany, Italy, and Spain.

We do not use these notations in the main text for simplicity's sake. The estimators $DID_{UK,t,l}$ correspond to the estimated effects in 2016 ($t = 2016,\ l = 0$), 2017 ($t = 2017, l = 1$), 2018 ($t = 2018, l = 2$), and 2019 ($t = 2019, l = 3$) for the United Kingdom in Table 3. The estimators $DID_{FR,t,l}$ correspond to the estimated effects in 2018 ($t = 2018, l = 0$) and 2019 ($t = 2019, l = 1$) for France in Table 4.

Placebo estimators: Plausibility of common trends hypothesis

De chaisemartin and D'Hautefeuille (2022) show that $DID_{treated,t,l}$ in our setting is an unbiased estimator of the cumulative effect of having announced/implemented the tax for *l+1* years if the common trends assumption holds, i.e. the trends of the mean sugar content would have been the same in both the countries control group and France or the United Kingdom in the absence of SSB tax.

It is possible that France or the United Kingdom and countries control group have experienced different evolutions of SSBs average sugar content over time. However, the DID approach can still produce unbiased estimators provided that those differential evolutions are accounted for by a linear model in $X_{c,t} - X_{c,t-1}$, the change in country's covariates between t and $t-1$. Furthermore, it is also possible that each SSB category follows its own linear sugar content trend, leading to biased DID estimators. A key specificity of De chaisemartin and D'Hautefeuille (2022) approach is that it also allows to control for group-specific linear trends by considering fixed effects.

Thus, we linearly consider in our analysis time- and country-varying covariates that may affect consumers' preferences and consequently/or companies' strategy regarding SSB sugar content in each country, but uncorrelated to the treatment, i.e. the policy implementation. Country's variable indicators of health (i.e. childhood obesity rate,[3] share of out-of-pocket medical expenses over total health spending,[4] death rate due to NCDs among populations aged 30--70 years,[5] and dietary and high body mass index risks[6]); the agricultural producer price index of sugar deflated by the GDP deflator;[7] and whether the beverage was manufactured and marketed by a national brand or not were considered. In our estimations, the country's variable indicators of health control for beverage sugar content variations caused by changes in a country's health context. For example, if out-of-pocket medical expenses increase (i.e., the health care system becomes less protective), an individual may be more motivated to adopt healthier food habits such as purchasing healthier food products, which in turn may encourage SSBs companies to remove sugar. Only the share of out-of-pocket medical expenses over total health spending were included in the estimations. For the other health variable indicators, it was difficult to distinguish their effects from those of country fixed effects given their weak variability over time. The agricultural producer price index of sugar controls for the cost of the main raw material in SSBs that might impact the level of the sugar content of new SSBs launched in the market. We also consider the share of national brands for each SSB category per year in each country, as national brands can have different strategy than private label brands,[8] as consumers of retailer brand products tend to be more motivated by price than by quality.

The common trends assumption is not directly testable, but to assess its plausibility de Chaisemartin and D'Hautefeuille (2022) propose "long-difference" placebo estimators computed using pre-policy observations.[1] Contrary to standard tests used in the dynamic two-way fixed effects regression, the test deployed in the analysis is robust even if tax effects are heterogeneous over time.[1] Following their analysis and notations defined above, we define the placebo estimator as the following DID estimator:

$$DID^{pl}_{treated,t,l} = \left(Y_{treated,t-2l-2} - Y_{treated,t-l-1}\right) - \sum_{c:F_{c,1>t}} \frac{N_{c,t}}{N^{nt}_{t}} \left(Y_{c,t-2l-2} - Y_{c,t-l-1}\right)$$

for $treated = UK, FR$ and if $(t,l) \in \mathcal{T}^{treated}$, and we let $DID^{pl}_{treated,t,l} = 0$ otherwise. The *lth* placebo estimator, $DID^{pl}_{treated,t,l}$, compares the evolution of the average sugar content in grams per 100 mL of new SSBs in a country *c* that has announced/implemented the tax (either France or the United Kingdom) for the first time in year *t-l*, and in countries that have not from 2010 to year *t, as* $DID_{treated,t,l}$, but between periods *t*−2*l*−2 and *t*−l−1 instead of *t*−*l*−1 and *t*. To illustrate, $DID^{pl}_{UK,t=201\ ,l=3}$ is the DID estimator comparing the evolution of the average sugar content in grams per 100 mL of new SSBs from 2011 to 2015 in the United Kingdom, that announced the tax in 2016 and in Germany, Italy, and Spain.

We not use these notations in the main text for simplicity's sake. The estimator $DID^{pl}_{UK,t,l}$ corresponds to the estimated difference in the evolution of the average sugar content from 2014 to 2015 ($t = 2016, l = 0$), 2013 to 2015 ($t = 2017, l = 1$), 2012 to 2015 ($t = 2018, l = 2$) or 2011 to 2015 ($t = 2019, l = 3$) in Table 3. The estimator $DID^{pl}_{FR,t,l}$ corresponds to the estimated difference in the evolution of the average sugar content from 2016 to 2017 ($t = 2018, l = 0$), or 2015 to 2017 ($t = 2019, l = 1$) in Table 4.

If common trend assumption holds, then de Chaisemartin and D'Hautefeuille (2022) show that $E[DID^{pl}_{treated,t,l}] = 0$. So finding an estimation of $DID^{pl}_{treat\quad,t,l}$, or say differently an estimated difference in the evolution of the average sugar content in the United Kingdom or France and in Germany, Italy, and Spain between periods t–2l–2 and t–l–1, for $(t,l) \in \mathcal{T}^{treated}$, significantly different from 0 implies that the common trends assumption is violated: the average sugar content of new SSBs launch on the French or the British market experienced different trend before announcement/implementation of the tax than that of new SSBs in countries belonging to the countries control group used to reconstruct new SSBs average sugar content counterfactual trend in France or the United Kingdom. Thus, the lth placebo, $DID^{pl}_{treated,t,l}$, estimator assesses whether common trends assumption holds over l+1 years, the number of years over which the assumption has to hold for the lth estimated dynamic effect, $DID_{treated,t,l}$, to be unbiased. Futhermore, de Chaisemartin and D'Hautefeuille (2022) show that the value of $DID^{pl}_{treated,t,l}$ can be used to sign $DID_{treated,t,l}$'s bias: the sign of the bias of $DID_{treated,t,l}$ is equal to the sign of $-E[DID^{pl}_{treated,t,l}]$.

The statistical method was first published in December, 2021 on the study's githhub webpage. Changes to protocol published since December, 2021 are also detailed in the webpage.

References

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