Empirical Economics (2024) 66:1867–1901
https://doi.org/10.1007/s00181-023-02509-4

Does the design of a soda tax matter? Evidence from school children in Europe

Selina Gangl[1]

Received: 19 December 2022 / Accepted: 26 September 2023 / Published online: 7 November 2023

Abstract
This paper compares the effects of two different health taxes on soda consumption and the body mass index (BMI) of school children in Europe. Hungary imposed a comprehensive tax on several unhealthy products in 2011. In contrast, France introduced a tax on sodas with sugar or artificial sweeteners, in 2012. To evaluate these taxation designs, I use a flexible semi-parametric difference-in-differences (DID) approach. The results suggest a counter-intuitive increase in soda consumption caused by the tax in Hungary. The effect of the soda tax on soda consumption in France is insignificant. The BMI is not affected by any tax.

Keywords Soda tax · Consumption · Health · Semi-parametric difference-in-differences · HBSC

JEL Classification H20 · H30 · I12 · I18 · L66

1 Introduction

Childhood obesity is a worldwide problem and poses long-term health risks. For example, obese children are more likely to remain obese as adults. They also have a higher risk of developing cancer, diabetes, and cardiovascular diseases (WHO 2020).

I thank Anikó Biró, Kamila Cygan-Rehm, Edel Doherty, Reiner Eichenberger, Martin Huber, Marco Portmann, Regina T. Riphahn, Andreas Steinmayr, Giannina Vaccaro, Erwin Winkler, and Christian Zihlmann for their helpful comments. I have benefited from comments by seminar participants at the Swiss Public Health Conference 2020, the EuHEA Ph.D. Student-Supervisor & Early Career Researcher Conference 2020, the Annual Congress of the Verein für Socialpolitik 2020, and a research seminar at the University of Fribourg. Earlier versions of this paper were titled “Do soda taxes affect the consumption and health of school-aged children? Evidence from France and Hungary.”

✉ Selina Gangl
selina.gangl@fau.de

1 Department of Economics, Friedrich-Alexander-Universität Erlangen-Nürnberg (Germany), Lange Gasse 20, 90403 Nuremberg, Germany

Consequently, obese children incur high healthcare costs which are borne by public payers (Biener et al. 2020). To limit such costs, policy-makers search for measures to curb or even prevent childhood obesity. One possible driver of childhood obesity is the consumption of sugary sodas (James and Kerr 2005; Ludwig et al. 2001) because a large amount of calories is consumed quickly.

A growing number of countries worldwide have introduced taxes on sodas (see Allcott et al. 2019 for an overview). These taxes aim to increase the soda price and reduce soda consumption. However, the empirical evidence for soda taxes is mixed. This finding is not surprising because the amount of the soda tax, the scope of the taxed products, and their respective sugar limits vary from country to country. An unanswered question in this context is *how important is the design of the soda tax for its effectiveness?* This paper compares two different taxes on sodas in Hungary and France. In 2011, Hungary introduced a broad tax on unhealthy products, which (among other products)[1] targeted sugar-sweetened sodas. The soda tax rate corresponded to converted 1.83 Eurocents per litre[2] (Ecorys 2014). One year later, France imposed a soda tax of 7.16 Eurocents per litre which also applied to artificial sweetener (Ecorys 2014). The results suggest a counter-intuitive positive and significant effect of the tax on soda consumption in Hungary. Since the prices of other unhealthy products, like energy drinks, increase as well, the substitution behavior of children could explain this result. Soda consumption is not affected by the tax in France. A reason for this finding might be the low soda tax rate of 7 Eurocents per litre. Children's body mass index is not affected by the tax in any country.

In the first analysis, I examine the effect of the broad tax on unhealthy products. Hungary forms the treatment group, while neighboring country Croatia, which does not levy such a tax, serves as the control group.[3] In the second analysis, analysis, I examine the effect of the soda tax. France constitutes the treatment group and Spain forms the control group without a soda tax. Methodologically, I exploit spatial variation of the tax and use a semi-parametric difference-in-differences (DiD) approach to evaluate the policy. This method uses inverse probability weighting (IPW) to control for differences in observable characteristics between the treatment and control group as well as over time. I use data from the cross-national survey Health-Behavior in School-Aged Children (HBSC) which ensures that the same question is asked in each country. This survey is conducted in cooperation with the World Health Organization (WHO) Europe and administered on a quadrennial basis. In the setting of this natural experiment, the year 2010 constitutes the pre-treatment and 2014 the post-treatment period. Furthermore, I use the survey years 2006 and 2010 as pre-treatment years to provide evidence for the parallel trend assumption.

The paper contributes to the literature in three ways: First, it provides evidence of different soda tax designs and their effect on soda consumption as well as BMI. While consumers' response to a local soda tax has been widely studied (Capacci et al. 2019; Cawley et al. 2019; Falbe et al. 2016; Zhong et al. 2018), it is less clear how important the tax design is. Therefore, this paper examines and compares the effect

[1] Syrups, energy drinks, confectionery, salted snacks, condiments, flavored alcohol, and fruit jams.

[2] Converted into Euros at the rate on 01.09.2011.

[3] The choice of the control group is explained in detail in section 4 Data.

of a broad tax on unhealthy products, including sodas above a certain sugar content, with a tax targeting only sodas. Second, it is one of the few studies to focus on Europe, as most of the evidence comes from the USA (see, e.g., Falbe et al. 2016; Zhong et al. 2018, 2020). Since Europe has a lower soda consumption than the USA, a soda tax could have a different impact in Europe. Third, it contributes to the evidence of soda taxes on children's soda consumption and health. The majority of the literature addresses the impact of soda taxes on adults and households (see, e.g., Falbe et al. 2016; Zhong et al. 2018; Fichera et al. 2021; Capacci et al. 2019; Berezvai et al. 2020). However, soda taxes might have a different impact on children than on adults due to their restricted budget. While there is scarce and mixed evidence from the USA (see, e.g., Fletcher et al. 2010;Cawley et al. 2019), it is to the best of my knowledge, the first study examining the effect on children in Europe by using a quasi-experimental approach. Understanding the effects of different soda taxes on soda consumption is important for children's future health. In particular, soda consumption can increase if several unhealthy products are taxed at different rates. If only sodas are taxed, the tax should be high enough to lead to a decrease in consumption.

The remainder of this paper is organized as follows: In the next section, I give an overview of the existing literature. Afterwards, I provide information about the implementation of the soda tax in France and Hungary. Thereafter, I present the data source, descriptive statistics, and define the subsample. Then, I discuss the empirical strategy and show the results. Finally, I conclude the empirical analysis.

2 Empirical evidence on soda taxes

This paper relates to two strands of literature. The first one addresses the impact of a soda tax on adults or households in different countries and several US jurisdictions. For example, Falbe et al. (2016) focus on poorer districts in North California and study the effect of a converted 31 Eurocents per litre[4] soda tax in Berkeley in 2015, compared to similar areas without such a tax in Oakland and San Francisco. They find a decrease in soda consumption by 21% after the tax implementation and an increase in water consumption by 63%. In the US state Philadelphia, the soda tax amounts to converted 49 Eurocents per litre[5] in 2017. Zhong et al. (2018) find that Philadelphians, compared to citizens of close and similar cities without such a tax, drink 40% fewer sodas directly after the tax implementation, yet the effect diminishes 1 year later (Zhong et al. 2020). However, Wilson and Hogan (2017) criticize that the soda tax can be easily circumvented, if the tax is implemented very locally, such as in a particular city. For this reason, Wilson and Hogan (2017) caution against over-interpreting the results of these studies.

Several European countries have recently implemented a soda tax. For example, Fichera et al. (2021) study the impact of a soda tax in Catalonia, a region of Spain, in 2017. They find that taxed sodas with a sugar level over a certain threshold are substituted by untaxed sodas with a lower sugar level. All in all, 2.2% less sugar is

[4] Converted into litre and Euros (at the rate on 01.03.2015)

[5] Converted into litre and Euros (at the rate on 01.01.2017)

consumed. In the neighboring country Portugal, both sodas with less and much sugar are taxed since 2017. Gonçalves and Pereira dos Santos (2020) examine the quantity of consumed sodas and find only limited evidence of the effectiveness of the soda tax. Although the consumption of sodas with less sugar decreased, the amount of sodas consumed with high levels of sugar did not.

The soda tax policies of France and Hungary are studied in this paper. The literature based on France reports a pass-through of the soda tax to the consumer between 39% (Etilé et al. 2018) and 100% (Capacci et al. 2019; Berardi et al. 2016). Capacci et al. (2019) analyze the number of purchased sodas at the household level in France compared to close regions in Italy. They apply a differences-in-differences approach and find a very small but imprecisely estimated decrease in soda consumption and explain their result with the low soda tax level. Biró (2015) evaluates the effect of the unhealthy product tax in Hungary but sodas are excluded from the analysis due to data restrictions. Kurz and König (2021) examine both the soda tax in France and the PHPT in Hungary using data on purchased sodas and apply a synthetic control group analysis. The findings directly after the implementation of the taxes suggest a slight decline in soda consumption in France and in Hungary. In the long term, however, the PHPT in Hungary lead to an increase in soda purchases. A consumption analysis by Berezvai et al. (2020) confirms this counterintuitive result.

The second strand of literature discusses the effect of the soda tax on children's and adolescents' outcomes. The evidence is mixed: Fletcher et al. (2010) finds a small decline in soda consumption of children and adolescents due to the implementation of a soda tax across all US states, which had an average soda tax between 1.5 and 2.3%. In contrast, (Sturm et al. 2010) ascertain that a low soda tax ($\leq 4\%$) has neither an effect on soda consumption nor on obesity rates of children in the US states. In Philadelphia, a tax of converted 49 Eurocents per litre[6] does not affect children's soda consumption (Cawley et al. 2019). However, subgroups like overweighted children, children from families with low incomes (Sturm et al. 2010) or children with a high soda consumption prior to the reform (Cawley et al. 2019) are more likely to react to a soda tax. Regarding the effect of the soda tax on BMI, Powell et al. (2009) find no significant change among adolescents in different US states. In Mauritius, a soda tax does neither affect the consumption nor the BMI of young people, but decreases soda consumption among boys (Cawley et al. 2022). A price war among the manufactures in Peru lead to a reduction of soda prices at the end of the nineties, which increased the obesity rate among children (Ritter 2018). Regarding Europe, there is little evidence for children's and adolescent's outcomes. Dubois et al. (2020) simulate the effect of the soda tax on consumption behavior "on-the-go" in the UK. They found that 13–21 year olds reduced their consumption the most.

3 Institutional background: soda taxes

Soda taxes represent a policy tool to combat sugar intake on a country and local level. Several US cities, as well as various countries, have implemented a tax on sugar-

[6] Converted into litre and Euros (at the rate on 01.01.2017)

sweetened sodas in recent years (Allcott et al. 2019). The first two countries which imposed a soda tax in Europe were Finland in 1940 followed by Norway in 1981 (Asen 2019).

Thirty years after Norway, Hungary levied a "Public Health Product Tax" (PHPT) on salted snacks, condiments, flavored alcohol, fruit jams, confectionery, energy drinks, and also on sugar-sweetened beverages (Ecorys 2014). Every product category reveals a different tax level, even among the sugar-containing beverages exist differences: Syrups are taxed by 200 Hungarian Forint (HUF)[7] per litre, whereas other sugar-sweetened sodas are taxed by 7 HUF[8] per litre. Additionally, the original tax level for sodas amounted to 5 HUF in 2011 and was increased to 7 HUF in 2012 (Biró 2015). This soda tax only affects sodas exceeding a sugar content of 8 gs per 100 mls, sodas with less sugar are not taxed. To make this threshold more apparent, an original Coca-Cola contains more than 10 gs of sugar per 100 mls.[9] Some sugared drinks like juices with more than 25% of fruit content were not taxed. The reason for the implementation of this tax was a public health crisis (WHO 2015). Non-communicable diseases have been a widespread cause of premature death, whereby the main risk factor was unhealthy diet (Institute for Health Metrics and Evaluation 2010). One year prior to the implementation of the health policy, the share of overweight adults[10] amounted to 61.7% (WHO 2017c) which exceeded the European average of 58.7% (WHO 2017d). Likewise, the share of obese adults was higher (25.3%) (WHO 2017a) than the European average (22.3%) (WHO 2017b).

According to the law, the consumer bears the tax burden, by paying retail price including the soda tax (Ecorys 2014). To answer the question whether the soda tax was passed through to the consumer, I tracked the development of the annual average price of 1.75 ls of Coca-Cola. Table 8 in the Appendix reports a price increase of Coca-Cola from the soda tax implementation in 2011 onwards. With this data at hand, I calculated the yearly price increase and the price index based on the previous year. The price of 1.75 ls of Coca-Cola rose from the pre-treatment year 2010 to the implementation year 2011 by 21 HUF. To see whether the price increase was driven by inflation or the soda tax, I compared the Coca-Cola price index with the consumer price index (CPI) of non-alcoholic beverages. The price of Coca-Cola increased more than the price of non-alcoholic beverages in general, which points to the pass-through of the soda tax. In 2012, the tax was slightly raised from 5 HUF to 7 HUF per litre and comparing the two different price indexes shows an even greater difference than in the year before. The price indexes started to converge in the year 2013 and approximated each other in 2014.

A beverage tax was implemented in France in January 2012 and it was originally intended to apply to sugar-sweetened sodas only. However, this was, according to Ecorys (2014), not possible, because the customs codification classifies sodas with added sugar and sweetener into the same category. Whereas Le Bodo et al. (2019)

[7] Equals 73 Eurocents on 01.09.2011.

[8] Equals 2.2 Eurocents on 01.01.2012.

[9] https://www.coca-cola.co.uk/our-business/faqs/how-much-sugar-is-in-coca-cola, last retrieved on 07.11.2021.

[10] Persons 18 years and older with a body mass index equal or bigger than 25.

Table 1 Comparison of taxes in Hungary and France

	Hungary	France
Implementation year	2011	2012
Tax	Unhealthy product tax	Beverage tax
Products	Sodas	Sodas
	Syrups	
	Energy drinks	
	Confectionery	
	Salted snacks	
	Condiments	
	Flavoured alcohol	
	Fruit jams	
Kind of sodas	Sugar-sweetened	Sugar-sweetened or artificial sweetener
Threshold of sugar	> 8 gs per 100 mls	None
Tax level per litre		
In implementation year	5 HUF (∼ 1.8 Eurocents)	7.16 Eurocents
In evaluation year (2014)	7 HUF (∼ 2.4 Eurocents)	7.45 Eurocents
Increase	40%	4%

The table presents the comparison of the Public Health Product Tax in Hungary with the soda tax in France. The information concerning Hungary and France stems from Ecorys (2014), the table was created by myself

reports that sodas with artificial sweeteners were included in the tax to generate higher tax revenues for the farm sector. Consequently, both kinds of sodas are taxed, independently of their quantity of sugar or sweetener. The tax increased over time from 7.16 Eurocents per litre in 2012, to 7.31 Eurocents in 2013, and reached 7.45 Eurocents in 2014 (Ecorys 2014). The aim of the soda tax is twofold: Firstly, it is designed to collect additional revenue for the health (Ecorys 2014) and farm sector Le Bodo et al. (2019). Secondly, the soda tax is supposed to reduce the obesity rate among French citizens (Ecorys 2014). One year prior to the implementation of the health policy, France revealed a share of overweight adults exceeding the European average by almost 2 percentage points (WHO 2017c, d). Every fifth adult had a BMI equal to or over 30 which indicates obesity among the WHO definition, yet the share of obese adults in France is lower than the European average (WHO 2017a, b). Moreover, the National Nutrition and Health Programme 2011 formulated the goal to decrease the share of children drinking more than half a glass of soda a day by at least a quarter in the following 5 years (Ministère du Travail and de l'Emploi et de la Sante 2011). The discussion about the implementation of the soda tax lasted from 2005 to 2011. In August 2011 the tax was decided unexpectedly, the implementation followed five months later (Le Bodo et al. 2019). The pass-through of the soda tax to the consumer is reported between 39% (Etilé et al. 2018) and 100% (Capacci et al. 2019; Berardi et al. 2016).

Table 1 highlights the main differences in the taxes in Hungary and France. Hungary's Public Health Product Tax includes a bunch of unhealthy products and not only sodas. However, exclusively sugar-sweetened sodas exceeding the threshold of 8 g sugar per 100 mls are taxed, whereas sodas with less sugar or artificial sweetener are exempt from the tax. France taxes sugar-sweetened soft drinks (regardless of sugar content) and soft drinks with artificial sweeteners. The tax level is different among the countries, yet both countries raised the tax after implementation.

In Hungary, certain regulations were implemented in January 2015 to enforce health requirements for food and beverage offerings in public canteens (Biró 2015). These regulations aimed to ensure compliance with specific health standards, including the prohibition of sugared soft drinks. It is important to note that the effective date of these regulations occurred after the time period covered by the empirical analysis, and therefore, they do not have any impact on the empirical results. Furthermore, a regulation was implemented in 2012 to promote overall health improvements in schools, including the provision of healthy food, although the regulation did not offer any specific guidance (Biró 2015). Therefore, the implementation of the regulation can vary greatly from school to school.

In France, there were several policies prior to the time period covered by the empirical analysis implemented. For example, nutritional guidelines have been in place for the entire public catering sector since 2001 (Vieux et al. 2018). Additionally, vending machines were banned in schools since 2005 (Capacci et al. 2018). The nutritional guidelines were replaced by mandatory regulations regarding the school meals in 2011 (Vieux et al. 2018), but sodas were not prohibited (European Commission 2015).

4 Data

I use data about the health behavior in school-aged children (HBSC) to undertake a cross-country comparison. This survey is conducted in cooperation with the World Health Organization (WHO) Europe on a quadrennial basis since 2001. The advantage of this survey is the use of the same questionnaire in each country. The school-aged children are asked about the frequency of their soda consumption. The exact question is: "How many times a week do you usually eat or drink Coke or other soft drinks that contain sugar?" The possible answers are presented as the following 7-point scale: (1) "never", (2) "Less than once a week", (3) "Once a week", (4) "2–4 days a week", (5) "5–6 days a week", (6) "Once daily" to (7) "More than once daily". The HBSC data do not provide any information about where the children get or buy the sugar-sweetened sodas. There are restrictions on sodas in both treatment countries. In France, vending machines have been banned in schools since the 2005 school year (more than 6 years prior to the pre-period in this study), see Capacci et al. (2018). In Hungary, the Office of the Hungarian Chief Medical Officer issued a recommendation on nutrition standards in public (school) catering in 2011, stating that sugary drinks should be avoided (Hungarian Chief Medical Officers Office 2011).

Another section in the survey addresses body measures like children's height and weight. Based on this information, the body mass index (BMI) is calculated and reveals whether a child is overweight. The random sampling is made class-wise which implies a repeated cross-sectional design.

Regarding the sample restriction, I excluded pupils with missing observations in the dependent variable like soda consumption and body mass index. In the survey year 2006 is no information about the BMI available, so I calculate it by the following formula BMI = bodyweight/(body height in m)^2.[11] Furthermore, I have excluded children with missing information about their age, sex, TV consumption on weekdays, and having their own bedroom. Moreover, observations are excluded from the sample that do not inform about the number of computers in the household, ownership of a car, family wealth, and whether the mother or the father lives in the main home.

A suitable control group for the treatment group is one that closely resembles it in all relevant aspects except for the presence of the implemented policy. By employing this approach, we can attribute the observed changes in the outcome variable to the specific policy implemented in the treatment group (Taillie et al. 2017). To note in this context is that soda consumption increases in wealth in Eastern European countries, whereas it decreases in Western European countries (Vereecken et al. 2005). Therefore, I use a resembling neighboring country, without a soda tax as a control group. It is important to find a similar neighboring country for the treated country to reduce the likelihood of confounding factors influencing both countries simultaneously.

Both country pairs (Hungary and Croatia and France and Spain) show comparable socio-economic conditions and health indicators. Table 10 in the Appendix presents an overview of relevant country-specific characteristics. For example, both country pairs reveal a similar share of overweighted children and adolescents 1 year prior to the implementation of the tax on sodas in Hungary and Croatia (22% and 21%) as well as in France and Spain (28% and 30%) (WHO 2017e). This similarity indicates that both country pairs may face similar challenges regarding diet, nutrition, and health outcomes related to excess weight. Therefore, using these neighboring countries as a control group can help isolate the effect of the soda tax specifically, without the confounding effects of drastically different obesity rates. Furthermore, it existed a similar level of soda consumption in Hungary and Croatia (Table 9, Panel A) as well as in France and Spain (Table 9, Panel B) before the implementation of the taxes. Hence, both country pairs were subject to similar underlying factors affecting consumer behavior in this regard. Additionally, the two country pairs rank similarly in terms of the Human Development Index (HDI), see (Table 10 in the Appendix). The HDI takes into account factors such as life expectancy, education, and income, providing a comprehensive measure of human development. Similar HDI rankings indicate that both countries have achieved similar levels of overall development and well-being. Therefore, similar HDI rankings suggest comparable socio-economic conditions between the treatment and control countries. Comparable socio-economic conditions are important because they can affect various aspects related to soda consumption, such as purchasing power, consumer behavior, and health outcomes. Furthermore, similar HDI rankings indicate that the country pairs may have similar governance structures, institutional frameworks, and policy environments, which can influence the implementation and effects of a soda tax.

[11] https://projekte.uni-hohenheim.de/wwwin140/info/interaktives/bmi.htm.

Table 2 Treatment and control groups

	Treated		Control	
	Country	Survey year	Country	Survey year
Panel A: Public Health Product Tax				
Pre-treatment	Hungary	2010	Croatia	2010
Post-treatment	Hungary	2014	Croatia	2014
Panel B: Soda tax				
Pre-treatment	France	2010	Spain	2010
Post-treatment	France	2014	Spain	2014

The table presents the treatment and control groups separately for the Public Health Product Tax (Panel A) and the soda tax (Panel B)

As Table 2 shows, Hungary has implemented the tax in 2011 and France followed 1 year later, yet the data is available every 4 years. Therefore, the survey year 2010 constitutes the pre-treatment period and 2014 the post-treatment period. In the treatment as well as in the control group are 11–15 years old surveyed pupils.

Table 3 reports the descriptive statistics for the treated children living in France and the untreated children living in Spain separately. For either group, the mean and the standard deviation (SD) of the variables are provided. The last two columns contain the mean differences across groups as well as the *p* values. In France, the share of boys and girls in the survey is almost balanced and children are on average 13.5 years old. The children watch on average 2 h TV on a weekday and the majority has their own bedroom. Most children live together with their mother and father at home. The family posses on average 1.7 cars and 2.3 computers, and reports well-being between "quite well off" and "average". All these before mentioned control variables are statistically significantly different across children in France and Spain. The lower part of Table 3 presents the descriptive of the outcome variables. The frequency of consumed sodas is measured as a categorical variable, a value of four corresponds to a soda consumption on 2–4 days a week. A body mass index (BMI) of 19 is within the normal range.[12] The mean differences of the two outcome variables are statistically significant between children in France and Spain. Regarding the sample size, 8821 children participated in the survey in France and 9744 children participated in Spain which sums up to 18,565 observations in total.

Table 4 reports the descriptive statistics for the second country-pair. Children living in Hungary belong to the treatment group and children living in Croatia form the control group. TV consumption is slightly higher among the children in Croatia and it is more likely that the father lives in the main household in Croatia. Families in Croatia have a higher probability to have more than one car in comparison to families in Hungary, whereas children in Hungary are more likely to have their own bedroom. The number of computers at home is slightly higher in Hungary than in Croatia, whereas the families in Croatia score higher in being well off. Children in Hungary consume slightly more frequently sodas than children in Croatia. The BMI is slightly higher in Croatia than

[12] https://www.stanfordchildrens.org/en/topic/default?id=determining-body-mass-index-for-teens-90-P01598.

Table 3 Descriptive statistics: Soda tax

	France (treated)		Spain (non-treated)		Mean difference	p value
	Mean	SD	Mean	SD		
Time						
Year	2011.97	2.00	2012.32	1.97	– 0.35	0.00
Control variables						
Child characteristics						
Female (Dummy)	0.51	0.50	0.52	0.50	– 0.02	0.04
Age (in years)	13.54	1.65	13.68	1.61	– 0.14	0.00
TV consumption on a weekday (categorical)	2.09	1.77	2.00	1.60	0.09	0.00
Household characteristics						
Mother living at main home (Dummy)	0.92	0.27	0.96	0.20	– 0.04	0.00
Father living at main home (Dummy)	0.75	0.44	0.83	0.37	– 0.09	0.00
Number of family cars	1.69	0.53	1.54	0.58	0.15	0.00
Own bedroom (Dummy)	0.85	0.36	0.83	0.38	0.02	0.00
Number of computers per family	2.30	0.80	2.23	0.83	0.07	0.00
Family well-off (categorical)	2.28	0.85	2.93	0.50	– 0.65	0.00
Outcome variables						
Frequency of sodas (categorical)	3.97	1.87	3.85	1.76	0.12	0.00
Body mass index (BMI)	18.97	3.18	19.94	3.30	– 0.97	0.00
Number of observations	8821		9744			

The table presents the mean and standard deviation of the control variables and the outcome variables separately for France (treated) and Spain (non-treated). Family well-off is measured on a 6-point-scale, a value between 2 and 3 means between "quite well off" and "average". The frequency of sugar-sweetened soda consumption is reported on a 7-point scale from "never" to "more than once daily", a value of 4 corresponds to soda consumption on 2–4 days a week. Statistics are based on 18,565 school-aged children in the estimation sample, i.e., observations without missing data in the control variables and in both outcomes. The data stem from Health behavior of school-aged children (HBSC)

Table 4 Descriptive statistics: Public Health Product Tax

	Hungary (treated)		Coratia (non-treated)		Mean difference	p value
	Mean	SD	Mean	SD		
Time						
Year	2011.74	1.98	2011.64	1.97	0.09	0.00
Control variables						
Child characteristics						
Female (Dummy)	0.52	0.50	0.51	0.50	0.00	0.64
Age	13.59	1.65	13.68	1.66	−0.10	0.00
TV consumption on a weekday (categorical)	2.04	1.65	2.48	1.74	− 0.43	0.00
Household characteristics						
Mother living at main home (Dummy)	0.95	0.23	0.98	0.13	− 0.04	0.00
Father living at main home (Dummy)	0.74	0.44	0.94	0.24	− 0.20	0.00
Number of family cars	1.04	0.71	1.34	0.59	− 0.30	0.00
Own bedroom (Dummy)	0.73	0.44	0.67	0.47	0.07	0.00
Number of computers per family	1.83	0.87	1.73	0.85	0.10	0.00
Family well-off (categorical)	2.40	0.83	2.15	0.91	0.25	0.00
Outcome variables						
Frequency of sodas (categorical)	4.03	1.98	3.94	1.84	0.09	0.00
Body mass index (BMI)	19.54	3.49	19.90	3.24	− 0.36	0.00
Number of observations	7544		9919			

The table presents the mean and standard deviation of the control variables and the outcome variables separately for Hungary (treated) and Croatia (non-treated). Family well-off is measured on a 6-point-scale, a value between 2 and 3 means between “quite well off” and “average”. The frequency of sugar-sweetened soda consumption is reported on a 7-point scale from “never” to “more than once daily”, a value of 4 corresponds to soda consumption on 2–4 days a week. Statistics are based on 17,463 school-aged children in the estimation sample, i.e., observations without missing data in the control variables and in both outcomes The data stem from Health behavior of school-aged children (HBSC) in Hungary. There are 7544 treated children in Hungary and 9919 non-treated children in Croatia, so 17,463 children in total.

5 Econometric approach

In this section, I discuss the difference-in-differences (DiD) strategy for identifying the Average Treatment Effect on the Treated (ATET) (see e.g., Lechner 2010), i.e., on children living in Hungary or France in 2014. The potential outcome Y (e.g., frequency of consumed sodas) depends on the time period $t \in \{0, 1\}$ and the potential treatment state $d \in \{0, 1\}$. The notation Y_t^d indicates the potential outcome in the potential treatment state d and in time period t. For example, the potential outcome of the treatment group ($d = 1$) in the pre-treatment period ($t = 0$) is represented by Y_0^1. This notation facilitates to state the identifying assumptions of the DiD framework, see Lechner (2010).

The first assumption, formulated in equation 5.1, requires the exogeneity of the covariates (X). This assumption would be violated if the soda tax affects the characteristics of the children or the household. Time-independent covariates, like gender, cannot be affected by the soda tax because they are constant over time. Time-dependent variables may be affected by the treatment, especially if these variables are measured after the implementation of the soda tax. Since I use repeated cross-sections, the covariates are measured in 2014, whereas the soda tax is in force since 2011 or 2012 respectively. However, it is rather unlikely that the soda tax affects, for example, children's TV consumption or whether the mother lives at the main home or not.

$$X^1 = X^0 = X; \;\; \forall x \in \chi. \tag{5.1}$$

The main identifying assumption in the context of DiD is the common trend assumption, formally stated in Eq. 5.2. Intuitively speaking, the soda consumption and the BMI of children living in Hungary and Croatia, would follow the same time trend in the absence of the soda tax.[13] For this reason, I need to control for child and household covariates that would lead to different time trends. For example, soda consumption increases with the age of the child (Grimm et al. 2004), such that the time trend differs between older and younger children. Another example represents children from low-income families which might have fewer available pocket money in time of an economic crisis. I provide a placebo test conditional on covariates using unaffected periods in Table 6 in Sect. 6 to support this assumption.

$$\begin{aligned} &E[Y_0^1|X = x, D = 1] - E[Y_0^0|X = x, D = 1] \\ &= E[Y_0^1|X = x, D = 0] - E[Y_0^0|X = x, D = 0] \\ &= E[Y_0^1|X = x] - E[Y_0^0|X = x]; \;\; \forall x \in \chi. \end{aligned} \tag{5.2}$$

A further assumption rules out an anticipatory effect (θ) of the policy in the pre-treatment period ($t = 0$) as formulated in Eq. 5.3. Accordingly, children in the treated

[13] This assumption must hold for France and Spain too.

countries Hungary and France must not anticipate the effect of the soda tax in 2010, i.e., they must not change their soda consumption prior to the implementation of the tax. Since the tax was discussed from 2005 to 2011 in the parliament in France, it might have raised the awareness of unhealthy beverages among French children. As a result, I may underestimate the impact of the soda tax. Conversely, the knowledge of this proposed tax could also have influenced consumers to stock up on sodas before the tax was introduced. However, I focus on school-age children who possess only their limited pocket money, so this caveat is unlikely. Additionally, the decision to pass this law was unexpected and the implementation time of five months was rather short (Le Bodo et al. 2019). In Hungary, the law was passed one and a half months before it came into force (Ecorys 2014), which represents even a shorter period for anticipatory behavior.

$$\theta_0(x) = 0;\ \forall x \in \chi. \tag{5.3}$$

The last assumption is known as the common support assumption and is formulated in Eq. 5.4. It demands that for each child in Hungary in 2014, another child exists with the same characteristics in the following three groups: (i) Hungary in 2010, (ii) Croatia in 2010, and (iii) Croatia in 2014.[14] Under assumptions 5.1–5.4, the ATET is identified.

$$\begin{gathered} P[TD = 1|X = x, (T, D) \in (t, d), (1, 1)] < 1; \\ \forall (t, d) \in \{(0, 1), (0, 0), (1, 0)\};\ \forall x \in \chi. \end{gathered} \tag{5.4}$$

A standard DiD approach models a linear relationship between the policy and the outcome, in this case, the outcome variable is continuous. The variable "Frequency of sodas" is measured as a categorical variable in the HBSC dataset. Therefore, this variable is a limited dependent variable, implying a non-linear relationship between the policy and the outcome. However, considering the non-linearity may lead to the violation of the identifying assumption of the DiD, the common trend assumption (Lechner 2010). To deal with this issue, I use a semi-parametric approach with a modified common trend assumption to model the relationship in a more flexible way than a parametric approach.

Equation 5.5 describes the identification of the semi-parametric ATET based on inverse probability weighting (Huber 2019). The outcome variable Y is multiplied by an inverse probability weight, where Π gives the share of treated observations in the post-treatment period and $\rho_{d,t}(X)$ is the probability of being in the treatment state d and in the time period t, conditional on covariates X. This propensity score is estimated by probit.

$$\begin{gathered} E\left[\left\{\frac{DT}{\Pi} - \frac{D(1-T)\rho_{1,1}(X)}{\rho_{1,0}(X)\Pi} - (\frac{(1-D)T\rho_{1,1}(X)}{\rho_{0,1}(X)\Pi}) - \frac{(1-D)(1-T)\rho_{1,1}(X)}{\rho_{0,0}(X)\Pi})\right\} Y\right], \\ where\ \Pi = Pr(D = 1, T = 1),\ \rho_{d,t}(X) = Pr(D = d, T = t|X). \end{gathered} \tag{5.5}$$

To ensure that the common trend assumption holds, I include the following covariates (X) in the estimation: On the individual level, I control for age and sex of the child, because older children reveal a different soda consumption than younger children and

[14] This assumption holds for France in 2014 too. In this case, the three groups are (i) France in 2010, (ii) Spain in 2010, and (iii) Spain in 2014.

boys differ in their consumption behavior from girls (Vereecken et al. 2005). Since TV consumption was associated with soda consumption (see Andreyeva et al. 2011; Gebremariam et al. 2017; Grimm et al. 2004; Vereecken et al. 2006), I control for television consumption on a weekday. On the household level, I take into account several characteristics: Firstly, I control for the household structure, in particular, whether the mother or the father lives in the same household as the child. Secondly, I control for the wealth of the family, because it is associated with different soda consumption levels (Drewnowski et al. 2019). I use the following proxies for family's wealth: Ownership of a family car, number of computers in the household, well-off of the family, a dummy indicating whether the child has his/her own bedroom. Furthermore, soda consumption increases with wealth in Eastern European countries, whereas it decreases in Western European countries (Vereecken et al. 2005). Country-specific characteristics, like the growth of the Gross Domestic Product (GDP), may affect the soda consumption of its inhabitants and thus bias the results. Controlling for country-specific covariates could serve as a solution for this problem, yet this is not possible because of the multi-collinearity with the treatment. Therefore, I inspect the GDP growth of each country pair in Sect. 6.

For the estimation, I use the didweight command of the causalweight package in R, with the default number of bootstrap replications of 1999 to calculate the standard errors, and the default trimming rule of 0.05 to drop observations with an extreme propensity score from the sample. Since the didweight command is designed for one pre- and one post-treatment-period, I use the survey years 2010 and 2014 in the estimation. Several pre-treatment years are available to test the parallel trend assumption. I use the survey years 2006 and 2010 and run the estimation with a fake treatment in the latter.

6 Results

This chapter provides the estimated results as well as the sensitivity analysis. Table 5 presents the conditional difference-in-differences estimates. The standard errors are estimated by bootstrap and the p values are obtained from t-tests. Panel A reports the effect of the policy package in Hungary, whereas Croatia constitutes the control group. The findings point at the first glance to a counter-intuitive positive and significant ($p < 0.01$) effect of the tax on consumption behavior among school-aged children.[15] Since a range of products is taxed, the substitution of sugar-sweetened products might drive this result. For example, a survey among adults who changed their nutritional behavior due to the PHPT suggested that 52% substituted energy drinks with sodas (Martos et al. 2016), which might be driven by the higher tax on energy drinks.[16] Another reason for this counter-intuitive result might be that some manufacturers circumvent the soda tax by decreasing the sugar content below the threshold of 8 gs per 100 mls. A study by the National Institute for Health Development (OEFI) 2013

[15] The effect size is not directly interpretable because soda consumption is measured as a categorical variable.

[16] 250 HUF/l if taurin > 100 mg per 100 ml or 40 HUF/l if no taurin but methylxanthine > 15 mg per 100 ml see Biró (2015).

Table 5 Conditional difference-in-differences results

	Effect	Standard error	*p* value	Number of observations
Panel A: Hungary and Croatia				
Frequency of sodas	0.35	0.07	0.00	18712
Body Mass Index (BMI)	0.12	0.13	0.36	17553
Panel B: France and Spain				
Frequency of sodas	– 0.08	0.08	0.31	20951
Body Mass Index (BMI)	– 0.07	0.15	0.66	18723

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting. The following control variables are included: Age, sex, and hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

suggests that about 40% of manufacturers whose products were affected by the cross-product PHPT changed their production formulas to avoid taxation. Another driver of this result might be the relatively stronger GDP growth in Hungary compared to Croatia (see Fig. 1 in the Appendix) and stronger income growth due to minimum wage increases in Hungary, i.e., children in Hungary could spend more money for sodas.[17] However, Berezvai et al. (2020) analyzed the purchasing behavior of Hungarians after the introduction of the tax and find an increase in purchased sodas among Hungarian households. The result might also be affected by the decrease in the inflation rate in Hungary (Fig. 2 in the Appendix) and the decrease unemployment rate in Hungary (Fig. 3 in the Appendix).

The second outcome, children's BMI, is not affected by the tax in Hungary. Panel B in Table 5 reports the effects of the soda tax on the frequency of sugar-sweetened soda consumption and the BMI for French children (treated) and Spanish children (untreated). The effects have the expected negative sign but are insignificant. This result is consistent with analyses of large quantities of sodas purchased at the aggregate level such as households (Capacci et al. 2019) and industry (Kurz and König 2021), which find only a small and imprecisely estimated decrease in sodas purchased. But Fig. 4 shows larger GDP growth in Spain than in France over time which might affect the result. Figures 5 and 6 in the Appendix show the development of the inflation and unemployment rate in France.

A downside of non-clustered standard errors in a DiD setting is the possibility of underestimating the standard errors (Bertrand et al. 2004). To check whether the empirical results in Table 5 are robust, I have re-estimated the results with clustered standard errors. The most conservative approach would be to cluster standard errors on an aggregate level. However, it is not possible to cluster on the country level in this setting, because of the small number of treated countries. Whenever cluster bootstrap does not draw the treatment group, the procedure does not work. Hence I cluster on the next lowest level which has variation in the data: the school-year level. Table 11 in

[17] Due to the multicollinearity with the treatment, I cannot control for the GDP growth.

Table 6 Unaffected periods

	Effect	Standard error	p value	Number of observations
Panel A: Hungary and Croatia				
Frequency of sodas	0.10	0.08	0.23	19069
Body Mass Index (BMI)	− 0.06	0.15	0.67	17949
Panel B: France and Spain				
Frequency of sodas	0.09	0.08	0.26	24919
Body Mass Index (BMI)	0.01	0.15	0.96	21826

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting using years prior to the treatment implementation. The following control variables are included: Age, sex, and hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

the Appendix shows that the clustered standard errors are almost equal to the robust standard errors in Table 5.

The identifying assumption of the DiD approach is the parallel trend assumption, implying that, conditional on the covariates, the treatment and control group follow the same time trend in the absence of the treatment. This assumption is not testable, yet it is possible to conduct a placebo test to support this assumption: I use the two pre-treatment periods 2006 and 2010 and pretend that in the latter a 'fake treatment' was implemented. Table 6 reports large p values in both panels, which supports the parallel trend assumption. Event study graphs are another useful tool and a more demanding test to inspect the parallel trend assumption. Figure 7 in the Appendix displays the group-time average treatment effects for each outcome and country pair in the years 2010 and 2014. The year 2006 serves as a reference period. Hungary implemented the soda tax in 2011 and France in 2012. Hence, the pre-treatment period is measured one (two) year(s) before treatment in Hungary (France) and the post-treatment period three (two) years after the treatment in Hungary (France). The dots represent the point estimates and the bands correspond to the pointwise 95% confidence intervals based on the multiplier bootstrap. Figure 7 shows that the group-time average treatment effects of the soda tax on the frequency of soda consumption and on the BMI in the pre-treatment year are close to zero and statistically insignificant at any conventional level. This finding reassures the validity of the parallel trend assumption.

As a robustness test, I use another neighboring country as an alternative control group in each panel: I substitute Croatia with Slovakia and Spain with Switzerland. Tables 12 and 13 in the Appendix report the descriptive statistics of the children and the household for these groups. Table 14 in the Appendix shows the placebo test of the unaffected periods for Hungary and Slovakia (Panel A) and France as well as Switzerland (Panel B) separately. It suggests that the parallel trends assumption holds for both Panels, except for the outcome variable BMI in Panel A[18]. Finally, Table 7 reports the results for robustness test. Even if the control group changes I find

[18] Table 15 in the Appendix shows the placebo test of the unaffected periods for France and Switzerland (Panel B) with school-year specific clusters. It suggests that the parallel trend assumption holds.

Table 7 Robustness test

	Effect	Standard error	*p* value	Number of observations
Panel A: Hungary and Slovakia				
Frequency of sodas	0.48	0.09	0.00	15425
Body Mass Index (BMI)	– 0.13	0.15	0.38	14059
Panel B: France and Switzerland				
Frequency of sodas	– 0.04	0.07	0.52	22986
Body Mass Index (BMI)	– 0.13	0.11	0.24	20258

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting by using an alternative control group. The following control variables are included: Age, sex, and hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

a highly statistically significant positive effect on the frequency of consumed sodas in Hungary[19], [20]. In France, the results on the soda consumption and the BMI have a negative sign, yet they are insignificant as in the main results in Table 5. Figures 8 and 9 in the Appendix report a parallel GDP growth of each country pair prior to the measured effect in 2014. Therefore, GDP growth can be excluded as a driver for the increase in soda consumption in Hungary.

One concern with using the difference-in-differences approach might be compositional changes in the population, such that the treatment and control group are not stable over time. However, it seems very unlikely and a disproportionate effort for families to move from Hungary to Croatia to circumvent the PHPT of 2.4 Eurocents per litre. A second concern with using a neighboring country as a control group might be the presence of spill-overs. Residents living close to the boarder region might start cross-border shopping after the implementation of the tax. The existence of spillover effects seems to be ruled out, as the price level in Croatia is more expensive than in Hungary, see eurostat (2022).

Boys and girls may react differently to a tax on sodas, see e.g. Cawley et al. (2022). Tables 23, 24, 25 and 26 in the Appendix show no gender-specific statistically significant change in the frequency of lemonade consumption due to the tax. Teenagers receive more pocket money and may therefore respond differently to a tax on sodas than younger children. Tables 27, 28, 29 and 30 in the Appendix tend to suggest that teenagers (13–15 years) might be more responsive to a drink tax than younger children (11 and 12 years).

19 Table 16 in the Appendix shows the robustness test with school-year specific clusters. The results are in line with Table 7.

20 Tables 17-22 show the results of the placebo test and robustness test for further control groups.

7 Conclusion

This paper examines the effect of two different health policies on sugar-sweetened soda consumption behavior and body mass index (BMI) of school-aged children in Europe. Hungary has implemented a Public Health Product Tax (PHPT) on several unhealthy products, including sugar-sweetened sodas, in 2011, while France only taxes sodas, containing sugar and artificial sweetener, since 2012. Methodologically, I apply a difference-in-differences (DiD) approach to evaluate this natural experiment and use neighboring countries without such a soda tax as a control group. I analyze the effect in Hungary and France separately, because of the different policy designs. Since the frequency of soda consumption is measured by a categorical scale, I use a semi-parametric method to estimate the effect in a flexible way. To the best of my knowledge, this is the first paper analyzing the impact of two different soda taxes on the consumption and health of school-aged children.

The results suggest that the PHPT had a statistically significant effect ($p < 0.01$) on soda consumption of school-aged children in Hungary, yet the sign is unexpectedly positive. This finding is in line with the study of Berezvai et al. (2020). An explanation for this counter-intuitive result might be the substitution behavior among children, as the price of other unhealthy products, such as energy drinks or syrups, are taxed even higher. Furthermore, some manufacturers changed their production formulas such that their products were not affected by PHPT. In France, the soda consumption of school-aged children is not affected by the soda tax. This result is in line with the analyses of Capacci et al. (2019) and Kurz and König (2021), who use soda sales data at a more aggregated level and find a very small, but not robust effect on the quantity of purchased sodas. Capacci et al. (2019) explain this finding by the very low tax level of 7.16 Eurocents per litre.

Moreover, I analyse the effect on children's BMI and find neither in France nor in Hungary a statistically significant effect. This finding is consistent with Powell et al. (2009) who analyses the effect of soda tax on BMI among adolescents. Regarding the sensitivity analysis, I run a placebo test with two unaffected periods. The results suggest an insignificant effect, which supports the parallel trend assumption. The results are robust to an alternative control group.

Consequently, policy makers should think carefully about the design and the tax rate before implementing a soda tax. The availability of data about children's quantity of soda consumption would help to estimate the effect of the soda tax in a more precise way.

Acknowledgements HBSC is an international study carried out in collaboration with WHO/EURO. The International Coordinator of the 2005/06 survey was Prof. Candace Currie and the Data Bank Manager was Prof. Oddrun Samdal.

Funding Open Access funding enabled and organized by Projekt DEAL.

Declarations

Conflicts of interest None.

Appendix

See Figs. 1, 2, 3, 4, 5, 6, 7, 8, 9 and Tables 8, 9, 10, 11, 12, 13, 14, 15, 16, 23, 24, 25, 26, 27, 28, 29, 30, 17, 18, 19, 20, 21, 22.

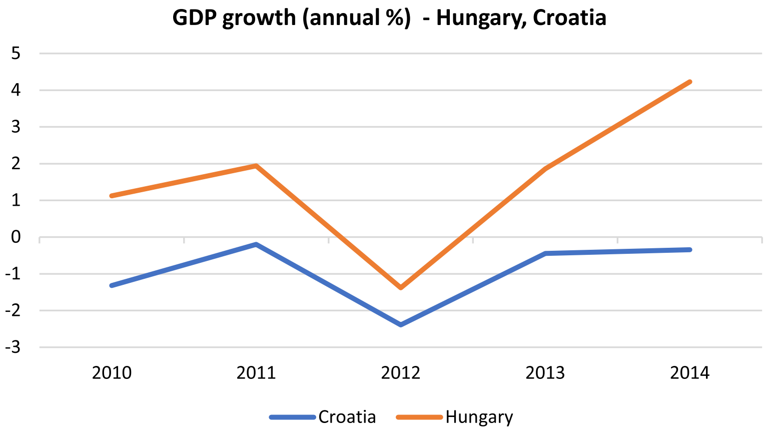


Fig. 1 GDP growth in Hungary and Croatia. Note: The figure presents the annual GDP growth in percent in Hungary and Croatia. The data stem from the World Bank (last accessed: 10.11.2021)

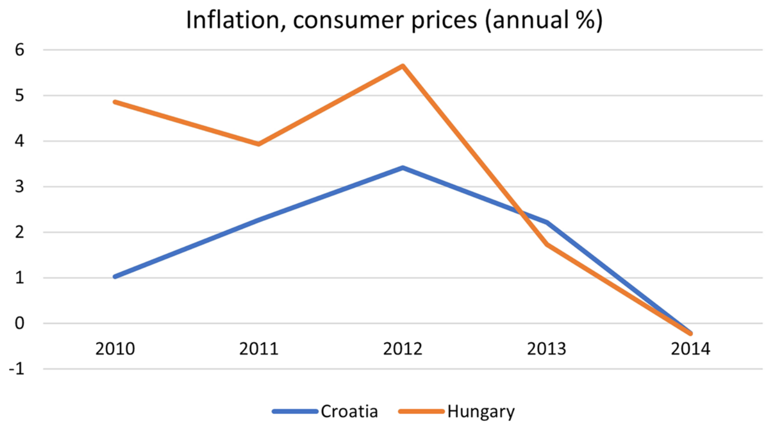


Fig. 2 Inflation, consumer prices—Hungary and Croatia. Note: The figure presents the inflation of consumer prices in percent in Hungary and Croatia. The data stem from the World Bank (https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?end=2014&locations=HU-HR&start=2010, last accessed: 23.06.2023)

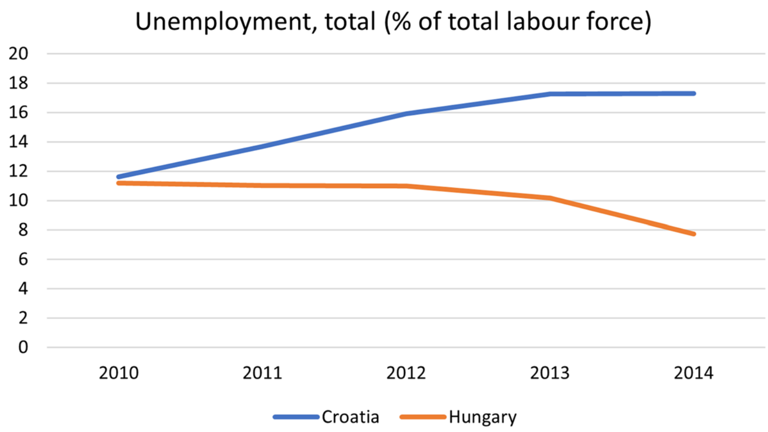


Fig. 3 Unemployment rate—Hungary and Croatia. Note: The figure presents the unemployment rate in percent in Hungary and Croatia. The data stem from the World Bank (https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS?end=2014&locations=HU-HR&start=2010&view=chart, last accessed: 23.06.2023)

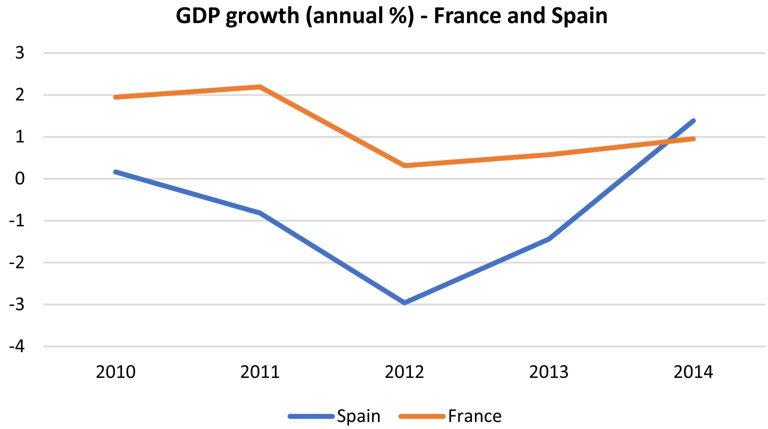


Fig. 4 GDP growth in France and Spain. Note: The figure presents the annual GDP growth in percent in France and Spain. The data stem from the World Bank (https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?end=2014&locations=FR-ES&start=2010, last accessed: 10.11.2021)

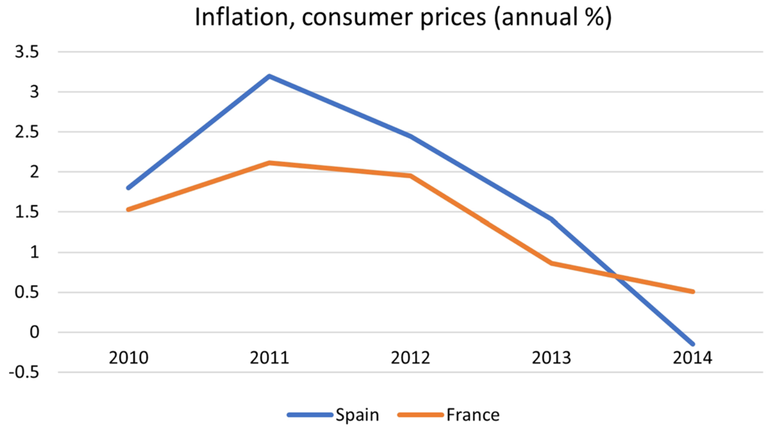


Fig. 5 Inflation, consumer prices—France and Spain. Note: The figure presents the inflation of consumer prices in percent in France and Spain. The data stem from the World Bank (https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?end=2014&locations=ES-FR&start=2010, last accessed: 23.06.2023)

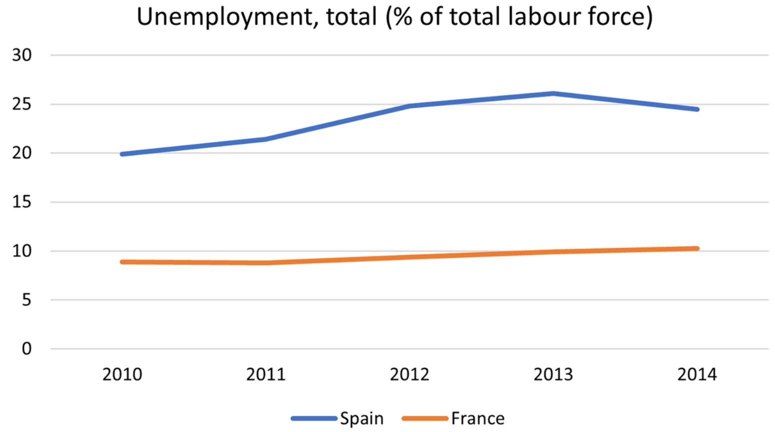
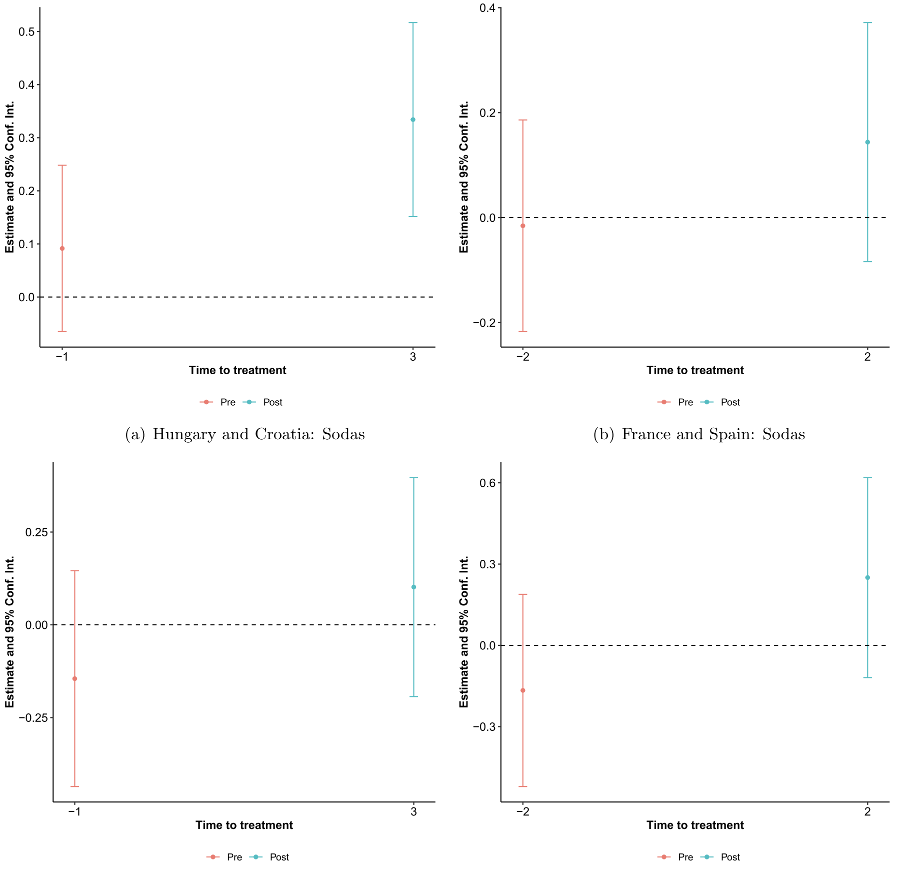


Fig. 6 Unemployment rate—France and Spain. Note: The figure presents the unemployment rate in percent in France and Spain. The data stem from the World Bank (https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS?end=2014&locations=FR-ES&start=2010&view=chart, last accessed: 23.06.2023)



(a) Hungary and Croatia: Sodas

(b) France and Spain: Sodas

(c) Hungary and Croatia: BMI

(d) France and Spain: BMI

Fig. 7 Event study graphs. Note: The figure presents the group-time average treatment effects for each outcome variable and country pair in the years 2010 and 2014. Dots provide the point estimates, bands correspond to 95% confidence intervals. The reference period is 2006. Hungary has implemented the soda tax in 2011 and France in 2012. Hence the pre-treatment period is measured one (two) years before treatment in Hungary (France) and the post-treatment period three (two) years after the treatment in Hungary (France). The following control variables are included: Age, sex, and hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary), and year dummies. The data stem from Health behavior of school-aged children (HBSC). For the estimation, I use the 'att_gt' command of the 'did' package (Callaway and SantAnna 2022) for the statistical software R, with inverse probability weighting

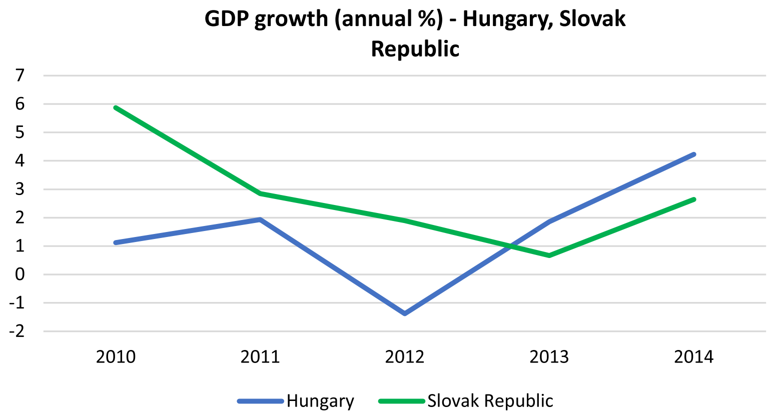


Fig. 8 Parallel GDP growth in Hungary and Slovakia. Note: The figure presents the annual GDP growth in percent in Hungary and Slovakia. The data stem from the World Bank (https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?end=2014&locations=HU-SK&start=2010, last accessed: 29.03.2021)

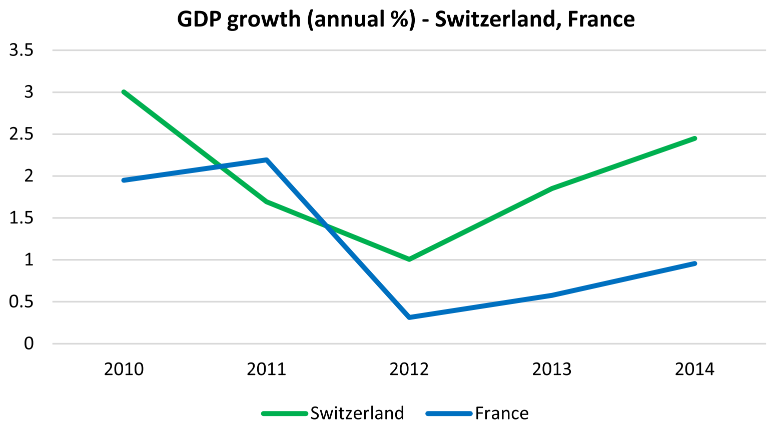


Fig. 9 Parallel GDP growth in France and Switzerland. Note: The figure presents the annual GDP growth in percent in France and Switzerland. The data stem from the World Bank (https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?end=2014&locations=CH-FR&start=2010) (last accessed: 29.03.2021)

Table 8 Price development of Coca-Cola & consumer price index (CPI) of non-alcoholic beverages

	2010	2011	2012	2013	2014
Coca-Cola average price (1.75 l)	295 HUF	316 HUF	351 HUF	366 HUF	373 HUF
Coca-Cola price increase (1.75 l)	0 HUF	21 HUF	35 HUF	15 HUF	7 HUF
Coca-Cola price index	100	107.1	111.1	104.3	102.0
CPI of non-alcoholic beverages	100.1	101.9	105.9	101.9	100.5

The table presents the price development of Coca-Cola and consumer price index (CPI) of non-alcoholic beverages. Data concerning the Coca Cola annual average price and the CPI of non-alcoholic beverages stems from the Hungarian Central Statistical Office. The Coca-Cola price increase and index is self-calculated. The official currency in Hungary is the Hungarian Forint (HUF), which had an average exchange rate of 0.004 USD in 2014

Table 9 Soda consumption in pre-treatment period

	Mean	SD	Mean	SD	Mean difference	*p* value
Panel A: Hungary and Croatia						
Frequency of sodas (categorical)	3.96	1.99	4.01	1.85	– 0.04	0.26
Number of observations	4270		5841			
Panel B: France and Spain						
Frequency of sodas (categorical)	3.97	1.87	3.93	1.73	0.04	0.26
Number of observations	4472		4081			

The table presents the mean and standard deviation of the pre-treatment soda consumption separately for each panel. The frequency of sugar-sweetened soda consumption is reported on a 7-point scale from "never" to "more than once daily", a value of 4 corresponds to soda consumption on 2–4 days a week. The data stem from Health behavior of school-aged children (HBSC)

Table 10 Overview of country-specific characteristics

	Treated	Control
Share of overweighted children and youth		
Panel A	Hungary 22%	Croatia 21%
Panel B	France 28%	Spain 30%
Human Development Index (HDI)		
Panel A	Hungary 0.831	Croatia 0.815
Panel B	France 0.882	Spain 0.878

The table presents national characteristics 1 year prior to the tax implantation, i.e., 2010 for Hungary and 2011 for France. Overweight is defined as a BMI > +1 standard deviation above the median and is a crude measure. Children and adolescents are between 10 and 19 years old. The data on overweight stem from WHO (2017e), data relating to the HDI come from countryeconomy.com

Table 11 Results with school-year specific clusters

	Effect	Standard error	*p* value	Number of observations
Panel A: Hungary and Croatia				
Frequency of sodas	0.35	0.10	0.01	18712
Body Mass Index (BMI)	0.12	0.15	0.42	17553
Panel B: France and Spain				
Frequency of sodas	– 0.08	0.09	0.36	20951
Body Mass Index (BMI)	– 0.07	0.15	0.67	18723

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting. The following control variables are included: Age, sex, and hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap and clustered by school-year. The data stem from Health behavior of school-aged children (HBSC)

Table 12 Descriptive statistics: Public Health Product Tax

	Hungary (treated)		Slovakia (non-treated)		Mean difference	*p* value
	Mean	SD	Mean	SD		
Time						
Year	2011.74	1.98	2011.53	1.94	0.21	0.00
Control variables						
Female	0.52	0.50	0.53	0.50	– 0.01	0.37
Age	13.59	1.65	13.98	1.35	– 0.39	0.00
TV consumption on a weekday	2.04	1.65	2.64	1.77	– 0.60	0.00
Mother living at main home (Dummy)	0.95	0.23	0.96	0.19	– 0.02	0.00
Father living at main home (Dummy)	0.74	0.44	0.88	0.33	– 0.14	0.00
Number of family cars	1.04	0.71	1.24	0.66	–0.20	0.00
Own bedroom (Dummy)	0.73	0.44	0.58	0.49	0.15	0.00
Number of computers per family	1.83	0.87	1.95	0.87	– 0.12	0.00
Family well-off	2.40	0.83	2.07	0.82	0.33	0.00
Outcome variables						
Frequency of sodas	4.03	1.98	4.36	1.89	– 0.33	0.00
Body mass index (BMI)	19.54	3.49	19.54	3.07	0.00	0.99
	7544		6419			

The table presents the mean and standard deviation of the control variables and the outcome variables separately for Hungary (treated) and Slovakia (non-treated). Family well-off is measured on a 6-point-scale, a value between 2 and 3 means between "quite well off" and "average". The frequency of sugar-sweetened soda consumption is reported on a 7-point scale from "never" to "more than once daily", a value of 4 corresponds to soda consumption on 2–4 days a week. Statistics are based on 13,963 school-aged children in the estimation sample, i.e., observations without missing data. The data stem from Health behavior of school-aged children (HBSC)

Table 13 Descriptive statistics: Soda tax

	France (treated)		Switzerland (non-treated)		Mean difference	p value
	Mean	SD	Mean	SD		
Time						
Year	2011.97	2.00	2011.93	2.00	0.04	0.15
Control variables						
Female	0.51	0.50	0.50	0.50	0.01	0.16
Age	13.54	1.65	13.58	1.57	– 0.04	0.08
TV consumption on a weekday	2.09	1.77	1.50	1.35	0.59	0.00
Mother living at main home (Dummy)	0.92	0.27	0.97	0.18	– 0.05	0.00
Father living at main home (Dummy)	0.75	0.44	0.81	0.39	– 0.06	0.00
Number of family cars	1.69	0.53	1.46	0.60	0.24	0.00
Own bedroom (Dummy)	0.85	0.36	0.87	0.33	– 0.03	0.00
Number of computers per family	2.30	0.80	2.41	0.76	– 0.11	0.00
Family well-off	2.28	0.85	2.50	0.84	−0.22	0.00
Outcome variables						
Frequency of sodas	3.97	1.87	4.11	1.85	– 0.14	0.00
Body mass index (BMI)	18.97	3.18	19.01	3.04	– 0.04	0.38
	8821		11352			

The table presents the mean and standard deviation of the control variables and the outcome variables separately for France (treated) and Switzerland (non-treated). Family well-off is measured on a 6-point-scale, a value between 2 and 3 means between "quite well off" and "average". The frequency of sugar-sweetened soda consumption is reported on a 7-point scale from "never" to "more than once daily", a value of 4 corresponds to soda consumption on 2–4 days a week. Statistics are based on 20,173 school-aged children in the estimation sample, i.e., observations without missing data. The data stem from Health behavior of school-aged children (HBSC)

Table 14 Unaffected periods

	Effect	Standard error	p value	Number of observations
Panel A: Hungary and Slovakia				
Frequency of sodas	0.06	0.09	0.51	16012
Body Mass Index (BMI)	– 0.33	0.14	0.02	14866
Panel B: France and Switzerland				
Frequency of sodas	– 0.01	0.06	0.84	22845
Body Mass Index (BMI)	– 0.13	0.09	0.15	20646

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting using years prior to the treatment implementation and an alternative control group. The following control variables are included: Age, sex, and hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

Table 15 Unaffected periods with school-year specific clusters

	Effect	Standard error	*p* value	Number of observations
Panel B: France and Switzerland				
Frequency of sodas	– 0.01	0.07	0.86	22845
Body Mass Index (BMI)	– 0.13	0.11	0.21	20646

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting using years prior to the treatment implementation and an alternative control group. The following control variables are included: Age, sex, and hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap and clustered by school-year. The data stem from Health behavior of school-aged children (HBSC)

Table 16 Results with school-year specific clusters

	Effect	Standard error	*p* value	Number of observations
Panel A: Hungary and Slovakia				
Frequency of sodas	0.48	0.11	0.00	15425
Body Mass Index (BMI)	– 0.13	0.18	0.46	14059
Panel B: France and Switzerland				
Frequency of sodas	– 0.04	0.07	0.57	22986
Body Mass Index (BMI)	– 0.13	0.11	0.24	20258

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting using an alternative control group with school-year specific clusters. The following control variables are included: Age, sex, and hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap and clustered by school-year. The data stem from Health behavior of school-aged children (HBSC)

Table 17 Unaffected periods: Not suitable control groups for Hungary

	Effect	Standard error	*p* value	Number of observations
Panel A: Hungary and Slovenia				
Frequency of sodas	– 0.78	0.01	0.00	18187
Panel B: Hungary and Romania				
Frequency of sodas	0.34	0.09	0.00	17164
Panel C: Hungary and Ukraine				
Frequency of sodas	0.91	0.10	0.00	18426

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting using years prior to the treatment implementation. The following control variables are included: Age, sex, and hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC). Serbia joined the Health Behavior and School-aged Children (HBSC) study only in 2017/18 (https://www.who.int/europe/news/item/07-11-2019-serbia-conducts-first-study-on-schoolchildren-s-health-behavior, accessed on 22.06.2023) and can therefore be not used as a potential control group

Table 18 Unaffected periods: Suitable control group for Hungary

	Effect	Standard error	*p* value	Number of observations
Panel A: Hungary and Austria				
Frequency of sodas	− 0.07	0.07	0.32	17020

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting using years prior to the treatment implementation. The following control variables are included: Age, sex, and hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC). Serbia joined the Health Behavior and School-aged Children (HBSC) study only in 2017/18 (https://www.who.int/europe/news/item/07-11-2019-serbia-conducts-first-study-on-schoolchildren-s-health-behavior, accessed on 22.06.2023) and can therefore be not used as a potential control group

Table 19 Further robustness tests

	Effect	Standard error	*p* value	Number of observations
Panel A: Hungary and Austria				
Frequency of sodas	0.54	0.08	0.00	15985

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting using years prior to the treatment implementation. The following control variables are included: Age, sex, and hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

Table 20 Unaffected periods: Not suitable control groups for France

	Effect	Standard error	*p* value	Number of observations
Panel A: France and Belgium (Flemish-speaking part)				
Frequency of sodas	0.33	0.07	0.00	19851
Panel B: France and Belgium (French-speaking part)				
Frequency of sodas	0.14	0.06	0.02	19085

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting using years prior to the treatment implementation. The following control variables are included: Age, sex, and hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

Table 21 Unaffected periods: Other suitable control groups for France

	Effect	Standard error	*p* value	Number of observations
Panel A: France and Luxembourg				
Frequency of sodas	– 0.05	0.06	0.38	19631
Panel B: France and Italy				
Frequency of sodas	0.16	0.27	0.55	20617
Panel C: France and Germany				
Frequency of sodas	– 0.01	0.05	0.81	23554

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting using years prior to the treatment implementation. The following control variables are included: Age, sex, and hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

Table 22 Further robustness tests

	Effect	Standard error	*p* value	Number of observations
Panel A: France and Luxembourg				
Frequency of sodas	0.08	0.07	0.23	16756
Panel B: France and Italy				
Frequency of sodas	0.04	0.07	0.60	19044
Panel C: France and Germany				
Frequency of sodas	– 0.09	0.06	0.14	20468

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting using years prior to the treatment implementation. The following control variables are included: Age, sex, and hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

Table 23 Hungary and Croatia—Heterogenous effects: Sex

	Effect	Standard error	*p* value	Number of observations
Boys				
Frequency of sodas	0.27	0.10	0.01	9025
Body Mass Index (BMI)	– 0.04	0.19	0.85	8521
Girls				
Frequency of sodas	0.51	0.11	0.00	9687
Body Mass Index (BMI)	0.37	0.17	0.02	9032

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting. The following control variables are included: Age, hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

Table 24 France and Spain—Heterogenous effects: Sex

	Effect	Standard error	*p* value	Number of observations
Boys				
Frequency of sodas	– 0.19	0.11	0.11	10147
Body Mass Index (BMI)	– 0.12	0.22	0.58	9123
Girls				
Frequency of sodas	0.04	0.11	0.69	10804
Body Mass Index (BMI)	0.06	0.20	0.77	9600

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting. The following control variables are included: Age, hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

Table 25 Hungary and Slovakia—Heterogenous effects: Sex

	Effect	Standard error	*p* value	Number of observations
Boys				
Frequency of sodas	0.36	0.11	0.00	7373
Body Mass Index (BMI)	– 0.10	0.22	0.67	6738
Girls				
Frequency of sodas	0.57	0.13	0.00	8052
Body Mass Index (BMI)	– 0.23	0.20	0.26	7321

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting. The following control variables are included: Age, hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

Table 26 France and Switzerland—Heterogenous effects: Sex

	Effect	Standard error	*p* value	Number of observations
Boys				
Frequency of sodas	– 0.14	0.09	0.14	11348
Body Mass Index (BMI)	– 0.18	0.16	0.27	10134
Girls				
Frequency of sodas	– 0.00	0.09	0.99	11638
Body Mass Index (BMI)	– 0.19	0.16	0.24	10124

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting. The following control variables are included: Age, hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

Table 27 Hungary and Croatia—Heterogenous effects: Age

	Effect	Standard error	p value	Number of observations
Age ≤ 12				
Frequency of sodas	0.36	0.13	0.01	6066
Body Mass Index (BMI)	− 0.17	0.22	0.46	5531
Age ≥ 13				
Frequency of sodas	0.28	0.09	0.00	13090
Body Mass Index (BMI)	0.30	0.16	0.06	12426

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting. The following control variables are included: Age, hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

Table 28 France and Spain—Heterogenous effects: Age

	Effect	Standard error	p value	Number of observations
Age ≤ 12				
Frequency of sodas	0.14	0.16	0.38	6373
Body Mass Index (BMI)	0.07	0.27	0.80	5531
Age ≥ 13				
Frequency of sodas	− 0.18	0.09	0.04	15223
Body Mass Index (BMI)	− 0.06	0.17	0.71	13639

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting. The following control variables are included: Age, hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

Table 29 Hungary and Slovakia - Heterogenous effects: Age

	Effect	Standard error	p value	Number of observations
Age ≤ 12				
Frequency of sodas	0.29	0.42	0.50	4078
Body Mass Index (BMI)	− 0.80	0.82	0.33	3546
Age ≥ 13				
Frequency of sodas	0.53	0.09	0.00	11759
Body Mass Index (BMI)	0.10	0.16	0.51	10873

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting. The following control variables are included: Age, hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

Table 30 France and Switzerland—Heterogenous effects: Age

	Effect	Standard error	p value	Number of observations
Age $\leq$ 12				
Frequency of sodas	− 0.01	0.11	0.96	7259
Body Mass Index (BMI)	− 0.19	0.20	0.33	6170
Age $\geq$ 13				
Frequency of sodas	− 0.08	0.08	0.33	16433
Body Mass Index (BMI)	− 0.08	0.13	0.53	14584

The table reports the estimates of the semi-parametric ATET based on inverse probability weighting. The following control variables are included: Age, hours of TV consumption on a weekday of the school-aged child, child has an own bedroom (binary), number of family cars, family well-off, mother or father live at the main home (binary). Standard errors are estimated by bootstrap. The data stem from Health behavior of school-aged children (HBSC)

References

Allcott H, Lockwood BB, Taubinsky D (2019) Should we tax sugar-sweetened beverages? an overview of theory and evidence. J Econ Perspect 33:202–27. https://doi.org/10.1257/jep.33.3.202

Andreyeva T, Kelly IR, Harris JL (2011) Exposure to food advertising on television: associations with children's fast food and soft drink consumption and obesity. Econ Hum Biol 9:221–233. https://doi.org/10.1016/j.ehb.2011.02.004

Asen E (2019) Soda taxes in Europe. https://taxfoundation.org/soda-taxes-europe-2019/. Accessed 10 July 2021

Berardi N, Sevestre P, Tépaut M, Vigneron A (2016) The impact of a 'soda tax' on prices: evidence from French micro data. Appl Econ 48:3976–3994. https://doi.org/10.1080/00036846.2016.1150946

Berezvai Z, Vitrai J, Tóth G, Brys Z, Bakacs M, Joo T (2020) Long-term changes of consumption after the introduction of unhealthy food tax in Hungary. SSRN Electron J. https://doi.org/10.2139/ssrn.3703830

Bertrand M, Duflo E, Mullainathan S (2004) How much should we trust differences-in-differences estimates? Q J Econ 119:249–275. https://doi.org/10.1162/003355304772839588

Biener AI, Cawley J, Meyerhoefer C (2020) The medical care costs of obesity and severe obesity in youth: an instrumental variables approach. Health Econ 29:624–639

Bíró A (2015) Did the junk food tax make the Hungarians eat healthier? Food Policy 54:107–115. https://doi.org/10.1016/j.foodpol.2015.05.003

Callaway B, Sant'Anna PH (2022) Getting started with the did package. https://cran.r-project.org/web/packages/did/vignettes/did-basics.html. Accessed 21 Aug 2023

Capacci S, Mazzocchi M, Shankar B (2018) Breaking habits: the effect of the French vending machine ban on school snacking and sugar intakes. J Policy Anal Manag 37:88–111. https://doi.org/10.1002/pam.22032

Capacci S, Allais O, Bonnet C, Mazzocchi M (2019) The impact of the French soda tax on prices and purchases: an ex post evaluation. PLoS ONE. https://doi.org/10.1371/journal.pone.0223196

Cawley J, Frisvold D, Hill A, Jones D (2019) The impact of the Philadelphia beverage tax on purchases and consumption by adults and children. J Health Econ 67:102225. https://doi.org/10.1016/j.jhealeco.2019.102225

Cawley J, Daly M, Thornton R (2022) The effect of beverage taxes on youth consumption and body mass index: evidence from Mauritius. Health Econ. https://doi.org/10.1002/hec.4497

countryeconomy.com. Human development index—hdi. https://countryeconomy.com/hdi. Accessed 14 May 2022

Drewnowski A, Buszkiewicz J, Aggarwal A (2019) Soda, salad, and socioeconomic status: findings from the Seattle obesity study (SOS). SSM Popul Health 7:100339. https://doi.org/10.1016/j.ssmph.2018.100339

Dubois P, Griffith R, O'Connell M (2020) How well targeted are soda taxes? Am Econ Rev 110:3661–3704. https://doi.org/10.1257/aer.20171898
Ecorys (2014) Food taxes and their impact on competitiveness in the agri-food sector: Annexes to the main report. https://ec.europa.eu/growth/content/food-taxes-and-their-impact-competitiveness-agri-food-sector-study-0_en. Accessed 10 July 2020
Etilé F, Lecocq S, Boizot-Szantai C (2018) The incidence of soft-drink taxes on consumer prices and welfare: evidence from the French "soda tax". Working paper halshs-01808198. https://halshs.archives-ouvertes.fr/halshs-01808198
European Commission (2015) School food policy country factsheets. https://joint-research-centre.ec.europa.eu/publications/school-food-policy-country-factsheets_en
eurostat (2022) Purchasing power parities (PPPs), price level indices and real expenditures for ESA 2010 aggregates. https://ec.europa.eu/eurostat/databrowser/view/prc_ppp_ind/default/table?lang=en
Falbe J, Thompson H, Becker C, Rojas N, McCulloch C, Madsen K (2016) Impact of the Berkeley excise tax on sugar-sweetened beverage consumption. Am J Public Health 106:1865–1871. https://doi.org/10.2105/AJPH.2016.303362
Fichera E, Mora T, Lopez-Valcarcel BG, Roche D (2021) How do consumers respond to "sin taxes"? New evidence from a tax on sugary drinks. Soc Sci Med 274:113799. https://doi.org/10.1016/j.socscimed.2021.113799
Fletcher JM, Frisvold DE, Tefft N (2010) The effects of soft drink taxes on child and adolescent consumption and weight outcomes. J Public Econ 94:967–974. https://doi.org/10.1016/j.jpubeco.2010.09.005
Gebremariam MK, Chinapaw MJ, Bringolf-Isler B, Bere E, Kovacs E, Verloigne M, Stok FM, Manios Y, Brug J, Lien N (2017) Screen-based sedentary time: association with soft drink consumption and the moderating effect of parental education in european children: The energy study. PLoS ONE. https://doi.org/10.1371/journal.pone.0171537
Gonçalves J, Pereira dos Santos J (2020) Brown sugar, how come you taste so good? The impact of a soda tax on prices and consumption. Soc Sci Med 264:113332. https://doi.org/10.1016/j.socscimed.2020.113332
Grimm GC, Harnack L, Story M (2004) Factors associated with soft drink consumption in school-aged children. J Am Diet Assoc 104:1244–1249. https://doi.org/10.1016/j.jada.2004.05.206
Huber M (2019) An introduction to flexible methods for policy evaluation. arXiv:1910.00641
Hungarian Chief Medical Officer's Office (2011) A Rendszeres Étkezést Biztosító, Szervezett Élelmezési Ellátásra Vonatkozó Táplálkozás-Egészségügyi Ajánlás Közétkeztetök Számára. https://www.antsz.hu/data/cms30236/szervezett_elelmezesi_ellatasra_vonatkozo_taplalkozas_egeszsegugyi_ajanlas_kozetkeztetoknek_20110805.pdf. Accessed 19 May 2022
Institute for Health Metrics and Evaluation (2010) GBD profile: Hungary. http://www.healthdata.org/sites/default/files/files/country_profiles/GBD/ihme_gbd_country_report_hungary.pdf. Accessed 10 July 2020
James J, Kerr D (2005) Prevention of childhood obesity by reducing soft drinks. Int J Obes 29:54–57. https://doi.org/10.1038/sj.ijo.0803062
Kurz CF, König AN (2021) The causal impact of sugar taxes on soft drink sales: evidence from France and Hungary. Eur J Health Econ 22:905–915. https://doi.org/10.1007/s10198-021-01297-x
Le Bodo Y, Etilé F, Gagnon F, De Wals P (2019) Conditions influencing the adoption of a soda tax for public health: analysis of the French case (2005–2012). Food Policy 88:101765. https://doi.org/10.1016/j.foodpol.2019.101765
Lechner M (2010) The estimation of causal effects by difference-in-difference methods. Found Trends R Econom 4:165–224
Ludwig DS, Peterson KE, Gortmaker SL (2001) Relation between consumption of sugar-sweetened drinks and childhood obesity: a prospective, observational analysis. The Lancet 357:505–508. https://doi.org/10.1016/S0140-6736(00)04041-1
Martos E, Bakacs M, Joó T, Kaposvári C, Nagy B, Sarkadi Nagy E, Schreiberné Molnár E (2016) Assessment of the impact of a public health product tax: Hungary. https://www.euro.who.int/en/countries/hungary/publications/assessment-of-the-impact-of-a-public-health-product-tax-hungary-2016
Ministère du Travail, de l'Emploi et de la Santé (2011) Programme National Nutrition Santé 2011-2015. https://solidarites-sante.gouv.fr/IMG/pdf/pnns_2011-2015-2.pdf. Accessed 10 July 2020
Powell LM, Chriqui J, Chaloupka FJ (2009) Associations between state-level soda taxes and adolescent body mass index. J Adolesc Health 45:57–63. https://doi.org/10.1016/j.jadohealth.2009.03.003

OEFI (2013) Impact study of the public health product tax. [A népegészségügyi termékadó hatásvizsgálata.] National Institute for Health Development [Országos Egészségfejlesztési Intézet]

Ritter PI (2018) Soda consumption in the tropics: the trade-off between obesity and diarrhea in developing countries. Working papers 2018–16. University of Connecticut, Department of Economics. https://ideas.repec.org/p/uct/uconnp/2018-16.html

Sturm R, Powell LM, Chriqui JF, Chaloupka FJ (2010) Soda taxes, soft drink consumption, and children's body mass index. Health Aff (Project Hope) 29:1052–1058. https://doi.org/10.1377/hlthaff.2009.0061

Taillie LS, Grummon AH, Fleischhacker S, Grigsby-Toussaint DS, Leone L, Caspi CE (2017) Best practices for using natural experiments to evaluate retail food and beverage policies and interventions. Nutr Rev 12:971–989

Vereecken CA, Inchley J, Subramanian S, Hublet A, Maes L (2005) The relative influence of individual and contextual socio-economic status on consumption of fruit and soft drinks among adolescents in Europe. Eur J Public Health 15:224–232. https://doi.org/10.1093/eurpub/cki005

Vereecken CA, Todd J, Roberts C, Mulvihill C, Maes L (2006) Television viewing behaviour and associations with food habits in different countries. Public Health Nutr 9:244–250. https://doi.org/10.1079/PHN2005847

Vieux F, Dubois C, Duchêne C, Darmon N (2018) Nutritional quality of school meals in France: impact of guidelines and the role of protein dishes. Nutrients 10(2):205. https://doi.org/10.3390/nu10020205

WHO (2015) Public health product tax in Hungary: an example of successful intersectoral action using a fiscal tool to promote healthier food choices and raise revenues for public health. https://www.euro.who.int/en/health-topics/Health-systems/health-systems-response-to-ncds/publications/2015/public-health-product-tax-in-hungary-an-example-of-successful-intersectoral-action-using-a-fiscal-tool-to-promote-healthier-food-choices-and-raise-revenues-for-public-health-2015

WHO (2017a) Prevalence of obesity among adults, BMI $\geq$ 30, crude: estimates by country. https://apps.who.int/gho/data/node.main.BMI30C?lang=en. Accessed 10 July 2020

WHO (2017b) Prevalence of obesity among adults, BMI $\geq$ 30, crude: estimates by WHO region. https://apps.who.int/gho/data/view.main.BMI30CREGv?lang=en. Accessed 10 July 2020

WHO (2017c) Prevalence of overweight among adults, BMI $\geq$ 25, crude: estimates by country. https://apps.who.int/gho/data/node.main.BMI25C?lang=en. Accessed 10 July 2020

WHO (2017d) Prevalence of overweight among adults, BMI $\geq$ 25, crude: estimates by WHO Region. https://apps.who.int/gho/data/view.main.BMI25CREGv?lang=en. Accessed 10 July 2020

WHO (2017e)Prevalence of overweight among children and adolescents, BMI $\geq$ +1 standard deviation above the median, crude: estimates by country, among children aged 10–19 years. https://apps.who.int/gho/data/view.main.BMIPLUS1C10-19v?lang=en. Accessed 18 May 2022

WHO (2020) Global strategy on diet, physical activity and health childhood overweight and obesity. https://www.who.int/dietphysicalactivity/childhood/en/ Accessed 01 July 2020

Wilson P, Hogan S (2017) Sugar taxes A review of the evidence. Working papers. NZIER. https://nzier.org.nz/static/media/filer_public/f4/21/f421971a-27e8-4cb0-a8fc-95bc30ceda4e/sugar_tax_report.pdf