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The evidence on the effects of soft drink taxes

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Executive summary

Key findings

Soft drink taxes have been implemented in 50 jurisdictions (as of August 2019). We review the evidence on their effects, summarising 27 studies of taxes in 11 jurisdictions.

All studies that look at the effects on prices find that soft drink taxes lead to increased prices. The size of the increase varies, reflecting differences in the size and structure of the tax, the set of products and the size of jurisdiction to which it applies. Pass-through is lower in smaller jurisdictions, where the ease of avoiding the tax leads to competitive pressures to keep prices down. In settings that are most similar to the UK, the estimates suggest that the tax is fully passed through to prices.

Most studies find that soft drink taxes have resulted in reductions in purchases of taxed drinks. The largest effects on purchases have been found in Philadelphia; here, the tax rate is high (almost double the average UK rate), it applies to soft drinks containing sugar and artificial sweeteners, and it is fully passed through to prices. In Mexico, which has been the focus of multiple studies, the tax on soft drinks containing added sugar led to reductions in purchases of taxed beverages. Studies on the effects of taxes in Catalonia, Chile, France and the state of Washington all found statistically significant reductions in the purchases of products subject to the tax. Differences in the estimated size of these effects reflect differences in the tax rates, the set of products taxed, the size of jurisdiction to which the tax applies, and the methodology of the study.

1. Summary

In this briefing note, we review the evidence on the effects of soft drink taxes, with a focus on its relevance to the UK context. As of August 2019, 50 jurisdictions levied taxes on soft drinks, many of which have been implemented in the past couple of years. We review all (to the best of our knowledge) published[1] studies that have carried out an ex-post analysis of the effects of soft drink taxes on prices or purchases[2] and are published in English (27 studies on 11 jurisdictions).

The majority of taxes on soft drinks apply to drinks containing added sugar. Such taxes aim to reduce sugar consumption by increasing the price of sugary drinks, which is likely to lead to a reduction in purchases and a commensurate reduction in consumption. A tax may also lead to reductions in sugar consumption through other channels; for example, due to product reformulation to lower sugar content, or by conveying information about the health costs of sugar consumption. The strength of these effects depends on how the tax is structured, as well as how people and firms respond to the tax.

Two things are important when evaluating the evidence and its applicability to the UK's setting. First, does the study credibly determine the effect of the tax in the setting studied – that is, are there any other factors that could be confounding the estimates of the effect of the tax? Second, how similar is the setting studied to the UK context? We discuss the credibility of the methods used by the different studies in Section 3, and we look at the comparability of the setting studied in our discussions of the evidence in Section 4.

All studies that look at the effects on prices find that soft drink taxes resulted in increases in prices. In most studies, the estimated pass-through was full or near to full (i.e. prices rose by the full amount of the tax), apart from studies considering the effect in Berkeley and one study of the soft drink tax in France (Etilé et al., 2018). A key source of the difference in the Berkeley findings is the fact that Berkeley is a small jurisdiction. The smaller the jurisdiction, the easier it is for shoppers to travel to nearby areas to avoid the tax. Where cross-border shopping is easy, there will be competitive pressure on firms to keep prices down, and so it is more likely that taxes will not be fully passed through to prices. The studies that look at larger jurisdictions are more relevant to the UK setting, because the taxes cover a wider geographical area, and therefore cross-border shopping is likely to be less important. Studies of taxes in these jurisdictions generally find that taxes are fully passed through to prices, with the exception of Etilé et al. (2018), who use a different methodology and find that the soft drink tax in France was only partially passed through to prices (two other studies find full pass-through of the French tax).

[1] We include all studies that we could find that were published in academic journals or working paper series. There is an unpublished study that looks at the impact of reforms to excise taxes on alcohol and soft drinks in Denmark (Bergman and Hansen, 2017) and another very recent unpublished study that looks at the rapid rise and then decline in the excise tax rate on soda in Denmark from 2012 to 2014 (Schmacker and Smed, 2019), which we do not include. There is at least one study that looks at the effect of broader-based taxes, the tax implemented in Finland that was applied to high-sugar foods and drinks, which we do not include (Kosonen and Savolainen, 2019).

[2] We also include two studies that consider only the impact on consumption, rather than purchases.

Soft drink taxes were found to lead to a reduction in purchases in all jurisdictions,[3] with the exception of Berkeley. In each of three jurisdictions – Philadelphia, Mexico and Berkeley – there are several well-executed studies of the effects of soft drink taxes.

The estimated effects on purchases were found to be largest in Philadelphia (Cawley et al., 2019; Seiler et al., 2018), where the tax applied to soft drinks containing added sugar and to those containing artificial sweeteners (diet soft drinks), and led to around a 34% increase in prices (Seiler et al., 2018). Seiler et al. (2018) estimate that there was a 46% reduction in purchases of taxed beverages within Philadelphia, but, once cross-border shopping is taken into account, purchases of taxed beverages fell by 22%.

The estimated effects on purchases in Mexico were significant, where the tax led to approximately a 15% increase in prices (Aguilar et al., 2018), and applied to all soft drinks containing added sugar. It was estimated to have led to falls in soft drink purchases of between 4% and 12%, with a central estimate of a 6% decline (Aguilar et al., 2018; Arteaga et al., 2017; Colchero et al., 2016).

Several studies look at the effect of the soft drink tax in Berkeley (Bollinger and Sexton, 2018; Rojas and Wang, 2017; Silver et al., 2017); these generally find small, or no significant, effects, once the effect of cross-border shopping is taken into account. The ease of cross-border shopping both dampens the effects of the tax on prices, as discussed above, and limits the effect of any price increases on purchases (as people can shop outside the city).

Other studies find statistically significant reductions in purchases of taxed drinks in Catalonia (Castelló and López-Casasnovas, 2018), Chile (Caro et al., 2018; Nakamura et al., 2018), France (Capacci et al., 2018) and Washington state (Rojas and Wang, 2017).

Several studies look at whether the effect of the tax on purchases varies across people. These suggest varying and sometimes contradictory findings. Four studies suggest that purchases fell most among higher socio-economic status households: Caro et al. (2018) and Nakamura et al. (2018) in Chile; Castelló and López-Casasnovas (2018) in Catalonia; and Seiler et al. (2018) in Philadelphia. One study finds that purchases fell most amongst lower socio-economic status households (Colchero et al., 2016, in Mexico) and one finds no statistically significant differences (Aguilar et al., 2018, in Mexico).

Even if a tax on soft drinks that contain added sugar is very effective at persuading people to switch away from sugary soft drinks, it is important to know what they are choosing to purchase instead. Some studies find evidence that people switch from sugary soft drinks to diet alternatives, but one study found that people instead switch to other sugary or high-calorie drinks (Fletcher et al., 2010), which offset the benefits of the reduction in soft drink purchases.

The rest of this briefing note is structured as follows. In the next section, we describe the structures of the soft drink taxes covered by the papers that we review. In Section 3, we summarise the main findings of the various papers and provide an outline of the different

[3] An exception is Gonçalves and Pereira dos Santos (2019), who do not find significant falls in the purchases of high-sugar soft drinks following the introduction of Portugal's soft drink tax. However, there is substantial statistical imprecision in their estimates and their methods are not as robust as others, so we do not place weight on these findings.

methodological approaches taken. In Section 4, we review the evidence jurisdiction-by-jurisdiction. An appendix provides further details on the papers we review.

2. Structure of soft drink taxes

As of August 2019, 50 jurisdictions had levied taxes on soft drinks,[4] with many of these taxes implemented in the last two years. Jurisdictions have structured their taxes in a variety of ways. The taxes differ in the magnitude of their rates, in their base (whether they apply only to drinks with added sugar or also to drinks containing artificial sweeteners) and in their specific structure (whether they are levied in volumetric terms or as an ad valorem tax).

The UK's tax, the Soft Drinks Industry Levy, has a banded structure and is levied volumetrically (i.e. pence per litre of product sold) within each band. High-sugar soft drinks (those with more than 8g sugar per 100ml) are subject to a higher tax rate than less sugar soft drinks with less sugar (those with 5–8g sugar per 100ml), and soft drinks with the lowest sugar and diet drinks (those with less than 5g sugar per 100ml) are exempt entirely.

Table 1 summarises the key characteristics of the taxes covered by the papers reviewed in this briefing note, with the exception of a set of historic US taxes studied by Fletcher et al. (2010). Not all of the taxes listed in Table 1 are still in place. For example, the state of Washington revoked its tax five months after its implementation. Other taxes have since altered their structure – France, for instance, has recently introduced a banded tax structure. Table 1 summarises the structure of the taxes as they were at the time that they were studied by the papers reviewed in this briefing note. Full details of each of the taxes are provided in Appendix A.

The UK's banded structure (with the tax levied by volume but with the rate increasing across bands that depend on the sugar content of products) provides incentives to lower the sugar content of products to move to a lower tax band. In contrast, soft drink taxes in most other jurisdictions are levied by volume of product sold. This means that if a drinks manufacturer were to reduce a product's sugar content, this would not lead to a reduction in the tax burden (unless all sugar is removed), thus limiting incentives to reformulate products. In contrast, a tax levied in proportion to sugar content ties the size of the tax burden directly to the sugar content of the product, and therefore provides a stronger incentive for manufacturers to reformulate products to lower the sugar content. The taxes in Catalonia, Chile and Portugal have banded structures, though we have not found any studies that look for evidence on the extent of reformulation in this setting.

[4] Global Food Research Program, University of North Carolina at Chapel Hill, *Sugary Drink Taxes around the World,* https://www.dropbox.com/s/bqbj501wgocor24/UNCGFRP_SSB_tax_maps.pdf?dl=0, 2019.

Table 1. Structure of soft drink taxes reviewed in this briefing note

Jurisdiction	Implemented	Base	Rate (as legislated)	Rate (p/litre)*
UK	April 2018	Drinks containing added sugar	18p/litre on drinks with 5–8g sugar/100ml, 24p/litre on drinks with >8g sugar/100ml	18p/litre on drinks with 5–8g sugar/100ml, 24p/litre on drinks with > 8g sugar/100ml
Berkeley, CA	March 2015	Drinks containing added sugar	1 cent/ounce	27.9p/litre
Boulder, CO	July 2017	Drinks containing added sugar	2 cent/ounce on drinks with > 5g caloric sweetener/12ounces	55.9p/litre on drinks with > 5g caloric sweetener/0.355 litre
Catalonia	May 2016	Drinks containing added sugar	8 cent/litre on drinks with 5–8g sugar/100ml, 12 cent/litre on drinks with >8g sugar/100ml	7.4p/litre on drinks with < 8g sugar/100ml, 11.1p/litre on drinks with > 8g sugar/100ml
Chile	October 2014	Drinks containing added sugar	10% ad valorem rate on drinks < 6.25g sugar/100ml, 18% ad valorem rate on drinks > 6.25g of sugar/100ml	
France	January 2012	Drinks containing added sugar or artificial sweeteners	7.16 cent/litre	6.6p/litre
Ohio	July 1991	Drinks containing added sugar or artificial sweeteners	5% increase in sales tax	
Maine	January 2003	Snacks, including drinks containing added sugar or artificial sweeteners	5.5% sales tax	
Mexico	January 2014	Drinks containing added sugar	1 peso/litre	2.1 p/litre
Philadelphia, PA	January 2017	Drinks containing added sugar or artificial sweeteners	1.5 cent/ounce	41.9 p/litre
Portugal	February 2017	Drinks containing added sugar or artificial sweeteners	8 cent/litre on drinks with < 8g sugar/100ml, 16 cent/litre on drinks with > 8g sugar/100ml	7.4p/litre on drinks with < 8g sugar/100ml, 14.7p/litre on drinks with > 8g sugar/100ml
State of Washington	June 2010	Carbonated drinks containing added sugar or artificial sweeteners	1/6 cent/ounce	4.7p/litre

Note: Full details of each tax are provided in Appendix A.

*Conversion of rates to pence per litre values are based on currency conversion rates on 14 August 2019: 1 p = 1.21 $ cent = 1.09 € cent = 23.66 peso.

3. Summary of studies and methods

Table 2 summarises the studies that we have reviewed; see Appendix B for more details on each paper. Most studies use a difference-in-differences approach, which compares the before–after change in the outcome variable for a treated and a control group (more details on this below). Column 3 of Table 2 reports the control group used in each case (or none, if the method was simply a before–after comparison).

Columns 4 and 5 summarise the findings of each paper on the effect of the tax on prices and purchases (a dash is shown if the outcome was not studied). Full pass-through means that prices increased by an amount equal to the tax, whereas partial pass-through means that prices increased by an amount less than the tax. Most papers study the impact of soft drink taxes on purchases, with three exceptions that consider consumption (i.e. the intake of drinks): Cawley et al. (2019) consider both purchases and consumption, and Falbe et al. (2016) and Fletcher et al. (2010) study only consumption.

Table 2. Published papers that conduct ex-post studies on the effect of soft drink taxes

Paper	Jurisdiction	Control group	Effect on prices	Effect on purchases
Aguilar et al. (2018)	Mexico	None (before–after comparison)	Full pass-through	Purchases fell
Arteaga et al. (2017)	Mexico	None (before–after comparison)	–	Purchases fell
Beradi et al. (2016)	France	Water	Partial (high) to full pass-through (varies by product)	–
Bollinger and Sexton (2018)	Berkeley	Untaxed areas (selected on basis of pre-tax trends)	Partial (low) pass-through	Limited evidence that purchases fell
Capacci et al. (2018)	France	Two neighbouring Italian regions	Full pass-through	Purchases fell
Caro et al. (2018)	Chile*	None (before–after comparison)	Increase in price (not stated in terms of pass-through)	Purchases fell
Castelló and López-Casasnovas (2018)	Catalonia	Untaxed products (water and diet drinks)	Full pass-through	Purchases fell
Cawley and Frisvold (2017)	Berkeley	Untaxed area (San Francisco)	Partial (low) pass - through	–
Cawley et al. (2018a)	Philadelphia	Untaxed areas (Delaware, Montgomery and Bucks counties)	Full pass-through	–
Cawley et al. (2018b)	Philadelphia airport	Untaxed side of airport	Partial to full pass-through	–
Cawley et al. (2018c)	Boulder	Untaxed areas (rest of Boulder County and Fort Collins)	Partial (high) pass-through	–
Cawley et al. (2019)	Philadelphia	Untaxed nearby areas (Delaware, Montgomery and Bucks counties)	–	Purchases fell

Colantuoni and Rojas (2015)	Maine and Ohio	Nearby areas	Full pass-through	No significant effects
Colchero et al. (2015)	Mexico	None (before–after comparison)	Full pass-through	–
Colchero et al. (2016)	Mexico	Untaxed beverages	–	Purchases fell
Debnam (2017)	Berkeley	Untaxed areas (rest of US and nearby county)	–	Purchases increased prior to tax's implementation
Etilé et al. (2018)	France	Water	Partial (low) pass-through	–
Falbe et al. (2015)	Berkeley	Oakland and San Francisco	Partial (low) pass-through	
Falbe et al. (2016)	Berkeley	Untaxed nearby areas (Oakland and San Francisco)	–	*Consumption* fell
Fletcher et al. (2010)	US taxes	Other US states	–	*Consumption* fell
Gonçalves and Pereira dos Santos (2019)	Portugal	Water	Partial (high) – full pass-through (varies by product)	No significant effects
Grogger (2017)	Mexico	Untaxed non-durable products (synthetic controls)	Increase in price (not stated in terms of pass-through)	–
Nakamura et al. (2018)	Chile*	None (before–after comparison)	Increase in price (not stated in terms of pass-through)	Purchases fell
Rojas and Wang (2017)	Berkeley and Washington	Untaxed areas (Oakland for Washington and nearby ZIP codes for Berkeley)	Berkeley: partial (low) pass-through Washington: full pass-through	Berkeley: most evidence suggests no significant effects Washington: purchases fell
Seiler et al. (2018)	Philadelphia	Untaxed nearby areas (surrounding ZIP codes excluding area within six miles of Philadelphia)	Full pass-through	Purchases fell
Silver et al. (2017)	Berkeley	Untaxed nearby areas (six adjacent cities)	Partial (high) pass-through	Purchases fell
Taylor et al. (2019)	Berkeley	Water	–	Purchases fell prior to tax's implementation

Note: To the best of our knowledge, the table lists all published studies (including working papers) that have carried out an ex-post analysis of the effects of such taxes on prices or purchases. Unless stated otherwise, effects refer to the effects of a tax's implementation; a '–'denotes that the outcome was not studied. Full pass-through means that prices increased by an amount equal to the tax, whereas partial pass-through means that prices increased by an amount less than the tax.

*In the case of Chilean tax, the rate of tax on high-sugar soft drinks was increased and the rate of tax on lower-sugar soft drinks was decreased; the effects reported in the table are the effects of the tax increase (applied to high-sugar soft drinks).

Methods

For a study to be informative about the effects of the introduction of a particular tax, it needs to isolate these effects from the influence of contemporaneous changes in potentially confounding factors. In order to do this, the study needs to evaluate how prices and purchases would have evolved in the absence of the tax – that is, a counterfactual (unobserved) world in which the only difference is that no tax was introduced. Two approaches to doing this are: before–after comparison and a difference-in-differences approach.

It is important to stress, however, that even if the causal impact of a particular tax is convincingly estimated, care must still be taken when extrapolating the results found in one setting to another setting, in which the context may be different.

Before–after comparisons

The simplest way to evaluate the effect of a tax is to compare prices and purchases before the tax is implemented with those after the tax is implemented. This assumes that, in the absence of the tax, prices and purchases would have been identical to their levels prior to the introduction of the tax.

This is unlikely to be true for many reasons; for example, seasonal variation in purchases, trends in how much people like soft drinks, or concern about the consequences of soft drinks for health are all likely to lead to changes in purchases, even if the tax were not introduced. It is sometimes possible to control for these confounding factors; for example, with a long enough time series, seasonal variation in purchases or prices can be modelled and controlled for. However, there will be many factors that are not – or cannot be – measured, and failure to account for these factors will lead to incorrect estimates of the effect of the tax. The before–after approach is typically most convincing when it is applied to a narrow time window around the implementation of the tax; in this case, it is more plausible that changes in price and purchases are primarily driven by the tax.

Difference-in-differences

The difference-in-differences estimator attempts to deal with concerns about unobserved confounding factors by using a control group. The basic idea is to compare the before–after change in the outcome variable for the treated group (e.g. people living in a city subject to a tax) with the before–after change in the outcome variable for the control group (e.g. people living in a similar city that is not subject to the tax). This uses the change experienced by the control group as a proxy for what would have happened in the treatment group, had the tax not been implemented.

The key issue is whether the control group that is used is valid. That is, is the change in outcome variable actually experienced by the control group the same as what would have been experienced by the treatment group in the absence of the tax? In the studies reviewed here, there are two common ways that control groups are defined. The first uses similar products that are sold in a different geographical area, which is similar in all other respects but not subject to the tax. The second is to use products that are not subject to

the tax, but are sold in the same geographical area, under the assumption that they are not affected by changes in purchases of the taxed products.

A common test of whether the control group is valid is to check whether the trends prior to the introduction of the tax in the treatment and control groups were similar (this is often referred to as 'checking parallel pre-trends'). A number of studies test this assumption directly (Cawley et al. 2018a, 2019; Seiler et al., 2018; Taylor et al., 2019). However, it is worth noting that, even if this test is satisfied, this does not provide a guarantee that the control group is valid. For example, if the tax leads to spillover effects from the treatment to the control, then even if parallel pre-trends are observed, the control group would not be a good one.

In the US, where taxes have been introduced city- or state-wide as opposed to nationwide, the set of nearby areas without a tax provide a plausible set of control groups. These are areas likely to be culturally and politically similar to the taxed area, and likely to have experienced similar changes in factors we do not or cannot measure, such as seasonal effects or general attitudes towards the consumption of soft drinks. This approach is taken by a number of papers that study the Philadelphia, Berkeley, Boulder, and Washington taxes, which use cities adjacent to the taxed area as their control groups (Cawley et al., 2017, 2018a, 2018c, 2019; Rojas and Wang, 2017; Silver et al., 2017).

However, one concern with using nearby geographical areas as a control group is that they may experience spillover effects. If residents of the taxed area decide to shop more in neighbouring untaxed areas, then this would lead to an increase in purchases in that area and therefore lead to the conclusion that the tax led purchases to fall by more than they actually did. It is also likely that stores in neighbouring areas will respond to increased cross-border shopping by changing their prices, leading to mis-measurement of the effect of the tax on prices. One approach to deal with this challenge is to exclude areas immediately adjacent to the taxed area from the control group; this approach is taken by Seiler et al. (2018) and Bollinger and Sexton (2018).

Using nearby geographical areas as a control group is more challenging when the tax is implemented nationwide. Capacci et al. (2018) use two Italian regions as a control group in their study of the French tax. Data limitations – and the fact that cross-country comparisons are potentially less plausible because it is less likely that factors that affect people's choices will be the same across countries – have led most papers studying national taxes to take an alternative approach. Usually this involves defining the control group as a set of untaxed products within the same country; in the studies discussed here this is either water (Beradi et al., 2016; Etilé et al.; 2018. Gonçalves and Pereira dos Santos, 2019; Taylor et al., 2019) or other untaxed beverages (Castelló and López-Casasnovas, 2018; Colchero et al., 2016; Grogger, 2017). This approach should be treated with caution for the following reasons. First, people are likely to switch from taxed to untaxed drinks as a result of the tax – for example, from sugary to diet products. This would lead to an overestimate of the reduction in purchases as a result of the tax, because the control group (the untaxed products) is also affected by the tax and is affected in the opposite way to the treated group. Second, firms may also change the price of untaxed products in response to the tax, which will also cause problems for measuring the effect of the tax on prices.

Data

Studies that estimate the effects of soft drink taxes use a number of different types of data. The four main types are: store-level scanner data, household-level scanner data, survey data and price data collected as part of the study.

Store-level scanner data refer to data recorded at the point of sale by a given store. They typically cover prices and volume sales at the product level. If a study had access to store-level scanner data covering all stores within a jurisdiction, then this would give them a complete picture of the purchases and prices of products sold in that area. However, studies using store-level scanner data typically have access to data covering only a subset of stores. This means that it is important to consider whether the data are representative of all purchases.

Household-level scanner data refer to data recorded by a sample of households using handheld scanning devices. These data record all of grocery purchases by households in the sample, including the prices and quantities purchased. They are usually linked to household demographics, allowing researchers to look at how soft drink taxes might have affected different types of households. These data include only prices of products that were purchased, and not those that were not purchased; therefore, a concern with these data is that, if some products are subject to a large price increase due to the tax and, as a result, are not purchased, they would not be observed in household-level scanner data.

Survey data are typically cross-sectional and contain questions about how much individuals or households purchase or consume. These data are typically collected by official statistical offices, in which case the strengths and weaknesses of the data are typically well understood. They may also be collected by individual researchers as part of their study, in which case there is often less information available on the quality of the data and sample sizes are often small.

Price data collected as part of a study refer to data that researchers have collected themselves from stores, capturing the price of products available in stores that were visited. In some of these studies, the number of stores covered is small; if prices have been collected only once before the tax and once after the tax, then the data may not measure true variation in prices well, for example, due to measurement error and day to day fluctuations in the prices of different soft drink products.

4. The evidence

In this section, we review the evidence from the studies listed in Table 2. We separately review the evidence for 11 jurisdictions, before we conclude with a short discussion of a set of smaller historic US taxes.

Berkeley

The Berkeley tax is the most widely studied US soft drink tax. It was introduced in March 2015 and applies to soft drinks containing added sugar.

Three papers look at the effects of the tax on both prices and purchases (Bollinger and Sexton, 2018; Rojas and Wang, 2017; Silver et al., 2017), two papers focus solely on prices (Cawley and Frisvold, 2017; Falbe et al., 2015), one paper looks directly at changes in consumption (Falbe et al., 2016) and two papers evaluate the effects of the vote passing (prior to implementation) on prices and purchases (Debnam, 2017; Taylor et al., 2019). All of these studies use a difference-in-differences approach and all but Taylor et al. (2019) use purchases in an untaxed area as their control group, although the choice of untaxed area varies.

Changes in prices

All but one of the studies find that the tax increase was passed through to the consumer price at a rate of less than 50% (although there is variation in the exact magnitude) – that is, prices increased by less than half the amount of the tax.

Cawley and Frisvold (2017) collect prices covering a near census of all stores in Berkeley and find a pass-through rate of 43%. Their difference-in-differences approach uses San Francisco as a control group; it is geographically proximate to Berkeley but does not share a border, and recently it also had a similar referendum that failed despite popular support. Although they do not test the parallel trends assumption, the arguments for using San Francisco as a control group seem reasonable. The absence of a shared border helps mitigate concerns that cross-border shopping biases their results. Falbe et al. (2015) find a similar pass-through rate of 47% using data on prices collected from stores as a part of the study and a difference-in-differences approach with stores in both San Francisco and Oakland as their control group. Bollinger and Sexton (2018) find a pass-through rate of 18% in supermarkets and no price changes in drugstores, and Rojas and Wang (2017) find an average pass-through rate of 24%. They both use store-level scanner data but, in each case, their data cover only a subset of stores in Berkeley (seven and ten, respectively), raising questions about the representativeness of their sample.

Silver et al. (2017) find slightly higher rates of pass-through (although still less than full). Using data that they collected from a small number of stores, they find full pass-through in supermarkets and lower pass-through in other types of stores. They also use store-level scanner data covering two supermarket chains to carry out a difference-in-differences analysis (using stores in the surrounding Bay area as their control group, including two stores in adjacent cities that may experience cross-border shopping) and find a pass-through rate of 67%. However, as Bollinger and Sexton (2018) note, of these two supermarket chains, one had committed to raising the price of taxed beverages by an

amount exactly equal to the tax, raising concerns that the findings are not representative of price changes in other stores.

It is likely that the ease of cross-border shopping has contributed to relatively low pass-through of the tax to prices in Berkeley. This is supported by evidence from Cawley and Frisvold (2017), who find that pass-through was higher the further stores were from untaxed stores.

Changes in purchases

The evidence on the effect of the Berkeley tax on purchases is relatively consistent: most studies find that purchases of taxed beverages fell only modestly (if at all) and that decreases in purchases occurred only at supermarkets.

In all but one of the various specifications they estimate, Bollinger and Sexton (2018) find no reduction in purchases. However, they do estimate one specification where they use a set of control areas within the same state as Berkeley (where these areas are selected on the basis of the similarity of their pre-tax trends to Berkeley's) and they find that purchases fell by 7–12% in supermarkets. Silver et al. (2017) finds that in the two supermarkets they study, purchases fell by 9.6%. Rojas and Wang (2017) find that, on average, purchases did not fall at all in Berkeley, though there was evidence of reductions of purchases of some specific brands.

There is also evidence that this small decrease in purchases was, in part, offset by cross-border shopping. Bollinger and Sexton (2018) find that roughly half of any reduction in sales of taxed soft drinks in Berkeley's supermarkets was offset by increased purchases just outside the taxed area. Silver et al. (2017) find that, although purchases fell by 9.6% in Berkeley, they increased by 6.9% in non-Berkeley stores. There is also some evidence that people switched towards purchasing untaxed products. Silver et al. (2017) find that purchases of untaxed beverages increased by 3.5%, with a particularly large increase (of 15.6%) in purchases of water.

Falbe et al. (2016) collect data on self-reported beverage consumption in order to look directly at the effects of the tax on consumption. They asked a sample of low-income and minority populations, in Berkeley and a set of control cities, how often they drank soft drinks before and after the introduction of the tax. They find that, on average, consumption of taxed beverages decreased by 25% relative to control cities, with reductions in the consumption of soda and sports drinks being particularly high. These are larger reductions than those implied by the evidence on changes in purchases; however, there is large statistical uncertainty around these numbers because the sample size is small, so we do not put much weight on these findings.

Effects of campaigns

Taylor et al. (2019) and Debnam (2017) look at the effects of the campaigns (prior to the implementation of the tax) on purchases, in order to try to disentangle the effect associated with the adoption of the tax on raised awareness of the health consequences of consuming soft drinks, from the effect the tax has on purchases through raising prices.

Taylor et al. (2019) study how purchases of taxed beverages changed on the campus of UC Berkeley, relative to purchases of untaxed beverages, as a result of the tax referendum campaign. They find that it led to a decline in purchases of 10–20%. These results suggest that the campaign may have played an informative role, but we should be cautious of extrapolating from this to a wider context as these results may well be specific to the university context. In addition, the comparison of taxed to untaxed beverages is likely to lead to an overestimate of the effect.

Debnam (2017) finds that purchases of taxed beverages in Alameda County (within which Berkeley is located) *increased* relative to a control group comprising the rest of the US. A concern with this study is that the whole of the US is unlikely to represent a valid control group for Berkeley (purchasing patterns will differ along a number of important dimensions), and so we discount these findings. When Debnam uses a neighbouring county as a control group they find no significant results.

Catalonia

Introduced in May 2017, the Catalan tax applies to soft drinks containing added sugar, and it is similar to the UK's tax in that it is banded, although the rates are much lower. The law also stated that the tax must be fully passed through to consumers, although it is unclear how compliance with this will be assessed.

Castelló and López-Casasnovas (2018) study the effects of the tax on prices and purchases using store-level supermarket data that account for around 10% of the Catalan market. They conduct a before–after analysis and confirm that the tax was fully passed through to prices. They carry out a difference-in-differences analysis using untaxed products as a control group in order to look at the effects of the tax on purchases. They find that, relative to zero/light products (i.e. untaxed products), purchases of taxed beverages fell by 22.2%. However, these results likely overestimate the effects of the tax because it is likely that the control group of untaxed zero/light products is also affected by the tax. They also use water as an alternative control group, and find even larger reductions in purchases. However, this will also lead to biased estimates if people switch from sugary drinks to water.

Chile

Chile has had a tax on soft drinks since the 1960s. In October 2013, the rate on high-sugar drinks was increased from 13% to 18% and the rate on low-sugar drinks was reduced from 13% to 10%, where this lower rate also applies to soft drinks containing added artificial sweeteners.

Two papers look at the effects of the tax on both prices and purchases (Caro et al., 2018; Nakamura et al., 2018). The unavailability of nearby geographical control areas and concerns about substitution to untaxed products led both studies to use a before–after comparison, controlling for pre-tax trends and seasonality. Both papers also use the same household-level scanner data, although Nakamura et al. (2018) cover three years prior to the introduction of the tax, whereas Caro et al. (2018) cover one year.

Caro et al. (2018) find that high-sugar drinks (which were subject to a tax increase) increased in price (by 2% for carbonated drinks and 3.9% for non-carbonated drinks), whereas low-sugar drinks (which were subject to a tax reduction) fell in price (by 1.5% for ready to drink products and 6.7% for concentrate products). Nakamura et al. (2018) find similar results, with high-sugar drinks increasing in price by 1.9% and low-sugar drinks reducing in price by 1.7%. In each case, the changes in price are less than the changes in tax, implying that the tax was only partially passed through.

Findings of the effects of the tax on purchases differ, reflecting differences in the statistical models used in the two studies, including how they treat zero purchases of soft drinks and how they account for permanent differences in purchasing behaviour across households. Caro et al. (2018) finds a 3.4% fall in the per capita volume of purchases of high-added-sugar soft drinks (and an accompanying 4% fall in calories). They also find an increase of 10.7% in purchases of low-added-sugar soft drinks (a set of products that were subject to a tax decrease), and a fall of 3.1% in purchases of untaxed beverages. By contrast, Nakamura et al. (2018) finds that the tax led to a 21.6% reduction in purchases of high-tax drinks but no significant change in purchases of low-sugar drinks.

France

Introduced in November 2011, the French tax is levied on soft drinks that contain either added sugar or artificial sweeteners. Three studies examine the introduction of the French tax, two of which look solely at the effect of the tax on the price of taxed products (Beradi et al., 2016; Etilé et al., 2018), and one of which looks at its effect on both prices and purchases (Capacci et al., 2018).

Beradi et al. (2016) collect price data from 'drive outlets' (a collection point for goods previously ordered on a supermarket web site; the prices are the same as those in physical stores). They carry out a difference-in-differences analysis, comparing the changes in prices of taxed drinks with the changes in prices of water between August 2011 and June 2012. They find that the tax was fully passed through to consumer prices for a range of carbonated soft drinks, and that pass-through was lower for fruit-flavoured drinks.

Capacci et al. (2018) find similar results using household-level scanner data to carry out a difference-in-differences analysis using two alternative control groups: (1) two nearby regions in Italy; (2) water. They find that the tax was fully passed through on soft drinks and that pass-through was lower for taxed fruit juices. They find that this led to a modest reduction in purchases of soft drink (around 2%). They also find evidence of a small increase in purchases of fruit juice.

Etilé et al. (2018) take a different approach and find much lower rates of pass-through. They use household-level scanner data to construct price indexes for soft drinks with added sugar and with artificial sweeteners, rather than looking at prices at the product level. They carry out both a before–after comparison and a difference-in-differences analysis using water as a control group. Under both approaches, they find that the pass-through for both sugar-sweetened beverages and artificially sweetened beverages was around 40%.

Mexico

Introduced in January 2014, Mexico's tax applies to soft drinks containing added sugar. It was introduced as part of a wider package of policies aimed at reducing obesity, including charging 8% VAT on high calorie foods (which had previously been exempt from VAT). This means that the effects of the tax are likely to be difficult to disentangle from the effects of other policies.

Two papers look at the effects of the tax on prices (Colchero et al., 2015; Grogger, 2017), two papers look at the effects of the tax on purchases (Arteaga et al., 2017; Colchero et al., 2016), and one paper looks at both prices and purchases (Aguilar et al., 2018).

Aguilar et al. (2018) use household-level scanner data to carry out a before–after comparison of the prices and purchases immediately before and after the introduction of the tax. They find full pass-through of the tax to prices, which is largely consistent with other findings. Grogger (2017) finds that prices increased by 14.1%. Colchero et al. (2015) find that pass-through varied substantially by region, with prices increasing by more than the tax (over-shifting) in Mexico City, Central North, North Border and the Northwest, but with prices increasing by less than the tax (under-shifting) for the remaining regions, where it is particularly low in the South.

Aguilar et al. (2018) find that the tax led to a 6% reduction in purchases of sugary drinks. Arteaga et al. (2017) find a slightly smaller reduction in purchases, of 3.8%, using industry data on aggregate sales to carry out a before–after comparison controlling for seasonality. Colchero et al. (2016) find that purchases of taxed beverages decreased by 6% in the first six months and continued to decrease at an increasing rate, reaching a 12% decrease by the end of the first year. They also find that the reduction in purchases was largest among households of low socio-economic status (17.4% compared to 5.5% for middle and high socio-economic status households).

Philadelphia

Introduced in January 2017, the tax in Philadelphia applies to soft drinks containing either added sugar or artificial sweeteners. Four studies have looked at the effects of the Philadelphia tax. One study looks at the effect of the tax on both prices and purchases (Seiler et al., 2018), one looks at its effect on purchases and consumption (Cawley et al., 2019), one looks at its effects on prices and availability (Cawley et al., 2018a) and one looks at its effects on prices in Philadelphia International Airport (Cawley et al., 2018b).

The findings across each of these papers are relatively consistent. Seiler et al. (2018) use store-level scanner data to carry out a difference-in-differences analysis, using stores within the surrounding area (but at least six miles away from the city boundary) as a control group. They find that the tax is almost fully passed through and that this led to a fall in purchases within Philadelphia of 46%. However, once cross-border shopping is accounted for, this reduction in purchases is 22%. They also find evidence of increases in purchases of (untaxed) juice, which suggests substitution towards untaxed products.

Cawley et al. (2018a) take a similar approach (though without excluding the area immediately surrounding Philadelphia) to look at the effect of the tax on prices, using data

on prices collected in person from stores. They also find that the tax was fully passed through to consumer prices. Cawley et al. (2018b) compare the price changes in a part of Philadelphia International Airport, which was subject to the tax, with an area that was not subject to the tax. In a before–after comparison in the taxed part of the airport, pass-through is estimated to be 93%. In a difference-in-differences estimation, using the untaxed part of the airport as a control, pass-through is estimated to be 55%. However, if prices in the untaxed part of the airport increased as a result of the tax, then this will bias downwards the difference-in-differences estimate of the pass-through of the tax to prices.

Cawley et al. (2019) carried out interviews as people exited the store. They find that reported purchases of taxed beverages fell by 8.9 ounces per shopping trip; as these are expressed in terms of volume reduction, we cannot directly compare the magnitude of effect to that found by Seiler et al. (2018). They also use data collected via a longitudinal consumption survey and find that consumption declines among adults but not among children. However, the sample size is small and there are concerns about how increased awareness of the health costs of consuming soft drinks may have affected reporting, so we do not place much weight on these findings.

The findings in Philadelphia are in contrast with those from the Berkeley studies. Both taxes are applied city-wide but the pass-through of the tax in Philadelphia is higher. Cross-border shopping (which limits retailers' ability to increase prices profitably) is likely to be more important in Berkeley than Philadelphia, as Berkeley is much smaller in size (18 square miles) than Philadelphia (134 square miles). Nonetheless, cross-border shopping still limits the effects of the tax in Philadelphia. Seiler et al. (2018) find that around half of the 46% reduction in purchases in Philadelphia was offset by cross-border shopping. Cawley et al. (2019) find that this is driven by individuals being more likely to buy soft drinks when they are already shopping outside the city, rather than by them increasing their frequency of shopping outside the city.

Portugal

The Portuguese tax was introduced in February 2017. It has a banded structure as in the UK, but unlike the UK tax, the lower rate applies to soft drinks containing either added sugar or artificial sweeteners.

Gonçalves and Pereira dos Santos (2019) look at the effects of the tax on both prices and purchases. They carry out a difference-in-differences analysis with water as their control group, and find that the tax was passed through almost fully for high-sugar drinks (drinks with more than 8g sugar per 100ml), more than fully for low-sugar drinks (drinks with less than 8g sugar per 100ml) and fully for artificially sweetened beverages. Their results on the effect on quantities purchased suggest that there was no statistically significant effect. In addition, the use of water as a control group might lead to overestimates of the effect on purchases, if people switch to purchasing water in response to the tax.

Other US jurisdictions (Boulder, Maine, Ohio and Washington)

Taxes have been also been introduced in the US states of Maine, Ohio and Washington as well as the city of Boulder in Colorado; we summarise the evidence on these taxes here.

We also review Fletcher et al. (2010), who look at the effects of US state-level taxes on the consumption of soft drinks between 1989 and 2006.

The Boulder tax was introduced in July 2017. It applies to soft drinks containing added sugar and, of all the taxes in place, it is the one with the highest rate. Cawley et al. (2018c) study the Boulder tax by collecting store-level data on prices. They carry out a difference-in-differences approach, using nearby counties as their control group. They find that pass-through was just under 80%, although a number of retailers did not include the price increases in their posted prices (the tax was added at the till). The ease of cross-border shopping may account for the fact that it was less than fully passed through.

The tax in Washington was introduced in July 2010 and applied to carbonated soft drinks containing either added sugar or added artificial sweeteners. Compared with other US taxes, it had a low rate and was repealed shortly after its introduction. Rojas and Wang (2017) study the Washington tax using store-level scanner data to carry out a difference-in-differences analysis using nearby Oregon – which is demographically similar to Washington – as their control group. They find that the tax was fully passed through to consumers and that this led to a reduction in purchases of 4–6%. This is a sizeable reduction in demand; despite the tax rate being low it led to increases in price and reductions in demand. One possible reason is that, in comparison with other US taxes studied, it was applied at the state level and is therefore less likely to be influenced by cross-border shopping.

The Maine and Ohio taxes are both ad valorem taxes (i.e. levied as a proportion of the price rather than by volume) and are small in size. The tax in Maine was introduced in January 2003 and applies to a wider selection of snacks. The Ohio tax was introduced in July 1991 and applies to soft drinks containing added sugar or artificial sweeteners. Colantuoni and Rojas (2015) study these taxes with a difference-in-differences approach, using nearby areas as their control groups. They find that both taxes were fully passed through to consumer prices but neither had significant effects on purchases. These findings have limited applicability to the UK setting because: (i) the Ohio tax study was almost 30 years ago, and (ii) the Maine tax applies to a much wider set of products, which means that consumers are likely to respond differently.

Fletcher et al. (2010) study all US state-level soft drink taxes between 1989 and 2006. In any given year during this period, around 20 states levied taxes on soft drinks. They use nationally representative survey data on consumption (i.e. reported calorie intake) and analyse the effects of changes to soft drink taxes on consumption among youths and adolescents, using a state and year fixed effects model. This approach is akin to the difference-in-differences approach but exploits differences in tax rates across many different states and within states over time (where the implicit control group for a given state is other US states not experiencing a tax rise at the same time). They find that a 1 percentage point increase in the tax rate on soft drinks led to a reduction of six calories from soft drinks. This was offset by an increase in calories from untaxed beverages, such as whole milk and juice-based drinks.

Appendix A: Details of taxes reviewed

In Table 1, we summarise the structure of each of the taxes covered in this review. In this appendix, we provide more detailed descriptions of each of the taxes and their implementation.

This list is not exhaustive of all soft drink taxes in existence but, to the best of our knowledge, includes details of all taxes for which published (including working papers) ex-post analyses of the effects on prices or purchases[5] have been carried out in English. Not all jurisdictions included in this list still have soft drink taxes in place. For example, the State of Washington revoked their tax five months after its implementation. Other taxes have since altered their structure; for example, France has recently introduced a banded structure. The text below summarises the structure of the taxes as they were structured at the time they were studied by the papers included in this report. Note that in the cases of Chile and Ohio, the tax change studied is not the implementation of a new tax but alterations to pre-existing taxes.

Berkeley

The Berkeley tax was introduced following a referendum vote in November 2014. It was planned to be introduced in January 2015 but delayed until March 2015 for large beverage distributors and until January 2016 for small retailers. It applies to soft drinks containing added sugar (excluding meal replacement and dairy drinks) and is levied at 1 cent per ounce.

Boulder

The Boulder tax was passed in November 2016 and introduced in July 2017. It applies to soft drinks with more than 5g of added caloric sweeteners (e.g. sugar or sweeteners such as high fructose corn syrup) and excludes milk-based drinks and 100% juices. It is levied at 2 cents per ounce.

Catalonia

The Catalan tax was passed in March 2017 and came into force in May 2017. It applies to soft drinks containing added caloric sweeteners (excluding drinkable yoghurt, drinkable fermented milks, and products used for medical reasons). It has a banded structure whereby drinks with less than 5g of sugar per 100ml are exempt, drinks with 5–8g sugar per 100ml are taxed at 8 cents per litre and drinks with more than 8g of sugar per 100ml are taxed at 12 cents per litre; the law includes a requirement that it is fully passed through to consumers.

Chile

Since 1960, Chile has had a tax on non-alcoholic drinks (since 1976, this had been set as an ad valorem tax of 13%). Changes to the tax were announced in March 2014 and implemented in October 2014. The changes applied to any soft drinks containing colourants, flavourings or sweeteners that have been added. For high-sugar drinks (those with at least 6.25g sugar per 100ml), the tax increased to 18%, and for low-sugar drinks (those with less than 6.25g sugar per 100ml) the tax decreased to 10%.

[5] We also include two studies that consider only the impact on consumption, rather than purchases.

France

The French tax was passed in November 2011 and implemented in January 2012. It applied to soft drinks containing added sugar or artificial sweeteners and is levied at 7.16 cents per litre. In July 2018, the government introduced a banded tax (with products containing more than 11g of sugar being taxed at 20 cents per litre and the tax rate increasing progressively up to this maximum tax). We do not examine the evidence on the effects of this recent change to the law.

Maine

The Maine tax was implemented in 1991 as a part of a wider 'snack tax' that applied to snack foods, soft drinks, ice cream and pastries. These products were taxed at 5.5%.

Mexico

The Mexican tax was passed in September 2013 and introduced in January 2014. It applies to all soft drinks containing added sugar and is levied at one peso per litre (approximately a 10% increase in price). It was introduced as part of a wider package of policies targeted at reducing obesity, including a tax on high-calorie foods.

Ohio

In Ohio, a 5% tax increase on soft drinks was implemented in 2003. It applied to soft drinks containing either added sugar or artificial sweeteners, except drinks containing milk, milk substitutes or drinks that are at least 50% fruit or vegetable juice.

Philadelphia

The Philadelphia tax was passed in June 2016 and introduced in January 2017. It applies to soft drinks containing either added sugar or artificial sweeteners but excludes products that are at least 50% milk. It was initially proposed as a tax of 4 cents per ounce but later scaled down to 1.5 cents per ounce.

Portugal

The Portuguese tax was passed in December 2016 and implemented in February 2017. It applies to soft drinks with added sugar or artificial sweeteners. It excludes milk, soy or rice-based drinks, fruit- or vegetable-based juices, cereal- or nut-based drinks, and those required for medical reasons. The tax has a banded structure: drinks with less than 80g sugar per litre (including diet drinks) are taxed at 8 cents per litre and drinks with more than 80g sugar per litre are taxed at 16 cents per litre.

Washington

The Washington tax was implemented in July 2010 and revoked five months later. It applied to carbonated soft drinks containing added sugar or artificial sweeteners and was levied at 1/6 cent per ounce.

UK

The UK tax was announced in 2016 and introduced in April 2017. It applies to soft drinks with added sugar and has a banded structure. Drinks with 5–8g sugar per 100ml are taxed at 18p per litre and drinks with more than 8g sugar per 100ml are taxed at 24p per litre.

Appendix B: Details of studies reviewed

In Table 2, we provide a summary of each of the studies included in this review and in Section 4 we discuss the evidence found by jurisdiction. In this appendix, we provide details of each of the studies, including details of the setting of the study, the data used, outcomes studied, methods and main findings. To the best of our knowledge, we have included all studies that carry out an ex-post analysis of the effects of soft drink taxes on prices or purchases,[6] which have been published (including working papers) in English. We do not look at the effects of taxes on body mass index or weight.

[6] We also include two studies that consider only the impact on consumption, rather than purchases.

Aguilar et al. (2018)

They examine the effects of two taxes introduced in Mexico: a tax on sugary drinks and a tax on high-calorie foods. We report only their findings on the effects of the soft drink tax on prices and purchases.

Data

- Scanner data (Kantar World Panel).
- Includes details of household-level purchases of all food and drink purchased for at-home consumption, including prices and volume purchased.
- Covers 9,953 households in 92 cities over the period from 2013 to 2014.

Outcomes of interest

- Changes in prices.
- Changes in purchases (volumes and calories).

Method

- Event study (before–after comparison).
- Control for seasonal effects.

Findings

- Changes in price: prices of sugary drinks increased by 14.6% (slightly more than full pass-through), as shown in column 1 of their table II, panel A.
- Changes in purchase: calories from sugary drinks fell by 6%, as shown in column 1 of their table II, panel B, as did litres of soft drinks (as shown in their appendix). The effects do not differ by socio-economic status.

Arteaga et al. (2017)

They examine the effects of the introduction of the Mexican tax on sugary soft drinks.

Data

- Monthly industry-level price and purchase data.
- Cover the period from January 2007 to March 2017, and cover purchases both for at-home and out-of-home consumption.

Outcomes of interest

- Changes in prices.
- Changes in purchases.

Methods

- Time series analysis (before–after comparison).
- Control for seasonality.
- Use a number of different specifications, allowing for both a trend in soft drinks purchases and a break in that trend following the tax's introduction. Their preferred specification includes a break but not a trend. We report their findings for that specification only.

Findings

- Changes in prices: they state in their introduction that the tax led to a 12.8% price increase (full pass-through). They do not provide any details on their methodology behind this finding, so we do not weight this result.
- Changes in purchases: per capita purchases fell by 3.8%, as shown in column 4 of their table 2.

Berardi et al. (2016)

They examine the effects of the introduction of the French soft drink tax on prices.

Data

- Store-level price data (collected by Prixing).
- Include details of prices collected from drive outlets (customers go to a drive-through to collect goods previously ordered on a supermarket web site, and the prices are the same as those in physical stores).
- Cover 845 products sold in 760 drive-throughs from which prices were collected over the period August 2011 to June 2012 (prices collected daily but they keep one observation per month, chosen as the most frequently observed price over that month).

Outcome of interest

- Changes in prices of taxed goods (by product type).

Methods

- Difference-in-differences.
- Control: they consider a number of different control groups in each case, drawing these from the pool of untaxed beverages (including water, all untaxed products and 'multiple matching'). In each case, the preferred control group is selected using a matching procedure based on similarity of pre-tax price evolution.
    - Soda: preferred control is water.
    - Flavoured water: all untaxed products.
    - Fruit drinks and tea: preferred control is water.
    - Pre-trends: not formally tested but control groups are selected on the basis of their pre-tax trends.

Findings

- By product type:
    - Soda: average prices increased by 7.55 cents per litre (100% pass-through, significantly different from zero at the 5% level) after six months, as reported in column 4 of their table 2. After eight months, pass-through is slightly higher but this is not statistically different from full pass-through at the six-month point.
    - Fruit drinks: prices increased by 7.1 cents per litre (94% pass-through, significantly different from zero at the 5% level) after eight months, as reported in column 6 of their table 2.
    - Flavoured waters: prices increased by 4.7 cents per litre (62% pass-through, significantly different from zero at the 5% level) after eight months, as reported in column 6 of their table 2.

Bollinger and Sexton (2018)

They examine the effects of the introduction of the Berkeley tax on prices and purchases.

Data

- Store-level scanner data (from Nielsen).
- Include details of the quantity of each beverage sold at a given store in a given week and its average weekly price.
- Cover purchases at seven stores in Berkeley (one supermarket and six drugstores) from January 2013 to December 2015. Also cover purchases at 22,673 untreated (i.e. untaxed) grocery stores, drugstores and mass-merchandise stores nationwide (1,101 of which are located in California). They use these stores as the set of potential controls.

Outcomes of interest

- Changes in prices.
- Changes in purchases.

Methods

- Difference-in-differences approach.
- Controls: they draw their controls from the pool of untreated (outside Berkeley) stores. They take two distinct approaches.
    - Synthetic controls: 'identifies among potential controls a subset of controls such that a weighted average of unit characteristics trends coincides with those of the treated units in the pre-intervention period'.
    - Select their controls on the basis of the similarity of their pre-tax trends to Berkeley stores. These choose four different controls using four different algorithms.
- In each case, they explore the robustness of their results to whether or not they select in-state controls (within the state of California but outside the San Francisco Bay Area that encompasses Berkeley) or out-of-state controls (stores located outside California).
- Pre-trends: not explicitly tested but the controls are selected on the basis of pre-trends

Findings

- Changes in prices.
    - Synthetic controls.
        - In-state controls: pass-through of 18% in supermarkets (significantly different from zero at the 1% level) and no significant price effects estimated

for drugstores. These results are shown in column 1 of their tables 3 and 4, respectively.
        - Out-of-state synthetic controls: pass-through of 8% in supermarkets (significantly different from zero at the 10% level) and no significant effects on prices at drugstores. These results are shown in column 2 of their tables 3 and 4, respectively.

    - Selected controls.
        - In-state controls: pass-through of 19% in supermarkets (significantly different from zero at the 5% level) and no significant effects on prices at drugstores. These results are shown in columns 1–4 of their tables 5 and 6, respectively (upper panels).
        - Out-of-state controls: pass-through ranges from 10% to 19% in supermarkets (all but one of the estimates significantly different from zero at the 5% level) and no significant effects on prices at drugstores. These results are shown in columns 1–4 of tables 5 and 6, respectively (lower panels).

- Changes in purchases.

    - Synthetic controls.
        - In-state controls: no significant effects on purchases in supermarkets or drugstores. These results are shown in column 5 of their tables 3 and 4, respectively.
        - Out-of-state controls: no significant effects on purchases in supermarkets or drugstores. These results are shown in column 6 of their tables 3 and 4, respectively.

    - Selected controls:
        - In-state controls: 7–12% decline in purchases of sugar sweetened beverages (SSBs) at the supermarket and no significant effects on purchases in drugstores (significantly difference from zero at the 5% level). These results are shown in columns 1–4 of their tables 9 and 10, respectively (upper panels).
        - Out-of state controls: no significant effects on purchases in supermarkets or drugstores. These results are shown in columns 1–4 of their tables 9 and 10, respectively (lower panels).

- Cross-border shopping: roughly half of the reductions in sales of SSBs at the taxed supermarkets were offset by increases in purchases outside of the taxed city. These results are discussed on page 22 of their paper.

Capacci et al. (2018)

They examine the effects of the introduction of the French soft drink tax on prices and purchases of soft drinks (excluding fruit juices) and fruit juices.

Data

- Household-level scanner data (from EuroPanel).
    - Include details of households' purchases of taxed and untaxed beverages and prices paid.
    - Cover 2,928 households in two French regions (Rhone Alpes and Provence-Alpes-Côte d'Azur) and 400 households in two nearby Italian regions (Piemonte-Val D'Aosta and Liguria) over the period from January 2011 to December 2012.
- They also use alternative data sources to validate their findings. We report only their findings using the EuroPanel data.

Outcomes of interest

- Changes in prices.
- Changes in purchases.

Methods

- Difference-in-differences.
    - Allow for fixed household and fixed time effects.
    - Control: (1) two nearby Italian regions (Piemonte-Val D'Aosta and Liguria); (2) water.
        - Pre-trends: not tested.
- Before–after (only for the effect on purchases).

Findings

- Changes in prices using the household-level scanner data (columns 5 and 6 of their table 5).
    - Taxed beverages.
        - Soft drinks: estimated prices increases range from 4.9–9% depending on specification, consistent with full pass-through (table 5 in their paper).
        - Non-pure fruit juice: small or statistically insignificant price increases depending on specification.
- Changes in purchases.
    - Taxed beverages.
        - Soft drinks: estimates suggest a 2% reduction; in one specification, this reduction is not significantly different from zero (results shown in columns (a)–

(c) of their table 6). They also look at the effect separately for heavy purchasers of taxed drinks and find that the falls in purchases are larger than these households (9.7–11.4%, as shown in columns (a)–(c) of their table 7).

- Non-pure fruit juices: one specification shows a statistically significant increase of 3.6%, and two other specifications show very small or insignificant increases (all results shown in columns (a)–(c) of their table 6).

Caro et al. (2018)

They examine the effects of changes in Chilean soft drink taxes (reduction in tax on low-sugar drinks and increase in tax on high-sugar drinks) on prices and purchases.

Data

- Household-level purchase data (Kantar World Panel).
- Include details of household's weekly beverage purchases for at-home consumption including quantity purchased and prices paid, as well as details of household characteristics such as socio-economic status.
- Cover 2,000 households, which is representative of the urban population.
- They match this with nutritional information from Mintel.

Outcomes of interest

- Changes in prices.
- Changes in purchases.

Methods

- Before–after comparison.
- Controlling for pre-tax trends, seasonality, national and regional trends and household characteristics.

Findings

- Changes in prices (all shown in column 6 of their table 2).
    - Taxed beverages.
        - Carbonated high-sugar drinks (subject to tax increase): increased by 2.0% (95% confidence interval: [1%, 3%]).
        - Non-carbonated high-sugar drinks (subject to tax increase): increased by 3.9% (95% confidence interval: [1.6%, 6.2%]).
        - Low-sugar concentrates (subject to tax decrease): decreased by 6.7% (95% confidence interval: [–8.2%, –4.6%]).
        - Low-sugar ready to drink (subject to tax decrease): decreased by 1.5% (95% confidence interval: [0.3%, 2.7%]).
        - By socio-economic status: no significant differences by socio-economic status.
- Changes in purchases: (all shown in column 6 of table 2).
    - Taxed beverages.
        - High-sugar drinks: no change in volume but 3.4% reduction in calories (95% confidence interval: [–5.9%, –0.9%])

- Low-sugar drinks: increased by 10.7% in volume (95% confidence interval: [0.5%, 13.9%]).
- By socio-economic status: purchases of high-sugar drinks by high socio-economic status households fell by 6.4% in volume and 6.5% in calories whereas low socio-economic status households showed no change in volume or calories of high-sugar drinks (all significant at the 5% level), in table 2.

Castelló and López-Casasnovas (2018)

They examine the effects of the introduction of the Catalan soft drink tax on prices and purchases. The law stated that the tax must be fully passed through to consumers.

Data

- Store-level supermarket data.
- Include details of weekly volume sales in each store of one large supermarket chain.
- Cover 160 stores within the chain (which accounts for roughly 10% of the market share in Catalonia) and cover the period from one month before the tax was implemented and one month after.
- They also have price data covering 105 products with one observation per product one month before the tax was implemented and one observation per product one month after the tax was implemented.

Outcomes of interest

- Changes in prices.
- Changes in purchases.

Methods

- Before–after comparison to examine whether the tax was fully passed through.
- Difference-in-differences to look at the tax's effects on purchases.
    - Control for seasonality and region income.
    - Control: (1) water; (2) zero/light products.
        - Pre-trends: tested and are parallel.

Findings

- Changes in prices.
    - Taxed beverages: as required by the Catalan law, the tax was fully passed through to consumers. This result is shown in their figures 4 and 5 and discussed on page 10 of the paper.
- Changes in purchases.
    - Taxed beverages: decreased by 22.2% relative to zero/light products (significantly different from zero at the 1% level) and by 59.2% relative to water (significantly different from zero at the 5% level) as shown in their table 7 and discussed on page 13 of the paper.
    - By household type: reductions in purchases were higher in high-income areas (27.5% in high-income areas and 17.7% in low-income areas relative to zero/light products, both significantly different from zero at the 1% level) as shown in their table 8 and discussed on page 14 of the paper.

Cawley and Frisvold (2017)

They examine the effects of the introduction of the Berkeley tax on prices of taxed goods.

Data

- Store-level price data (collected as part of the study).
- Include details of the prices of various brands and sizes of SSBs and other beverages before and after the implementation of the tax.
- Cover a near-census of convenience stores and supermarkets in Berkeley and a random sample of stores in San Francisco (collected once before the tax and once after the tax).

Outcome of interest

- Change in prices of taxed goods.

Methods

- Difference-in-differences.
- Controls: San Francisco.
- Pre-trends: not tested.
- To estimate ease of cross-border shopping, they use the ReferenceUSA database to estimate the distance of taxed Berkeley stores to their closest untaxed store.

Findings

- Taxed beverages.
    - On average: prices of taxed beverages increased by 0.431 cents per ounce (pass-through of 43%; 95% confidence interval: [27.7%, 58.4%]). This result is discussed on page 313 beneath their table 2.
- Cross-border shopping: they find that, for each mile of distance between the store and the closest store selling untaxed SSBs, pass-through rose 33.3% for 2L bottles and 25.8% for 12-packs of 12 ounce cans (both significantly different from zero at the 10% level). This suggests that the low pass-through rate may be related to the ease of cross-border shopping. These results are shown in their table 3.

Cawley et al. (2018a)

They examine the effects of the introduction of the Philadelphia soft drink tax on prices and availability (we focus only on the effects on prices) of both taxed and untaxed products.

Data

- Store-level price and availability data (collected as part of the study).
- Include details of prices of products prior to and following the introduction of the tax.
- Cover a representative sample of over 60 stores in Philadelphia and over 70 stores in control areas, with stores visited once in November–December 2016 and once in November–December 2017.

Outcome of interest

- Changes in prices.

Method

- Difference-in-differences.
- Controls: stores in Delaware, Montgomery and Bucks counties (outside Philadelphia but within the Philadelphia Metropolitan Statistical Area).
    - Pre-trends: tested and are parallel.

Findings

- Changes in prices: prices of taxed beverages increased in line with a full pass-through of the tax, and prices of some untaxed beverages also increased.
    - Taxed beverages: increased by 1.558 cents per ounce (tax fully passed through, significantly different from zero at the 5% level) as shown in column 1 of their table 2.
    - By distance to nearest untaxed competitor: pass-through is higher in stores farther away from untaxed stores outside the city.

Cawley et al. (2018b)

They study price changes in Philadelphia International Airport following the introduction of the soft drink tax. The airport straddles the city border and therefore contains both taxed and untaxed stores.

Data

- Store-level price data (collected as part of the study).

- Include details of prices of Coke or Pepsi at stores in Philadelphia International Airport. Each store was visited once before the tax (December 2016) and twice after the tax took effect (January and February 2017). Only stores that had a similar counterpart on the other side of the airport were included (21 taxed stores and 10 untaxed stores).

Outcome of interest

- Changes in prices.

Method

- Difference-in-differences.
    - Control: untreated side of the airport (they exploit the fact that only half of Philadelphia International Airport is in Philadelphia and therefore subject to the tax).
    - Pre-trends: not tested directly but very plausible.

- They also carry out a before–after comparison of prices in taxed stores (in response to concerns that untaxed stores will raise their prices in response to the tax).

Findings

- Difference-in-differences: prices of taxed goods increased in taxed stores by 0.83 cents per ounce relative to untaxed stores two months after the tax was introduced (implying a pass-through of 55%; 95% confidence interval: [0.33, 1.33] cents). This result is shown in column 4 of their table 1.

- Before–after comparison: prices of tax goods in taxed stores increased by 1.39 cents per ounce relative to the pre-tax period two months after the tax was introduced (implying a pass-through was 93%; 95% confidence interval: [1.20, 1.58] cents). This result is shown in column 5 of their table 1.

Cawley et al. (2018c)

They examine the effects of the introduction of the Boulder soft drink taxes on prices.

Data

- Store-level data on prices (collected as part of the study).
- Include details of posted prices and register prices at stores and restaurants in Boulder and two control localities.

Outcome of interest

- Changes in prices of taxed and untaxed products (on average and by product size).
- Timing of price changes (changes in prices between June–August and June–October).

Methods

- Difference-in-differences.
- Control: two comparison areas are Boulder County minus the city of Boulder, and Fort Collins.
    - Pre-trends: tested and are parallel.
- They evaluate price changes at two points after the introduction of the tax (August and October), in order to examine the timing of price changes.

Findings

- Changes in prices of taxed beverages.
    - Posted prices: increased from June to August by 1.018 cents per ounce (50.9% pass-through) and remained constant through October. These results are shown in their table 1.
    - Register prices: stores that did not post the tax in their prices increased their prices by 2.438 cent per ounce (122% pass-through) from June to August. These stores accounted for approximately 20% of stores, meaning the average price increase at the register across stores was 1.578 cents per ounce (pass-through of 78.9%). These results are not presented in a table but are discussed on page 11 of the paper.

Cawley et al. (2019)

They examine the effects of the Philadelphia soft drink tax on the purchase and consumption of taxed and untaxed drinks.

Data

- Survey data (collected as part of the study).
    - Include details of quantity of taxed and untaxed drinks purchased collected via consumer interviews as consumers exited the stores.
    - Cover a representative sample of stores in Philadelphia and adjacent counties (Delaware, Montgomery and Bucks counties). In Philadelphia, the sample includes 600 interviews in 2016 and 763 interviews in 2017. In comparison areas, the sample includes 705 interviews in 2016 and 738 interviews in 2017. Sample includes only shoppers who live in a household with children.
- Consumption survey: when asking people to participate in their store exit interviews they also recruited participants (adults and children) for a longitudinal survey of consumption. This includes details of beverage consumption over the previous 30 days. The sample included 241 participants in Philadelphia and 199 participants in comparison areas.

Outcome of interest

- Changes in purchases.
- Changes in consumption.

Method

- Difference-in-differences (using the repeated cross-sectional survey).
- Controls: stores in Delaware, Montgomery and Bucks counties.
    - Pre-trends: their survey data do not cover the trends in the preceding time period. However, they use Nielsen Retail Scanner Data to check this, and they find that average weekly sales volume of a regular soda, diet soda and juice drinks were all parallel in the year before the tax.
- Fixed effects regression to look at consumption (using longitudinal survey).

Findings

- Purchases.
    - Taxed beverages: purchases of taxed beverages fell by 8.9 ounces per shopping trip in Philadelphia stores (significantly different from zero at the 10% level) as shown in the final column of their table 2.
- Consumption: (as shown in their table 7 and discussed on pages 20 and 21).

    - Adults: regular soda consumption declined by around one-third and no significant effect on the frequency of adults' consumption of other untaxed beverages.
    - Children: no significant effects.

- Cross-border shopping: increases in cross-border shopping were not driven by individuals being more likely to travel outside of Philadelphia to shop but by them being more likely to purchase beverages that would be taxed in Philadelphia when they did travel outside. These results are shown in their table 4 and discussed on page 15 of the paper.

Colantuoni and Rojas (2015)

They look at the effects of the introduction of sales tax on snacks in Maine and an increase in the sales tax on soft drinks in Ohio on prices and purchases of soft drinks.

Data

- Store-level scanner data (provided by IRI, a large market research firm).
- Include details of weekly volume sales and prices for a large number of beverages.
- Cover purchases at stores in Maine, Massachusetts, New York and Connecticut over the period from 1988 to 1992, and in Ohio, Michigan, Illinois and Pennsylvania from 2001 to 2006.

Outcomes of interest

- Changes in prices.
- Changes in purchases.

Methods

- Difference-in-differences.
- Control: nearby geographical areas (Massachusetts, New York and Connecticut for Maine; Michigan, Illinois and Pennsylvania for Ohio).
    - Pre-trends: tested and are parallel.

Findings

- Changes in prices.
    - Maine: no significant effects on tax-exclusive price (implying full pass-through), as shown in column 2 of their table 4.
    - Ohio: no significant effects on tax-exclusive price (implying full pass-through), as shown in column 2 of their table 5.
- Changes in purchases.
    - Maine: no significant effects, as shown in column 1 of their table 4.
    - Ohio: no significant effects, as shown in column 1 of their table 5.

Colchero et al. (2015)

They examine the effect of the introduction of the soft drink tax on prices in Mexico.

Data

- Product-level price data (from National Institute of Statistics and Geography).
- Include details of monthly prices for all 'ready to drink beverages', as well as details of pack size.
- Cover 46 cities and 16,000 points of sale in each city (e.g. stores, vendors) over period from January 2011 to December 2014.
- They combine these data with Nielsen purchase data to weight the prices according to how often they are purchased (where the weights are time variant).

Outcome of interest

- Changes in price.
- Timing of price changes.

Methods

- Before–after comparison.

Findings

- Taxed beverages: prices increased by close to one peso per litre (full pass-through, significantly different from zero at the 5% level) in January 2014 and remained at that level over the year (except for November and December when the price was lower). These results are shown in column 1 of their table 2.
- By region: they find that the tax was more than fully passed through in Mexico City, Central North, North Border and the Northwest but only partially passed through for the remaining regions, where it is particularly low in the South (all significantly different from zero at the 5% level). These results are shown in columns 2–8 of their table 2.
- By product type: price increases were higher for carbonated sweetened drinks (108–150% depending on pack size, all significantly different from zero at least at the 10% level) than for non-carbonated sweetened drinks (36–75% pass-through, all significantly different from zero at the 5% level). These results are shown in column 1 of their table 3.

Colchero et al. (2016)

They examine the effect of the introduction of the soft drink tax on purchases in Mexico.

Data

- Household-level scanner data (from Nielsen).
- Include details of the quantity of each beverage purchased by households on a given day.
- Cover 5,253 households in 53 cities over the period from January 2012 to December 2014.

Outcome of interest

- Change in purchases of taxed and untaxed beverages by socio-economic status.
- Timing of changes in purchases.

Method

- Difference-in-differences with household fixed effects.
- Control: untaxed beverages (exact products not stated).
    - Pre-trends: not tested

Findings

- Taxed beverages.
    - On average: purchases of taxed beverages decreased by 6% in the first six months (significantly different from zero at 5% level) and continued to decrease at an increasing rate, reaching a 12% decrease by the end of the first year (significantly different from zero at the 5% level) as shown in column 5 of their table 2.
    - By socio-economic status: reductions in purchases of taxed goods were largest for households of low socio-economic status (17.4% by the end of the year compared to 5.5% for middle and high socio-economic status households; significance level not stated), as shown in supplemental tables 3 and 4, discussed on pages 4–5 in the paper.
- Untaxed beverages.
    - They also report findings for untaxed beverages but it is unclear what their control group is, so we do not report these findings.

Debnam (2017)

She studies the effect of the passage of the Berkeley referendum (prior to the tax's implementation) on purchases of SSBs and sodas.

Data:

- Household-level scanner data (from Nielsen).
- Include details of purchases of around 60,000 households annually, as well as details of each household's key characteristics.
- Also include geographical information including county code (allowing identification of households from Alameda County and control areas).

Outcome of interest

- Change in purchases of SSBs and soda (carbonated soft drinks) following the referendum but prior to the tax being implemented.

Methods

- Difference-in-differences.
- Controls: she uses two alternative controls: (i) households in the US; (ii) households in San Mateo County (neighbouring Berkeley).
    - Pre-trends: not tested.

Findings

- Purchase of taxed beverages.
    - Relative to other US households: increased by 8.89 ounces (significantly different from zero at the 10% level) as shown in column 1 of her table 4.
    - Relative to households in San Mateo County: no significant effects as shown in column 3 of her table 4.

Etilé et al. (2018)

They examine the effects of the introduction of the French soft drink tax.

Data

- Household-level scanner data (from Kantar World Panel).
- Include details of all food and drink purchased for at-home consumption, recorded at the transaction level, including detailed product and store information.
- Cover over 20,000 households in each time and cover the period from 2008 to 2013.

Outcome of interest

- Change in prices.

Methods

- Before–after comparison.
  - They control for shocks to input prices, particularly the 'confounding shock of the cost of sugar', as this is a key input into the production of SSBs (shock came from a revision in the EU quota in 2011).
  - Concerns about other potential confounding changes lead them to also carry out a difference-in-differences analysis.
- Difference-in-differences (note that they use this approach to validate the findings of the before–after comparison but the majority of their analysis is not carried out within a difference-in-differences framework).
  - Control: untaxed products (water).
  - Pre-trends: tested and are parallel.

Findings

- Changes in prices.
  - Before–after comparison.
    - SSBs: increased by 4.1% (implying a pass-through rate of 39.1%, significantly different from zero at the 1% level) as shown in column 2 of their table 4.
    - Artificially sweetened beverages: increased by 4.2% (also implying low pass-through, significantly different from zero at the 1% level) as shown in column 2 of their table 4.
  - Difference-in-differences: consistent with the before–after results, the price of SSBs increased by 4.2% (significantly different from zero at the 1% level) and the price of non-carbonated sweetened beverages increased by 3.2% (significantly different from zero at the 1% level). Although the difference-in-differences result for non-carbonated sweetened beverages is somewhat lower than the before–after comparison, the results are not significantly different. These results are shown in column 3 of their table 4.

Falbe et al. (2015)

They examine the effects of the introduction of the soft drink tax in Berkeley on prices of taxed and untaxed beverages.

Data

- Product-level price data (collected as part of the study).
- Include prices of different products five months prior to the tax and three months after the introduction of the tax in Berkeley and in nearby control cities. Products covered were selected on the basis of industry reports of top-selling beverages in the US.
- Stores were selected based on likelihood of low-income households shopping there. In the stores visited, prices were collected wherever visible (recording promotions separately from regular prices).

Outcomes of interest

- Changes in prices.

Method

- Difference-in-differences.
- Controls: nearby cities (San Francisco and Oakland).
    - Pre-trends: not tested.

Findings

- Taxed beverages.
    - On average: increase in price of SSBs was 0.47 cents per ounce (implying a pass-through of 47%; 95% confidence interval: [0.25, 0.69]).
    - Price changes do not statistically differ across product type.
        - Soda: larger than average price increase of 0.69 cents per ounce (69% pass-through; 95% confidence interval: [0.36, 1.03]).
        - Fruit-flavoured beverages: price increase of 0.47 cents per ounce (implying a pass-through of 47%; 95% confidence interval: [0.08, 0.87]).
        - Flavoured teas: smaller than average price increase of 0.32 cents per ounce (32% pass-through; 95% confidence interval: [0.25, 0.69]).
- All of these results are shown in the final column of their table 3.

Falbe et al. (2016)

They examine the effects of the introduction of the soft drink tax in Berkeley on consumption of taxed and untaxed beverages.

Data

- Survey data (collected as part of the study).
- Beverage frequency questionnaire given to 990 participants before the tax (328 in Berkeley and 662 in control cities) and 1,689 after the tax (545 in Berkeley and 1,144 in control cities).
- Questions asked were of the form, 'How often do you drink…?'.
- Sampling focused on low-income and minority populations (not representative of full population).

Outcomes of interest

- Change in consumption of taxed and untaxed beverages.

Method

- Difference-in-differences.
- Controls: Oakland and San Francisco as control cities.
    - Pre-trends: not tested.

Findings

- Taxed beverages.
    - On average: consumption of SSBs decreased by 21% in Berkeley and increased by 4% in control cities (significantly different from zero at the 5% level).
    - By product.
        - Regular soda: consumption of regular soda decreased by 26% in Berkeley and increased by 10% in control cities (significantly different from zero at the 5% level).
        - Sports drinks: consumption of sports drinks decreased by 36% in Berkeley and increased by 21% in control cities (significantly different from zero at the 5% level).
        - Other taxed beverages: differences not significant.
- All of these results are shown in columns 4 and 8 of their table 2.

Fletcher et al. (2010)

They examine the effects of soft drink taxes on consumption in a number of states across the US between 1989 and 2006.

Data

- Survey data (National Health and Nutrition Examination Survey, collected by the US National Center for Health Statistics).
- Include answers to a 24-hour diet recall questionnaire (used to construct measures of how many soft drinks and other untaxed beverages individuals consumed.
- Also contain information on which state individuals live in.
- The study focuses on youths and adolescents (aged 3–18), although the survey covers a representative sample of 5,000 individuals each year. They use data covering the period 1989–2006.

Outcomes of interest

- Changes in consumption of taxed and untaxed beverages among youths and adolescents.

Methods

- State and year fixed effects model using repeated cross-sectional data.
- This approach is akin to the difference-in-differences approach but exploits differences in tax rates across many different states and within states over time. The implicit control group for a given state is other US states not taxed at that point in time.

Findings

- Consumption of taxed beverages: a one percentage point increase in the soft drink tax rate reduces calories from soft drinks by nearly six calories per day (5% of average calories from soft drinks, significantly different from zero at the 5% level), as shown in column 3 of their table 3.
- Consumption of untaxed beverages.
    - Juice or juice-related drinks: an increase in the tax rate of one percentage point had positive but statistically insignificant effects on consumption of juice or juice-related drinks, as shown in column 2 of their table 4.
    - Whole milk: an increase in the tax rate of one percentage point led to a 12% increase in whole milk consumption (significantly different from zero at the 1% level), as shown in column 3 of their table 4.
- Calories: they find that the tax had no significant effect on calories (implying that the reduction in calories from soft drinks is offset by the increase in calories from whole milk). This result is shown in their table 5.

Gonçalves and Pereira dos Santos (2019)

They examine the effects of the introduction of a banded soft drink tax in Portugal on prices and purchases.

Data

- Store-level price data.
- Include details of monthly prices and quantities sold at the store-product level.
- Cover all stores owned by one of the two largest retailers in Portugal (20% market share) over the period February 2015 to January 2018.

Outcomes of interest

- Changes in prices.
- Changes in purchases.

Methods

- Difference-in-differences.
- Include product fixed effects and quarter of the year fixed effects.
- Control: water.
    - Pre-trends: tested and are parallel.

Findings

- Changes in prices.
    - High-sugar products (products that did not reformulate): increased by 16–17 cents per litre on average (close to full pass-through, significantly different from zero at the 1% level). These results are shown in columns 1–3 of their table 2.
    - Medium-sugar products (products that were high-sugar products but reformulated): increased by 14–15 cents per litre (more than full pass-through, significantly different from zero at the 1% level) after implementation. These results are shown in columns 1–3 of their table 3.
    - Low-sugar products (products that are subject to the lower band of the tax and were not reformulated): increased by 15–16 cents per litre (more than fully passed through, significantly different from zero at the 1% level) after implementation. These results are shown in columns 1–3 of their table 4.
    - Timing: in each case, the price changes during discussion and approval, but prior to implementation, of the policy were small, negative and generally insignificant.
- Changes in purchases.
    - There are no statistically significant changes.

Grogger (2017)

He examines the effects of the introduction of the Mexican soft drink tax on prices of taxed and untaxed drinks.

Data

- Product-level price data (published monthly by Mexico's statistical agency).
- Include average monthly prices in 46 cities across Mexico.
- Cover the period from January 2011 to June 2015.

Outcome of interest

- Changes in prices.

Method

- Difference-in-differences.
- Control: synthetic controls constructed from the set of untaxed non-durables whose prices are available from Mexico's CPI program (covers roughly 120 products, most of which are food, beverages or clothing).
    - Pre-trends: not tested.

Findings

- Taxed beverages.
    - Regular soda: prices increased by 14.09% (significantly different from zero at the 10% level). This result is shown in the first row of their table 3 and discussed on page 490 of the paper.
    - Other drinks with added sugar: no significant effects.

Nakamura et al. (2018)

They look at the effects of a reduction in the tax rate on less sugary soft drinks and an increase in the tax rate on more sugary soft drinks on prices and purchases of soft drinks in Chile.

Data

- Household-level scanner data (Kantar World Panel).
- Include details of all purchases of household beverages for at-home consumption and the prices paid. Also include details of household characteristics such as socio-economic status, region of residence and body mass index of all household members.
- Cover 2,836 households living in cities and representative of the urban population in Chile over the period from 2011 to 2015.

Outcomes of interest

- Changes in prices by tax band of product.
- Changes in purchases by tax band of product.

Methods

- Before–after comparison.
- Control for seasonality, polynomial time trend, temperature, economic fluctuations and time-invariant household characteristics.

Findings

- Changes in price.
    - All soft drinks: prices rose by 1.6% (significantly different from zero at the 5% level) immediately after the announcement of the policy but fell back down towards a long-term trend after its implementation. These results are shown in column 1 of their table 3.
    - High-tax soft drinks: prices rose by 1.9% (significantly different from zero at the 10% level) immediately after the announcement of the policy but fell back down towards a long-term trend after its implementation. These results are shown in column 2 of their table 3.
    - Low-tax soft drinks: prices fell by 1.7% (significantly different from zero at the 10% level) upon implementation of the tax. These results are shown in column 3 of their table 3.
- Changes in purchases.
    - All soft drinks: 5.8% reduction in purchases (significantly different from zero at the 10% level). These results are shown in column 1 of their table 2.
    - High-tax soft drinks: 21.6% reduction in purchases (significantly different from zero at the 1% level). These results are shown in column 1 of their table 2.

- Low-tax soft drinks: no significant change in purchases. These results are shown in column 1 of their table 2.
- By socio-economic status: reductions in high socio-economic status households of 31.3% (significant at the 1% level) but no significant reductions in low socio-economic status households. These results are shown in their table 2.

Rojas and Wang (2017)

They examine the effects of the introduction of the Berkeley and Washington soda taxes on prices and purchases.

Data

- Store-level scanner data (from Nielsen).
- Include details of the quantity of each beverage sold at a given store in a given week and its average weekly price. Also include the three-digit ZIP code of the store. This is used to identify treatment and potential controls.
- Cover purchases in Washington and Oregon between January 2009 and December 2012 (685 stores in Washington and 382 stores in Oregon), and cover Berkeley and control areas between January 2014 and December 2015 (10 stores in Berkeley and 426 stores in the control).

Outcome of interest

- Changes in prices for taxed and untaxed beverages.
- Changes in purchases for taxed and untaxed beverages.

Methods

- Difference-in-differences.
- Controls.
    - Washington: Oregon (demographically similar and proximate to Washington, yet divided from Washington by a mountainous body called the Cascade Range).
    - Berkeley: Eight three-digit ZIP code areas covering the neighbouring areas. They carry out their analysis using a number of different specifications. Where they perform their analysis at the region-month level, they use synthetic controls constructed from all eight areas. When conducting their analysis at the barcode-store-month level, they focus on San Francisco as a control group.
    - Pre-trends: trends in prices shown graphically. Hold closely in Washington and Oregon but less clearly in Berkeley and San Francisco.

Findings

- Washington.
    - Changes in prices.
        - Taxed beverages: increase of between 0.163 and 0.179 cents per ounce (implying a pass-through of 98–107%, all significantly different from zero at the 1% and 5% levels).
        - Untaxed beverages: no significant price changes.
    - Changes in purchases.

        - Taxed beverages: reduction of 4.1–6% (Table 6 in their paper), though not all results are statistically significant. They also find that the effects were smaller for highest market share soda products.
        - Untaxed beverages: small effects (reduction of 1.3%) found in one specification (Table 6 in their paper).

- Berkeley.
    - Changes in prices.
        - Taxed beverages: most results statistically insignificant; significant results in one regression using all three-digit ZIP code areas as a control, suggesting an increase of 0.244 cents per ounce (implying a pass-through of 24%). Results for all specifications shown in columns 3 and 6 of their table 9A.
        - Untaxed beverages: most results statistically insignificant; small fall in prices of 0.098 cents per ounce in one specification using San Francisco as a control. Results for all specifications shown in columns 1 and 4 of their table 9.
    - Changes in purchases:
        - Taxed beverages: on average, no significant effects in Berkeley, as shown in columns 3 and 6 of their table 9.
        - Untaxed beverages: no significant effects found as shown in columns 1 and 4 of their table 9.

Seiler et al. (2018)

They examine the effects of the Philadelphia soft drink tax on prices and purchases.

Data

- Store-level sales data (collected by IRI, a large market research firm).
- Include details of the quantity of each beverage (at the barcode level) sold at a given store, and its average weekly price.
- Cover purchases of taxed and untaxed beverages at 357 stores located in Philadelphia and 870 stores located in the surrounding area over the period from January 2015 to September 2018.
- They combine this highly localised demographic information to examine the demographics of each store's catchment area and to explore whether the response to the tax varies as a function of local population characteristics (including median household income and obesity rates).

Outcome of interest

- Changes in prices.
- Changes in purchases.
- Degree of cross-border shopping.

Method

- Difference-in-differences.
- Controls: stores in the surrounding three-digit ZIP code areas that are at least six miles away from the city limits (to ensure the control group is not affected by the treatment, e.g. through price competition or cross-shopping behaviour).
    - Pre-trends: tested and are parallel.

Findings

- Changes in prices.
    - Taxed beverages.
        - On average: prices increase by 1.45 cents per ounce (pass-through of 97%, significantly different from zero at the 1% level). This result is shown in column 1 of their table 2.
- Changes in purchases.
    - Taxed beverages.
        - On average: weekly demand for SSBs in the taxed area decreases by 46%, as shown in column 3 of their table 3 and discussed on page 15 of the paper.

        - By demographics: purchases decrease more (by around 10%, significant at the 5% level) in high socio-economic status areas (measured using the income level of the local area), whereas obesity rates have no significant effect, as shown in columns 5 and 6 of their table 3.
    - Untaxed beverages: when looking at all untaxed beverages they find no significant substitution to untaxed beverages. However, when looking at individual product types, they find a 9% increase in purchases of natural juice (significant at the 5% level) and no significant change in purchases of bottled water. These results are shown in columns 1, 2 and 3 of their table 4, respectively, and discussed on page 17 of the paper.

- Compared with the 46% reduction in purchases observed in Philadelphia, the reduction in volume sold in Philadelphia and stores less than six miles outside the city is 22%. This suggests substantial cross-border shopping. This result is shown in column 1 of their table 5 and is discussed on page 19 of the paper.

Silver et al. (2017)

They examine the effects of the introduction of the Berkeley soft drink tax on prices and purchases.

Data

- Store-level scanner data (not from Nielsen but requested from supermarkets directly).
- Include details of volume sales and prices at two large supermarket chains.
- Cover three Berkeley stores and six nearby control non-Berkeley stores between January 2013 and February 2016.
- They also use collected data on prices (collected as part of the study), which cover prices of 70 beverages at 26 Berkeley stores (including supermarkets, small chain supermarkets, chain and independent gas stations, drugstores and corner shops) in December 2014 (pre-tax), June 2015 (four months post-tax) and March 2016 (13 months post-tax). In total, 744 prices were collected in December 2014, 798 prices in June 2015, and 633 prices in March 2016.

Outcomes of interest

- Changes in prices.
- Changes in purchases.

Methods

- Difference-in-differences analysis using store-level scanner data
- Controls: other supermarkets in the bay area (two in adjacent cities, one in San Francisco and three in cities further than 20 miles from Berkeley).
    - Pre-trends: not tested.
- Before–after comparison using the price data they collected at 26 Berkeley stores.

Findings

- Change in prices of taxed goods.
    - Difference-in-differences.
        - Taxed beverages: increased by 0.67 cents per ounce (67% pass-through, significantly different from zero at the 1% level) and there were no significant effects on the price of untaxed goods. This result is shown in their figure 3 and discussed on page 7 of the paper.
    - Before–after comparison.
        - Large chain supermarkets: increased from December 2014 to June 2015 by 1.31 cents per ounce – by March 2016, fell to 1.07 cent per ounce (pass-through rates of 131% and 107%, respectively, both significantly different

from zero at the 1% level). These results are discussed on page 7 of the paper.
        - Small chain supermarkets and gas stations: experienced price increases from December 2014 to June 2015 of 2.2 cents per ounce – also fell, by March 2016, to 1.31 cent per ounce (pass-through rates of 220% and 131%, respectively, both significantly different from zero at the 1% level). These results are discussed on page 7 of the paper.
        - Pharmacies: smaller price increases of 0.90 cent per ounce by June 2015, falling to 0.45 cent per ounce by March 2016 (pass-through rates of 90% and 45%, respectively, both significantly different from zero at the 5% level). These results are discussed on page 7 of the paper.
        - Independent corner shops and gas stations: increases not seen (–0.09 cent per ounce and –0.64 cent per ounce; pass-through rates of –9% and –64%, respectively, both significantly different from zero at the 5% level). These results are discussed on page 7 of the paper.

- Changes in purchases.
    - Difference-in-differences.
        - Taxed beverages: purchases fell by 9.6% in Berkeley but rose by 6.9% in non-Berkeley stores (significantly different from zero at the 5% level). These results are shown in their figure 4A and discussed on pages 9–11 of the paper.
        - Untaxed beverages: rose by 3.5% in Berkeley and 0.5% in non-Berkeley stores. Water saw a particularly large increase in demand, with purchases increasing by 15.6% (significantly different from zero at the 5% level). These results are shown in their figure 4B and discussed on pages 9–11 of the paper.

Taylor et al. (2019)

They examine the effects of the Berkeley soft drink tax campaign on purchases of soft drinks at university retailers.

Data

- Store-level data from university retailers in Berkeley.
- Include details of prices and volume of all beverages sold (covers soda, water, juice, energy drinks, milk, coffee, tea and diet drinks).
- Cover all university retails in Berkeley from January 2013 to December 2016.
- They supplement this with Nielsen scanner data covering drugstores in Berkeley and other counties containing a different University of California campus but in nearby ZIP code areas. This data set covers 48 months and 80 stores (five treated and 75 controls).

Outcome of interest

- Changes in sales following the election but prior to the tax being implemented.

Methods

- Difference-in-differences approach.
    - Compares pre-campaign periods to four different periods: post-campaign and pre-election; post-election and pre-policy implementation; post-policy implementation in the city of Berkeley; and post-policy implementation on campus.
    - Controls: untaxed products (water, juice, energy drinks, milk, tea and diet drinks).
    - Pre-trends: tested and are parallel.
    - Note that, because of the costs of changing prices, campus retailers chose not to pass through the tax to consumers for a year after receiving the tax invoices, so they observe the timing of the pass-through precisely.

Findings

- Effects of the campaign and the introduction of tax on soda purchases.
    - Post-campaign and pre-election: no significant effects of the campaign on soda sales.
    - Post-election and pre-policy implementation: sales reduced by 10–20% (significantly at the 10% level).
    - Post-policy implementation in the city but before implementation on campus: sales reduced by 18–36% (significantly at the 10% level).
    - Post-policy implementation on campus: no further reduction in sales (results not statistically different from post-policy implementation period in the city).
    - These results are all shown in column 1 of their table 2 and discussed on page 19 of the paper.

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