The Effectiveness of Sin Food Taxes: Evidence from Mexico

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We measure the effects of two federal taxes in Mexico aimed at reducing obesity by taxing sugary drinks (SDs) and high caloric foods (HCFs). We use a weekly scanner panel dataset with more than 58,721 product barcodes. We find 6 percent lower SD consumption but no decrease in HCFs consumption. We find substantial substitution towards non-taxed goods, smaller unit sizes, and in the case of HCFs to higher calorie per gram foods. Overall, sugar consumption decreased 2 percent, saturated fat and cholesterol increased 2 and 6 percent, but total calories remained unchanged. Available evidence shows no effect on BMI.

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I. Introduction

The growing concern that obesity represents a public problem has been followed by the design and implementation of different policies aimed at combatting it. Among these policies, the introduction of special taxes on high caloric products has received considerable attention from policy makers and the academic community alike.[1] The implementation of special taxes on high caloric foods and beverages in Mexico in January 2014 is a remarkable case to study for at least three reasons. First, the taxes were introduced at a national level. Second, the magnitude of the imposed taxes was considerably larger than that of those introduced in other contexts. And third, Mexico did not only focus on taxing sugary drinks, but also levied a special tax on packaged foods with high caloric content. In this paper, we take advantage of the sudden nature of the price change induced by these measures to study how households respond to the new incentives and explore their substitution patterns in dimensions such as product package size, quality and towards untaxed goods. We also study the taxes nutritional implications. We show that despite the taxes achieving some of their objectives (e.g. reducing soda consumption), they were ultimately unsuccessful at reducing overall caloric consumption, at least in the short run.

Taxes to fight obesity are controversial and difficult to design, not only because of the complexity introduced by substitution possibilities across different products, but also because food is a physiological need, and only *over*consumption should be discouraged. These difficulties and the shortage of empirical evidence may explain the wide disagreement among economists about the effectiveness of food specific taxes to combat obesity; the evidence so far is inconclusive. Cawley (2015), an expert on the economics of obesity, recently concluded that: “The results of [existing price] studies are inconsistent; overall, there is weak

[1]Most saliently, the UK recently announced a tax on SDs. Some US states have imposed taxes on sodas. In 2011, Denmark implemented a tax on all foods with saturated fat content above 2.3 percent, only to revoke it a year later. Finland has imposed extra taxes on candies, ice cream, and soft drinks since 2011. In that same year, Hungary levied a tax on a range of products such as soft drinks, energy drinks, pre-packed sweetened products, salty snacks, and condiments. In France, a tax on all beverages with added sugar was introduced in 2012. Ireland, Japan, and the US have implemented or are considering implementing such taxes. The city of Berkeley recently introduced similar taxes.

evidence that cheaper food (in terms of money price or time costs) contributes to obesity."[2] In the face of this uncertainty Gruber (2010) recommends starting cautiously and trying out a sugary drink tax like the one we study.

Whether taxes to fight obesity work is a first order question for economists, not only because tens of thousands of people are dying yearly of its complications and because its care costs billions of dollars per year, but also because their introduction is about corrective taxation and consumer choice. Why then do we know so little about it and related policies? According to Cawley (2015) "this literature is limited by a scarcity of powerful and valid instruments for prices, time costs, and generally missing data on the intermediate step of food consumption." Our paper contributes with both: valid instrument for prices and very detailed data on food consumption. We also have the benefit of using large tax-induced variation in prices for a broad base of foods; the implied tax rates introduced in Mexico are 2 to 3 times higher than those of U.S. States. To our understanding, this is the first paper to measure the causal effect of a large and country-wide tax on both sugar-added drinks (SDs) and high caloric dense foods (HCFs) on calorie consumption, and the substitution patters they implied.

Our empirical strategy uses an event study design –which could also be thought of as a regression discontinuity design– to exploit the sharp change in prices induced by the start of the tax implementation in January 2014. The policy involved adding a one peso per liter tax on SDs and an 8 percent VAT on HCFs.[3] For our analysis, we rely on an extraordinarily detailed proprietary home scanner panel dataset from Kantar World Panel, which contains

[2]Policy-makers promoting food-specific taxes cite correlations between food prices, soda consumption, and weight (e.g., Duffy et al. (2010), Malik et al. (2006)) as supporting evidence for these taxes. Philipson and Posner (2008) argue that "Probably any feasible tax response would cost more to enforce than it would be worth in reducing the social costs of obesity" and Gruber (2010) argues that "a simple tax on calories could do more harm than good by deterring low-income people from getting enough nutrition." On the other hand, Brownell and Frieden (2009) argue for an excise tax and claim that it would not only be effective, but also that "it is difficult to imagine producing behavior change of [the magnitude of a tax] through education alone". Finally, Griffith and O'Connell (2010) discuss the complexity of such taxes but do not take a strong position for or against them due to the lack of empirical evidence. Other academics such as Bhattacharya and Sood (2011) question whether the very existence of negative externalities caused by obesity, and suggest there may not be a need for corrective taxation at all.

[3]This tax has attracted an enormous amount of international attention. For instance, a Google query of "obesity tax Mexico" in February 2016 resulted in 490,000 hits.

information on the weekly purchase of 58,721 product-barcodes for 9,953 households in 92 cities across Mexico to study the impact of the taxes on prices, purchases, nutritional content of households' consumption bundles, and Body-Mass Index (BMI). In addition, we explore how the design of these taxes may contribute to explaining their differential effectiveness. By the nature of an event-study design, our analysis will focus on short run effects.

We find pass-through to consumer prices of 100 percent for the SD tax and 66 percent for the HCF tax. While the tax was aimed at more obese households, we find that price incidence almost does not vary for households with different BMIs or socioeconomic status (SES). We then explore how these price changes translate into changes in the consumption of the taxed goods. We find a 6 percent decrease in liters of SDs purchased, but no change in kilos of HCFs purchased. We find that calories from SDs decreased by the same 6 percent, but calories from taxed HCFs *increased* slightly. Calorie consumption out of non-taxed drinks and foods increased as well. Regarding total nutrient intake, which is what the tax was finally hoping to improve, we find the following: total calories consumed from all products captured in our dataset did *not* change. We document a decrease in the consumption of 2% sugar, but an increase of 1% in fat, 5% in sodium, and 6% in cholesterol, indicating a change in the composition of the food basket away from sugar and towards fat.[4] The results are robust to a series of checks: accounting for the potential increase in prices associated with the start of the new year, testing for the potential bias from household stockpiling behavior; and estimating the effects on prices and quantities with aggregate industry level *production* data instead of consumption the household level.

Finally, we document some mechanisms behind these effects, shedding light on the relative effectiveness of per unit versus ad-valorem taxes. We show that consumers substituted towards untaxed goods and smaller package sizes of SDs, which experienced a lower percentage increase in price. In contrast, for HCFs, consumers substituted towards relatively cheaper products with *higher* caloric content, as these experienced a favorable relative price adjustment.

[4]Using a difference-in-differences strategy that compares Mexico with four countries in Central America in the Appendix, we find no change in BMI as a result of the taxes two years after their implementation.

What is our contribution to the academic literature? Most studies estimate the demand elasticity for SDs, not the effect of actual taxes. These studies can be classified into those that use randomized experiments and those that use naturally occurring variation. The non-experimental literature has the big problem of using raw price variation across markets to estimate elasticities, conflating supply and demand. This may explain the wide range of estimates. For instance, Andreyeva et al. (2010) survey more than 180 studies and find price elasticities of sodas ranging from -0.33 to -1.24 and price elasticities of foods between -0.27 and -0.81. Other non-experimental studies estimate the direct relationship between weight vs soda and food prices, and find small correlations (Powell et al. (2009) and Lakdawalla and Zheng (2011)). The experimental strand has better identification. Their main problem is that they only observe consumption at the experimental site (e.g. a hospital cafeteria) and cannot take into account substitution across other sites. These studies also find wide ranging and sometimes conflicting results.[5] The closest studies to ours are Fletcher et al. (2010) and Colchero et al. (2016). The former exploits across-state variation in soda taxes in the U.S. to estimate a difference-in-differences model of state level taxes on liters of soda consumed, calories consumed, and weight. They find that a 1 pp increase in the tax implies a reduction of only 6 soda-calories per day. Colchero et al. (2016) analyze the SD tax introduced in Mexico in 2014 (not the HCF tax) using a different data set and a different methodology from ours. Like us, they find a 6% decrease in SDs consumption. They do not explore substitution patterns nor the effect on nutritional content of household consumption bundles, and they do not claim to estimate a causal effect as they rely on extrapolation.

The paper proceeds as follows. Section II reviews the obesity outlook in Mexico and provides details on the taxes we evaluate. Section III describes our data sources. Section IV outlines our empirical strategies. Section V presents the main results, while sections VI and VII discuss mechanisms and robustness checks. The last section concludes.

[5]In an extensive meta-study of 23 papers on experimental results, Epstein et al. (2012) show that the price elasticity of foods oscillates between -0.5 and -3.8 depending on the product and setting. Giesen et al. (2011) finds, as we report in our paper, that although changes in prices cause changes in consumption, this is not reflected in changes in calories. In contrast, Yang and Chiou (2010) study price changes in SDs and find price-calories elasticities of -0.6.

II. Context

Obesity has been growing at an alarming rate in several countries (see our online appendix) and Mexico leads this trend, with one of the fastest growth rates in its overweight population: the percentage increased from 30 to 70 percent over the past 25 years Gracner (2015). This has large health implications: obesity is a major cause of chronic diseases like diabetes and hypertension (Kahn et al. (2006), Eckel et al. (2011)), which account for more than one third of the costs of health care in Mexico.[6] The cost is also high in terms of lives: the mortality rate due to type 2 diabetes increased from 77.9 to 89.2 per 100,000 inhabitants between 2000 and 2007, making it the number one cause of death in the country (Sánchez-Barriga, 2010) (see Olshansky et al. (2005) and Bhattacharya and Sood (2011) for US evidence).

As a response to this problem, on January 1st 2014, the Mexican government introduced two taxes aimed at fighting obesity as part of Mexico's Special Tax on Production and Services (IEPS for its acronym in Spanish). One tax for SDs and another for HCFs.[7] The 2014 IEPS reform established that SDs were to be taxed at one peso (6 cents USD) per liter of SDs, which amounts to approximately 12 percent of their average price. SDs include sodas, some nectars, concentrates with added sugar, and powdered drink mixes, among other drinks described in detail in the appendix.[8] Exemptions to taxed SDs include alcoholic beverages, which are subject to another tax rate also defined in the IEPS law[9] and dairy products. Drinks sweetened with non-caloric sugar substitutes are also excluded. The reform also stipulates a

[6]According to Barquera et al. (2010), the direct and indirect costs of obesity in Mexico increased from 35 billion pesos in 2000 to 67 billion in 2008, and are projected to be 150 billion by 2017. According to the Mexican Ministry of Health, 3 out of 4 hospital beds are devoted to patients with obesity-related diseases. Similarly, Finkelstein et al. (2009) note that "The estimated annual medical cost of obesity in the US was $147 billion in 2008; the medical costs for people who are obese were $1,429 higher than those of normal weight." Also, the UN (2011) predicts that the cost of diabetes, hypertension, and related chronic diseases in low-and middle-income countries will surpass $7 trillion by 2030.

[7]IEPS was established in 1980, and it imposed specific tax rates on the acquisition or import of products such as alcoholic drinks, tobacco, and fuel and on activities such as lotteries and gambling. In fact, the 1980 tax included SDs and was later modified in 1987 to exclude them. Before 2014, the government only taxed SDs as part of a 16 percent VAT, while HCFs were VAT exempt. The tax instituted in 2014 applies in addition to the VAT for SDs.

[8]See Section A3 in the appendix. The law establishes that sugars include monosaccharides, disaccharides, and polysaccharides employed as sugar substitutes with caloric content. Partial liters would be proportionately taxed. For example, a 355ml soda would be charged a tax of 35.5 Mexican cents.

[9]If a soda is mixed with an alcoholic beverage to form a cocktail and sold, then it is considered an alcoholic beverage (and is taxed as such), and the SD tax does not apply.

separate tax on HCFs, which consist of an 8 percent tax on products with a caloric content greater than or equal to 275 kilocalories per 100 grams, with some exceptions that were considered part of the basic Mexican diet (such as tortillas and cooking oil). Products subject to this tax include snacks, candies, chocolate, pudding, marmalade, peanut butter, cereals, and others. The caloric density is determined using the information on the product's nutritional content information label. If a product lacks this information it is automatically taxed. The taxes are relatively large (about 3 times the average state-level soda tax in the US) and have a fairly broad base: they apply to 54.9 percent of food products and 50.2 percent of drinks in our data. Taxed products account for about 30 percent of expenditures captured in our data, 56 percent of total calories from packaged goods, and 13.9 percent of total food expenditures, according to our estimates using the National Expenditure Survey (ENIGH, 2014). The introduction of these taxes resulted in $31,945 million pesos of tax revenues in 2014, $18,280 from SDs and $13,666 from HCFs. This represents a significant fraction of IEPS.[10]

III. Data Sources

We exploit two main data sources. A very detailed proprietary dataset on household consumption collected by Kantar World Panel (KWP), and data on caloric and nutritional content for each product from KWP's dataset gathered by our own research team.

A. Household Barcode-level Consumption

Measuring consumption is difficult for many reasons. Comprehensive measures require long questionnaires, which lead to respondent fatigue and non-compliance (Beegle et al., 2012); they typically measure unit values instead of prices, and they rarely measure consumption at a fine level of disaggregation both in terms of products and frequency of purchase. The ideal data to measure the effect of taxes on consumption would be a household-level panel with

[10]In 2014, IEPS revenue was $124,061 million pesos, an increase of 51.7 percent with respect to 2013. Source: `http://finanzaspublicas.hacienda.gob.mx/es/Finanzas_Publicas/Estadisticas_Oportunas_de_Finanzas_Publicas`, last consulted on March 25, 2016.

high frequency consumption data, with scanned product barcode-level information on quantities and prices, where prices are gathered from ticket receipts to eliminate reporting errors. This data will ideally include measures of BMI and other socioeconomic characteristics to study effect heterogeneity. We have such a dataset from KWP.

KWP is an international company that operates in over 50 countries and has over 60 years of experience. They specialize in the collection of high quality household consumption data that they process to give advice and information to producers and retailers. In order to ensure a high quality panel, KWP recruits and gives incentives to households to participate, selecting them to be a representative sample of households in the country. Our data covers 93 cities. Households participate in the panel for up to 4 years, during which they are required to keep ticket receipts for all purchases made in formal and informal establishments. They are visited by surveyors weekly and all tickets collected are scanned and saved. For each purchase, the scanned information allows KWP to record the week of the transaction, barcode of the product, number of units purchased, price per unit, and the type and name of the store in which it was bought. The barcode itself contains information about the type of product (such as carbonated flavored beverages, coffee, snacks, soup, yogurt, etc.), brand, package size (e.g., a 2 liter bottle or 355 ml. can of soda), flavor, regular/light, and main ingredient (such as milk and non-milk based).[11] In our main results, we exploit the information in this dataset for all weeks in 2013 and 2014, restricting our inquiry to households that were interviewed at least once in 2013, which amounts to 9,953 households in 93 cities and 762,706 household-week observations.[12] Our data has 9,017 SD barcodes and 13,464 barcodes on food. KWP also implements a yearly questionnaire that captures a set of socioeconomic and demographic characteristics that include household assets (which we use to classify households by SES) and the male and female household head's age, weight, and height, which we use to calculate BMI. [13]. For SES categories, we group households into

[11]Figures A8 and A9 in the online appendix show examples of the level of detail available in the data.

[12]Of all households in our sample, 11.4 percent report their purchases every week in the 2013-2014 period, 27 percent report for all except three weeks at most, and 71.4 percent report purchases on more than half of all weeks in 2013 and 2014.

[13]BMI measures are self-reported, which may impose limitations on our analysis. Nonetheless, data checks suggest they are good measures of individuals' body weight. Table I shows that BMI as measured in the KWP

three groups (ABC+, CD+, and DE), where ABC+ refers to the highest SES level. Using BMI we classify households as normal weight if the reported BMI of the female head is lower than 25, overweight if it lies between 25 and 30, and obese if it is above 30.[14]

Table I shows that KWP matches important moments of Mexico's 2014 Income and Expenditure Survey and the 2012 Health and Nutrition Survey (ENIGH and ENSANUT for their acronyms in Spanish), which are the main consumption and health surveys in the country. The average age of household heads is 46 years and 79 percent are male. It also matches closely asset holdings, from which KWP constructs SES categories. Finally, BMIs are similar even though the ENSANUT BMIs are measured rather than self-reported.

While extraordinarily detailed and well-suited for the study of the impact of the taxes in the Mexican context, the data has some limitations. First, it measures purchases, which do not necessarily correspond perfectly to consumption. However, we show later that there is no indication of changes in households' inventories. Since our identification strategy measures changes in quantities, as long as waste is unaffected by the tax, our estimates should approximate changes in consumption well. Second, our data has information only on processed packaged foods (it does not include information on the purchase of fresh foods like fruits and meat). Table I shows that, according to ENIGH, the average Mexican household's food expenditures amount to 3,256 pesos, while, on average, KWP only captures expenditures in food products of 1,417 pesos. However, ENIGH captures *fewer* expenditures on the goods included in KWP. Importantly, taxes are levied on packaged products (included in KWP), not on fresh food. As long as the degree of substitutability and complementarity between packaged and fresh foods is low, our estimates of the *change* in consumption of nutrients from the set of products included in KWP will not be biased. In addition, given that the existing literature argues that the availability of *packaged* foods and drinks is likely one of the most

survey is very close in levels with the Mexican Health and Nutrition Survey (ENSANUT), which measures BMI in situ by professional nurses. The online appendix provides further evidence that BMI as measured by KWP is consistent with the rankings of BMI across countries and shows reasonable densities, time trends, and relationships with structural variables such as age. Self-reported BMI is the norm more than the exception. More than half of the countries that report BMI measures to the World Health Organization rely on self-reported BMIs.

[14]We find a large within household correlation above 0.5 for BMI of male and female heads of the same household. Because strong positive correlations of BMI across members of a household are typical, we will take the liberty of referring to household BMI even if we are using the female household head BMI only.

important forces behind the increase in obesity (Cutler et al. (2003), Brownell and Frieden (2009)), our focus on these goods is not out of place. Finally, KWP records only in-home consumption. According to ENIGH 2014, 20 percent of all food expenditures correspond to out-of-home consumption in Mexico. Importantly, to explore if our results are biased due to the exclusion of out-of-home consumption from our data, we compare our estimates of the impact of the tax on SD with those obtained using total soda production from national statistics and find similar results.[15]

B. Data on Caloric and Nutrient Content

For the taxes to be an effective tool to combat obesity they need to affect caloric intake. Our main analysis explores if this was the case and provides information on the change in the purchase of other nutrients, namely sugar, carbohydrates, fat, saturated fat, cholesterol, and sodium. However, KWP does not collect information about the nutritional content of products. An additional contribution of this paper is the systematic collection of nutrient information for a large share of barcodes in KWP. This was possible because the majority of products in our data are packaged and display nutritional content labels as mandated by law. Our enumerator team collected information for barcodes representing 71.7 percent of all purchase events, which corresponds to 68 percent of expenditures in our data. Because coding the nutritional content required direct observation of products' label in supermarkets and convenience stores, the information for products only available in specific regions had to be imputed based on a careful procedure described in detail in the online appendix. We are aware that our imputation procedure may introduce measurement error in one of our main outcomes of interest. We have performed several tests of the imputation quality and concluded that this problem is small.[16] The fact that we find statistically significant effects

[15]Dubois et al. (2014) is probably the closest paper in terms of data and faces the same limitations. Section A11.C in the online appendix explores in greater detail the potential bias in our estimates driven by partial observation of consumption and concludes that we are not underestimating the tax impact. Table A9 of the online appendix presents additional descriptive statistics for the KWP dataset: 68.9 percent of total expenditures in KWP are devoted to food and drinks, while 14.2 and 13.5 percent of total expenditures correspond to taxed HCF and SD respectively.

[16]One such check randomly deletes the nutritional information for 10 percent of the products captured and uses the remaining 90 percent of captured products to perform our imputation procedure. We compare the real

for some nutrients suggests that noise is not too large.

IV. Empirical Strategy

Identifying the effects of the introduction of a tax reform like the one studied in this paper is not an easy task for three reasons. The first is that the taxes were not a universal tax on food and sugar, but were instead aimed at thousands of specific high calorie products. To analyze the taxes' impact, we first have to identify which of the barcodes in KWP were subject to which of the taxes. For this, we relied on the content of the IEPS law and detailed statements provided by Mexico's tax authority.

A second challenge is that the impact of the tax may differ across products, and complex substitution patterns may operate across to untaxed but also within taxed barcodes. We are not so much concerned with the product-to-product substitution but with the aggregate implications for consumption and nutrition. Substitution is important as it could undo the intended effects of the tax. We focus on substitution across broad categories of foods, taxed and untaxed. For quantities we focus on total calories of taxed SDs and HCFs, as well as calories from taxed and the untaxed groups. For prices we constructed a Laspeyres-type price index. Conducting the analysis at this level of agregation has several advantages. First, it makes the size of the dataset more manageable. Second, it automatically weights the results by the appropriate consumption quantities, making our results representative for Mexico. Third, it allows us to focus on salient substitutions, namely between taxed and untaxed goods in a parsimonious way.[17] Fourth, we don't throw away all interesting heterogeneity, we present results separately by BMI and socio economic status of the households to look at quantity effectiveness and price incidence. Finally, we are ultimately concerned about total calorie consumption and are therefore forced to aggregate quantities. We did run regressions

values to the imputed values and show that the imputation error is tiny. The interquartile range *of the imputation error* of calories for SDs is 6.3cal/100gr, with a mean close to zero (see Appendix). This compares favorably with the interquartile range of calories 40.2cal/100gr and a mean of 97.4cal/100gr of the raw data for SDs.

[17] We could look for substitutions across all products in our sample but this quickly runs into a dimensionality problem as we have thousands of products; it also leads to a statistical problem of multiple testing. Another avenue would be to choose a particular subset of products like milk and water, but this would be ad-hoc.

at the barcode level with barcode fixed effects. This works well for prices and results are similar, but note that we have to use weights proportional to household consumption to get meaningful results. For quantities we are forced to aggregate across barcodes anyways. We prefer to be transparent about our weighting rather than relying on OLS to do it for us.

A third challenge is to isolate exogenous variation in taxes. Most of the literature uses comparisons across markets or across persons, conflating supply and demand. Furthermore, the literature uses variation in prices, not in taxes, and therefore cannot measure the pass-through of taxes to prices or the effect of tax reforms for that matter.[18] In order to identify causal effects, our main empirical strategy exploits the sharp price variation at the moment at which the taxes were enacted together with high-frequency data in an event study design.

A. Construction of the Main Variables

To study the broad substitution patterns we decided to aggregate the information on individual barcodes at the household-week level, and then agregate at taxed and non taxed categories for SDs and HCFs separately. We had to be careful to identify which barcodes were taxed and which weights should be used in the aggregation.

Tax variable. To identify the barcodes in the KWP dataset that were subject to each tax, we rely on the IEPS law and detailed statements by Mexico's tax authority.[19] In general, drinks that have added sugar are classified as subject to the SD tax (1 peso per liter) and food products not classified as basic food staples that have more than 275 kilocalories per 100 grams are classified as subject to the HCF tax (8 percent ad-valorem). Ad valorem taxes are proportional to price so, all else constant (like elasticities), one may expect higher absolute price increases for more expensive (higher quality) goods within the HCF category.

Quantity variables. We aggregate detailed weekly household and barcode level information in the KWP data as follows. For each household i in week t of year y, we calculate

[18]For expositional purposes, and to show that our data is consistent with this literature, Figure A7 confirms two of the stylized (correlational) facts in the existing literature: the cross-sectional relationship between SD prices and liters consumed and the cross-sectional relationship between SD price and BMI are negative. This, however, is not necessarily a causal relationship.

[19]See section A4 of the online appendix for details on the construction of the tax variable.

a measure of calories of taxed SD consumed (C_{ity}^{SD}) by first multiplying the units of barcode b consumed, u_{bity}^{SD}, by their calories, c_b, and then summing across b for all products and package sizes in the SD category (identified as the elements in the set S^{SD}). Formally, $C_{ity}^{SD} = \sum_{b \in S^{SD}} u_{bity}^{SD} c_b$. We apply the analogous aggregation for liters (L_{ity}^{SD}). We do this separately for non-SDs, HCF and for all food products consumption.

Price variables. Creating an aggregate measure of price per liter requires a bit more care. We cannot use current expenditure per liter, as expenditure involves quantities purchased that the 2014 taxes may have affected. We therefore construct a quantity-weighted average price index using weights from 2013 consumption that are then independent of any tax effect. We use a Laspeyres-type index keeping the average 2013 basket fixed for each household. That is, each household has a weight for each barcode that is equal to the quantity (in liters or kilos) it bought a year before the tax. This is precisely the weighting we want as it represents the quantity consumed in the economy. We compute the cost of these baskets each week with quantity weights fixed but varying prices. Formally, the price index for SDs for each household i in week t year y (P_{ity}^{SD}) is calculated as follows:

(1)
$$P_{ity}^{SD} = \sum_{b \in S^{SD}} \left(\frac{L_{bit,2013}^{SD}}{L_{i,2013}^{SD}} \right) p_{bity}^{SD}$$

Where $L_{i,2013}^{SD} = \sum_{t=1}^{52} L_{it,2013}^{SD}$ measures the total liters of SD consumed by household i in 2013, and p_{bity}^{SD} is the price of barcode b that household i incurs in week t of year $y = \{2013, 2014\}$. Note that p_{bity}^{SD} is not always observed, as household i may not have purchased that particular item in that particular week. In such cases, prices are imputed following a sequential procedure. We first compute the average price for each item in the respective week, city, and store (i.e., cell). When barcode-level prices are still not observed for a given barcode in a given week, city, and store, we proceed to a higher level of aggregation. The details are provided in section A5 of the online appendix.[20] We follow an analogous

[20]Several facts make us confident that these imputations are a good approximation of true prices. First, if we estimate a *barcode-level* regression similar to equation 2 but at the barcode level with week, household, and barcode fixed effects, it turns out that the estimated increase in SD and HCF prices are 12 and 6.5 percent,

procedure to calculate an index of price per kilogram of HCF and a price per calorie for all products.

Although not the main focus of the paper, we will estimate the price effects of the tax. One could do this by using regressions at the barcode level with barcode fixed effects. To be representative of the economy, we would need to weight each observation by the quantity consumed of each barcode. We would also need to decide the level of error clustering. When we do this, regressions give the approximate same answer as what we get from using the index described here.

B. Identification Strategy

Our empirical strategy exploits the sharp change in prices observed on the date when the taxes came into effect. It can be viewed as an event study or as a regression discontinuity design that uses time as a running variable, with the date after which the taxes were introduced (January 1st, 2014) as the treatment of interest. The main identification assumption is that absent the tax change, prices and quantities of food consumed would have followed a smooth trend after controlling for seasonality, and that any sharp change in prices in January 2014 can be attributed to the taxes. Many recent papers have profitably used this empirical design (e.g. Byker (2016), Chetty et al. (2014a), Chetty et al. (2014b)), but it has a long tradition in economics and finance (MacKinlay (1997)).

Figure I illustrates that these new taxes affected the final prices of the taxed goods but not those of untaxed goods. Since quantities are kept constant at their 2013 level, the jump observed in January 2014 is only attributable to changes in prices, not changes in consumer behavior. Panel A of Figure I displays a very sharp increase in the cost of the taxable consumption bundle just when the tax came into effect. Panel B, on the contrary, shows no such increase for the cost of the non-taxable consumption bundle, which suggests that the discon-

respectively, which are very close to the price estimates presented in Section V. Second, in each step of the procedure, imputation-cell dummies explain more than 95 percent of the price variation, which means that the procedure of imputing cell means captures almost all variation in prices. Finally, since our strategy is to compare across time and we follow the same methodology for each year, the imputation should not have an important influence on our estimates.

tinuous jump we observe in Panel A is due to the tax. Panels C and D distinguish between taxed SDs and HCFs. It plots the price per liter of SDs and the price per kilogram from HCFs as defined in equation 1 for each week of 2013 and 2014. It is evident that the price per liter of SDs is very stable, around 8 pesos, for most of 2013. There is a small increase in July 2013, which is later dwarfed by the increase to 9 pesos in the first week of January 2014, which is strikingly close to the size of the tax change. There is also a discontinuous jump for HCFs.[21] The sharp jumps observed and the fact that they are only present for taxable goods, strongly suggest that the taxes caused the price changes.

Two additional pieces of evidence support a causal interpretation of this price jump. First, the appendix (Table A10) shows that the price only increased in Mexico and not in neighboring Central American countries, which suggest it is not driven by international cost of commodities like sugar or others. Second, Figure A14 and Table A11 in the appendix show that for HCF the 2014 price jumped at exactly the 275 calories per 100 grams threshold.

Our main specification is laid out in equation 2, where i, t, and y denote household, week of the year, and year, respectively, $I(y \geq 2014)$ is an indicator for all observations in 2014 and afterwards.

$$ln(P_{ity}^{SD}) = \alpha_{it} + \beta I(y \geq 2014) + f(ty) + \epsilon_{ity} \tag{2}$$

We include household-week of the year fixed effects (α_{it}) as well as a quadratic time trend $f(ty)$. Thus, our estimation controls for seasonality and relies on within-household variation in prices close to January 1st, 2014 to identify the effect of the taxes. For ease of interpretation, we transform all dependent variables x by taking the log of $1 + x$, although our results hold for the untransformed variables as well. The coefficient of interest is β, which can be interpreted approximately as the percent change in the outcome due to the introduction of the taxes. We cluster standard errors at the week level.

[21] Section A11 of the online appendix shows the analogous graphs for a broader set of price indices, including an extra year of data, in the analysis. No sharp price change is observed in 2014 for the price per liter of non-SDs and price per calorie for non-taxed-foods.

V. The Impact of the Taxes

In this section, we first explore the incidence of taxes on prices. Then we focus on quantities of SDs, HCFs, total calories, and other nutrients. We present results separately by BMI and SES categories because tax incidence is important. We would like the tax to target more obese consumers, and to not fall hard on the lower income segments.

A. Sugary Drinks

Table II shows the effect on SDs. Panel A uses the log of our price index as the dependent variable, and Panel B uses the log of calories as the outcome of interest. Column 1 presents the estimate for the full sample, while columns 2 through 7 restrict the sample according to our BMI and SES categories. Panel A shows a precise average price increases of 14 percent. The results are in line with those in Grogger (2015), who measures the impact of the SD tax on prices using public data obtained from INEGI and finds slightly more than full tax pass-through of about $1.2 to $1.5 pesos. Columns 2 to 7 estimate regressions separately by BMI and SES. Interestingly, SD price changes do not vary considerably across groups. This means that the actual burden of the SD tax falls on normal weight and low SES people to the same extent as the obese and high SES.

Panel B shows that calories from SDs decreased by 6.3 percent for the full sample. This decrease is stronger for richer segments of the population (7.8 percent) and slightly larger (6.8 percent) for households with obesity. The appendix shows that decreases in liters of SDs are about the same as decreases in calories. Overall results for prices and quantities of SDs are similar to other recent papers that have looked at this with different data and different methods (e.g. Colchero et al. (2016)). Pointing this out is important to note since KWP data is not public and replication is not easy, and since the tax has been politically very controversial and ideologically charged, pinning industry against government health centers and tax authorities.

B. High Caloric Foods

Table III presents the results for HCF. Panel A uses the log of the price per kilogram of HCF as the dependent variable, while Panel B uses the log of calories from HCF purchased as outcomes of interest (the appendix also shows results for Kilos of HCF). All columns present the results for the same subsamples as those described in Table II. For the full sample, we find an increase of 5.3 percent in HCF prices. Given that the tax was an 8 percent ad-valorem tax, this constitutes about a 66 percent pass-through. Interestingly, the price increase is 0.8 percentage points larger for low income households, while there is no differential effect by BMI. In spite of the increase in price, we find no change in calories (or kilograms) consumed on average for the full sample.

Interestingly, the tax on HCFs was less effective in decreasing calories than the SD tax. As we discuss later, this has to do with the fact that the HCF ad-valorem tax induced counterproductive relative price-per-calorie changes. Package sizes that contain more calories exhibited *lower* price increases.

C. Total Calories and Other Nutrients

Taxes like the one we study here aim at decreasing caloric intake and obesity. The event study methodology we use is not well suited to study long term outcomes like obesity, but can be used to measure changes in calorie consumption in the shorter run. We only know of one study that has attempted to measure caloric consumption and taxes. Fletcher et al. (2010) finds that soda taxes in the U.S. led to a decrease in daily soda consumption of 18 grams, associated with 6 fewer calories per day, but no decrease in calories once other substitute foods are taken into account. There are several differences in the taxes we study. First, the taxes we study are about 3 times larger, and since ours is national and applies to a much broader set of goods, one may expect less substitution. We study some specific substitution patterns in the next section. An advantage of focusing on total calories from all foods and drinks is that it parsimoniously takes into account potentially complex substitution patterns, and that it is the actual intermediate outcome we care most about.

Table IV presents our estimates of the total change in consumption of calories and other nutrients attributable to the introduction of the taxes. Panel A focuses on total calories, and panel B shows the impact on other nutrients. All estimations in panel B are run with the full sample, but each column uses the log of a different nutrient as the dependent variable: sugar, carbohydrates, fat, saturated fat, cholesterol, and sodium. Panel A shows that there was a small positive but statistically insignificant *increase* of 1.6 percent on total calories purchased for the full sample. Furthermore, for those households with the lowest level of BMI and income level, we actually find positive and statistically significant increases of 4.2 and 2.4 percent, respectively. We do not find that the obese are consuming less calories. Panel B suggests that the tax caused a change in food basket composition from sugars to fats. We find a 2 percent statistically significant reduction in total sugar and increases of 6.4, 4.9, and 2 percent in cholesterol, sodium, and saturated fat, respectively.

Could measurement error explain why we do not detect a decrease in calories? We don't think so. The fact that we were able to detect changes in some nutrients discredits measurement error as the explanation for the null effect on total calories. Note also that we *did* find calorie reductions for SDs alone of the same magnitude as the decrease in liters consumed, but this decrease is overturned once we consider untaxed drinks and taxed and untaxed food. Could it be that calories do decrease but only for products outside the KWP dataset in a way that we do not capture? We think this is unlikely. For starters, our data contains most goods to which the new taxes applied. For substitution patterns to overturn the null effect, households would have had to *decrease* their consumption of *untaxed* goods not included in our dataset in a significant way. We explore this possibility in Section A11.C of the online appendix by ordering households based on the (estimated) share of total food consumption we observe. Based on this analysis, we conclude that, if anything, we may be biased against finding a zero or negative effect on calories, since we find that the more expenditure we capture the larger is the positive effect we estimate. Secondly, as we will show below we find similar results when we use production instead of consumption as the dependent variable.[22]

[22]Since international trade in sodas is negligible, we think national production approximates total national consumption well, even if it is outside the household.

A third and final piece of evidence for the null decrease in total calories comes from estimating a zero change in BMI. Section A9 of the online appendix uses data from other Central American countries where the tax was not implemented as a control group and performs a difference-in-differences estimation in BMI. We find no evidence of a decrease in BMI or weight, neither in the short run (2014) nor in the medium run (2015).[23]

We find the following simple back of the envelope calculation persuasive; it also provides a benchmark to think about the potential effects and gives credibility to our estimates. Stern et al. (2014) are one of the main proponents of the SDs tax and we use their numbers. Using the main national health survey that covers in-home and out-of-home consumption, they find that children (1 to 4 years old) consume only 20 calories from soda per day, while they consume close to 100 from milk plus 75 from flavored milk and 25 from juice drinks. Adults consume less than 100 daily calories from sodas. If we take the 6 percent reduction in soda consumption found by Mexico's National Health Institute team (Colchero et al. (2016)) and us, and 100 daily calories as baseline, we would conclude that the SD tax achieved a reduction of only 6 calories per day, and that is before taking substitution into account![24]

So far, our results provide strong evidence that the taxes did not decrease consumption of calories from HCF, and although they did decrease consumption of SDs, the result on total calories suggests that this was compensated by substitutions that led to an increase in caloric intake from other products. In the absence of a reduction in caloric intake, the taxes introduced are unlikely to have the desired effect of reducing obesity. Hill et al. (2003) estimate that to prevent weight gains among 90 percent of the population, caloric intake has to decrease by 100 calories per day, while Butte and Ellis (2003) estimate that such decreases should be 200 calories per day at least. A word of caution is in order. Even if calories are unchanged, the taxes could have an impact on health as there is a shift from sugar to fats. Medical research would have to say if such a shift and its magnitude is the desired one.

[23]We put less emphasis on this result in the paper as one may argue that more than 2 years are needed for changes in weight to materialize, and that we have too few observational units (countries).

[24]Another way to benchmark this is again to cite Stern et al. (2014). They say that "From 1999 to 2012, total daily energy from beverages increased among children aged 5-11 (+45.3 kcal), females aged 12-19 (+57.3 kcal), and adult females aged 20-49 (+96.4 kcal)." The before-substitution effect of the tax is about 10% of the recent increase in caloric intake of beverages.

VI. Mechanisms and Unexpected Consequences

This far, we have shown that the introduction of the taxes did not have the desired impact on caloric intake. In this section, we explore in detail the potential mechanisms behind this result. Specifically, we will focus on substitution.

A. Substitution across product types

In the previous section, we described two main direct results: the effect of the two taxes on the consumption of taxed products, and the effect of the tax on calorie consumption. The latter effect captures the net effect of all mechanisms, like complementarities and substitution beteween products. Here we focus on the task of understanding some of those indirect effects and mechanisms in a parsimonious way. We group the data into four categories: taxed and untaxed food and drinks. We use specification 2 to estimate separately the effects on quantities for each of these groups.

Both groups of solid food products show *increases* in caloric intake. Table V shows that calories Non Taxed Food (NTFs) exhibit significant increases of 249 calories per household per week. Meanwhile, calories from taxed HCFs exhibit non-significant increases of 20 calories per household per week. As for drinks, calories from SDs are reduced in the order of 147 calories per household per week. However, untaxed drinks counterweight this reduction by displaying a 141 calories per household per week increase. On aggregate, these changes imply an increase of 263 calories per household per week. Substitution towards non-taxed products, but also within HCFs, limits the effectiveness of these taxes. For completeness Figure II shows event study graphs of calories for the different groups.

B. Substitution within products

Why was the tax on sugary drinks (moderately) effective, while the tax on high caloric foods was not? It turns out that the SD and HCF taxes had opposite effects on the relative price of calories.[25] First, we found out that the price changes induced by the taxes varied considerably across barcodes in both the SD and HCF categories (see Figure A19). The percent quantity variation across years is also very heterogeneous across barcodes[26] Second, we found that while SDs barcodes[27] with more calories experimented the larger percent increases in prices, while the opposite happened for HCFs, as shown in Panels (a) and (b) of Figure III. This meant that SD barcodes with more calories experienced the largest decline in consumption, Panel (c); while within HCFs, consumption shifted toward barcodes of *larger* caloric content, Panel (d). We believe these patterns of relative price adjustments contribute to the explanation of the differential effectiveness of the SD vs the HCF taxes.[28]

Table VI presents evidence exploring the substitution patterns within categories in order to shed further light. Column 1 studies if consumers switch to cheaper calories. We use specification equation 2 with the log of the 2013 price per liter of the SDs purchased by each household each week as the dependent variable; that is, we compute how much the household would have paid for its current 2014 SD bundle if barcode prices were at their average 2013 price. Column 2 uses as dependent variable the average liters per unit purchased as a measure of package size. Column 3 simply uses the log of total units purchased as the dependent variable.[29] Analogously, Column 4 uses the log of the 2013 price per 100 calories given each household's current consumption basket of HCF in each week. Columns 5 and 6 use the log of total calories per unit and the log of total units purchased for HCFs as dependent variables, respectively.

The results show that the decrease in liters of SD bought can be decomposed into a 2.4

[25] We understand that it is difficult to isolate the effect of the tax on sodas from that of the tax on caloric foods because they were enacted at the same time and because of substitutability and complementarity between the two sets of goods. This section proceeds under the assumption that the direct effect of the tax dominates the indirect effect that the other tax might have.

[26] As expected with negatively sloped demands and exogenous variation in prices, there is a negative correlation for SD and HCFs between the change in price and the change in quantities across barcodes.

[27] Recall that among the variables that define barcodes are the sizes of products. In Figure A22 we document that larger soda package sizes experienced larger price increases.

[28] The appendix studies in more detail substitution within the SDs using and AIDS model, and shows that consumers switched towards buying smaller package sizes. It also estimates structural elasticites and simulates alternative taxes, showing that lower tax rates could achieve the same revenue by taxing sodas with of larger volumes of liters.

[29] By unit we mean, for instance, a 255 ml can of soda or a 1L bottle of soda. Multiplying units by liters per unit we get total liters, so columns 2 and 3 can be viewed as a decomposition of liters.

percent decrease in units bought and a 4.7 percent decrease in the *liters per unit* purchased, i.e. more than half of the decrease in the consumption of liters of sugary drinks is explained by households demand shift to smaller package sizes. This switch towards smaller package sizes is also reflected in the increase of 1.3 percent in the counterfactual expense of Column 1, since smaller units are pricier per liter. In contrast, for high caloric foods, individuals consumption shifted towards ex-ante relatively cheaper products, with a higher caloric content: there is a 2 percent reduction in units bought, but the units bought have almost 1 percent more calories per unit. This may happen, as consumers are buying what previously would have been 1.3 percent cheaper calories.[30] The HCF tax may have been counterproductive. It distorted purchase decisions by pushing consumers toward cheaper and probably lower quality goods while promoting the acquisition of higher caloric content units. These results show how complex it is to design taxes when the objective is to reduce the intake of specific nutrients. Taxing nutrients directly may be more effective.

The appendix contains a more involved analysis estimating structural elasticities between SDs of different sizes with an AIDS model. Using the model we simulate revenue equivalent taxes that achieve larger decreases in SD liters consumed. It also documents that there is a positive correlation between BMI and SD unit size, suggesting that taxing larger package sizes may achieve better tax targeting.

VII. Robustness

A. Anticipatory effects

A crucial assumption of our methodology is that consumers and producers reacted to the taxes on the date at which they came into effect. In our estimation, we assume that inventories stayed constant before/after the tax. If consumers anticipated higher prices in 2013, then we would see inventories increasing right before the tax was imposed. In such a case, our previous estimation we would be overestimating the effect of the tax, as we would observe

[30] Table A14 shows that this holds within product categories as well. In particular, the price per calorie of the 2013 basket of Snacks, Bread, Cookies, Crackers, Cereal, Spreadbles decreases by 11.5, 3.3, 7.5, 4.5, 0.4, and 0.8 percent, respectively.

higher than normal purchases before the implementation of the tax and fewer purchases in the short term after its implementation, i.e. a larger quantity decline. Note that if this is the case, it would go against our argument that changes in calories were minuscule.

We perform three checks on whether this channel is operational. First, following the literature in marketing, Section A11.A of the online appendix explores if (a) there were more purchase expense of SDs and HCFs in December 2013 vis-à-vis December 2012 and December 2014; (b) whether the probability of purchasing SDs or HCFs was lower in January 2014 than in January 2012 or 2013; and (c) how many weeks a household went without purchases of SD or HCF in January 2014 and if this number is greater than that of the corresponding January in 2012 and 2013. We cannot reject the null of no difference in each case, which strongly suggest that inventories behaved similarly in 2014 and other years.

Second, we redo our estimates by excluding one, two, and three weeks before and after the introduction of the tax. The results in Table VII show the results of these estimations. As can be seen, none of the estimated changes in dependent variables vary significantly when excluding one, two, or three weeks around the introduction of the new tax, suggesting that our estimates are not being driven by households' short-term stockpiling behavior strategies.

In a third exercise we conduct a placebo test following the logic of a Fisher exact test in the Appendix. We estimate our main regressions with our main specification, pooling the years 2012, 2013, and 2014, except that we construct different placebo tax dummies taking the value of one on each of the 34 months between February 2012 and November 2014 and estimate the "treatment effects" of these placebos. We then rank the estimated $\beta_t's$ and find out where our true tax effect lies in the distribution of these placebo estimates. We find that January 2014 is an atypical month for price increases and for the decrease in liters of SD, but not for decreases of HCF kilos or total calories, consistent with our previous results. We do not find that months previous to the tax are atypical, which suggests that anticipatory effects are not important.

B. More robustness tests

Our main identification assumption has been that once we control for week dummies and smooth time trends, the sharp increase in prices in January is due to the new taxes. We argued that (a) the sharpness of the increase, (b) the fact that the magnitude was very close to the tax and (c) present only for taxed foods, together with the (d) RD evidence across the caloric density threshold provide strong evidence for the validity of this assumption. We now run two additional checks: comparing our estimates with those obtained from four other Central American countries of the KWP, and comparing two different periods in Mexico.

As placebo checks, Table A10 shows the results of our main specification estimated separately for Costa Rica, Guatemala, Panama, and El Salvador. Because we do not have nutritional information for products in these countries, we only use the log of the price per liter of SDs (Panel A) and the log of the cost of households' consumption baskets in 2013 (Panel B) as dependent variables. Compared to the coefficient for Mexico, the coefficient on price is negative and 20 times smaller for Guatemala, positive and 4 times smaller for Panama, and negative and 7 times smaller for El Salvador.

Seasonality or beginning of the year effects may be different in Mexico than in Central America however. Instead of comparing Mexico to other countries, one could compare Mexico from 2013 to 2014 vs. Mexico in 2012 to 2013. Regression 3 augments our main specification adding data from 2012 and by including variable $Year_y$ which increases by 1 unit each year. This variable captures the average beginning of year change in price each year, while our tax variable $I(y \geq 2014)$ measures the change in price only in 2014. By including them together, $I(y \geq 2014)$ captures the *extra* increase in prices at the beginning of 2014 above and beyond the beginning of year effect of 2013. Specifically, we run the following specification:

$$ln(P^{SD}_{ity}) = \alpha_{it} + \beta I(y \geq 2014) + \delta Year_y + f(ty) + \epsilon_{ity} \quad (3)$$

Table VIII presents the estimates of δ and β. Panel A focuses on our price indices of liters of SD (Column 1), kilograms of HCF (Column 2), and the price per 100 calories from all barcodes (Column 3). Panel B uses total liters of SD (Column 4), total kilograms of HCF (Column 5), and total calories (Column 6) as dependent variables. Results are very close in magnitude to those presented in Section V, meaning that end of the year effects are not driving our results.

C. Industry level production

A final potential caveat we consider is that of in-home vs. out-of-home consumption. As described in Section III, KWP only measures the former, so our results apply only to home consumption. How problematic is this? According to the ENIGH, about 20 percent of food expenditure corresponds to out-of-home consumption. By this measure the out-of-home consumption elasticity would have to be big for us to reach different conclusions. We already have some evidence suggesting that this is not the case: our estimates indicate that BMI did not change significantly as a result of the tax, implying that calories must not have been reduced much. This section provides more evidence.

We analyze changes in total production of sodas in Mexico as a function of the tax. Given that less than 2 percent of sodas sold in Mexico are imported/exported, that neither exports nor imports of sodas changed with the introduction of the taxes[31], and that inventories should not vary considerably in periods covering several months; *total* domestic production should be a good proxy of total domestic consumption. Detecting a drop in production of a similar magnitude as that reported above would provide strong evidence that we have not reached erroneous conclusions for total consumption.

To conduct this test we follow an empirical strategy that is as close as possible to that of equation 2, except that we are forced to use aggregate time series information on national prices and production. For prices we use Mexico's consumer price index (INPC), and for quantities we use the monthly manufacturing survey (EMIM); both are collected by Mexico's INEGI. INPC is gathered from more than 16,000 stores in 46 cities countrywide, while

[31] See figure A27(a) in the online appendix.

EMIM originates from more than 1,200 food and beverage manufacturing plants. EMIM survey is designed to cover, on average, more than 80 percent of production in every product category, but for the specific case of sodas all producing plants are surveyed. Soda production is measured in thousands of liters and is classified into five packaging and flavor categories. For the analysis, we sum these to get total production. An added advantage of this analysis is that since information is public it is easy to replicate.

We run the following specification:

$$log(Y_{ty}) = \alpha_t + \theta I(y \geq 2014) + f(ty) + \epsilon_{ty} \tag{4}$$

Where Y_{ty} refers to prices and volume produced, $f(.)$ is a second order polynomial in time, α_t are monthly dummies, and $I(y \geq 2014)$ is our variable of interest. We have monthly data from 2007 to 2015 on soda prices and quantities.[32]

Columns 1 and 2 of Table IX present the estimated θ coefficient when the dependent variable is the soda price index and thousands of liters respectively, while Column 3 presents an elasticity estimate using the tax as an instrument for price. The main takeaway is that the results are quantitatively close to our previous results: we find an increase of 12 percent in price of sodas and a decrease of 6.9 percent in liters of sodas produced. This strongly suggests that we are not reaching erroneous aggregate conclusions by not observing out-of-home consumption in the KWP data.

To assess whether these results are spurious, we also estimate *placebo* regressions, where instead of using January 2014 as the start of the tax regime we use January 2012 and 2013. Columns 4 and 5 present placebo results for 2013 for price and quantity, while columns 6 and 7 do the same for 2012. Placebos show no changes in quantities and small decreases in price. The online appendix presents graphical evidence.

[32]Figure A27(b) in the online appendix plots the log of the soda price index and the log of seasonally adjusted liters produced and reveals two important facts: there is a sharp jump in the price of sodas and a slowdown in the growth of soda production, thus qualitatively replicating our main finding using KWP data.

VIII. Conclusions

Several governments and other organizations have recently advocated for the introduction of special taxes on food in order to combat obesity. Unfortunately, there is little evidence to date of the effectiveness of such taxes. This paper contributes to the current debate by exploiting a uniquely detailed and high quality home-scanner dataset to estimate consumers' (and producers') responses to a very ambitious, large, and national fiscal policy aimed at combating obesity through taxation.

The richness of the data allows us to estimate the pass-through of the taxes to consumer prices and their effect on the consumption of total calories and other nutrients, and to explore consumers' substitutions across and within product categories. We find that the SD tax is moderately effective in decreasing consumption, while the HCF tax is ineffective. The fact that several foods and drinks were exempt from the tax encouraged substantial substitution with untaxed foods. The design of the taxes caused changes in the relative price of calories even within taxed products, which implied a substitution toward smaller SD package sizes and cheaper higher caloric HCFs. We estimate a statistically significant but small decrease in the consumption of sugar and an increase in the consumption of saturated fat and sodium, but no change in total calories. Finally, we found imperfect targeting as tax incidence and quantity reductions were not concentrated on the obese.

Our results provide useful lessons for those who wish to achieve a reduction in obesity through special taxes. Taking substitution into account in the design of the tax base is hugely important. This is especially important in countries with large informal markets in which sales taxes are largely avoided.[33] Taxing calories directly through taxing liters rather than price was more effective. Package size can be used to have larger consumption effects and target the tax towards higher BMI consumers (see Appendix A10.C). We abstracted from discussing of there is a rationale for government interventionat all or the regressive nature of the taxes introduced. The social costs of obesity and the distribution of the burden imposed

[33]Stern et al. (2014) show that in the Mexican context, "aguas frescas" usually sold informally, provide as many calories as sodas for children, for instance. In these cases, a tax on sugar at the source may be more effective.

by taxes as those introduced in Mexico should be explored in the future.

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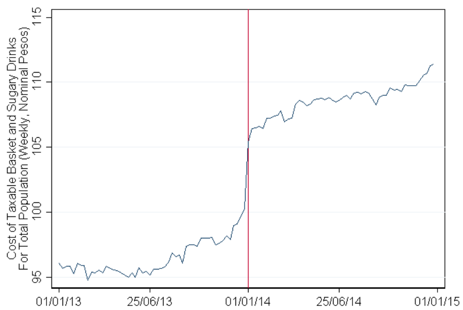
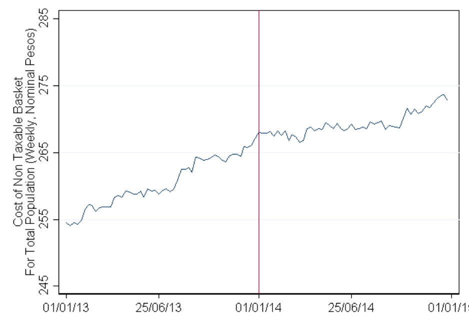
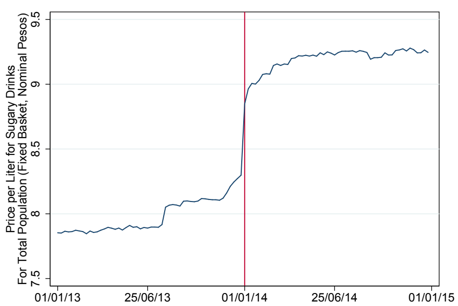
FIGURE I. WEEKLY COST OF HOUSEHOLDS' 2013 TAXABLE, NON-TAXABLE, SD, AND HCF



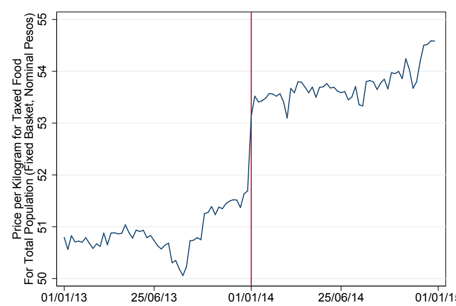
(a) Taxable



(b) Non-Taxable



(c) Price per Lt, SD



(d) Price per Kg, HCF

Note: Average consumption bundles keep the 2013 basket constant for each household for each week, so that only changes in prices drive the changes in cost. To calculate the cost for the consumption bundles, we multiply the number of units of each barcode in each households' 2013 by their current price. The assignment of current prices to barcodes is explained in detail in section A5 of the online appendix. In panel (c) and (d) we plot prices defined in equation (1)

TABLE I—SUMMARY STATISTICS

Variable	KWP	ENIGH	ENSANUT
Household's Head Characteristics			
Age	46.44	48	49.39
	[13.93]	[15.2]	[33.49]
Male (percentage)	0.79	0.72	0.75
	[0.4]	[0.45]	[0.43]
Schooling Level			
Primary (percentage)	0.56	0.49	0.67
	[0.5]	[0.5]	[0.47]
Secondary (percentage)	0.2	0.16	0.11
	[0.4]	[0.37]	[0.31]
More than Secondary (percentage)	0.24	0.35	0.22
	[0.42]	[0.48]	[0.42]
Body Mass Index (BMI)	27.6	-	28.34
	[4.56]		[5.49]
Overweight (percentage)	0.36	-	0.39
	[0.48]		[0.48]
Obese (percentage)	0.38	-	0.33
	[0.42]		[0.33]
Household Assets			
TV (percentage)	0.95	0.96	0.93
	[0.23]	[0.19]	[0.26]
Computer (percentage)	0.39	0.39	0.24
	[0.49]	[0.49]	[0.42]
Car (percentage)	0.43	0.49	0.41
	[0.49]	[0.5]	[0.49]
Expenditure			
Total Expenditure	-	10155.45	-
		[10574.96]	
Food	-	3256.87	-
		[2274.17]	
KWP goods^{a}	1560.26	1490.71	-
	[652.36]	[1063.07]	
Sugary Drinks	234.14	219.99	-
	[162.7]	[232.1]	
Snacks	28.34	12.35	-
	[33.81]	[43.82]	

Note: This table presents means and standard deviations for households in the Mexican chapter of the Kantar World Panel used in our empirical analysis, along with descriptive statistics from the 2014 Mexican National Expenditure Survey (ENIGH), and the 2012 National Health and Nutrition Survey (ENSANUT). ENIGH provides the national reference values for household demographics, expenditures and income. ENSANUT provides the national reference values for health and nutrition statistics. In particular, ENSANUT measures height and weight in situ. We apply the same filters in all the samples for comparative purposes. Total expenditures are measured in Mexican pesos per week. ^{a} KWP goods were constructed for comparison purposes with ENIGH. In this case, only consumption of packaged goods found in the KWP data were considered in the average shown for ENIGH.

TABLE II—IMPACT OF THE TAX ON SUGARY DRINKS

Panel A. Dependent Variable: Log of Household-level Price per liter of SD Index

		By Body Mass Index			By Socio-Economic Status		
	Total	BMI	Overweight	Obese	ABC+	CD+	DE
Tax	0.146	0.141	0.145	0.148	0.141	0.146	0.147
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Mean	7.98	8.09	8.01	7.90	8.24	7.93	7.92
Observations	762,706	143,255	329,988	289,277	148,408	348,672	265,440
R-squared	0.983	0.985	0.982	0.982	0.980	0.983	0.983

Panel B. Dependent Variable: Log of the Purchase of Calories from Sugary Drinks

		By Body Mass Index			By Socio-Economic Status		
	Total	BMI	Overweight	Obese	ABC+	CD+	DE
Tax	-0.063	-0.058	-0.063	-0.068	-0.078	-0.059	-0.061
	[0.006]	[0.007]	[0.007]	[0.006]	[0.007]	[0.006]	[0.006]
Mean							
Observations	762,706	143,255	329,988	289,277	148,408	348,672	265,440
R-squared	0.777	0.779	0.772	0.776	0.789	0.773	0.774

The *tax* variable indicates if the observation is captured after January 1st 2014. All estimations include household-week of the year fixed effects and a quadratic time trend. Each column shows the result for a different subsample. Data employed for this estimation comes from the weekly KWP Mexico chapter for 2013 and 2014. The unit of observation is the household-week pair. Standard errors clustered at the week level in brackets.

TABLE III—IMPACT OF THE TAX ON HIGH CALORIC DENSE FOODS

Panel A. Dependent Variable: Log of Household-level Price per kilogram of HCF Index

		By Body Mass Index			By Socio-Economic Status		
	Total	BMI	Overweight	Obese	ABC+	CD+	DE
Tax	0.053	0.055	0.053	0.053	0.043	0.052	0.061
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Mean	50.9	51.2	51.1	50.5	51.5	50.9	50.6
Observations	762,706	143,255	329,988	289,277	148,408	348,672	265,440
R-squared	0.983	0.984	0.983	0.982	0.979	0.982	0.986

Panel B. Dependent Variable: Log of the Purchase of Calories from HCF

		By Body Mass Index			By Socio-Economic Status		
	Total	BMI	Overweight	Obese	ABC+	CD+	DE
Tax	0.005	0.019	0.003	0.000	-0.054	0.025	0.010
	[0.021]	[0.024]	[0.022]	[0.022]	[0.029]	[0.023]	[0.017]
Mean							
Observations	762,706	143,255	329,988	289,277	148,408	348,672	265,440
R-squared	0.650	0.664	0.649	0.644	0.658	0.639	0.659

The *tax* variable indicates if the observation is captured after January 1st 2014. All estimations include household-week of the year fixed effects and a quadratic time trend. Each column shows the result for a different subsample. Data employed for this estimation comes from the weekly KWP Mexico chapter for 2013 and 2014. The unit of observation is the household-week pair. Standard errors clustered at the week level in brackets.

TABLE IV—IMPACT OF THE TAX ON CALORIES AND OTHER NUTRIENTS

Panel A. Dependent Variable: Log of 1 plus household level Total Calories

		By Body Mass Index			By Socio-Economic Status		
	Total	BMI $\leqslant$ 25	Overweight	Obese	ABC+	CD+	DE
Tax	0.016	0.042	0.014	0.006	-0.007	0.020	0.024
	[0.012]	[0.012]	[0.014]	[0.013]	[0.015]	[0.013]	[0.012]
Mean	16852	15686	16676	17642	17876	17225	15782
Observations	762,706	143,255	329,988	289,277	148,408	348,672	265,440
R-squared	0.669	0.692	0.666	0.661	0.675	0.659	0.678

Panel B. Dependent Variable: Log of 1 plus household level Total Nutrients

	Calories	Sugar	Carbohydrates	Fat	Sat. Fat	Cholesterol	Sodium
Tax	0.016	-0.020	-0.004	0.012	0.020	0.064	0.049
	[0.012]	[0.010]	[0.011]	[0.014]	[0.011]	[0.012]	[0.012]
Mean	16852	1371	1958	909	231	0.47	25.06
Observations	762,706	762,706	762,706	762,706	762,706	762,706	762,706
R-squared	0.669	0.705	0.691	0.656	0.675	0.669	0.668

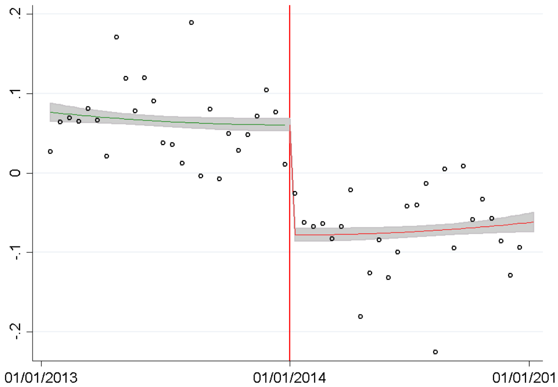
The *tax* variable indicates if the observation is captured after January 1st 2014. All estimations include household-week of the year fixed effects and a quadratic time trend. Each column in Panel A shows the results for a different subsample. Each column in Panel B shows the impact of the tax for different nutrients' consumption. Data employed for this estimation comes from the weekly KWP Mexico chapter for 2013 and 2014. The unit of observation is the household-week pair. Standard errors clustered at the week level in brackets.

TABLE V—EFFECTS ON TAXED AND UNTAXED FOODS AND DRINKS

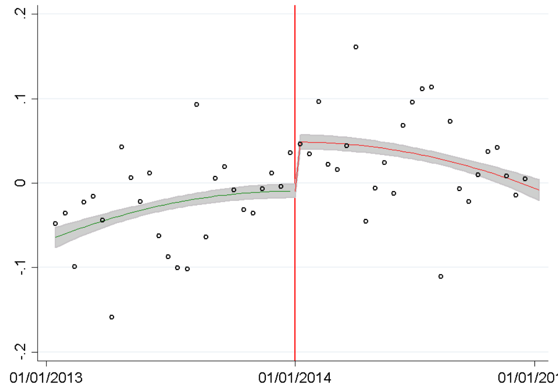
Impact on Calories				
	Calories of Foods		Calories of Drinks	
	NTF	HCFs	NTDs	SDs
Tax	249.8	20.8	141.1	-147.7
	[45.3]	[26.9]	[22.3]	[15.5]
Mean	6765	4398	3100	2723
Observations	762,706	762,706	762,706	762,706
R-squared	0.63	0.66	0.72	0.79

Note: The tax variable indicates if the observation is captured after January 1st 2014. All estimations include household-week of the year fixed effects and a quadratic time trend. In each column the unit of observation is the caloric consumption per household per week that originates from the consumption of the goods classified as follows: column 1 is non-taxed foods (NTF), which are solid products with a density below 275 kcal per 100 grams and above but exempt from the tax; column 2 are HCFs, which is the group of solid foods subject to the 8 percent VAT; column 3 refers to non-taxed drinks (NTDs), that is, drinks that fall under a tax exemption (e.g. milk) or that do no have added sugar (e.g. water); and column 4 SDs, which is the group with a one peso per liter tax. Data employed for this estimation comes from the weekly KWP Mexico chapter for 2013 and 2014. The unit of observation is the household-week pair. Standard errors clustered at the week level in brackets.

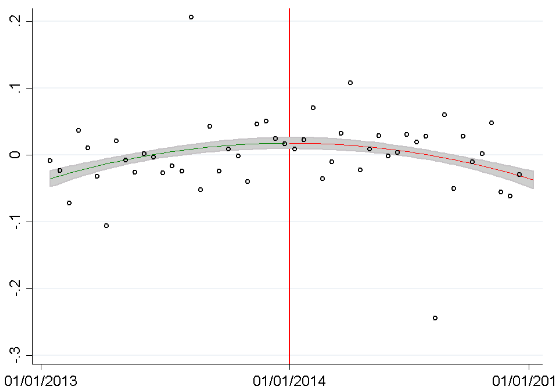
FIGURE II. EVENT STUDY PLOTS



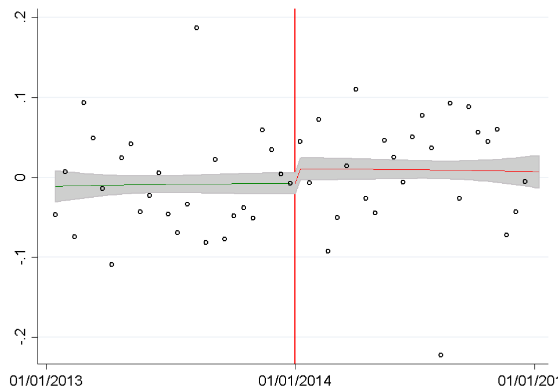
(a) Log Taxed Drinks (SD)



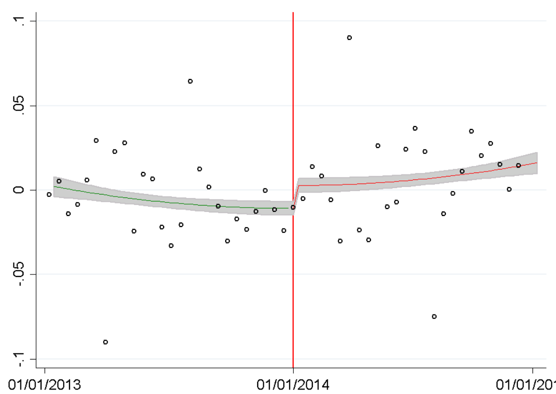
(b) Log Non-Taxed Drinks (NTD)



(c) Log Taxed Foods (HCF)



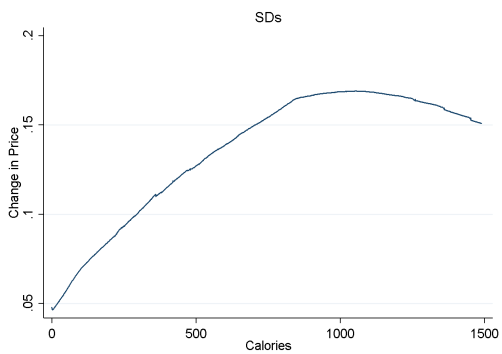
(d) Log Non-Taxed Foods (NTF)



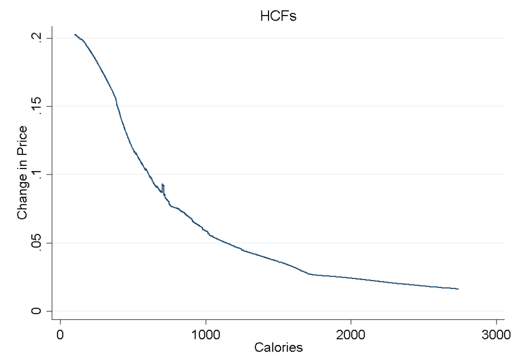
(e) Log Total Calories

Note: Each dot represents the bi-weekly average level in logarithm terms after partialling out for household and week fixed effects. The line corresponds to a cubic parametric estimation with different slopes before and after the tax reform. The shadowed area represents the 95% confidence interval. The vertical line indicates the moment in which the tax reform began to be implemented (January 1, 2014).

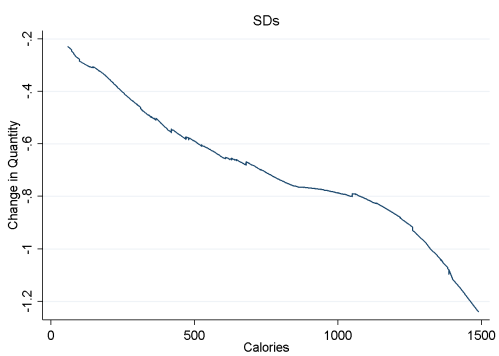
FIGURE III. PRICE AND QUANTITY CHANGES BY CALORIES OF BARCODE



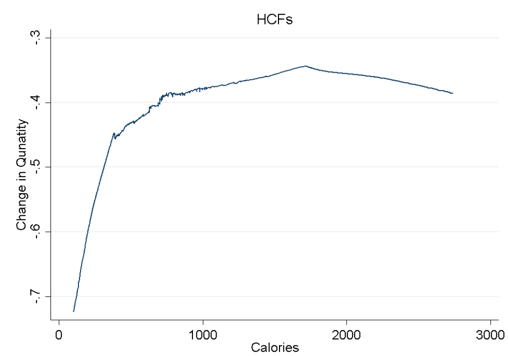
(a) %ΔPrice vs Calories, SD



(b) %ΔPrice vs Calories, HCF



(c) %ΔQ vs Calories, SD



(d) %ΔQ vs Calories, HCF

Note: These graphs represent non-parametric regressions of the the caloric content of a barcode against either the change in price of that barcode fron 2013 to 2014, or the change in the quantity. This is done separately for SDs in Panels (a) and (c) or HCFs in Panels (b) and (d).

TABLE VI—SUBSTITUTION WITHIN SDS AND HCFS

Units, Sizes and Calories						
	Sugary Drinks			Taxed Food		
	Log 2013 PL	Log liters per Unit	Log Units	Log 2013 PC	Log calories per Unit	Log Units
Tax	0.013	-0.047	-0.024	-0.013	0.008	-0.020
	[0.001]	[0.002]	[0.006]	[0.001]	[0.002]	[0.006]
Observations	762,706	762,706	762,706	762,706	762,706	762,706
R-squared	0.678	0.707	0.757	0.642	0.679	0.694

The *tax* variable indicates if the observation is captured after January 1st 2014. All estimations include household-week of the year fixed effects and a quadratic time trend. The dependent variable for each column is as follows: columns 1 and 4 use the logarithm of households consumption of SDs and calories from HCFs, respectively, but keep 2013 prices constant; columns 2 and 5 use log liters of SDs and calories of HCFs per unit (a unit is a packaged good sold individually that is identified by a barcode); finally, columns 3 and 6 use the logarithm of units of SDs and HCFs bought. Data employed for this estimation comes from the weekly KWP Mexico chapter for 2013 and 2014. The unit of observation is the household-week pair. Standard errors clustered at the week level in brackets.

TABLE VII—ROBUSTNESS TO INVENTORY

Robustness: Anticipatory Behavior with SDs and HCFs								
	Log Price per Liter (SDs)				Log Price per Kilogram (HCFs)			
Ommited weeks	None	One	Two	Three	None	One	Two	Three
Tax	0.146	0.147	0.147	0.148	0.053	0.054	0.053	0.053
	[0.002]	[0.002]	[0.002]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Observations	762,706	734,512	705,742	676,610	762,706	734,512	705,742	676,610
R-squared	0.983	0.983	0.983	0.983	0.983	0.983	0.983	0.983
	Log(1+Liters) (SDs)				Log(1+Kilograms) (HCFs)			
	None	One	Two	Three	None	One	Two	Three
Tax	-0.067	-0.068	-0.069	-0.069	0.003	0.004	0.004	0.004
	[0.006]	[0.006]	[0.006]	[0.007]	[0.003]	[0.003]	[0.003]	[0.003]
Observations	762,706	734,512	705,742	676,610	762,706	734,512	705,742	676,610
R-squared	0.777	0.777	0.777	0.777	0.677	0.676	0.676	0.676

The *tax* variable indicates if the observation is captured after January 1st 2014. All estimations include household-week of the year fixed effects and a quadratic time trend. The column classification *None*, *One*, *Two* and *Three* refers to the number of weeks that were omitted before and after the introduction of the taxes (i.e. January 1st 2014). Data employed for this estimation comes from the weekly KWP Mexico chapter for 2013 and 2014. The unit of observation is the household-week pair. Standard errors clustered at the week level in brackets.

TABLE VIII—DIFFERENCES IN DIFFERENCES ESTIMATES: USING MEXICO 2013 AS A CONTROL

All Dependent Variables in Logs						
	Panel A: Price per			**Panel B: Quantities**		
	Liter	Kilogram	Calories	Liters	Kilograms	Calories
Year (2013 effect)	0.028	0.017	-0.000	-0.027	0.009	-0.001
	[0.003]	[0.002]	[0.006]	[0.015]	[0.010]	[0.029]
Tax	0.145	0.054	0.041	-0.062	0.005	0.023
	[0.002]	[0.001]	[0.003]	[0.006]	[0.003]	[0.013]
Observations	1,071,550	1,071,550	1,071,550	1,071,550	1,071,550	1,071,550
R-squared	0.979	0.974	0.776	0.682	0.552	0.525

The $Year$ variable contains the values 2012, 2013 or 2014 and measures the *beginning of the year* effect for 2013. The *tax* coefficient indicates if the observation is captured after January 1st 2014. In this specification the *tax* coefficient will capture the extra *beginning of the year* effect for 2014 over 2013. All estimations include household-week of the year fixed effects and a quadratic time trend. Data employed for this estimation comes from the weekly KWP Mexico chapter for 2012, 2013 and 2014. The unit of observation is the household-week pair. Standard errors clustered at the week level in brackets.

TABLE IX—EFFECT OF TAX ON INDUSTRY PRODUCTION AND NATIONAL SODA PRICES

	Effects and Placebos						
	2014			2013		2012	
	Price	Liters	Elasticity	Price	Liters	Price	Liters
Tax	0.12	-0.069	-0.57	-0.04	-0.01	-0.03	-0.02
	[0.006]	[0.026]	[0.20]	[0.01]	[0.02]	[0.015]	[0.015]
Month FE	yes	yes	yes	yes	yes	yes	yes
Deg. Polynomial	Quadratic	Quadratic	Quadratic	Quadratic	Quadratic	Quadratic	Quadratic
Observations	107	107	107	107	107	107	107
R-squared	0.99	0.89	0.87	0.98	0.91	0.98	0.92

This table presents the results using EMIM industry data. All regressions use month fixed effects and a quadratic trend. The tax variable reports the θ coefficient from equation 4. Columns 1, 4 and 7 use the log of the price index as dependent variable. Columns 2, 5 and 8 use the log of liters consumed. Column 3 shows the resulting elasticity that results from the columns 1 and 2 estimates. Robust standard errors clustered at the date level in brackets.