Soda Consumption in the Tropics: The Trade-Off between Obesity and Diarrhea in Developing Countries

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Abstract

Increases in carbonated soft drinks (CSD) consumption mirror the increase in the prevalence of obesity in many countries of the world, including developing countries. This association, however, might be explained by many third factors that are correlated with both trends. This paper exploits a natural experiment in Peru and finds that a 10% decrease in the price of CSD increases consumption by 10%, increases BMI of adult women by 0.5%, and obesity rate by 8.5%. Effects are largely stronger for families without running water access at home. Additionally, this study finds that a 10% decrease in the price of CSD reduces diarrhea prevalence by 16% in women without running water access at home. This study suggests that taxes on CSD could generate unintended consequences for developing countries, while improving access to drinking water may not only reduce diarrheal prevalence but also alleviate obesity.

“Coca-Cola is said to be the second most well-known phrase in the world. The most well-known is "okay." So if you say "Coca-Cola is okay" you will be understood in more places by more people than any other sentence.” (Tedlow, R. 1990)

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1 Introduction

Obesity is an escalating worldwide epidemic, with 30% of the world's population now overweight. The rise in this epidemic began in developed countries, but developing countries are beginning to catch up [Swinburn et al., 2011]: the number of overweight individuals in developing countries has more than tripled in the last 30 years, and two-thirds of the world's overweight people live in these countries [Keats et al., 2014].

Technological progress has been identified as the main explanation for the current obesity epidemic. Lakdawalla et al. [2005] develop a model that predicts individuals' weight increases as a consequence of technology that lowers the cost of calories and raises the cost of physical activity. Cutler et al. [2003] provide evidence that the switch from individual to mass preparation of food has reduced the time spent in food consumption. Individuals have increased their number of meals per day more then the amount of calories per meal, and have increased the amount of calories from snacks more than from regular meals. Bertrand and Schanzenbach [2009] argue that technology has also changed the way individuals spend their time and provide evidence that eating and drinking as a secondary activity (while doing something else) has increased the amount of calories consumed.

Carbonated soft drinks (CSD) are a good example of how technology has contributed to changes in consumption patterns and calorie intake. Inventions such as soda fountains, shelf-stable food, artificial flavors and vending machines have made possible the expansion of CSD markets to almost every corner of the US and every country in the world. CSD are consumed both as part of main meals and as snacks at any time during the day, and many times while engaged in other daily activities or in transit from place to place.

CSD consumption and obesity prevalence are correlated across countries [Basu et al., 2013], but the expansion of the CSD industry also mirrors the increase in obesity rate within countries. In the last few decades, the real price of CSD in the US decreased more than 20% [Powell et al., 2013] and consumption has more than tripled [Allshouse, 2004], while obesity rates have more than doubled. Moreover, the increase in CSD consumption alone could explain the increase in obesity rates in the US; an energy imbalance equivalent to 12 oz. of CSD per day is enough to explain the increment in average weight in the US in the last few decades [Cutler et al., 2003] and today an average American consumes approximately 15 oz. of CSD per day Silver [2015]. Similar associations can be found in other countries, especially in developing countries where both obesity prevalence and CSD consumption are increasing. In fact, in the last decade, the increase in CSD consumption in developing countries has been greater than in developed countries, with more than half of the CSD consumption occurring in developing countries [Basu et al., 2013].

While these pieces of evidence are suggestive, they do not prove causality. Technology has simultaneously increased the supply (and decreased the price) of many other processed and high-caloric foods and has contributed to sedentary work regimes and life styles, and heavier people consume more calories (including more calories from CSD).

This paper exploits a natural experiment to provide causal evidence of the effects of changes in the price of CSD on obesity prevalence. Additionally, this paper tests the hypothesis that obesity prevalence in developing countries might be especially sensitive to changes in the price of CSD due to poor access to safe drinking water. The main argument is that individuals should be more willing to substitute away potentially contaminated water than clean water. Hence, if the price of CSD decreases, individuals with access to potentially contaminated water should be more willing to substitute their consumption of CSD for water than individuals with access to clean water. From this prediction it follows that these individuals should experience a higher increase in weight, since water has no calories, while most CSD and other beverages do. Moreover, individuals with access to potentially contaminated water should experience decreases in their probability of contracting diarrheal diseases, since diarrheal diseases are (at least in part) generated by the consumption of contaminated water.

The empirical strategy of this paper consists of two specifications. In the first specification, I exploit a natural experiment in Peru in the late 1990s, where the entrance and expansion of a new firm and a subsequent price war in the CSD industry prompted a sharp drop in prices in different regions of Peru at different points in time. This variation across regions and through time allows me to control for region and year fixed effects. Hence, the assumption of this specification is that within-region changes in CSD prices during the period of analysis were exogenous. It could be the case, however, that prices decreased more in regions where consumption or obesity was already increasing to a greater degree. Fortunately, this was not the case, as I show in the robustness section.

In my second specification, I exploit the expected differential responses to the decrease in CSD price by access potential contaminated water using access to piped water in the home, as a proxy. A significant differential effect provides evidence of the causal effect of CSD prices on consumption, weight and diarrhea. This specification relaxes the assumption that within-region changes in CSD prices are exogenous, since it compares households within the same region and time but with different access to piped water in places where prices of CSD dropped, controlling for the difference between these two types of households in regions where the price of CSD has remained relatively stable. Hence, the assumption of this specification is that if there are unobservable variables that are correlated with changes in CSD prices and in weight outcomes, this correlation is not significantly stronger in households without access to piped water compared to households within the same region and time but with access.

I find that a 10% decrease in the price of CSD increases (Body Mass Index) BMI of adult women of childbearing age by 0.12 units (0.5%), and obesity rate by 0.9 percentage points (8.5%). These effects are explained by an elasticity of demand of 1.3 units in young families (and of 1.0 in the general population) with no substitution effect on milk, non-carbonated soft drinks or alcoholic beverages. I do find complementary effects on food prepared outside the home but consumed at home. I find no effect on the number of times the families eat outside home. Thus, the increase in weight outcomes cannot be explained by the proliferation of fast food restaurants. The effects are significantly higher for families without access to piped water in their homes; the effects on BMI and obesity rates are more than twice as high in absolute terms than those for women with piped water at home. Moreover, I find that a 10% decrease in the price of CSD reduces severe diarrhea prevalence by 16% in women without access to piped water in their homes.

These results highlight the disproportionate effect the expansion of CSD consumption can have, and probably is having, on obesity in developing countries, where access to safe water is limited. Access to public sources of drinking water has improved significantly in the last decades, but a significant proportion of families still live without piped water at home and this population is not confined to rural areas; almost 1 in every 3 urban dwellers in the developing world have no piped water at home [TheWorldBank, 2015, UnitedNations, 2015]. Furthermore, this study suggests that taxes on CSD could yield unintended results for developing countries, and that improving access to drinking water could not only reduce diarrheal prevalence but also prevent obesity.

2 Background

During the 1980s and early 1990s Peru suffered greatly from continual violent attacks from guerrilla movements, mainly from the Shinning Path Movement. They started to operate in Ayacucho, a city in the highlands, but subsequently expanded their control over most of the Andean highlands and the roads connecting the rest of the country to these areas. As a result many companies, including CSD companies, stopped supplying these areas. In 1988 a small family, the Ananos, from Ayacucho decided to start producing their own CSD, "Kola Real", to fill the unsatisfied demand. [Rivera, 2012] This humble and informal family business grow up to be what is now known as the Aje Group with plants in 20 countries in America, Asia and Africa and exports to United States and Spain[1].

Initially they expanded their operations in regions where traditional companies did not have a great presence, but little by little they began to enter bigger cities. The main strategy of the firm was to work at very low costs and charge very low prices. [Republica, 2005] This strategy allowed the firm not only to steal clients from traditional companies but also to attract new consumers from low socioeconomic sectors, who did not traditionally consume much CSD.

In 1997, the Aje Group entered Lima, the biggest market for CSD. They were especially lucky because of two circumstances: first, that year a very strong Niño Effect affected Lima and other areas of the country, raising temperatures and extending the summer of 1998. This unexpected (and temporary) high temperature and longer summer generated a

[1] http://www.ajegroup.com/about-aje/map/

demand that went unsatisfied by the traditional companies, which benefited the entrance of KR.[Republica, 2005] Second, Pepsi Company stopped selling in the North of the country and the two biggest companies Coca-Cola and Inca-Kola spent all their attention and energy fighting each other to gain the market share left by Pepsi's departure from the area, ignoring the expansion of KR in Lima. Hence, it was not until 1999, after Coca-Cola bought Inca-Kola, that they began to fight KR by greatly lowering prices.[Rivera, 2012] In Figure 1, we can see the changes in monthly CSD prices and the general index price from 1997 to 2001 in Lima. The big decrease in prices occurs at the beginning of 1999. In other cities, however, prices decreased earlier or later or did not change significantly depending on when Kola Real entered in the market and if and when the other companies fought back also by lowering their prices. As an example, Figure 2 shows the differences in the evolution of CSD prices in the 4 biggest cities of Peru.

As a response to the shock in the price of CSD, consumption increased significantly between 1997 and 2001, as shown in Figure 3. The present study seeks to find out whether this increase in consumption of CSD leads to in an increase in the obesity rate of the country. Figure 4 reveals that during the same period women's BMI and obesity rates increased significantly. Of course, a causal relation may not exist between these two phenomena. An increase in the consumption of CSD does not necessarily imply an increase in weight; this mainly depends on precisely what is being substituted for CSD. If the reduction in CSD prices made Peruvians substitute water for CSD, then very likely there should have been an effect on body mass index (BMI); given that CSD has significantly more calories than water. This type of substitution is especially possible in a country like Peru, where drinking water access and quality is very poor. During the years analyzed here in particular, 1997-2001, approximately 40% of homes did not have piped water in their homes[2]. Alternative sources of water, even water sold by privately owned trucks do not necessarily meet the minimum sanitary criteria demanded by the Ministry of Health [Bonifaz and Aragón, 2008], and hence, water from these sources is potentially contaminated. Given these circumstances, it seems reasonable to believe that low cost CSD will be well received as a sweet and non-contaminated alternative for water.

This context is not so different from the rest of developing countries. In the last decade, both the increase in CSD consumption [Basu et al., 2013] an in obesity rate [Swinburn et al., 2011] in developing countries has been greater than in developed countries, and almost one in three urban dwellers in the developing world have no piped water at home [TheWorldBank, 2015, UnitedNations, 2015]

[2]Source: National Household Survey (or ENAHO, for its Spanish acronyms) 1997-2001

3 Theoretical Framework

This section presents a simple framework to formalize the intuition that if the price of CSD decreases, individuals should be more willing to replace CSD for water, the more contaminated the water is. It also develops predictions that I am able to test in this study. The goal of this section is not to show that these predictions hold for the most general case, but to show a simple example where it does hold.

3.1 Model Set-Up

Suppose an individual chooses foods that have consequences for the probability of getting diarrhea (D) and for her weight. Suppose that the only foods she consumes are soda (s) and water (w). Assume utility is quasi-linear, such that

$$U{=}u(s){+}w - D(w;\pi) \text{ -}\triangle Weight(s;\gamma)$$

where u is monotone increasing in s, respectively, twice differentiable and strictly concave. π is the contamination level of water and γ is the number of calories per unit of soda consumed, and both are positive.

The budget constraint is

$$w + ps = I$$

where I stands for income, the price of water has been normalized to 1 and the price of soda is given by p. For the sake of simplicity assume weight increase is a linear function such that

$$\triangle Weight = \gamma s$$

Rewriting the utility function in terms of soda we get:

$$U{=}u(s){+}u(I-ps) - D(I-ps{,}\pi)\text{-}\gamma\text{s}$$

The first order condition (FOC) is:

$$u_s - p(1-D_w) - \gamma = 0$$

The second order condition (SOC) is:

$$u_{ss} - p^2 D_{ww} < 0$$

The production function of diarrhea is monotone increasing in water consumption and contamination levels, twice differentiable and is strictly concave:

$$\begin{aligned} D_w &> 0 \\ D_{ww} &< 0 \end{aligned}$$

In order to avoid giffen goods assume additionally

$$1 - D_w + spD_{ww} > 0$$

Finally, the key assumption is that water consumption and water contamination level are substitutes in the production function of diarrhea, such that,

$$D_{w\pi} < 0$$

and as a result :

$$\begin{aligned} \frac{dw}{d\pi} &> 0 \\ \frac{ds}{d\pi} &< 0 \end{aligned}$$

This assumption seems reasonable, especially for high levels of contamination, due to two characteristics related to diarrheal diseases: (1) individuals build a natural immunity against the bacteria and viruses that causes diarrhea; exposure to these bacteria or viruses results in severe episodes of diarrhea early on, but subsequent episodes are milder or asymptomatic (Malik2008, WHO 2006). Thus, the higher the levels of water contamination, the higher the probability that the individual has built immunity, and the fewer incentives individuals have to reduce their water consumption. (2) Diarrhea is highly contagious; thus, individuals who do not consume water may nonetheless contract diarrhea as long as others are consuming it (and as long as contamination levels are positive). The higher the levels of water contamination, the higher the probability of contracting diarrhea through contagion, the fewer incentives individuals have to reduce their water consumption. This result is similar to the complementarities between different improvements in fighting diseases commonly found in the health literature (Becker 2006, Oster 2012); if government invests in reducing the contamination level of water, individuals have greater incentive to invest in consuming soda.

Prediction 1: The higher the level of water contamination, the more the individual will increase her consumption of soda, given a reduction in the price of soda.

Using the FOC and the implicit function theorem we get:

$$\frac{ds}{d\pi} = \frac{D_{w\pi}}{-(u_{ss} + p^2 u_{ww} - p^2 D_{ww})} < 0$$

$$\frac{ds}{dp} = \frac{-(1 - D_w) - sp(D_{ww})}{-(u_{ss} - p^2 D_{ww})} = \frac{A}{B} < 0$$

where B is positive. Derivating with respect to the level of water contamination we get:

$$\frac{d\frac{\partial s}{\partial p}}{d\pi} = \frac{D_{w\pi} - 2p_s(D_{ww})\frac{ds}{d\pi}}{B} < 0$$

Assuming third derivatives equal 0.

Prediction 2: The higher the level of water contamination, the more the individual will decrease her consumption of water, given a reduction in the price of soda.

Proof:

Differentiating the budget constraint with respect to the price of soda and with respect to the level of contamination we get:

$$0 = \frac{d\frac{ds}{dp}}{d\pi} + \frac{ds}{d\pi} + \frac{d\frac{dw}{dp}}{d\pi}$$

From which follows that:

$$\frac{d\frac{dw}{dp}}{d\pi} > 0$$

Prediction 3: The higher the level of water contamination, the more individuals will increase their weight, given a reduction in the price of CSD.

Proof:

Derivating the weight increase with respect to the price of soda and then with respect to the level of water contamination we get:

$$\frac{d\triangle Weight}{dp} = \gamma\frac{ds}{dp}$$

$$\frac{d\frac{d\triangle Weight}{dp}}{d\pi} = \gamma\frac{d\frac{ds}{dp}}{d\pi} < 0$$

Prediction 4: The level contamination has an ambiguous effect on the effect of a reduction in the price of CSD on diarrhea prevalence.

Proof:

Derivating the diarrhea function with respect to the price of soda and then with respect to the level of water contamination we get:

$$\frac{dD}{dp} = D_w\frac{dw}{dp} \lesseqgtr 0$$

$$\frac{d\frac{dD}{dp}}{d\pi} = (D_{w\pi} + D_{ww}\frac{dw}{d\pi})\frac{dw}{dp} + D_w\frac{d\frac{dw}{dp}}{d\pi} \lesseqgtr 0$$

4 Identification Strategy

The main purpose of this paper is to determine whether a reduction in the price of CSD increases obesity rates, through the increase in CSD consumption. In order to do this I estimate a reduced-form equation of the effect of CSD prices on BMI and obesity rates. I also estimate the effect of CSD prices on CSD consumption, as a means of verifying that consumption of CSD is the mediator between prices and BMI or obesity rates.

The empirical strategy consists of two specifications. For the first specifications, the regression Equation for the demand be:

$$C_{i,j,t} = \beta_o + \beta_1 P_{j,t} + \beta_2 X_{i,j,t} + \omega_j + \phi_t + \varepsilon_{i,j.t}$$

Where $C_{i,j,t}$ stands for the per-capita monthly consumption of CSD in liters of family i, in region j and month-year t. $P_{j,t}$ stands for the real index price of CSD, with 1997 as the base year in region j and month-year t. $X_{i,j,t}$ stands for demographic characteristics and living conditions (including poverty level) of family i, in region j and month-year t, as well as regional characteristics like average temperature in month-year t. ω_j stands for region fixed effects. ϕ_t stands for year fixed effects. Finally $\varepsilon_{i,j.t}$ stands for the error term.

In order to estimate the effect of the price of CSD on weight outcomes, I run the weight outcome of a person, for example, BMI, measured on a specific date on the average price of CSD of the previous six months of that measurement date. The 6-month average period was chosen arbitrarily just with the purpose of reflecting recent lagged prices, while capturing the short-term variability of the prices in my sample. In order to test the sensibility of my results to this average period I also run the regressions with 3-month, 9-months and 1-year average prices; results are shown in the appendix.

The reduced-form Equation for BMI or weight outcome would be:

$$BMI_{i,j,t} = \gamma_o + \gamma_1 \bar{P}_{j,t} + \gamma_2 X_{i,j,t} + \omega_j + \phi_t + \varepsilon_{i,j.t}$$

where $BMI_{i,j,t}$ stands for the BMI or weight outcome of woman or child i, in region j and month-year t. The other variables are the same as in the demand equation, except for the fact that the price and the weather variables reflect the 6-months averages. Since we do not have a panel data at the individual level, we cannot construct an average for the demographic characteristics and living conditions, so we just use the contemporaneous levels.

The reduced-form Equation for the effects on diarrhea prevalence is similar to the equation for weight outcomes, only that prices are averaged over three months since the information of diarrhea I have is over a three-month period.

With this strategy I control for the possibility that prices decreased more sharply in places where there is a higher consumption of CSD and/or higher levels of obesity, such as Lima, for example. I also control for yearly shocks common across all regions that may have generated changes in the consumption of CSD or in the obesity rates. Nevertheless, I do not control for unobservable variables that might be correlated with changes in the price of CSD and in changes in weight outcomes. Note that it is easy to find unobservable variables that are *positively* correlated to changes in both variables. For example, changes in individual consumption patterns with respect to prepared food (including CSD), because the opportunity cost of cooking has increased, would accelerate the increase both in BMI (considering this food has generally more calories than home cooked food) and in the price of CSD. Nevertheless, such a variables tend to change smoothly in time and more or less simultaneous across the different regions. Hardly could a story like that explain drops in prices of 30% in only a couple of months and some regions. Moreover, the omission of these types of variables generates a bias that goes against my results. Hence, the real matter of concern here are unobservable variables that are correlated negatively with changes in weight outcomes and positively with changes in CSD prices, or vice versa. I claim that exogeneity resulted from variations in the supply of CSD generated by the staggered entry of a new CSD producer in different regions of Peru at different points of times and the responses of incumbent firms that lower prices sharply. In order to further increase the confidence on my empirical strategy, I include a robustness section where I tests whether prices decreased more in regions where consumption or obesity was already increasing to a greater degree. I also test whether the drop in CSD prices is not correlated with a broader drop in the price of calories.

For the second specification I add an interaction term between the prices of CSD and the availability of water in the homes. The coefficient of this interaction term provides us with the additional effect of prices on women living in homes without running water access

$$
\begin{aligned}
C_{i,j,t} &= \beta_o + \beta_3 P_{j,t} W_{i,t,j} + \beta_1 P_{j,t} + \beta_2 X_{i,j,t} + \omega_j + \phi_t + \varepsilon_{i,j.t} \\
BMI_{i,j,t} &= \gamma_o + \gamma_6 \bar{P}_{j,t} W_{i,t,j} + \gamma_1 \bar{P}_{j,t} + \gamma_2 X_{i,j,t} + \omega_j + \phi_t + \varepsilon_{i,j.t}
\end{aligned}
$$

where $\bar{P}_{j,t} W_{i,t,j}$ stands for the product of the average price of CSD and the availability of water in the house, and $X_{i,j,t}$ includes $W_{i,t,j}$.

As explained in Section 3, the effect of prices both on consumption and on BMI should be greater for women who live in homes without access to running water. If my account is right, then, the coefficient of the interaction term should be negative and significant. This specification relaxes the assumption that within-region changes in CSD prices are exogenous, since we compare households within the same region and time, but with different access to running water. Instead, this specification relies on the weaker assumption that if there are unobservable variables that are correlated with changes in CSD prices and with changes in weight outcomes, this correlation is not significantly stronger for households without running water access at home than for households within the same region but with running water access at home.

5 Data and Summary Statistics

For the purposes of this paper, I combine several datasets from the years 1997 to 2001. As we saw in Section 2, this is the period during which the price of CSD decreased the most given the expansion of the new firm in several regions of the country, making it the ideal period of time for my analysis. A longer-term analysis would diminish the leading role of the supply in the variation of the prices, and would therefore reduce the degree of exogeneity of the price for the estimation of the elasticity of the demand and the effects on weight outcomes. Nevertheless, even if I wanted to expand our period of analysis we would not be able to do so due to constraints in our data sets.

I work with three samples. The first sample (hereafter "demand sample") is used to estimate the elasticity of demand of CSD. For this sample I use the National Household Survey (or ENAHO, for its Spanish acronym). This dataset is representative at the national level and includes monthly information from the last quarter of each year, of each of the 25 regions. It contains data on household food consumption, including CSD consumption, as well as other demographic characteristics for the members of the household. I match this datasets with the series of monthly food prices of the National Institute of Statistics and Informatics' (or INEI for its Spanish acronyms). The Information on prices is from the largest 25 cities, each of which belongs to one of the 25 regions. Thus, I merge these two datasets at the regional level. Finally, I match these data sets with the series of monthly average temperature of the National Service of Meteorology and Hydrology's (or SENAMHI for its Spanish acronyms) by region. I keep in my sample only the households in which the "women" (head of the household if it is a female or of the wife of the head of the household if the latter is a man) are 19 to 49 years old. The original sample includes women ages 14 to 98, but I wanted to make my sample more comparable to the women's weight sample, given that the estimation of the effect of prices on consumption is made here to verify that consumption of CSD is the mediator between prices of CSD and obesity. This sample has approximately 22 thousand observations.

The second sample (hereafter the "weight sample") is used to estimate the effect of CSD prices on adult women's weight outcomes. For this sample I use the first round of the National Nutritional Indicators Survey (or MONIN I, for its Spanish acronyms). This dataset is representative at the national level and contains monthly information about anthropomorphic measures and demographic characteristics of women of child-bearing age[3]. I also match this dataset with the series of monthly prices and average temperature by region. I eliminate pregnant women from the sample. This sample has approximately 10 thousand observations with some regions missing for certain month-year combinations.

The third sample (hereafter "diarrhea sample") is used to estimate the effects on diar-

[3] A second round, called MONIN II, collects very similar information from 2002 to 2006, but differences in the instruments and sampling design make them incomparable

rhea prevalence. For this sample I also use the National Household Survey (or ENAHO, for its Spanish acronym) but at the individual level and for years 1998 to 2000, since these are the only years for which the survey contains information about diarrhea prevalence. I also match this datasets with the series of food prices and average temperature. This sample has approximately 60 thousand observations.

Table 1 presents summary statistics from the three samples. Note, that according to my data, the average consumption of CDS during these years is 0.9 liters per month per person. This number is very low but it includes only the consumption of CSD at home. The total consumption of CSD is significantly higher; for example in 2000 it was approximately 4 liters, which amounts to 48 liters per year [Gestion, 2000]. This is still small compared with countries like the US, where the per-capita consumption of CSD in the same year was estimated at 120 liters per year Vartanian et al. [2007]. The consumption of non-carbonated soft drinks (bottled water and fruit drinks) is even smaller: 0.14 liters per month, per person.

Table 1 also shows that obesity was not particularly high among Peruvian women. We can see that the average BMI of the women of my sample is 25 and 13% of the women are obese, where obesity is defined as a BMI of 30 or more. These figures are similar to those of the US circa 1975.

The demand sample and the women's weight sample are similar but with some important differences; women are more highly educated and have more access to water and electricity in the demand sample than in the women's weight sample. Also, in the women's weight sample there is no poverty variable, so I include the variables of materials used to construct the house's floor, roof and walls, as a proxy for satisfied basic needs. In this sample there is also no variable for rural-versus-urban areas. Nevertheless, this variable changes very little across time, so given that I use fixed effects at the regional level, the absence of this variable should not affect results significantly.

6 Results

6.1 Effect on Consumption

Tables 2, 3 and 4 presents the effects of CDS price on monthly per-capita consumption of different foods. All regressions include fixed effects for regions and years and the following control variables: dummy variables for the poverty level of the household, dummy variables indicating whether or not the district is rural, whether or not the household has access to running water inside the house, and whether or not the house has electricity, the average monthly temperature of the region, and dummy variables for the age and level of education of the head of household. Standard errors are clustered by region.

The first and second columns correspond to the full sample and to the first and second specification, respectively. My estimate indicates that a 10 percent decrease in the real price of CSD increases monthly per-capita consumption in 0.09 liters. Given the average consumption of CSD in 1997, this effect is equivalent to an elasticity of demand of -0.95. In the second column, we can see that, consistent with the predictions derived in the conceptual framework, the effect on CSD consumption of households living in homes without piped water at home is significantly higher than the effect on households living in homes with piped water. The difference in the elasticities is even higher; the elasticity of demand of households living in homes without piped water at home is 2.33, while the elasticity of demand of households living in homes with piped water is only 0.50 and it is not statistically significant from 0. Note that homes without water access tend to be the poorest, but this does not mean that the effect was stronger among the poorest households. In fact, in Table A1 of the appendix, we see that the effect is significantly higher in non-poor or moderately poor households than in extremely poor households.

In the next section we are going to see the effect on weight outcomes of women of childbearing age (age 19 to 49). Typically, individuals in this age range consume more CSD than older individuals or children. Unfortunately, the data on consumption is at the household level, thus we cannot estimate the effect of the decrease in the price of CSD on different subsamples of individuals. Nevertheless, in an effort to estimate the effect on a more comparable sample column 3 and 4 show the effect for households with the head of ages 19 to 49. As expected, the effect in young households is higher in absolute terms. The following tables present the effects on this subsample of households.

Tables 3a and 3b reveals the effects of changes in CSD prices on potential substitute goods. A significant and positive coefficient for the price of CSD would indicate evidence of substitution. For these regressions, I add as a control variable the price of each good, except for the regression of bottled water and fruit juices, for which prices are not available. As we can see, the price of CSD has no effect on the consumption of milk or alcohol. In the case of bottled water and fruit juices[4], only the effect on households without water is significant, but negative: a 10 percent decrease in the real price of CSD increases consumption of non-carbonated soft drinks in 0.06 liters per month for individuals who live in homes with no water access. This result probably reflects the fact that CSD companies also produce bottled water and fruit juices, so that prices might have closely followed declines in the price of CSD. Unfortunately, as mentioned above, such prices are not available.

Table 4 shows the effects on potential complementary goods. A significant and negative coefficient would indicate evidence of complementarity. For these regressions, I add as a control variable an index price of food prepared away from home. We can see that a 10 percent decrease in the real price of CSD increases the monthly per-capita consumption of prepared food by 0.07 kilos. This is food prepared outside home, for example in a market, but consumed at home. Assuming an average portion of food weights a pound, what these

[4]It would be interesting to see the effect separately on bottle water and on fruit juices, unfortunately, there is not such a disaggregation in my data.

results are telling us is that half the time that an individual buys a 12 oz. can of CSD, he/she ends up buying a portion of food with it. Note that the effect is significantly higher (in absolute terms) in households without water access than in households with water access at home.

In Table 4 we can also see that there is no effect on the number of times these families eat outside the home. This result is important in order to reject the hypothesis that the proliferation of fast food restaurants might have been associated with the decrease in CSD prices and that the increases in weight outcomes are a consequence of individuals eating more outside the home. Moreover, the difference between the two types of households is positive and significant. Hence, it seems that the decrease in the price of CSD is prompting these households to substitute restaurant visits with buying prepared food and CSD and eating at home. This result makes sense, since the restaurant price of CSD tends to be more inelastic, meaning that the price of prepared food and CSD in this market has dropped relatively more than the price of having a meal in a restaurant.

6.2 Effects on Adult Women Weight Outcomes

Table 5 presents the effects of CDS price on adult women's BMI and obesity prevalence. Regressions include regions' and years' fixed effects and the following control variables: a dummy that indicates whether the house has running water, another that indicates whether the house has electricity, dummies for the materials in floor, roof and walls, the 6-month average monthly temperature of the region, and dummies for the age and level of education of the woman. I find that a 10% percent decrease in the 6-month average real price of CSD increases BMI by 0.12 units, or equivalently 0.05%. In columns 2 we can see that, consistent with the predictions of the conceptual framework, the effect is significantly higher in magnitude for households without water access: a 10 percent decrease in the price of CSD increases the BMI of adult women without water access by 0.013 *additional* units or 0.54%.

Column3 shows that a 10 percent decrease in the 6-month average real price of CSD increases the rate of obese women by approximately 0.9 percentage point, the equivalent of 8.5%. Again, the effect is significantly higher in magnitude for households without water access: a 10 percent decrease in the price of CSD increases the rate of obese women by additional 1.5 percentage points or 14.8%.

Tables A3 and A4 of the appendix show the results of the 3-month, 9-month and 1-year average real price of CSD, respectively. As can be seen, estimations are very similar both for the effects on BMI and for the effects on obesity rate. Only in the case of the estimations with 1-year average real prices does significance decrease; this is to be expected, since the longer the period of average the more variation is lost.

In order to put the results into context, we can compare them with the total increase in BMI and obesity rates between 1997 and 2001 in Peru. During this period, the 6-month average price decreased about 14%, meaning that the accumulated effect of the decrease in the price of CSD on women's BMI is approximately 0.17 units and on women's obesity rate is 1.22 percentage points. During the same period, the average BMI of women ages 19 to 49 in Peru increased 0.6 units and the obesity rate increased 2.76 percentage points. Thus, approximately 28% of the total increase in BMI and around 44% of the total increase in obesity in Peruvian women between 1997 and 2001 can be explained by the decrease in the price of CSD.

In the case of women living in homes with no access to running water, as we would expect, the effect of the decrease in CSD explains a larger part of the total increase in BMI and obesity rate. The accumulated effect between 1997 and 2001 on average BMI is 0.3 units and on obesity rate is 2.75 percentage points. During the same period, average BMI and obesity rate of this subpopulation increased 0.69 units and 4.02 percentage points, respectively. Thus, approximately 44% of the increase in average BMI and 69% of the increase in the obesity rate of women living in homes with no running water in Peru can be explained by the decrease in the price of CSD.

6.3 Effects on Diarrhea Prevalence

Table 6 presents the effects of CSD price on adult and children's diarrhea prevalence. All regressions include fixed effects for regions and years and the following control variables: dummies for the poverty level of the household, dummy variables indicating whether or not the district is rural, whether or not the household has access to running water inside the house, and whether or not the house has electricity, the average monthly temperature of the region, and dummies for the age and level of education of the head of household. Standard errors are clustered by region.

Column 1 shows that there is no effect on diarrhea in the general population. Column 2 shows that, consistent with the predictions derived in the conceptual framework, a decrease in the price of CSD had higher effects on individuals with access to potentially contaminated water; although the difference is not statistically significant. However, as shown in Column 3, in the case of women the difference is significant; a 10% percent decrease in the real price of CSD decreases diarrhea rates by 0.2 percentage points or 16%. This result is also consistent with the predictions derived in the conceptual framework, since the proxy for potentially contaminated water used in this study is lack of access to piped water at home, and women spend more time in the home than men.

6.4 Magnitudes and Consistency among Estimated Effects

We can use the estimations on the demand of CSD in order to get a rough idea of whether the magnitudes of the estimates are reasonable. As we mentioned above, the price of CSD declined 14% between 1997 and 2001 and generated, according to my estimates, an accumulated effect on BMI of 0.17, or equivalently 0.85 pounds (given the average height in my sample of 1.51 m.). Applying the rule of thumb of Hall et al. [2011], for an increase in weigh of 0.85 pound during that period of time, we need an increase in consumption of about 8.5 calories per day[5]. In this study, I estimated that a 10% decrease in the price of CSD generated an increase of 0.12 liters per-capita for families with the head of the household ages 19-49. This estimate, however, only takes into account the consumption of CSD at home, but as mentioned above, the total consumption outside home of CSD in Peru is more than 3 times higher than the consumption of CSD at home. Thus, assuming the same elasticity of demand for the consumption of CSD outside the and inside the home, the effect of total consumption should be approximately 0.36 liters. Thus, the effect of a decrease of 14% in the price of CSD should be approximately 0.5 liters per month, which corresponds to 16.8 milliliters per day or 6.7 calories. This estimate is large enough to explain the estimated increase in weight, if we take into account that I find no substitution effect on high-caloric beverages and I do find complementary effect on food prepared outside the home but consumed at home. Moreover, this calculation has been made with the average consumption per-capita of a family, while the effect on weight outcomes have been estimated for women, and evidence from other countries shows that obesity rates have increased more in women than men [swinburn2011global, cutler2003have]. Thus, presumably women might have increased their consumption of CSD by more than what I have estimated for the average individual in the household. Finally, in the case of women with no access to piped water at home, the reduction in diarrhea might have contributed to the increase in weight. Thus, the magnitude of my estimated effects on weight outcomes seems reasonable.

We can also use the estimations of the demand of CSD to get a rough idea of whether the magnitudes of the estimated effects on diarrhea prevalence are reasonable. The price of CSD declined 12% between 1998 and 2000, and generated, according to my estimates, an increase in the consumption of CSD of 16 milliliters per day (again assuming total consumption is three times the amount of consumption at home) and a decrease of 0.13 percentage points on diarrhea prevalence in individuals without piped water at home. In other words, the decrease in the price of CSD eliminated diarrhea problems in 0.13 individuals of every 100. Assuming diarrhea problems are eliminated only when individuals completely eliminate their consumption of potentially contaminated water, and assuming that before the decline in CSD prices individuals were consuming 2 liters of water daily. The effect on CSD consumption noted here would be enough to explain the effect on diarrhea, since 2 liters times 0.13 individuals of every 100 represents an average increase of 2.6 milliliters per day per person. Thus, the magnitude of the estimated effect on diarrhea

[5]Half of the weight increase should happen in the first year and 95% of the total weight increase should happen in the first 3 years.

prevalence are conservative.

7 Robustness

The empirical analysis of this paper provides credible evidence that the decrease in CSD prices has generated an increase in weight among women of childbearing age in Peru and a decrease in diarrhea prevalence. Nevertheless, it does not completely rule out the possibility that there exists an omitted variable that is correlated with CSD prices and is the real originator of the observed effects on weight and/or diarrhea outcomes. In order to further enhance the credibility of my results, in this section I test two of the main alternative stories that could invalidate or at least bias my results.

7.1 Alternative Story 1: Increase in Weight generated by Reverse Causality

It is possible, that the price of CSD decreased more in regions where obesity rate was increasing to a greater degree. For example, it is possible that the Ananos Family chose to introduce its CSD in cities where CSD consumption was increasing more relatively to other cities. And that in these regions CSD was increasing more, because obesity was increasing more. In this case, my estimated effects, at least those from the first specification, would be overvalued. In order to test this alternative story, column 1 of table 7 explores whether CSD prices can be predicted by the regional average of CSD consumption in the preceding 6 months. Likewise, column 2 and column 3 of table 7 explore whether CSD prices can be predicted by the regional average BMI and obesity rate in the preceding 6 months, respectively. As we can see in table 7, none of the estimated coefficients is significant, and the point estimates are either very close to zero or positive, meaning we can also discard this alternative story.

7.2 Alternative Story 2: Decrease in Diarrhea generated by Omitted Variables.

It is possible that the decrease on diarrhea in homes with no piped water was generated by an omitted variable that is correlated with the price of CSD. For example, the government might have increased their efforts to decrease diarrhea in areas where the decrease in the price of CSD was greater in absolute terms.

If the explanation for the decrease in diarrhea were something other than the drop in the price of CSD, we would expect the effect to be the highest on children, since they are the ones who most frequently contract diarrhea. On the other hand, if the explanation for the decrease in diarrhea were price of CSD, we would expect the effect to be the lowest on children since they consume less CSD than adults. Table 8 shows that there is no significant effect on children age 0 to 5. There is, however, a significant effect on adults and children older than 5, who have no piped water at home; a 10% percent decrease in the real price of CSD decreases diarrhea rates by 0.14 percentage points or 8%.

Additionally, if the explanation for the decrease in diarrhea were the price of CSD, we should not expect an effect on asthma or pneumonia, or on other diseases. On the other hand, if the explanation were something else, like better public health services, we could expect effects on other diseases. Tables 9a and 9b show that there is no improvement in any other disease. Only in the case of pneumonia, the decrease in the real price of CSD is correlated with an increase in the incidence of pneumonia for woman with piped water at home. This correlation most likely does not imply any causal relationship.

8 Conclusions

In this study I investigate the role of a sharp decrease in the price of CSD on obesity prevalence in Peru. I find that a 10% decrease in the real price of CSD increases consumption in 13% in my sample of young families (and in 10% in the general population), BMI in 0.5%, and obesity rates in 8.5% among adult women of childbearing age. The estimated effects on consumption and weight outcomes are much higher for women living in homes without running water. Moreover, I find that a 10% decrease in the price of CSD reduces severe diarrhea prevalence by 16% in women without access to piped water in their homes.

The contributions of this study are threefold. First, this study provides causal evidence that the expansion of the CSD industry can have, and is probably having, a significant effect on obesity prevalence in the case of developing countries, where access to safe water is limited. Second, this study provides evidence about the channels through which a decrease in the price of CSD affects weight; through the substitution of CSD for water, through an increase in the consumption of complementary goods and through a reduction of diarrhea prevalence. Finally, this study entails important policy implications; taxes on CSD could yield unintended results for developing countries, while water sanitation programs may not only reduce diarrheal prevalence, but also prevent obesity.

Although the results of this paper originate in a particular context, CSD prices have declined and consumption of CSD has increased significantly in many countries around the world, and practically all developing countries in the world lack universal access to piped water. The degree of effectiveness of large-scale taxes on CSD and of water sanitation programs as means to combat obesity are beyond the scope of this paper, but are important questions for future research.

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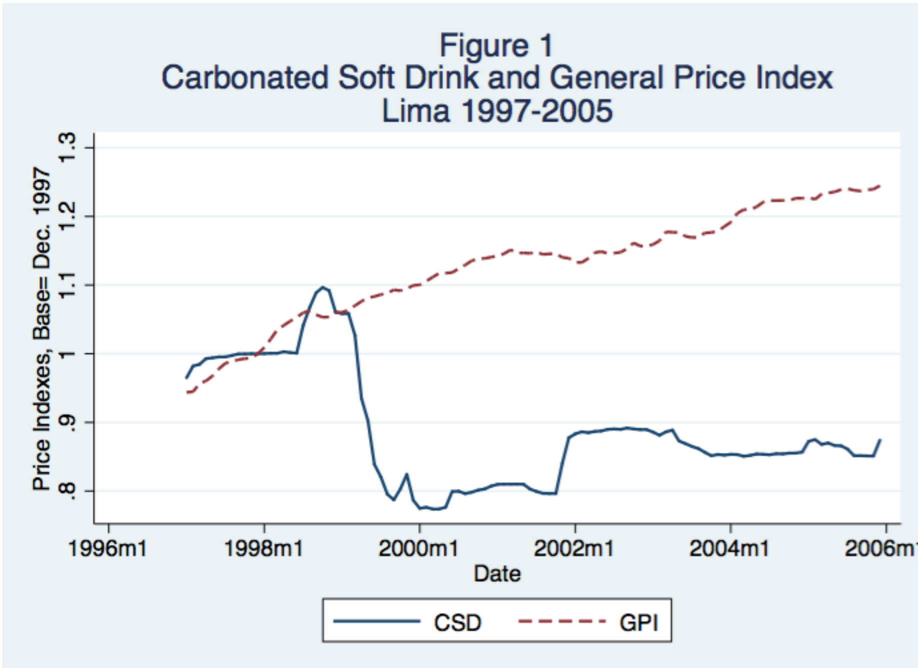
Figure 1
Carbonated Soft Drink and General Price Index
Lima 1997-2005
Price Indexes, Base= Dec. 1997
.8
.9
1
1.1
1.2
1.3
1996m1
1998m1
2000m1
2002m1
2004m1
2006m1
Date
CSD
GPI

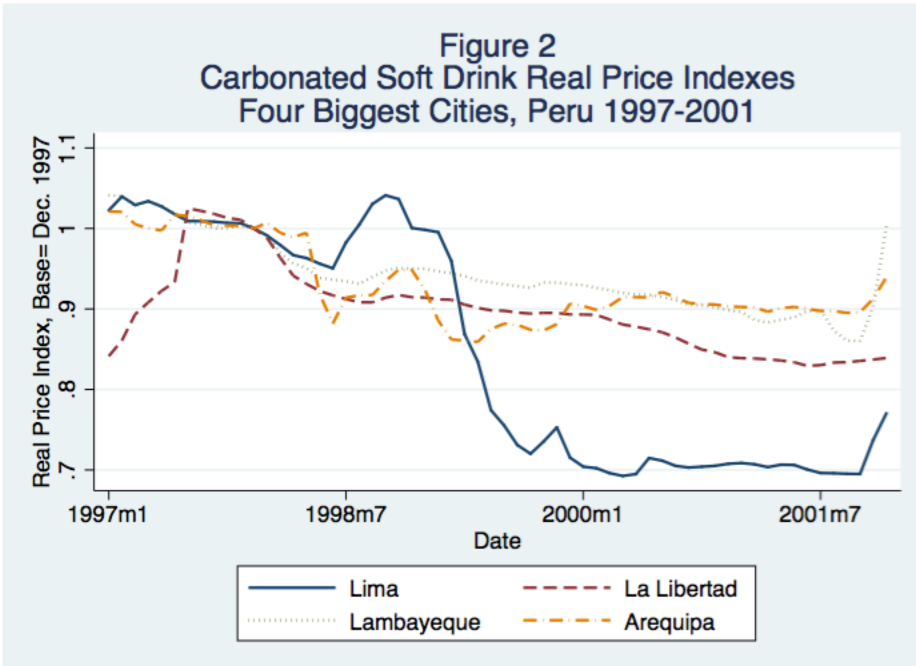
Figure 2
Carbonated Soft Drink Real Price Indexes
Four Biggest Cities, Peru 1997-2001
Real Price Index, Base= Dec. 1997
.7
.8
.9
1
1.1
1997m1
1998m7
2000m1
2001m7
Date
Lima
La Libertad
Lambayeque
Arequipa

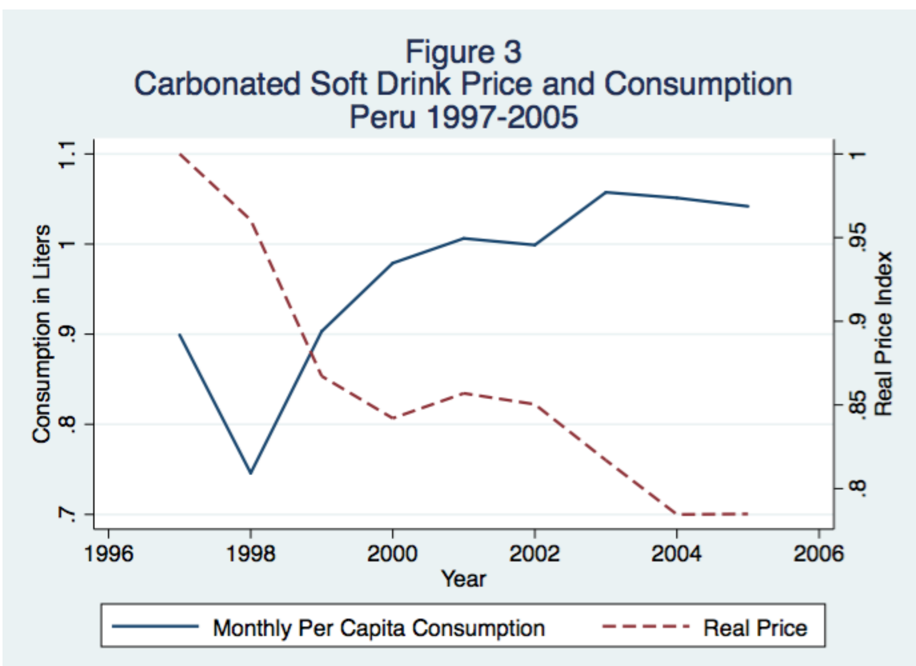
Figure 3
Carbonated Soft Drink Price and Consumption
Peru 1997-2005
Consumption in Liters
.7
.8
.9
1
1.1
Real Price Index
.8
.85
.9
.95
1
1996
1998
2000
2002
2004
2006
Year
Monthly Per Capita Consumption
Real Price

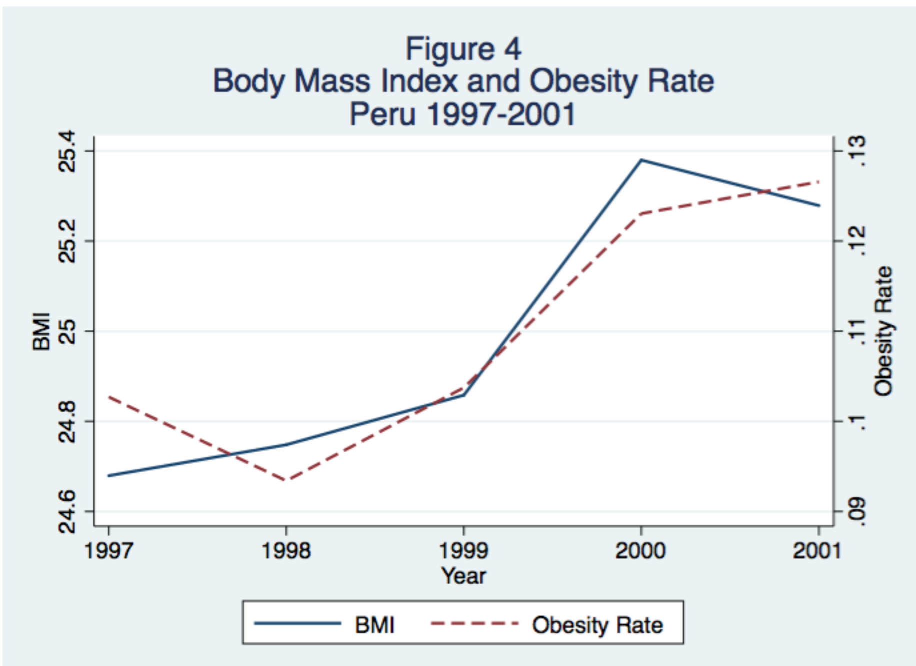
Figure 4
Body Mass Index and Obesity Rate
Peru 1997-2001
BMI
24.6
24.8
25
25.2
25.4
Obesity Rate
.09
.1
.11
.12
.13
1997
1998
1999
2000
2001
Year
BMI
Obesity Rate

Table 1
Summary Statistics

Sample 1: Demand

a) Monthly per capita Consumption	Mean
Carbonated Soft Drinks (in Liters)	0.885
	(1.75)
Milk (in Liters)	1.307
	(2.50)
Alcohol (in Liters)	0.102
	(0.623)
Bottled Water and Fruit Juices (in Liters)	0.142
	(1.108)
Water Expenditure/Total Expenditure (in %)	4.358
	(9.611)
Prepared Food (in Kilograms)	0.302
	(1.653)
Food eaten away from Home (Number of times)	2.855
	(2.134)
b) Real Price Indexes (Base year = 1997)	
Carbonated Soft Drinks	90.391
	(8.680)
Alcoholic Beverages	101.868
	(4.339)
Dairy Products	95.176
	(5.086)
Food Prepared Outside the Home	101.797
	(3.165)
c) Control Variables	
Average temperature of the region	18.703
	(5.042)
Age of the household head (HH)	35.403
	(7.842)
HH with primary education (%)	47.999
	(49.961)
Houses located in rural areas (%)	32.127
	(46.698)
Houses with piped water (%)	53.735
	(49.861)
Houses with electricity (%)	66.820
	(47.087)
Extremly poor households (%)	20.967
	(40.708)
Poor households (%)	27.254
	(44.528)

Sample 2: Women´s Weight Outcomes

a) Anthropometric Indicators	Mean
Weight (in Kg)	57.874
	(10.159)
Height (in Mts)	1.510
	(0.059)
Body Mass Index	25.369
	(4.129)
Obesity Rate	12.553
	(33.133)
c) Control Variables	
Average temperature of the region	17.064
	(5.510)
Age of the woman	31.993
	(8.340)
Women with primary education (%)	59.422
	(49.107)
Houses with drinking water (%)	59.316
	(49.127)
Houses with electricity (%)	71.955
	(44.924)
Houses with adequate wall materials (%)	38.797
	(48.731)
Houses with adequate roof materials (%)	66.995
	(47.025)
Houses with adequate floor materials (%)	55.722
	(49.674)

Sample 3: Diarrhea Outcomes

a) Diarrhea Indicators	Mean
Severe diarrhea	0.891
	(9.395)
Severe diarrhea Individuals without piped water	4.613
	(20.977)
Severe diarrhea in women	2.979
	(17.002)
Severe diarrhea in women without piped water	4.217
	(20.101)
Severe diarrhea in children age 0-5	6.591
	(24.818)
Severe diarrhea in children age 0-5 without piped water	8.858
	(28.428)

Table 2
Impact on Carbonated Soft Drink
Monthly per Capita Consumption (in Liters)

	All Households		Household Head Age 19-49	
	(1)	(2)	(3)	(4)
CSD Real Price (10%) x No Piped Water		-0.07***		-0.08***
		(0.03)		(0.03)
CSD Real Price (10%)	-0.09**	-0.06	-0.12**	-0.09*
	(0.04)	(0.04)	(0.05)	(0.05)
Number of observations	27,928	27,928	19,658	19,658
R2	0.133	0.133	0.143	0.143

Control variables include: poverty level, degree of rurality, access to drinking water electricity, temperature, age and level of education of the household head, region and year fixed effects.
Standard errors clustered by region
Note: *** p<0.01, ** p<0.05, * p<0.1

Table 3a
Impact on Potential Substitutes
Monthly per Capita Consumption (in Liters)

	Milk^		Alcohol^^	
	(1)	(2)	(1)	(2)
CSD Real Price (10%) x No Piped Water		-0.04		-0.00
		(0.05)		(0.02)
CSD Real Price (10%)	0.02	0.04	0.00	0.00
	(0.03)	(0.04)	(0.01)	(0.01)
Number of observations	19,658	19,658	19,658	19,658
R2	0.163	0.163	0.020	0.020

Control variables include: poverty level, degree of rurality, access to drinking water electricity, temperature, age and level of education of the household head, region and year fixed effects.
^Additional control: real price of dairy products
^^Additional control: real price of alcoholic beverages
Standard errors clustered by region
Note: *** p<0.01, ** p<0.05, * p<0.1

Table 3b

Impact on Potential Substitutes
Monthly per Capita Consumption (in Liters)

	Bottled Water and Fruit Juices		Relative Water Expenditure (%)	
	(1)	(2)	(1)	(2)
CSD Real Price (10%) x No Piped Water		-0.04**		11.66**
		(0.02)		(0.04)
CSD Real Price (10%)	-0.03	-0.02	-2.64	-7.48***
	(0.02)	(0.02)	(0.03)	(0.02)
Number of observations	19,658	19,658	18,995	18,995
R2	0.027	0.027	0.036	0.037

Control variables include: poverty level, degree of rurality, access to drinking water electricity, temperature, age and level of education of the household head, region and year fixed effects.

Standard errors clustered by region

Note: *** p<0.01, ** p<0.05, * p<0.1

Table 4

Impact on Potential Complementary Goods

	Prepared Food (kg/month)^		N. of Meals Away from Home	
	(1)	(2)	(1)	(2)
CSD Real Price (10%) x No Piped Water		-0.09**		0.21*
		(0.044)		(0.127)
CSD Real Price (10%)	-0.07**	-0.03	0.02	-0.06
	(0.03)	(0.02)	(0.15)	(0.16)
Number of observations	19,658	19,658	12,088	12,088
R2	0.033	0.034	0.067	0.067

Control variables include: poverty level, degree of rurality, access to drinking water electricity, temperature, age and level of education of the woman, region and year fixed effects.

Standard errors clustered by region

^Additional control: real price of prepared food

Note: *** p<0.01, ** p<0.05, * p<0.1

Table 5

Impact on Weight Outcomes

	BMI (Units)		Obesity (Percentage Points)	
	(1)	**(2)**	**(1)**	**(2)**
CSD Real Price (10%) x No Piped Water		-0.13*		-1.52**
		(0.07)		(0.63)
CSD Real Price (10%)	-0.12*	-0.08	-0.87*	-0.45
	(0.07)	(0.07)	(4.76)	(0.49)
Number of observations	10,443	10,443	10,443	10,443
R2	0.133	0.133	0.079	0.079

Control variables include: poverty level, degree of rurality, access to drinking water electricity, temperature, age and level of education of the woman, region and year fixed effects.
Standard errors clustered by region
Note: *** p<0.01, ** p<0.05, * p<0.1

Table 6
Impact on Severe Diarrhea
In Percentage Points

	Full Sample		Women	
	(1)	**(2)**	**(3)**	**(4)**
CSD Real Price (10%) x No Piped Water		0.11		0.20**
		(0.08)		(0.09)
CSD Real Price (10%)	-0.00	-0.03	0.05	0.00
	(0.04)	(0.04)	(0.06)	(0.06)
Number of observations	62,176	62,176	32,110	32,110
R2	0.005	0.005	0.005	0.005

Control variables include: poverty level, degree of rurality, access to drinking water electricity, temperature, age and level of education of the household head, region and year fixed effects.
Standard errors clustered by region
Note: *** p<0.01, ** p<0.05, * p<0.1

Table 7

The Impact of Lagged Consumption, BMI and Obesity Rates on CSD Prices (Reverse Causality)

	Real CSD Price Index Base 1997=100)		
	(1)	**(2)**	**(3)**
CSD Consumption	0.01		
(Centiliters per month^)	(0.01)		
Number of observations	249		
R2	0.645		
BMI (1/10 units^)		-0.00	
		(0.05)	
Number of observations		535	
R2		0.679	
Obesity rate (In %^)			0.07
			(0.07)
Number of observations			535
R2			0.680

Regressions include region and year fixed effects.

Standard errors clustered by region

^Units have been chosen, so that In the case of perfect reverse causality the estimated coefficients would approximate to -10.

Note: *** p<0.01, ** p<0.05, * p<0.1

Table 8

Impact on Severe Diarrhea
In Percentage Points

	Adults and Children Age > 5	Children Age 0-5
	(1)	(2)
CSD Real Price (10%) x No Piped Water	0.14**	-0.09
	(0.07)	(0.30)
CSD Real Price (10%)	-0.05	0.14
	(0.04)	(0.18)
Number of observations	62,176	62,176
	0.005	0.014

Control variables include: poverty level, degree of rurality, access to drinking water electricity, temperature, age and level of education of the woman, region and year fixed effects.
Standard errors clustered by region
Note: *** p<0.01, ** p<0.05, * p<0.1

Table 9a

Impact on Other Diseases
In Percentage Points

	Asthma	Women Pneumonia	Any Disease
	(1)	(2)	(3)
CSD Real Price (10%) x No Piped Water	-0.18	0.24	-0.12
	(0.22)	(0.34)	(0.89)
CSD Real Price (10%)	-0.24	-0.41**	0.38
	(0.19)	(0.19)	(0.46)
Number of observations	62,176	62,176	32,110
	0.009	0.005	0.031

Control variables include: poverty level, degree of rurality, access to drinking water electricity, temperature, age and level of education of the woman, region and year fixed effects.
Standard errors clustered by region
Note: *** p<0.01, ** p<0.05, * p<0.1

Table 9b
Impact on Other Diseases
In Percentage Points

	Adults and Children Age > 5		
	Asthma	**Pneumonia**	**Any Disease**
	(1)	**(2)**	**(3)**
CSD Real Price (10%) x	-0.01	-0.03	-0.39
No Piped Water	(0.09)	(0.10)	(0.81)
CSD Real Price (10%)	-0.05	-0.00	0.12
	(0.06)	(0.04)	(0.39)
Number of observations	56,388	56,388	56,388
R2	0.008	0.004	0.024

Control variables include: poverty level, degree of rurality, access to drinking water electricity, temperature, age and level of education of the woman, region and year fixed effects.

Standard errors clustered by region

Note: *** p<0.01, ** p<0.05, * p<0.1