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The Impact of Medicaid Expansion on the Healthfulness of Non-alcoholic Beverage Choices among Low-Income Households*

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Abstract: This article investigates the impact of Medicaid expansion under the Affordable Care Act (ACA) on beverage choices by low-income households. A theoretical analysis indicates that Medicaid expansion could induce an income effect from relaxation of the budget constraint that could increase unhealthy beverage purchases, and a nutrition education effect that could decrease them. To empirically test these effects, we utilize household-level data of beverage purchases from 2013 to 2016 in 52 U.S. metropolitan areas in Medicaid expansion and non-expansion states. The start of ACA Medicaid expansion enrollment in 2014 by 31 states and household Medicaid eligibility were used as the identification strategy. Results from a triple-differences model with nearly one million observations on purchases of seven beverage categories indicate that Medicaid expansion resulted in eligible households buying more soda and fruit drinks and less bottled water. Results from a mixed-logit model with nearly 17 million purchase observations at the household-brand level indicate that Medicaid expansion led to overall increases in eligible households' purchases of and valuation of sugary beverages and a decrease in their price elasticities of demand. Overall, the empirical results lend support to income effect hypothesis of Medicaid expansion but not to the nutrition education effect hypothesis. The unintended impacts found in these empirical results highlight the need to complement the benefits of Medicaid expansion with effective diet quality programs or investigate nudges to improve the healthfulness of low-income household beverage choices.

Keywords: Medicaid expansion; demand; soda; carbonated soft drinks; low-income households

JEL codes: D12; I18; I38

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1. Introduction

In 2010, the U.S. Congress passed, and President Barak Obama signed into law, the Patient Protection and Affordable Care Act (ACA). The ACA included a nationwide expansion of Medicaid, under which all adults and children whose incomes were at or below 138% of the federal poverty level became eligible for the program. However, in 2012, the U.S. Supreme Court ruled that the ACA Medicaid expansion was unconstitutionally coercive to states (Rosenbaum and Westmoreland 2012), and, thus, it became optional for states to adopt. Medicaid enrollment under ACA began on January 1, 2014, and by 2017 approximately 75 million Americans in 33 states were participating in Medicaid (U.S. Centers for Medicaid and Medicare Services 2017). Variation in ACA Medicaid expansion across states (due to the Supreme Court ruling) provides an opportunity to identify how changes in health care provision impact the welfare and health of low-income U.S. households.

The goal of the Medicaid expansion was to improve the health of low-income Americans through increased health care access and reduced out-of-pocket health care spending. Since the expansion began, research has found increases in the number of low-income individuals with insurance coverage, a reduction in emergency room trips and hospital stays, improved self-assessed health, and a reduction in the number of unpaid bills and debt (Nikpay et al. 2016; Simon et al. 2017; Sommers et al. 2016; Cunningham 2008; Hu et al. 2016).

In addition, Medicaid participation has been found to increase utilization of outpatient care and preventive care services, which often include nutrition education, particularly recommendations for diet changes for patients with type 2 diabetes, obesity, and cardiovascular and other diseases that can be managed partially through improved nutrition (Bhattarai et al. 2013; Sommers et al. 2016). Consequently, increased nutrition knowledge acquired from health care providers may result in diet quality improvements among low-income Americans. The provision of health care through the expansion of Medicaid relaxes a household's budget constraint, reducing out-of-pocket expenses on health care and possibly increasing wage earning potential. Since food is a normal good, particularly for low-income households, Medicaid expansion should increase food expenditures for households that benefit from this policy change and therefore have impacts on diet quality.[1]

Two published studies to date have examined how the Medicaid expansion affects food choices and diet quality. Nguyen et al. (2016) provided baseline data on low-income, uninsured residents' diet quality in Medicaid expansion versus non-expansion states from 2007 to 2012, well before the expansion formally began in 2014. Cotti et al. (2019), hypothesized that health care insurance provision would lead to increased "risky behaviors," such as unhealthy food consumption. However, they found little evidence that the ACA Medicaid expansion increased purchases of candy, cookies, snacks, and carbonated soft drinks. These studies used reduced form models, such as difference-in-differences, which may mask the identification of the factors behind changes in food choices and diet quality. Further research is needed to assess how the Medicaid expansion affects food purchasing decisions made by low-income Americans.

[1] While there is some evidence in the public health literature that poorer U.S. households would eat healthier foods if they had more resources (Rao et al. 2013; Aggarwal et al. 2016), others argue that eating healthfully is not cost prohibitive even for low-income households in the U.S. (Carlson and Frazao 2012; Stewart et al. 2016).

To add to this body of literature, the present study examines changes in non-alcoholic beverage purchasing and preferences for beverage attributes, specifically sugar content, among low-income Americans impacted by the ACA Medicaid expansion. Examination of non-alcoholic beverage choices provides a useful case study to examine the causal impact of Medicaid expansion on diet quality. There is substantial variation in the healthiness of non-alcoholic beverages available for consumption in the U.S. Water and milk are classified as healthy beverages according to the 2015-2020 Dietary Guidelines for Americans, while other beverages, for example, sugar-sweetened beverages (SSBs), are discouraged (U.S. Department of Agriculture and U.S. Department of Health and Human Services 2015). This is because a large body of evidence links diet-related chronic diseases like obesity and type 2 diabetes to consumption of SSBs (Bleich et al. 2008; Drewnowski and Specter 2004; Han and Powell 2013; Hu 2013; Hu and Malik 2010). Second, from a policy standpoint, reducing added sugar consumption, in particular SSBs, is a major focus of public health efforts in the U.S., and various policy options have been considered to achieve this goal. These include taxes, educational campaigns, and restrictions in federal nutrition programs such as SNAP (Finkelstein et al. 2013; Pomeranz 2012). As Figure 1 shows, U.S. per capita consumption of carbonated soft drinks (CSDs), which constitute the lion's share of U.S. SSB sales, has been declining since 2014, while consumption of bottled water and other SSBs has been increasing. However, these trends are for the general population, and analysis on changes in purchasing behavior by low-income households, particularly in light of Medicaid expansion, is lacking.

[FIGURE 1 AROUND HERE]

We first develop a conceptual analysis of Medicaid expansion effects on the healthfulness of non-alcoholic beverage choices. For our identification strategy, we utilize the variation in the

expansion of Medicaid across U.S. states after the passage of the ACA and subsequent Supreme Court decision. Two complementary models are used to investigate changes in non-alcoholic beverage purchases. A triple difference, household fixed effect model is used to examine the impact of Medicaid across broad beverage categories using a control and treatment group based on Medicaid eligibility, and a mixed logit demand model is used to examine the impact of Medicaid on sugar content of beverages chosen using a structural model that allows for counterfactual simulation of Medicaid eligibility. While DID or triple differences models are the workhorses in assessing impacts of Medicaid, the application of the mixed logit model to assess the role of sugar content is a novel. Data on household grocery store purchases of non-alcoholic beverages is drawn from the Kilts Center's Nielsen Consumer Panel from 2013 to 2016. Non-alcoholic beverages examined include: CSDs, non-carbonated soft drinks (nCSDs, e.g., juices, juice drinks, and tea), milk, and bottled water.

Results indicate that Medicaid expansion led to increases in soda, fruit juice, and fruit drink purchases and reductions in bottled water purchases among the Medicaid-eligible population. No discernable effects on milk and tea purchases were found. Results from the mixed logit demand model indicate that Medicaid-eligible households increased both their purchase of and preference for sugary beverages after Medicaid expansion. These results are statistically significant and robust, and they contradict those of Cotti et al. (2019), who found no effects of ACA expansion on the purchase of CSDs. We attribute the unintended impact of increased purchases and preference for SSBs to two factors: First, these beverages are normal goods, and Medicaid expansion relaxes the household budget constraint, creating an income effect. Second, studies have shown that lower-income households prefer taste over nutrition in choosing their foods and beverages. This is consistent with the findings of Chidmi and Lopez (2007), who found that households in the lower

income quintile have a higher preference for sugar and a lower preference for fiber than higher income households. Given this, federal social safety net programs, especially those that could enhance the health and nutrition of low-income households, should be designed to avoid the unintended negative diet quality consequences our study found.

2. Conceptual Analysis

The conceptual model focuses on the effects of Medicaid expansion on changes in consumer valuation of healthy vs. unhealthy beverage options due to two economic effects: an income effect from the partial relaxation of the budget constraint and an education effect due to nutrition knowledge transmitted to participants by medical practitioners. The conceptual model is based on the following assumptions. First, let the beverage choices in question be divided into two groups: healthy and unhealthy. Second, let consumer utility be separable from purchasing non-beverage products. Third, Medicaid participation enhances the consumer budget by an amount m by relieving the budget constraint. Fourth, Medicaid participation provides access to health care that may increase nutrition knowledge (ε) to encourage healthy beverage choices and discourage unhealthy ones, so that the potential marginal utility of this education is positive for healthy beverages and negative for unhealthy ones. Note that education, if effective, can change a consumer's preferences as reflected in a utility function. Accordingly, adopt a constant elasticity of substitution (CES) utility function depicted by:

$$u(H,U) = A[(\beta + Med\varepsilon)H^{\gamma} + (1 - \beta - Med\varepsilon)U^{\gamma}]\, 1/\gamma, \quad (1)$$

where A is a scale parameter; H is the quantity of healthy beverages; U is the quantity of unhealthy beverages; β is the utility weight of the healthy relative to the unhealthy beverages; Med equals one if the consumer participates in Medicaid expansion (and zero otherwise); ε indicates nutrition

education received under Medicaid expansion; and $\gamma = (\sigma - 1)/\sigma$, where σ is the constant elasticity of substitution between healthy and unhealthy foods. It is important to note that nutrition education for Medicaid participants shifts the CES utility function in (1). The term $(\beta + Med\varepsilon)$ is the weight on healthy foods, while the term $(1 - \beta - Med\varepsilon)$ is the weight on unhealthy foods. In the absence of Medicaid, the lower bound for $\beta = 0$ when there is no utility weight assigned to healthy food and $\beta = 1$ when there is an absolute preference for healthy food.

We define the consumer's budget constraint as $y + Medm$, where m is the Medicaid subsidy applicable to participants, and *y* is the budget in the absence of Medicaid.[2] The consumer's choice problem is to maximize the following Lagrangian function:

$$\text{Max } F(H, U, \lambda) = A[(\beta + Med\varepsilon)H^{\gamma} + (1 - \beta - Med\varepsilon)U^{\gamma}]\, 1/\gamma$$

$$+\lambda(y + Medm - P_h H - P_u U), \qquad (2)$$

where P_j is the price of beverage j (H or U) and other notations are as defined above. The first-order conditions for the maximization of (2) yield the following Marshallian demands for healthy and unhealthy beverages:

$$H^* = \left(\frac{\beta+Med\varepsilon}{P_h}\right)^{\sigma} \frac{y+Medm}{\omega}, \quad U^* = \left(\frac{1-\beta-Med\varepsilon}{P_u}\right)^{\sigma} \frac{y+Medm}{\omega}, \qquad (3)$$

where $\omega = (\beta+Med\varepsilon)^{\sigma} P_h^{1-\sigma} + (1-\beta-Med\varepsilon)^{1-\sigma} P_u^{1-\sigma}$, and other notations are as defined above. Thus, the income effect of Medicaid expansion leads to an increase in both types of foods under this model. Taking the ratio of both expressions in (3) yields:

[2] The term m applies only to the direct income effect on the consumer, which is only a portion of the actual total cost of the program.

$$\frac{H^*}{U^*} = \frac{\beta + Med\varepsilon}{1-\beta-Med\varepsilon}\frac{Ph}{Pu}. \quad (4)$$

An important feature of the model is that income increases are depicted along linear income paths with constant H^*/U^* ratios. Taking the derivative of (4) with respect to ε: $\frac{\partial(H^*/U^*)}{\partial\varepsilon} = \frac{Med}{(1-\beta-Med\ \varepsilon)^2}\frac{Ph}{Pu} > 0$. The nutrition education effect could change the ratio of healthy to unhealthy foods purchased by Medicaid participants. Figure 2 illustrates the potential income and education effects of Medicaid participation for otherwise identical households. A budget increase of *m* for Medicaid participants moves the consumer equilibrium from point A to B (or A' to B'). An education effect that changes the preference function towards healthier beverages could move the consumer equilibrium and, therefore, the indifference curve from point A to A' (or B to B'). Including both effects, the net effect is to increase the ratio H*/U*. Given that changes in Medicaid participation can affect the healthfulness of beverage choices from both income and nutrition education effects, the following propositions are made:

[FIGURE 2 AROUND HERE]

Proposition 1: Medicaid participation relaxes the consumer's budget constraint and results in an increase in the purchase of beverages, regardless of their healthfulness.

Proposition 2: By increasing the nutrition knowledge of participants, Medicaid participation results in a decrease in the valuation of unhealthy beverages, thus reducing their purchase share of unhealthy beverages.

Proposition 3: Whether or not participation in Medicaid results in an increase or decrease in the valuation (and purchase) of unhealthy beverages depends on the strengths and direction of the underlying income and education effects.

3a.) If the nutrition knowledge effects of Medicaid are weak relative to the increased income effects, consumers will increase their purchases of unhealthy beverages.

3b.) If the nutrition knowledge effects of Medicaid are strong relative to the increased income effects, consumers will decrease their purchases of unhealthy beverages.

Importantly, these effects are also conditioned on the sensitiveness and resilience of consumer preference in the first place. To that end, we propose the following empirical models to assess the impact of Medicaid on the non-alcoholic beverage purchasing choices made by Medicaid-eligible consumers.

3. Data and Empirical Methods

3.1 Data Source and Identification Strategy

The data used in this study came from the Nielsen Consumer Panel dataset (NCP) at the University of Chicago Kilts Center for Marketing.[3] The NCP dataset contains about 60,000 households each year, and approximately 80% of households continue to participate in the following year; therefore, this household-level panel dataset provides substantial advantages for empirical identification. In the triple-difference household fixed effect model, we use purchase data from January 2013 to December 2016 for seven non-alcoholic beverage products, categorized as zero-calorie carbonated soft drinks, full-calorie carbonated SSBs, nCSDs (including fruit drinks, fruit juice, and tea), milk, and water. In the mixed logit model, we use purchase data for 27 leading non-alcoholic beverage products, including 12 CSDs, six nCSDs, and nine bottled water brands.[4] To generate enough

[3] Access to the Nielsen Consumer Panel data was obtained through the Zwick Center for Food and Resource Policy at the University of Connecticut. For access to the data (for a fee), researchers are directed to the University of Chicago Kilts Center for Marketing to request permission.

[4] We dropped milk in the sample for the mixed-logit due to the lack of significance of Medicaid in the triple differences model and because there were only four brands for cow milk (all non-descript private labels) and two plant-based milk brands in the top 50 brands in terms of volume purchased. In addition, the current sample

variation for identification, this data spans one year prior to and three years after the Medicaid expansion that began in January 2014 for most states.

Medicaid expansion under the ACA and income eligibility rules are used to identify the Medicaid-eligible population.[5] Although households with incomes below 138% of the federal poverty level (FPL) could be eligible for Medicaid under the ACA expansion, we follow Cotti et al. (2019) and exclude households whose incomes are between 100% and 138% of the FPL to avoid issues of crowding out due to the ACA provision allowing households whose incomes are between 100 and 400% of the FPL to purchase subsidized private health insurance. We also restrict the sample to households in which all household heads are younger than 65 years because persons over 65 are eligible for Medicare. Households with members participating in the Women, Infants and Children program (WIC) are also excluded from the sample. Finally, households with children are excluded from analysis because Medicaid eligibility and the Children's Health Insurance Program (CHIP) eligibility rules are closely related for these types of households.

Figure 3 lists the 31 states participating in the Medicaid expansion as of December 31, 2016. Our analysis excludes four states (DE, MA, NY, and VT) and Washington, D.C., which already had significant health insurance coverage for low-income households before the Medicaid expansion in 2014. The identification comes from comparing the beverage choices of households that are likely to be eligible for Medicaid under the expansion (households with incomes below

generated approximately 16 million observations making computation time-consuming and complicated. One should note that cow milk purchases are important at the national level, but brand-level purchases are restricted geographically due to federal marketing orders that, since 2010, have channeled milk marketing into 10 well-defined U.S. regions (down from 31 in the 1930s, when the orders were first implemented).

[5] Because the data does not contain indicators for Medicaid participation, we utilize Medicaid eligibility instead, following Cotti et al. (2019). In alternative tests we use matching techniques to see if the results are robust to alternative indicators, such as predicted participation or eligibility for the CHIP program.

100% of the FPL) with households that are likely to be ineligible before and after Medicaid expansion (households with incomes above 138% of the FPL).[6]

[FIGURE 3 AROUND HERE]

3.2 Impact of Medicaid Eligibility on Non-alcoholic Beverage Purchases by Category

To investigate the impact of Medicaid expansion on Medicaid-eligible households' beverage categories (tests of Proposition 1), we first estimate models similar to triple-difference models to test how Medicaid expansion affects households' purchases of non-alcoholic beverage categories, including low-calorie carbonated SSBs, full-calorie carbonated SSBs, bottled water, fruit juice, fruit drinks, tea, and milk. To this end, the following household fixed effects model is used to test how a household's likely eligibility for Medicaid due to household income and a state's Medicaid expansion (intent-to-treat) affect within-household variation in purchases of non-alcoholic beverage products:

$$y_{ijst} = \alpha_0 + \alpha_1 E_{ist} + \alpha_2 M_{ist} + \alpha_3 E_{ist} * M_{ist} + \beta X_{ist} + \theta_i + \varphi_{st} + \epsilon_{ijst}, \quad (5)$$

where $i, j, s, and\ t$ denote household, non-alcoholic beverage category, state, and month, respectively. y_{ijst} represents household $i's$ purchase of product category j at time t. E_{ist} equals 1 if a household is eligible for Medicaid at time t, and M_{ist} equals 1 if state s participates in Medicaid expansion at time t . X_{ist} denotes household demographics, including household size; household head education, race, age, and employment status; and household income. Household

[6] Although it's true that Medicaid expansion could be endogenous because there are systematic differences between the purchase levels of non-alcoholic beverages of households in Medicaid expansion and non-expansion states, it's quite unlikely that the Medicaid expansion decision is affected by the differing trends in purchases of non-alcoholic beverages between Medicaid-eligible and Medicaid-ineligible households in expansion and non-expansion states. We checked this pre-trend and did not find evidence that the non-alcoholic beverages purchase trends of Medicaid-eligible and ineligible households in expansion and non-expansion states were different.

fixed effects θ_i and state by time fixed effects φ_{st} are included to control for household invariant characteristics and systematic differences across states over time. ϵ_{ijst} is an error term. The coefficient we are interested in is α_3, which measures how purchases of beverages by Medicaid-eligible household i change compared with those of Medicaid-ineligible households when the state participates in Medicaid expansion.

As previously mentioned, the underlying assumption of the model (5) is that pre-expansion trends in purchases between high and low-income households converged or diverged in similar ways in expansion and non-expansion states. We restrict the sample to data before 2014 and test the pre-expansion trend in non-alcoholic beverage categories using the following dynamic model:

$$y_{ijst} = \alpha_0 + \alpha_1 E_{ist} + \alpha_2 M_{ist} + \sum_{k=1}^{12} \alpha_k E_{ist-k} * M_{ist-k} + \beta X_{ist} + \theta_i + \varphi_{st} + \epsilon_{ijst} \quad (6)$$

If the coefficients of the interaction terms α_k are not significant, then the purchase trends of Medicaid-eligible and ineligible households in expansion and non-expansion states are similar and the identification assumption is satisfied.

After aggregating households' purchases by month from 2013 to 2016, our sample consists of 61,176 households, with 979,934 household-month observations over 48 months in 52 designated metropolitan areas (DMAs). Table 1 presents the summary statistics for consumer purchases of the six non-alcoholic beverage products by Medicaid-eligible and Medicaid-ineligible households. Columns (1)-(2) present summary statistics of the purchase amount for Medicaid-eligible and Medicaid-ineligible households, while columns (3)-(4) present the share of households that purchase certain beverage categories for Medicaid-eligible and Medicaid-ineligible households from 2013 to 2016. On average, Medicaid-eligible households purchase more non-alcoholic

beverages than ineligible households. In particular, eligible households buy more soda and fruit drinks and less bottled water than ineligible households.

[TABLE 1 AROUND HERE]

3.3 *Impact of Medicaid Eligibility on Valuation of Sugar Content in Non-Alcoholic Beverages*

We then use mixed logit models to test how consumers' valuation of sugar changes after Medicaid expansion (tests of Propositions 2 and 3). We include 12 major CSD brands, nine major bottled water brands, and six non-CSD brands in the analysis, accounting for nearly half of the quantity of non-alcoholic beverages in the U.S. between 2013 and 2016, according to the Nielsen dataset. Total sugar content per beverage is the primary product attribute of interest in the mixed logit models. However, because brand and other characteristics affect consumer choices, we include price and other product nutrition characteristics, such as carbonation, sodium, and caffeine content, in the mixed logit model. Table 2 presents the product characteristics of the brands included in the sample and mixed logit models.[7]

[TABLE 2 AROUND HERE]

The mixed logit model is used because it permits analysis of heterogeneity in consumer preferences for product characteristics (McFadden and Train 2000; Walker and Ben-Akiva 2002).[8]

[7] An advantage of Nielsen scanner data over public health datasets, such as the Consumer Expenditure Survey and others, is that it provides highly disaggregate data at the product brand level, offering precision about nutritional choices, particularly for the identification of sugar content.

[8] Compared with other discrete choice models such as BLP (Berry, Levinsohn, and Pakes 1995), a mixed logit model incorporates individual-level information efficiently and is less computationally intensive. In our case, we use the mixed logit model to estimate the change in a consumer's purchases of CSDs as well as marginal willingness to pay (WTP) for sugar content attributed to Medicaid expansion.

More specifically, we assume that consumer i chooses a product $j = \{1, \dots \dots, J\}$ from a set of competing products to maximize their utility:

$$u_{ijst} = \alpha_i p_{jst} + \beta_i X_{kj} + sugar_j(\gamma_{0i} + \gamma_{1i} X_{ist} + \gamma_{2i} E_{ist} + \gamma_{3i} M_{ist} + \gamma_{4i} E_{ist} * M_{ist}) + \xi_{jst} + \epsilon_{ijst}, \quad (7)$$

where p_{jst} is the price of product brand j in market s at time t. X_{kj} is a vector of brand $j's$ observable product attributes other than sugar. $sugar_j$ denotes the sugar content of brand j and is the product attribute of major interest. Since we are interested in any changes in sugar valuation, we interact $sugar_j$ with other variables to test how the valuation of sugar changes. As in the reduced-form analysis in Section 3.1, we include a set of household demographics X_{ist} to test how consumers with different incomes, education, ages, and marital status value sugar content differently. We also include three variables: E_{ist}, which indicates whether or not a consumer i is eligible for Medicaid at the moment they purchase beverages; M_{ist}, which denotes if a household resides in a Medicaid-expansion state; and an interaction term $E_{ist} * M_{ist,}$ which captures how a Medicaid-eligible household's preference for sugar changes before and after Medicaid expansion. The parameter γ_{4i} captures the Medicaid participation effect by measuring changes in consumer valuation of sugar content offered in the choice set. ξ_{jst} denotes unobserved brand characteristics, which are captured by parent company dummies. ϵ_{ijst} is an iid error term. Parameters $\alpha_i, \beta_i, \gamma_{1i}, \gamma_{2i}$ vary across consumers and follow normal distributions.

Because we are particularly interested in the role of income in shaping the preference for sugar content, we further specify that the response to Medicaid expansion is heterogeneous and varies by demographics, which is specified as:

$$\gamma_{4i} = \bar{\gamma_2} + \theta_4 D_i + \kappa_4 \psi_{4i}, \quad (8)$$

where D_i is a vector of consumer demographics, including income. We also examine whether or not the education level of the household purchaser modifies or mediates our results. ψ_i is a standard multivariate normal distribution with the scaling factor κ. Price endogeneity is a lesser issue than when using market-level data, as in the typical BLP model, because we are using data at the individual consumer level, where price is exogenous.

Combining equations (5) - (6), the final utility is specified as:

$$u_{ijst} = \alpha_i p_{jst} + \beta_i X_{kj} + (\gamma_{1i} + \gamma_{2i} E_{ist} + \gamma_{3i} M_{ist} + \gamma_{5i} X_{ist}) sugar_j + (\overline{\gamma_4} + \theta_4 D_i + \kappa_4 \psi_{2i}) sugar_j * E_{ist} * M_{ist} + \xi_{jst} + \epsilon_{ijst.} \quad (9)$$

The probability of consumer i purchasing product j is:

$$Prob_{ijst} = \frac{\exp(u_{ijst})}{\sum_{j=1}^{J} \exp(u_{ijst})}. \quad (10)$$

The coefficients of the term γ_{4i} measure how a consumer's preference corresponds to the Medicaid expansion in terms of sugar content in beverages. If the marginal effect takes a positive sign, it means that consumers pay more attention to sugar content in beverages because of the Medicaid expansion. Conversely, if the marginal effect is negative, consumers put less weight on sugar content in beverages after the health care expansion. Changes in the marginal effect of sugar content on of choice probability $\partial Prob_{ijst}/\partial sugar_j$ due to the Medicaid expansion are expressed as:

$$\frac{\Delta(\partial Prob_{ijst}/\partial sugar_j)}{\Delta E_{ist} * M_{ist}} = \int (\overline{\gamma_4} + \theta D_i) L_{ijst}(\psi) \left(1 - L_{ijst}(\psi)\right) g(\psi) d\psi \,, \quad (11)$$

where $L_{ijst}(\psi)$ is the conditional probability on ψ. If the marginal effect is negative, it means that consumers put less weight on sugar content in their decision making for beverages after the Medicaid expansion.

4. Results

4.1 Results of Parallel Trends Assumption

The reduced-form triple differences results are based on 61,176 households with 979,934 household-month observations over 48 months in 52 designated metropolitan areas (DMAs), while the mixed logit results are based on 16,684,992 observations covering 27 beverages products. Before proceeding to the triple difference results, we checked the beverage purchase trends between eligible and ineligible households in expansion and non-expansion states. The results are presented in Figure 4. We do not find evidence that the pre-expansion trends are different, and the results in Table 3 are thus not driven by systematic pre-expansion trends. That is, consistent with the findings of Cotti et al. (2019), we do not find significant divergence in purchase patterns before expansion. Although one could attribute this to lack of *ex-ante* moral hazard or conclude that Medicaid expansion did not have a discernable effect on the patterns of beverage purchases, one can explore this conclusion as a working hypothesis with a more detailed and structured analysis of beverage purchasing among low-income households as we do below.

[FIGURE 4 AROUND HERE]

4.2. Impact of Medicaid Eligibility on Non-alcoholic Beverage Purchases (Proposition 1)

Table 3 presents the triple differences estimation results via equation (5) using OLS to test Proposition 1. These results show that, overall, Medicaid expansion has no significant impact on non-alcoholic beverage purchases, although there are significant substitution effects across

beverages. In particular, we find strong evidence that the ACA Medicaid expansion increased purchases of CSDs, fruit juice, and fruit drinks, and significantly reduced purchases of bottled water. This finding indicates that Medicaid-eligible households are more likely to purchase sugary drinks as a result of the Medicaid expansion.

[TABLE 3 AROUND HERE]

4.3 Impact of Medicaid Eligibility on Valuation of Sugar Content in Non-Alcoholic Beverages (Propositions 2 and 3)

4.2.1 Econometric results

Table 4 presents the estimation results for the mixed logit model to test whether there were changes in the valuation of sugar content in non-alcoholic beverages after the Medicaid expansion. Model (1) does not investigate the heterogeneity of the impact of Medicaid participation on the preference for sugar content across income and education levels. Models (2) and (3) explore the econometric results when either education or income is excluded with respect to Medicaid participation and sugar content. Model (4) investigates the heterogeneity of the impact of Medicaid participation on the preference for sugar content across income and education levels. We focus on the estimation results under model (4).

As expected, the probability of beverage selection decreases at higher price levels. As for sugar content, eligibility to receive Medicaid benefits in expansion states results in an increased valuation of sugar content, i.e., eligible households purchase more sugary beverages than non-eligible ones. In addition, results indicate great heterogeneity in how sugar content affects consumer preferences for non-alcoholic beverages. Older, married, and more educated individuals prefer lower levels of sugar compared to younger, single, and less-educated individuals. In addition,

the coefficient for *Sugar*Eligibility* is significantly positive, indicating that Medicaid-eligible households value a higher sugar content in beverages more than Medicaid-ineligible households, while the significantly positive sign for *Sugar*Expansion* indicates that households in Medicaid expansion states value a higher sugar content more. These results are reinforced by the estimated coefficient for *Sugar*Eligibility*Expansion*, which is significantly positive, indicating Medicaid-eligible households value a higher sugar content more after Medicaid expansion. These results are in line with the previous results for beverage categories in that Medicaid-eligible households increase sugary beverage purchases after Medicaid expansion. For the majority of households participating in Medicaid, the effect of participation results in increased preference for sugar. Regarding other nutrition attributes of non-alcoholic beverages, consumers' preferences increase for beverages with higher levels of caffeine and carbonation; their preference decreases for higher levels of sodium.

4.2.2 Changes in Marginal Effect of Sugar on Beverage Purchases and Own-Price Elasticities of Demand

We apply equation (11) to measure the impact of Medicaid expansion on the marginal effects of sugar content in non-alcoholic beverage purchases, as shown in Figure 5. On average, Medicaid expansion increases the marginal probability of purchasing non-alcoholic beverages with a higher sugar content among Medicaid-eligible consumers, reinforcing previous results. This is an unintended effect of Medicaid expansion, and it is robust and consistent with the results for beverage categories.

[FIGURE 5 AROUND HERE]

We calculate own-price elasticities of demand for each brand in the sample with and without Medicaid expansion. The results are presented in Table 5 and indicate that Medicaid participants experience a significantly lower price elasticity of demand for non-alcoholic beverages, particularly for those with high sugar content. As the purchases of these households become less sensitive to the price of non-alcoholic beverages, they may be paying more attention to beverage nutritional characteristics than to price. On the other hand, as indicated in Table 5, with Medicaid expansion consumers become less price-responsive to changes in prices of sugary CSDs but not to changes in prices of other beverages. Demand for other types of beverages, particularly diet CSDs and water, becomes more price elastic with Medicaid expansion.

5. Concluding Remarks

This study analyzed the impact of the 2010 ACA Medicaid expansion on non-alcoholic beverage purchases and preferences for beverage attributes among low-income households impacted by the expansion. Specifically, we focus on the effects of Medicaid expansion on consumers' preference for sugar content in non-alcoholic beverages.

The empirical results lead to several salient conclusions. First, Medicaid-eligible consumers increased their purchase of unhealthy beverages, including regular and diet CSDs and fruit drinks, while decreasing their purchase of healthier drinks such as bottled water. Results also indicate that milk purchases did not change due to the expansion and that, overall, there was not an increase in total beverage purchases among the Medicaid-eligible population after the expansion. However, Medicaid-eligible households' preference for sugar content in non-alcoholic beverages increased after the expansion began in 2014. Moreover, the own-price elasticities of demand increase significantly for all beverage brands after the Medicaid expansion except for sugary CSDs.

In terms of the theoretical hypotheses, we empirically confirm Proposition 1 in that Medicaid eligibility participation results in an increase in purchases of non-alcoholic beverages in expansion states, regardless of the healthfulness of the beverages in question. However, Medicaid eligibility also results in an increase in the valuation of beverages with higher sugar content, supporting Proposition 3a in that either the possible nutrition education effects are weak relative to the increased income effect or non-existent. One possible explanation is that the nutrition effects evolve slowly, while income effects are immediate. Given the short time span of the data, it may be too early to conclude that Medicaid nutrition effects do not matter.

There are limitations to the methods used in this study that warrant discussion. First, our dataset did not identify households actually participating in Medicaid; we identified *Medicaid-eligible* households in expansion states using an income cut-off. Second, inclusion of non-alcoholic beverages purchased away from home may provide a more accurate representation of consumer choices and a more comprehensive measure of the impact of Medicaid expansion. Regarding the unintended effects reported in this article, we do not extend the analysis to fully examine the potential welfare consequences of an increase in purchases of sugar-sweetened beverages among less educated, low-income households following Medicaid expansion. Such outcome is likely to be welfare-reducing due to the external health costs of increased added sugar consumption. Finally, extending the analysis to food and beverage products beyond the beverages in our sample would be a fruitful avenue for future research

The unintended impacts found in the empirical results, that Medicaid expansion has resulted in increased preference for and purchases of sugary beverages, highlights the need to supplement the medical benefits of Medicaid with diet quality programs, such as nutrition education. These results

may also indicate that health care providers should be more closely monitoring beverage consumption among their patients and advising them to reduce the intake of sugary ones.

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Table 1. Average Households' Purchase Quantity and Probability of Beverage Categories Per Month

	Average purchase amount (oz)		Ratio of households that purchase certain category	
	Medicaid-eligible	Medicaid-ineligible	Medicaid-eligible	Medicaid-ineligible
Total Non-alcoholic beverages (oz)	618.424	573.186		
	(705.609)	(723.500)		
Regular CSDs (oz)	153.124	104.035	0.265	0.225
	(417.285)	(347.918)	(0.441)	(0.417)
Diet CSDs (oz)	107.973	111.417	0.189	0.195
	(369.970)	(394.134)	(0.391)	(0.396)
Bottled water (oz)	118.962	130.605	0.170	0.180
	(419.511)	(461.356)	(0.376)	(0.384)
Fruit juice (oz)	24.981	27.723	0.180	0.198
	(82.140)	(84.908)	(0.384)	(0.398)
Fruit drinks (oz)	47.270	43.276	0.192	0.191
	(166.290)	(145.789)	(0.394)	(0.393)
Liquid tea (oz)	23.456	24.160	0.087	0.092
	(130.330)	(123.767)	(0.282)	(0.290)
Milk (oz)	138.617	127.677	0.415	0.421
	263.783	245.8	0.493	0.494
N	32809	947125	32809	947125

Note. Medicaid-eligible (Medicaid-ineligible) households are households that are eligible (ineligible) for Medicaid in all states. Standard deviations are in the parentheses. Data from the Nielsen Consumer Panel 2013-2016. N=979,934.

Table 2. Nutritional Characteristics of Beverage Brands Used in the Mixed Logit Sample

Number	Brand Product	Calories per 12 oz	Sugar g/12 oz	Sodium mg/12 oz	Caffeine mg /12 oz	Market share (2013-2016)
	CSDs (12)					
1	Coca-Cola Classic Regular	140	39	50	35	3.05%
2	Coca-Cola Diet	0	0	40	47	2.65%
3	Private Label Diet	0	0	40	31	2.47%
4	Pepsi Regular	150	41	30	38	2.45%
5	Private Label Regular	155	42	53	23	1.96%
6	Pepsi Diet	0	0	35	35	1.82%
7	Mountain Dew Regular	170	46	65	54	1.54%
8	Dr Pepper Regular	150	40	55	42	1.43%
9	Mountain Dew Diet	0	0	50	54	1.07%
10	Coca-Cola Zero Diet	0	0	40	35	0.98%
11	Dr Pepper Diet	0	0	55	42	0.88%
12	Sprite Regular	144	38	70	0	0.78%
	WATER (9)					
13	Private Label	0	0	0	0	11.40%
14	Nestle Pure Life	0	0	0	0	2.14%
15	Poland Spring	0	0	0	0	1.20%
16	Aquafina	0	0	0	0	0.90%
17	Dasani	0	0	0	0	0.86%
18	Ice Mountain	0	0	0	0	0.83%
19	Deer Park	0	0	0	0	0.76%
20	Crystal Geyser	0	0	0	0	0.75%
21	Ozarka	0	0	0	0	0.57%
	nCSDs (6)					
22	Lipton	35	10	64	83	0.88%
23	Arizona	105	26	15	23	0.85%
24	Gatorade	95	20	143	0	0.79%
25	Ocean Spray	150	39	45	0	0.61%
26	Tropicana	168	33.6	24	0	0.61%
27	Powerade	80	20	150	0	0.57%

Note: In the estimation, we exclude calories as a nutrition characteristic because it is very highly correlated with sugar, which is practically the only source of calories in CSDs. For Lipton liquid, which includes a small amount of green tea, we use the average of sweetened and unsweetened green tea.

Table 3. Effects of the ACA Medicaid Expansion on Purchases of Non-alcoholic Beverages across Categories

	Total	Regular CSDs	Diet CSDs	Bottled water	Fruit juice	Fruit drinks	Liquid tea	Milk
Dependent variable: Purchase quantity per month (oz)								
Expansion*Eligibility	7.718	6.615*	9.394**	-11.062**	2.154**	4.384**	0.351	-3.504
	(8.133)	(3.826)	(3.816)	(5.236)	(0.985)	(1.797)	(1.400)	(2.303)
Eligibility	26.369***	-3.147	6.207**	24.556***	-2.511***	-2.790*	3.314***	0.214
	(6.456)	(3.037)	(3.029)	(4.156)	(0.782)	(1.427)	(1.111)	(1.828)
Expansion	14.620***	2.560***	2.448***	2.679**	2.021***	1.005**	1.464***	2.229***
	(1.797)	(0.845)	(0.843)	(1.157)	(0.218)	(0.397)	(0.309)	(0.509)
Household demographics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	979,934	979,934	979,934	979,934	979,934	979,934	979,934	979,934

Note. This table presents the results of equation (5). Household demographics include household size; household head education, race, age, and employment status; and household income. Standard errors are clustered at the state level. *, **, and *** present significance level at 10%, 5%, and 1%, respectively.

Table 4. Mixed Logit Demand Results

	(1)		(2)		(3)		(4)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Price	4.845***	-6.681***	4.845***	-6.680***	4.846***	-6.679***	4.846***	-6.678***
	(0.044)	(0.085)	(0.044)	(0.085)	(0.044)	(0.085)	(0.044)	(0.085)
last dummy	0.245***	5.809***	0.245***	5.809***	0.244***	5.811***	0.244***	5.811***
	(0.046)	(0.104)	(0.046)	(0.104)	(0.046)	(0.104)	(0.046)	(0.104)
Sodium	-0.00259***	-0.000155	-0.00260***	-0.000155	-0.00260***	-0.000156	-0.00260***	-0.000156
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Caffeine	0.00159***	-0.000247	0.00159***	-0.000247	0.00159***	-0.000247	0.00159***	-0.000247
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Carbonation	0.472***	0.0435***	0.472***	0.0435***	0.472***	0.0435***	0.472***	0.0435***
	(0.004)	(0.014)	(0.004)	(0.014)	(0.004)	(0.014)	(0.004)	(0.014)
Sugar	0.0131***		0.0139***		0.0133***		0.0140***	
	(0.001)		(0.002)		(0.001)		(0.002)	
Sugar*High Income	0.00139		0.000594		0.00126		0.000589	
	(0.001)		(0.001)		(0.001)		(0.001)	
Sugar*College	-0.00680***		-0.00680***		-0.00686***		-0.00686***	
	(0.000)		(0.000)		(0.000)		(0.000)	
Sugar*Young	0.00682***		0.00682***		0.00681***		0.00680***	
	(0.000)		(0.000)		(0.000)		(0.000)	
Sugar*Married	-0.00217***		-0.00217***		-0.00217***		-0.00217***	
	(0.000)		(0.000)		(0.000)		(0.000)	
Sugar*Eligibility	0.0104***		0.00969***		0.0103***		0.00968***	
	(0.001)		(0.001)		(0.001)		(0.001)	
Sugar*Expansion	-0.000489***		-0.000489***		-0.000491***		-0.000491***	
	(0.000)		(0.000)		(0.000)		(0.000)	
Sugar*Eligibility*Expansion	0.00425***		0.00393***		0.00274***		0.00249**	
	(0.001)		(0.001)		(0.001)		(0.001)	
Sugar*Eligibility*Expansion*High-income			0.00302				0.00254	
			(0.003)				(0.003)	
Sugar*Eligibility*Expansion*College					0.00620***		0.00613***	
					(0.002)		(0.002)	
N	16,684,992		16,684,992		16,684,992		16,684,992	
Log likelihood	-1,768,802.5		-1,768,801.9		-1,768,795.9		-1,768,795.5	

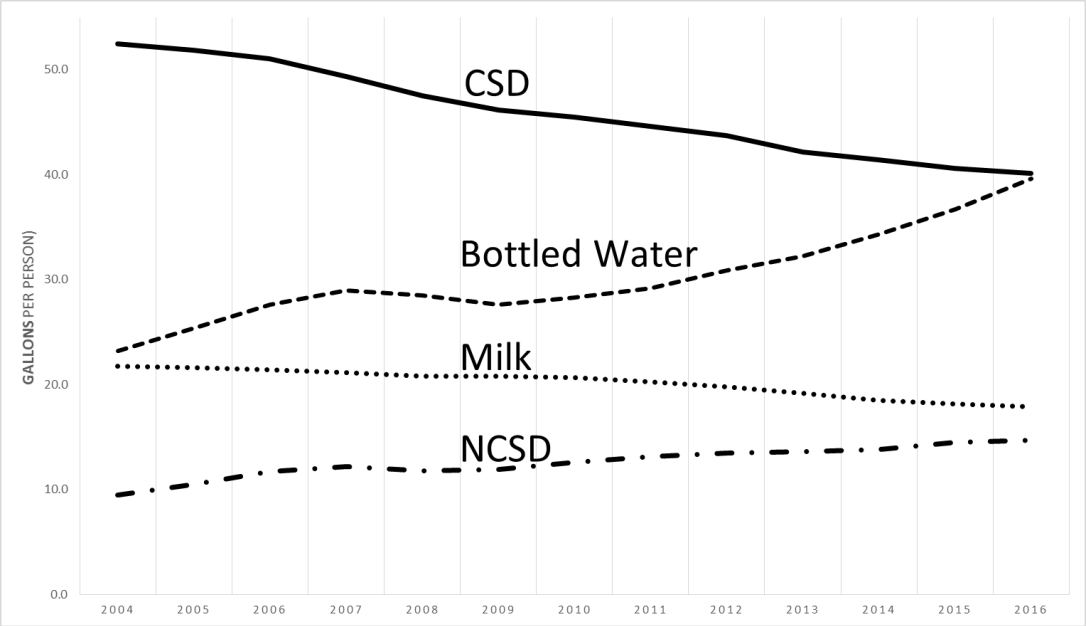
Note: This table reports the mixed logit estimation results. Standard errors are in parentheses. *, **, *** denote significance level of 10%, 5%, and 1%, respectively.

Table 5. Changes in the Own-Price Elasticities of Demand in Medicaid Expansion and Non-expansion States

Brand	Brand names	Simulated price elasticity without Medicaid	Actual price elasticity with Medicaid expansion	Change in demand elasticity
CSDs				
1	Coca-Cola Classic Regular	-0.127	-0.066	-0.060
2	Coca-Cola Diet	-0.014	-0.071	0.057
3	Private Label Diet	-0.012	-0.061	0.049
4	Pepsi Regular	-0.177	-0.063	-0.114
5	Private Label	-0.468	-0.053	-0.415
6	Pepsi Diet	-0.015	-0.072	0.058
7	Mountain Dew Regular	-0.130	-0.068	-0.062
8	Dr Pepper Regular	-0.161	-0.069	-0.092
9	Mountain Dew Diet	-0.015	-0.074	0.059
10	Coca-Cola Zero Diet	-0.014	-0.072	0.057
11	Dr Pepper Diet	-0.016	-0.081	0.065
12	Sprite Regular	-0.131	-0.069	-0.062
Bottled Water (9)				
13	Private Label	-0.035	-0.176	0.141
14	Nestle Pure Life	-0.013	-0.063	0.050
15	Poland Spring	-0.012	-0.059	0.047
16	Aquafina	-0.016	-0.078	0.062
17	Dasani	-0.015	-0.076	0.061
18	Ice Mountain	-0.013	-0.064	0.051
19	Deer Park	-0.014	-0.069	0.055
20	Crystal Geyser	-0.012	-0.058	0.046
21	Ozarka	-0.012	-0.060	0.048
NCSDs (6)				
22	Lipton	-0.015	-0.072	0.057
23	Arizona	-0.064	-0.063	-0.001
24	Gatorade	-0.020	-0.077	0.057
25	Ocean Spray	-0.053	-0.084	0.032
26	Tropicana	-0.036	-0.095	0.059
27	Powerade	-0.028	-0.068	0.041

Note: This table reports the simulated price elasticity without Medicaid expansion, the actual price elasticity, and the percentage changes in the two elasticities.

Figure 1. U.S. Per Capita Consumption of Non-Alcoholic Beverages, 2012-18



Sources: *Beverage Digest Fact Book* (2017).

Figure 2. Potential Income and Education Effect of Medicaid Expansion on the Healthfulness of Food Choices

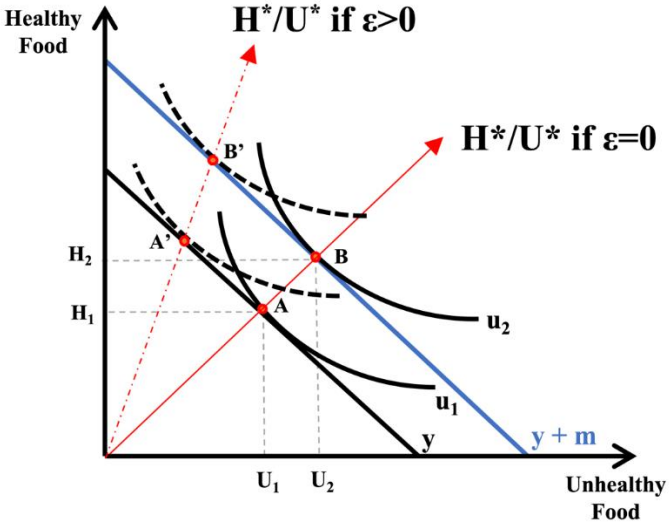
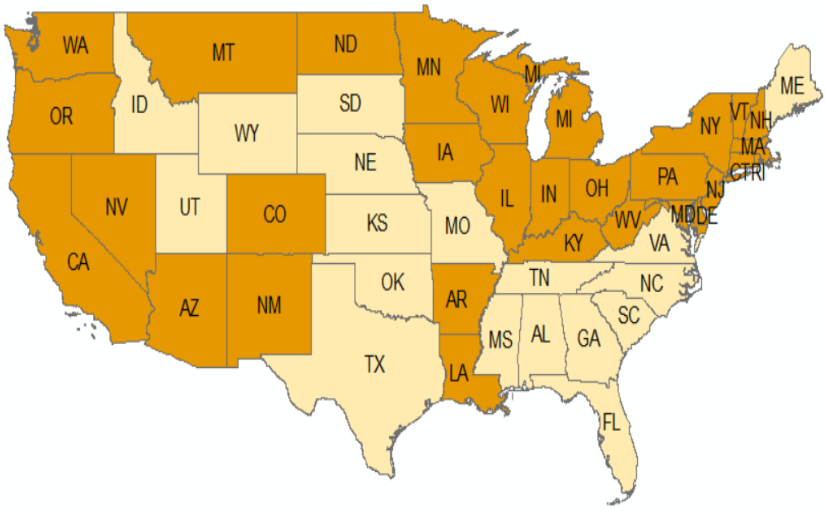


Figure 3. States Adopting Medicaid Expansion as of December 31, 2016.



Note: States in the darker color had adopted Medicaid expansion by the end of 2016, while states in light color had not. Specifically, there are 25 states: AR, AZ, CA, CO, CT, DE, HI, IA, IL, KY, MA, MD, MN, ND, NJ, NM, NV, OH, OR, RI, VT, WA, WI, and WV as well as Washington, D.C., which had adopted Medicaid expansion as of January 2014. MI adopted the ACA expansion in April 2014. NH enrolled in August 2014. PA, IN, and AK enrolled in January 2015, February 2014, and September 2015, respectively. MT adopted in January 2016, and LA adopted as of July 2016. Households in four states (DE, MA, NY, and VT) and Washington, D.C., are excluded from the analysis because of high coverage for low-income households through Medicaid before 2014.

Figure 4. Pre-Trend Tests for Purchases of Non-Alcoholic Beverages Across Categories

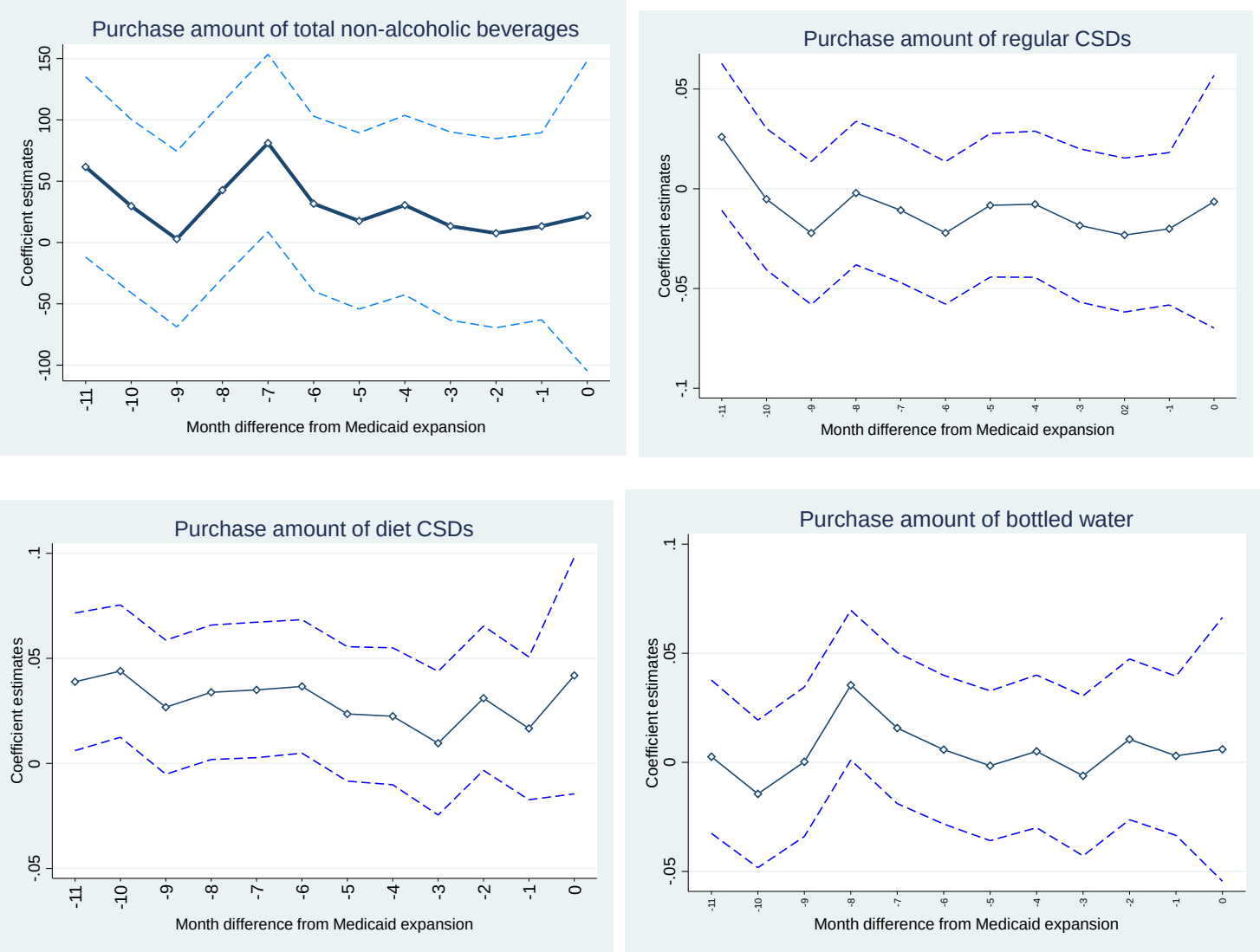
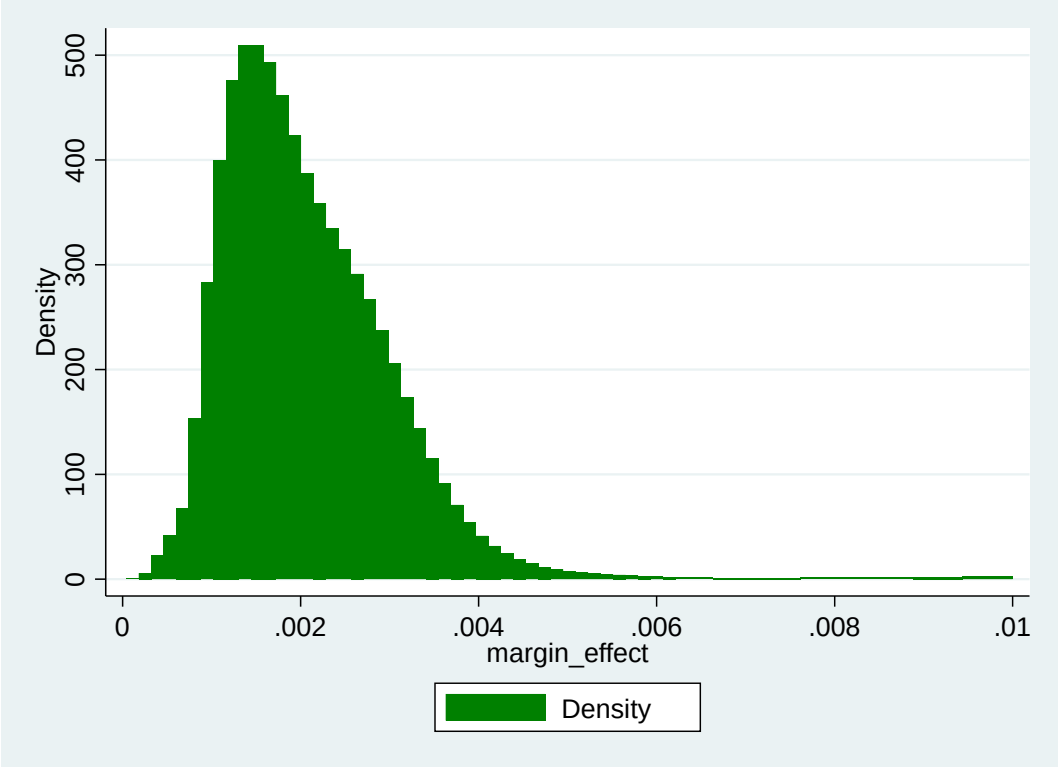


Figure 5. Density Distribution of the Impact of Medicaid Expansion on Marginal Effects of Sugar Content in Non-Alcoholic Beverage Purchases



Note: The average change in the marginal effect of sugar content on the probability of purchasing a non-alcoholic beverage due to Medicaid eligibility is 0.023.