The Impact of the 2009 WIC Food Package Revision on Participants' Food and Beverage Purchases

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Abstract

The goal of the 2009 food package revision of the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) was to promote a healthier diet among the participant population by prescribing healthier versions of WIC foods. This study examines whether there was a structural change in WIC households' demand when the revision was implemented. Using the flexible Exact Affine Stone Index demand to estimate the structural preference parameters of WIC households, we find that demand for skim/low-fat milk and whole grain became less price elastic post revision. The model also detects a spillover effect to demand for carbonated beverages that are not included in WIC food packages. These results are consistent with the hypothesis that the 2009 revision increased WIC households' preferences for healthier foods.

Keywords: WIC package revision, EASI demand system, preference change

Introduction

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is the third largest nutrition assistance program, after the Supplemental Nutrition Assistance Program (SNAP) and the National School Lunch Program, in the United States. In 2019, WIC served 6.4 million low-income pregnant and postpartum women, infants and children up to age five at a cost of $5.2 billion, of which $3.2 billon is food cost (FNS 2020[1]). Unlike SNAP food benefits that participants use to purchase retail foods with few restrictions, the WIC food packages prescribe specific supplemental foods to participants. Since the inception in 1972 and until 2009, the WIC food packages remained largely unchanged. In 2005, National Academy of Medicine (formerly called the Institute of Medicine, 2006) recommended changes to the WIC food packages with the goal of aligning WIC supplemental foods with current scientific evidence regarding the nutritional needs of WIC participants, the 2005 *Dietary Guidelines for Americans*, and infant feeding practice guidelines of the American Academy of Pediatrics.

The US Department of Agriculture (USDA) Food and Nutrition Service (FNS), which administers WIC, largely adopted the recommended changes and state WIC agencies implemented the food package revisions in 2009. Some of the prominent revisions include the introduction of fruit and vegetables (F/V) issued in $6.00–$10.00 cash value vouchers, and whole-grain cereals and bread. The revision restricted milk fat content and reduced maximum quantities or elimination of milk, eggs, juice, and cheese from some food packages. For example, the maximum quantity of 100% juice prescribed to children aged 1 to 4 years was reduced from 288 fl oz before to 128 fl oz after the revision. FNS also gave discretion to states in allowing food substitutes. For example, soy products may be prescribed as substitutes for milk, and brown rice, bulgur, oatmeal, barley, tortillas or whole wheat pasta as substitutes for whole wheat bread. Overall, the goal of the 2009 revision was to promote a healthier diet among the participant population while recognizing the

[1] https://www.fns.usda.gov/pd/wic-program

diverse cultural eating patterns of the participants.

The objective of this study is to evaluate the effect of the 2009 food package revision on WIC household preferences for food and beverage. We attempt to contribute to the WIC literature in three ways. First, we leverage the between-state difference in the timing of the revision in 2009 to identify its effect on preferences. This allows us to avoid problems associated with the well-documented under-reporting of participation in WIC (Bitler, Currie and Scholz 2003) and other safety net programs (Meyer, Mok and Sullivan 2009) in self-reported surveys. Second, we use a flexible demand system to examine whether there has been a structural change in the preference parameters when the food packages were revised. Structural modeling allows us to detect not only changes in the level of purchases but also potential shifts in the price coefficients. This secondary effect, if exists, will help us better understand the nature of the preference change induced by the 2009 revision. Third, the demand system approach allows us to explore changes in preferences for sugary drinks, which were never in the WIC food packages, at the time of the revision. Analyses of these distal outcomes complement the existing literature (Schultz et al. 2015), which is largely concerned with the more proximal outcomes (such as whole grain intake) directly targeted by the revision. As WIC households may compensate the revised food packages by increasing purchases of unhealthy non-WIC items, examining the distal measures is important for detecting any unintended consequences of the 2009 revision.

We estimate WIC household preferences using Nielsen Homescan data from households self-reporting to be WIC recipients. Preferences are approximated by a flexible functional form demand system where we account for zero purchases, price endogeneity and other unobserved heterogeneity. Our results indicate that the 2009 WIC food package revision led to increases in healthier foods encouraged by WIC and decreases in less healthy food and beverage WIC seeks to limit. In addition to changes in the level of demand, we also present a pattern of shifting price elasticities that are consistent with a change in preferences toward healthier foods among WIC households.

The rest of the article is organized as follows. The next section reviews previous evaluations of the 2009 revision, followed by a description of the scanner data. We then discuss the strategy for identifying the effect of the WIC food package revision on recipient households' preferences. Afterward, the demand system model and econometric considerations are discussed. The last two sections present the empirical results and conclude.

The Literature on the 2009 Food Package Revision

The bulk of the scientific literature on WIC lies in public health. A cursory Google Scholar search of articles since 2000 based on the phrase "women, infants and children program WIC" returned 17,300 results! The majority of this largely descriptive literature examines the associations of WIC enrollment with birth and breastfeeding outcomes, dietary intake, obesity, and health outcomes. Of the fewer economics studies that paid close attention to the role of unobservable in the non-random selection into WIC, several found WIC improved birth outcomes (Bitler and Currie 2005; Hoynes, Page and Stevens 2011). Still, the lack of significant policy changes prior to 2009 made it difficult to establish causation out of many observed WIC-diet associations.

The 2009 food package revision, being the most significant change to WIC since its inception, offers a rare policy experiment with which causal inferences are possible. Schultz et al. (2015) reviewed twenty studies of the 2009 food package revision, including nine that collected purchase quantities or dietary intake. The review concluded that the 2009 policy change was associated with healthier amounts of intake or purchase of the food groups targeted by the revision. Among these, Ishdorj and Capps (2013) analyzed food frequencies collected from two cross sections of Native American WIC participating children before and after the food package revision. They found that the revision was associated with healthier eating patterns including increased frequencies of fruit, vegetable, whole grain and reduced-/low-fat milk consumption. The authors later conducted a similar analysis for Texas WIC children aged 2 to 4 (Ishdorj and Capps 2017). They found the

amount of reduced/low-fat milk increased to partially offset the reduction in whole milk. They also found frequencies of 100% juice and diet drinks declined but the frequency of SSBs increased after the food package changes.

Several studies used scanner data to track changes in purchases of WIC households before and after the 2009 revision. Andreyeva and colleagues acquired loyalty card-linked scanner data from a supermarket chain. Using a pre-post design, the authors found that 1) the reduced maximum allowance of 100% juice was associated with net reductions in 100% juice and SSB purchases (Andreyeva et al. 2013); 2) the introduction of whole-grain bread and brown rice was associated with a significant increase in the share of whole-grain products in total bread and rice purchases (Andreyeva and Luedicke 2013); and 3) the reduced maximum allowance of milk and restriction of milk fat content for women and children aged 2+ years were associated with a net reduction of saturated fat from milk and cheese (Andreyeva et al. 2014).

There are a few studies based on the Nielsen Homescan household scanner data. Oh, Jensen and Rahkovsky (2016) were interested in the effect of the 2009 revision on whole-grain purchases. Using propensity score matching to form a control group, the authors estimated that WIC participation was associated with higher whole-grain expenditures, and the 2009 revision doubled the magnitude of this association. In a unique study, Frisvold, Leslie and Price (2020) asked the question: how long do purchase patterns shaped by WIC food packages last after a household ages out of the program? The authors exploited the variation in the length of WIC eligibility after the food package revision to identify the long-run effect of WIC on purchase habits. They found that, although the 2009 revision increased whole grain demand among WIC households, habits over whole grains formed by WIC dissipated after the household losing eligibility.

Of these evaluations of the 2009 revision, three design issues remain. First, most use the pre-post design that lacks a control group. Second, for the one study (Oh, Jensen and Rahkovsky 2016) that uses eligible nonparticipating households as the control group, there

are significant pre-revision differences in preferences between WIC and control households as evidenced by WIC households' higher whole grain purchases before the revision. Third, underreporting of WIC status causes Frisvold, Leslie and Price (2020) to focus on estimating the intention-to-treat effect among WIC eligible households. Over the last decade, WIC participation continues to decline (Oliveira 2017). It can be argued that estimates of the effect of WIC on participants are more useful to policymakers than intention-to-treat estimates. We address these issues by leveraging the different timing of the food package revision across states to identify its effect on households self-reporting as WIC participants.

Data and Descriptive Statistics

Household purchase data come from Nielsen Homescan household scanner data over the 2006–2013 period. Our sample consists of 1,143 WIC-eligible households who self-reported as participating WIC participants. WIC eligibility is met if household income is below 185% of the federal poverty guideline and at least one household member is less than 5 years old.[2] Nielsen ScanTrack retail scanner data provide price information that we use to create food group price indexes and their instruments. We focus on purchases of select groups of packaged food and beverage. Items are identified at the Universal Product Code (UPC) level. We rely on the (post-revision) federal requirements for WIC-eligible foods[3] to categorize items into WIC-eligible food groups and ineligible groups. We focus on food and beverage that are prescribed in significant quantities, barring infant formula, and their less healthy counterparts. This leads to four WIC-eligible groups: skim/reduced-fat milk, whole grain cereal, whole grains, and 100% juice; and five less healthy substitutes: whole milk, other sugary cereal, refined grains, juice drinks, and carbonated beverage.

Table 1 shows the descriptive statistics for WIC households and, for comparison,

[2] A low-income household without a child < 5 years old could be eligible for WIC if it has a pregnant household member. Because only birth year is available for the Kilts Nielsen data, we could not determine with confidence whether a household has a pregnant member. So some self-reported WIC households with pregnant members may have been mistakenly dropped from our sample.

[3] https://www.fns.usda.gov/wic/wic-food-packages-regulatory-requirements-wic-eligible-foods

eligible nonparticipating households from the 2006–2013 period. The 1,143 WIC households provided 20,643 household-months of purchase data. The average household income is $2,364.17 per month and the average household size is 4.77 persons. Among the 5,001 eligible households who reported not in WIC, their average income is slightly higher than that of WIC households at $2,614.19 and their average household size is also slightly higher at 4.87 persons.

WIC households on average purchase more food and drinks than non-participants. WIC households purchase 24.88 oz whole grain bread per month, which is about 3.62 oz more than purchase of eligible nonparticipants. Similar patterns also appear in the purchase of skim/reduced-fat milk (357 v. 313 oz) and 100% juice (70 v. 61 oz). Because WIC vouchers can be considered as additional income for low-income households, after households receive the prescribed food in kind, the freed-up income may be spent on other foods and goods. Table 1 shows WIC households purchased more WIC-ineligible food and beverage than eligible nonparticipants, including carbonated beverage (603 v. 537 oz). This pattern is also consistent with eligible households with higher food preferences self-selecting into WIC.

Table 2 shows the change in purchase of WIC participant after WIC package revision. WIC participant's purchase of whole grain bread increased from 19.43 oz to 30.43 oz, which is consistent with previous studies (Oh et al, 2016; Ng et al, 2018; Frisvold, 2020). WIC participants also purchased more skim/reduced-fat milk (from 352.51 oz to 360.60 oz) and 100% juice (68.63 oz to 71.40 oz). Changes are not limited to WIC food groups. After the revision, WIC households purchased 104.11 oz less of carbonated beverages. These observations motivate us to take a more formal examination of the direct and spillover effects of the revision on WIC household preferences.

Identification Strategy

We leverage the difference in the timing of the revision across states to identify the effect of the revision on WIC households' preferences. This affords us not having to use

eligible nonparticipants, who as we have shown likely have different preferences from WIC households, as the control group. Instead, WIC households in state that implemented the policy earlier than the federal deadline of October 1, 2009 can be considered to be in the treatment group while those in state that implemented the policy later than the treatment group can be considered to be in the control group until themselves are treated with the revised food packages. For example, New York state revised the WIC packages in January 2009. New York WIC households can be classified as the treatment group who received the treatment in January 2009. In comparison, WIC households in Georgia, which did not implement the revision until the October deadline, serve in the control group until they started to receive the revised food packages in October 2009.

Of the 48 contiguous states and Washington, DC, 16 states (figure 1) implemented the revision before October 2009. New York and Delaware were the first to implement the revision in January 2009. An inspection of figure 1 reveals no obvious regional differences in timing of the implementation. Nevertheless, our identification strategy would be in jeopardy if timing was determined by state-level socio-economic conditions that were also determinants of WIC households' preferences. That is, there is a possibility that the change in WIC households' preferences is caused by shocks other than the food package revision. To examine the exogeneity of a state's timing decision, we use a logit model to regress a dummy variable for October implementation ($st10$) on state characteristics. $st10$ is equal to 1 if the revision is implemented in October, and 0 if earlier. We also estimate an ordered logit model, where the dependent variable $st\_imp = (1, 5, 6, 7, 8, 9, 10)$ indicates the month of implementation.

Table 3 reports the logit and ordered logit results. These regressions find no significant correlation between the choice of timing and state characteristics. In particular, there is no evidence that poor economic conditions as measured by high unemployment rate and high poverty rate induced a state to move up implementation of the revision. Demographics and education are also not associated with the timing of implementation. These results indicate

that a state's decision on the timing of revision was unlikely to be based on the state's economic situation, thus minimizing the concern about endogeneity of the revision policy.

The Demand System

To detect the preference change, including behavior related to prices and income, we need to estimate a structural demand system with a flexible functional form. We choose the Exact Affine Stone Index (EASI) demand system developed by Lewbel and Pendakur (2009) for this purpose. Compared with the Almost Ideal Demand (Deaton and Muellbauer 1980) and its quadratic extension (Banks, Blundell and Lewbel 1997), EASI has three advantages. First, EASI allows the Engel curves take arbitrary shapes as it is not restricted by the rank three limitation of Gorman (1981). Second, the EASI Hicksian (as well as Marshallian) demand varies with income while conventional demand systems only allow the Marshallian demand to vary with income through the income effect. Third, the regression errors in the EASI estimating equations can be interpreted as unobserved preference heterogeneity. By contrast, the regression residuals in most other demand systems do not have such an economic underpinning.

We specify the two-way EASI demand system with structural change as:

$$
\begin{aligned}
(1) \qquad w_{iht} = {} & \alpha_i + \sum_{r=1}^{R} b_{ir} y_{ht}^{r} + \sum_{j=1}^{n} A_{ij} \log\left(p_{jht}\right) + \sum_{j=1}^{n} B_{ij} \cdot y_{ht} \cdot \log\left(p_{jht}\right) + \\
& \boldsymbol{c_i Z_{ht}} + \boldsymbol{d_{i1} Year} + \boldsymbol{d_{i2} Month} + \boldsymbol{d_{i3} Region} + \boldsymbol{d_{i4}} \cdot \boldsymbol{Region} \cdot \boldsymbol{time} + \\
& \boldsymbol{\delta_{i1} MM_t} + \boldsymbol{\delta_{i2} ST} + \delta_{i3} Revise + \sum_{j=1}^{n} \gamma_{ij} \cdot Revise \cdot \log\left(p_{jht}\right) + \\
& \theta_i \cdot Revise \cdot y_{ht} + \epsilon_{iht}
\end{aligned}
$$

where w_{iht} is budget share of household h for food category i $(i = 1, \dots, n-1)$ at time t. $n = 10$ is the number of goods in the demand system that includes four WIC food groups, five non-WIC food groups, and a numéraire representing all other goods and services. y_{ht} is equal to household income deflated by a stone price index. p_{jht} is the price index of food category j for household h at time t. $\boldsymbol{Z_{ht}}$ contains a series of demand shifter including household demographic characteristics. $\boldsymbol{Year}$, $\boldsymbol{Month}$ and $\boldsymbol{Region}$ are year, calendar month, and Census region dummies, respectively. $\boldsymbol{time}$ is a

linear time trend. $\boldsymbol{Region \cdot time}$ captures region-specific secular trend in demand. $\boldsymbol{MM}_t$ is a 7×1 vector of indicators with elements $MM_{t,T} = 1[t \geq T]$, where $1[\cdot]$ is the indicator function and $T = \{\text{Jan, May, June, Jul, Aug, Sept, Oct}\}$ of 2009. These are the months in 2009 when at least one state started prescribing the revised food packages. For example, for the March 2009 purchases of a household, $\boldsymbol{MM}_t = \{1,0,0,0,0,0,0\}$. The role of $\boldsymbol{MM}_t$ is to control for national demand shocks occurring at the time when some states implemented the revision. $\boldsymbol{ST}$ is a vector of seven state group dummies, where we classify states into seven groups based on their months of implementation. We use $\boldsymbol{ST}$ to control for unobserved preference heterogeneity common across states that implemented the revision in the same month. $Revise$ is an indicator equal to 1 if WIC household h made the purchase after the revision was implemented in its state, and 0 otherwise. The α, b, A, B, c, d, δ, γ, and θ's are structural preference parameters to be estimated. ϵ_{iht} is the residual.

We use the interaction terms $Revise \cdot \log(p_{jht})$ and $Revise \cdot y_{ht}$ to detect preference changes as related to the price and income effects, respectively. The existing literature focuses on changes in the level of demand and overlooks potential shifts in how WIC households respond to prices and income. Under our specification, the effect of the food package revision on the budget share of food category i is measured by $\delta_{i3} + \sum_{j=1}^{n} \gamma_{ij} \cdot \log(p_{jht}) + \theta_i \cdot y_{ht}$.

To account for the zero purchases, the budget share w_{iht} is modeled as a censored dependent variable. We apply the extended Amemiya's generalized least squares (AGLS) estimator developed by Zhen et al. (2014) to the system of eq. (1) to estimate the structural parameters. The extended AGLS estimator expands the original AGLS estimator (Amemiya 1979; Newey 1987) from a single Tobit regression, with endogenous explanatory variables, to a system of Tobit regressions. In the case of a demand system, the extended AGLS estimator offers the option of imposing the cross-equation restrictions of homogeneity, symmetry and adding up.

The price coefficient estimates A, B, and γ could be biased if endogeneity in p_{jht} is not corrected for. There are three sources of endogeneity. First, there is the unit value bias (Cox and Wohlgenant 1986; Deaton 1988). Within each food group, a number of products are available at very different prices. Much of the within-group price difference is driven by product quality, either real or perceived. If we use the average price of products household h purchased as p_{jht}, the price coefficient estimates will likely be biased measures of the household's quantity response to price changes. This occurs because the average price is a function of the household's (mostly unobserved) preferences over quality that also enters the residual ϵ_{iht}. To correct the unit value bias, we follow the approach of Zhen et al. (2011) by using the Törnqvist index as p_{jht} in eq. (1).

The Törnqvist price index is constructed as

$$p_{jht} = \exp(0.5 \cdot \sum_v (s_{v0} + s_{vht}) \cdot \ln(\pi_{vht}/\pi_{v0})) \tag{2}$$

where π_{vht} and s_{vht} are the price and budget share (within food group j) of UPC v for household h in period t, respectively; and π_{v0} and s_{v0} are base price and base budget share of UPC v. We set the base at the national average over the same period. When a household did not purchase anything in food group j in period t, we replace the household index with the average retail Törnqvist index of stores shopped by household. We calculate the retail Törnqvist index using barcode-level prices and sales from the ScanTrack retail scanner data. The household and retail price indices for each food group use the same base such that the index numbers are comparable. The Törnqvist price index is a superlative in the sense that it is exact for the translog cost function (Diewert 1976). This allows us to build a cost-of-living index for each food group that accounts for barcode-level quality differences without explicitly estimating a demand system for products differentiated at the barcode level.

The second source of price endogeneity relates to unobserved preference heterogeneity over quantity. For households with above-average preferences for food group j, they are likely to pay below-average prices even after accounting for quality because savings from

employing cost minimization strategies such as intensive comparison shopping are greater when demand is higher. In this case, the causation is reversed: higher demand leads to lower prices paid. The final source of bias comes from the familiar supply-demand simultaneity. This could be caused by local demand shocks that are common across households and to which retailers respond through price actions. We instrument the endogenous p_{jht} by the weighted average retail Törnqvist index of all counties in a 100-mile radius from the household's home county, excluding the home county. The weight for each county is its inverse distance to the home county. Hausman (1997) proposed using surrounding-area prices as instruments in demand systems where supply-side variables lack the specificity to identify the price effects for highly disaggregated goods. This strategy was later popularized in Nevo's (2001) analysis of brand-level demand for breakfast cereal. The identification assumption is that local demand shocks are spatially uncorrelated after controlling for observed demographics, or are not responded to by chain retailers. We account for broader demand shocks at the national, regional, and state level and over time by the rich set of fixed effects in eq. (1). In terms of firms' pricing decisions, there is strong evidence that chain retailers do not price to local demand (DellaVigna and Gentzkow 2019).

Empirical Results

The highest order of income polynomial R in eq. (1) determines the shape of the Engel curves. However, too high of a value of R will cause severe multicollinearity. We test the joint significance of the b_{iR}'s, starting at $R = 2$, increase R by one and re-test if the last test is significant. This testing procedure leads to our determination that $R = 3$, a rank four demand, is appropriate given the narrow range of y_{ht} owing to the low income of WIC households.

Table 4 presents the income elasticities for the ten food groups and the numéraire. Almost all income elasticities lie between 0 and 1 indicating that the food groups covered in the demand system are necessities for WIC households. The income elasticities shifted

significantly for some food groups post revision. Among those that changed by 50% or more, skim/reduced-fat milk and CSD experienced an increase while whole grain cereal, other sugary cereal, refined grains, and 100% juice experienced a decline. The income elasticities are identified by within- and between-household income variations. A decomposition of the variance of y_{ht} finds that 90.74% of the variance comes from between-household variation with within-household variation accounting for the rest.

The last column of table 4 also shows how the budget share for ten food groups including numéraire changed after WIC package revision. As a complement of previous studies, our structural model accounts for price and income effects driven by the WIC package revision. Our result is consistent with some previous studies (Andreyeva et al, 2013; Odoms-Young et al, 2013; Oh et al, 2016; Ng et al, 2018; Frisvold, 2020). After WIC package revision, WIC participants tended to consume more skim/reduced-fat milk and whole grain and less whole milk, which is consistent with the recommendations of Dietary Guidelines for Americans (DGA). Under interim rule, whole grain/wheat bread and other whole grain food were added in Food Packages III, IV, V and VII (FNS, 2007), leading to an increase in purchase of whole grain products. The revision has reduced the maximum allowances of juice for women and children in Food Packages IV-VII (FNS, 2007[4]) since excessive intake of fruit juice has increased the risk of obesity in children (Wojcicki and Heyman 2012; Shefferly 2016) and juice provides no additional nutritional benefit over whole fruit (FNS 2007; Heyman et al. 2017). Therefore the purchase of juice has decreased after package revision. We also find a decrease in the purchase of carbonated soft drinks, suggesting a spillover effect of WIC package revision to the food groups not covered by the packages.

Table 5 and 6 report the pre- and post-revision Marshallian price elasticities, respectively. Regarding cross-price effects, skim/reduced-fat milk and whole milk turned

[4] For children, the maximum monthly allowance of juice reduced from 288 fl oz to 128 fl oz. For pregnant and partially breastfeeding women, the maximum monthly allowance of juice was reduced from 288 fl oz to 144 fl oz; for postpartum women from 192 fl oz to 96 fl oz; and for fully breastfeeding women, from 336 fl oz to 144 fl oz.

from substitutes before the revision to complements after the revision. This shift in the cross-effect between milk types is consistent with the change in WIC guidance on the prescription of milk. Before the revision, there was few restrictions on milk fat content. So a WIC agency may very well treat milk of different fat content as substitutes. After the revision, whole milk may only be prescribed to children aged 12 months to 2 years and skim/reduced-fat milk to older children and women (FNS, 2014[5]). A WIC household in the post-revision period is more likely to have both skim/reduced-fat milk and whole milk than the pre-revision period, thus creating a situation of complementarity at the household level.

The reduction in skim/reduced-fat milk own-price elasticity and increase in whole milk own-price elasticity (both in absolute value) are also consistent with the programmatic change to milk prescription. In theory, WIC households are not very price elastic for the prescribed food. As the amount of prescribed skim/reduced-fat (whole) milk increases (decreases), price sensitivity will decline (rise). Similarly, with the introduction of whole grain in the WIC package, the WIC household's demand for whole grain has become less price-sensitive. The package revision also increased WIC participants' price sensitivity to beverages through spillover effects. This finding implies that as the WIC program has improved, WIC households have become more concerned about a healthy diet, and hence the price effect on their demand for healthy food has decreased. However, a food group being WIC eligible does not imply the price elasticity should be zero. There are seven WIC food packages post revision.[6] Not all households are prescribed the same type and amount of foods. Those who do not receive a food type or not in sufficient amount (for the entire household) must purchase additional using other cash or other forms of payment. As the demand system estimates price responses at the margin for an average household, the price elasticities will not be zero for WIC-eligible foods. For example, after the revision households may choose cheese, tofu/soy-based beverages as substitutes for milk. Those

[5] https://www.federalregister.gov/documents/2014/03/04/2014-04105/special-supplemental-nutrition-program-for-women-infants-and-children-wic-revisions-in-the-wic-food

[6] https://www.federalregister.gov/documents/2007/12/06/E7-23033/special-supplemental-nutrition-program-for-women-infants-and-children-wic-revisions-in-the-wic-food

who choose milk substitutes in their WIC packages would have to pay for milk and are likely sensitive to changes in milk price.

Conclusion

This study estimates a WIC-household demand system for WIC food groups and several closely related food groups. We leverage the 2009 WIC food package revision as a policy experiment to test whether there has been a structural change in WIC households' preferences post revision. Our results indicate that the 2009 revision led to increases in healthier foods encouraged by WIC and decreases in less healthy food and beverage WIC seeks to limit. In addition to changes in the level of demand, we also present a pattern of shifting price elasticities that are consistent with a change in preferences toward healthier foods among WIC households. The finding of spillover effects is new and not explored by previous studies. This finding illustrates the importance of understanding how multiple food policies may interact with each other to amplify or dampen the effect of each policy.

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Table 1: Descriptive statistics for WIC participants and nonparticipants

	WIC participant		WIC non-participant		
	Mean	STD	Mean	STD	Difference
Budget Share (% of income)					
Skim/reduced-fat milk	0.531	0.013	0.380	0.009	0.152
Whole milk	0.355	0.009	0.267	0.008	0.088
Whole grain breakfast cereal	0.081	0.005	0.062	0.003	0.018
Other cereal	0.593	0.013	0.437	0.010	0.156
Whole grains	0.173	0.005	0.133	0.005	0.041
Refined grains	0.362	0.008	0.333	0.007	0.029
100% juice	0.224	0.007	0.145	0.005	0.079
Juice drink	0.550	0.015	0.407	0.011	0.142
Carbonated beverage	0.864	0.020	0.671	0.016	0.193
Purchase (OZ)					
Skim/reduced-fat milk	356.5	481.9	312.8	444.4	43.7
Whole milk	191.2	372.3	158.6	318.9	32.6
Whole grain breakfast cereal	9.3	24.4	8.5	23.5	0.7
Other cereal	58.5	71.2	53.3	70.4	5.2
Whole grains	24.8	43.6	21.2	40.6	3.6
Refined grains	77.0	97.3	75.9	95.4	1.0
100% juice	69.9	125.6	60.6	125.5	9.3
Juice drink	240.1	333.6	220.4	330.5	19.6
Carbonated beverage	602.8	823.7	536.6	802.2	66.1
Characteristics					
Household size	4.775	1.503	4.870	1.462	
Income ($/month)	2364	1007	2614	1062	
White	0.789	0.408	0.781	0.414	
Black	0.106	0.307	0.113	0.317	
Asian	0.020	0.141	0.028	0.164	
College	0.740	0.439	0.771	0.420	
Number of unique households	1143		5001		

Note: we use UPC description and refer to the federal requirements for WIC-eligible foods to classify items into food and beverage groups encouraged by the revised food packages and those not WIC eligible. Some of the federal requirements are:

Skim/reduced-fat milk: should be skim, low-fat, or reduced fat (2% reduced); should contain vitamin A and D.

Whole grain cereal: Should be plain, whole grain or whole wheat; should be instant ready-to-eat or instant cereal (e.g. oatmeal)

Whole grain: whole wheat/grain bread, buns and rolls; whole wheat tortillas; brown rice, bulgur, oatmeal

without added sugar, oil and salt.
100% Juice: 100% unsweetened juice.
Carbonated beverage: carbonated regular soft drinks and diet soft drinks.

Table 2: Budget share, purchase and expenditure for WIC participants before and after package revision

	Pre		Post		
	Mean	STD	Mean	STD	Difference
Budget Share (% of income)					
Skim/reduced-fat milk	0.547	0.015	0.516	0.011	-0.031
Whole milk	0.402	0.010	0.307	0.008	-0.094
Whole grain breakfast cereal	0.078	0.003	0.083	0.006	0.006
Other cereal	0.563	0.012	0.624	0.014	0.061
Whole grains	0.119	0.004	0.229	0.006	0.110
Refined grains	0.376	0.007	0.349	0.008	-0.027
100% juice	0.230	0.006	0.218	0.007	-0.012
Juice drink	0.542	0.014	0.558	0.016	0.016
Carbonated beverage	0.881	0.020	0.847	0.020	-0.034
Purchase (OZ)					
Skim/reduced-fat milk	352.5	495.2	360.5	467.9	8.0
Whole milk	222.7	432.0	159.3	296.4	-63.4
Whole grain cereal	9.5	22.9	9.0	25.9	-0.5
Other cereal	58.7	69.2	58.2	73.1	-0.5
Whole grains	19.4	37.8	30.4	48.1	10.9
Refined grains	88.8	104.0	65.0	88.4	-23.8
100% juice	68.6	132.4	71.3	118.3	2.7
Juice drink	237.4	328.5	242.8	338.6	5.3
Carbonated beverage	654.5	860.4	550.3	781.1	-104.1
Expenditure ($)					
No-fat/low-fat milk	9.090	12.807	9.080	11.703	-0.010
Whole milk	6.473	11.297	4.993	8.488	-1.480
Whole grain cereal	1.247	2.925	1.290	3.911	0.043
Other sugar cereal	9.525	10.663	10.359	12.516	0.834
Whole grain	2.015	3.978	4.043	6.407	2.028
Refined grain	6.386	6.967	5.601	6.729	-0.785
100% juice	3.713	6.592	3.396	5.448	-0.317
Juice drink	8.094	10.811	8.515	11.498	0.421
Carbonated beverage	14.149	19.787	13.489	19.668	-0.660

Table 3: Determinants of state's implementation timing for WIC package revision

	imp10		imp_all	
variable	Coeff	std.err	Coeff	std.err
Unemployment rate	-0.206	0.215	-0.187	0.202
Poverty rate	-0.041	0.168	-0.047	0.162
Education (% of bachelor degree)	-0.041	0.063	-0.067	0.070
Proportion of Asian	17.301	23.229	11.977	22.521
Proportion of Black	10.679	14.190	7.859	13.447
Proportion of White	8.329	15.433	5.454	14.687
Number of observation	48		48	

Notes: imp10 indicates whether the state implemented the WIC package revision on Oct 1st, 2009. We run logit model to examine whether the choice of states is affected by some economic factor. imp_all is an ordinal variable indicating which month (how earlier) the state would choose to implement the package revision before the last date of mandatory. We run ordered logit model to examine whether the economic factor would affect the state's choice.

Data source:

Unemployment rate: U.S. Bureau of Labor Statistics, https://www.bls.gov/lau/rdscnp16.htm

Poverty rate: U.S. Census Bureau, Small Area Income and Poverty Estimates (SAIPE) Program, https://www.census.gov/programs-surveys/saipe.html

Education: FRED, https://fred.stlouisfed.org/release/tables?rid=330&eid=391444&snid=391485#

Race: Bridged-Race Population Estimates. CDC, U.S. Census Bureau and NCHS, https://wonder.cdc.gov/bridged-race-population.html

Table 4: Income elasticities and change in budget share

	Income Elasticities		Change in Budget share
	Pre	Post	
Skim/reduced-fat milk	0.06083	0.51832	0.00135
Whole milk	0.42100	0.35788	-0.00121
Whole grain cereal	1.13271	0.69709	-0.00201
Other cereal	0.50049	0.12022	0.00070
Whole grains	0.77985	0.61520	0.00146
Refined grains	0.88934	0.40148	-0.00330
100% juice	0.80737	0.12324	-0.00086
Juice drink	0.88859	0.77440	-0.00250
Carbonated beverage	0.26408	0.68985	-0.00212
Numéraire	1.04285	1.04786	0.00849

Table 5: Price elasticities before the WIC package revision

Pre	Skim/reduced-fat milk	Whole milk	Whole grain cereal	Other cereal	Whole grains
Skim/reduced-fat milk	-0.927	0.461	-0.06	0.948	-0.241
Whole milk	0.586	-0.616	-0.048	-0.368	0.269
Whole grain cereal	-0.038	-0.047	-2.145	-0.829	0.177
Other cereal	0.996	-0.291	-0.400	-1.901	-0.315
Whole grains	-0.520	0.535	0.202	-0.653	-1.081
Refined grains	-0.050	0.003	-0.651	0.155	0.149
100% juice	-0.010	-0.306	-0.330	-0.960	0.055
Juice drink	-0.712	-0.251	-0.042	0.040	0.022
Carbonated beverage	-0.329	-0.169	0.523	0.178	0.264
Numéraire	0.002	-0.001	0.008	0.011	-0.003

Pre	Refined grains	100% juice	Juice drink	Carbonated beverage	Numéraire
Skim/reduced-fat milk	-0.008	0.004	-0.793	-0.447	1.038
Whole milk	0.027	-0.180	-0.351	-0.293	0.569
Whole grain cereal	-0.798	-0.316	-0.120	1.465	1.509
Other cereal	0.092	-0.448	0.065	0.266	1.462
Whole grains	0.211	0.075	0.055	0.738	-0.327
Refined grains	-2.155	-0.992	0.279	1.841	0.536
100% juice	-1.159	-1.100	0.636	1.161	1.203
Juice drink	0.146	0.259	-0.791	-0.282	0.728
Carbonated beverage	0.761	0.397	-0.214	-1.377	-0.269
Numéraire	0.003	0.005	0.006	-0.015	-1.061

Table 6: Price elasticities after the WIC package revision

Post	Skim/reduced-fat milk	Whole milk	Whole grain cereal	Other cereal	Whole grains
Skim/reduced-fat milk	-0.743	-0.383	0.333	0.134	0.658
Whole milk	-0.502	-1.293	-0.474	-0.158	-0.280
Whole grain cereal	0.754	-0.714	-1.272	0.255	-0.018
Other cereal	0.185	-0.080	0.150	-0.864	-0.112
Whole grains	1.273	-0.402	-0.016	-0.182	-0.801
Refined grains	1.241	-0.576	-0.496	0.129	-0.614
100% juice	-0.368	0.202	0.399	-0.258	-0.042
Juice drink	0.254	0.221	-0.585	0.377	-0.497
Carbonated beverage	-0.195	-0.115	-0.384	1.620	-0.133
Numeraire	-0.017	0.014	0.014	-0.031	0.007

Post	Refined grains	100% juice	Juice drink	Carbonated beverage	Numeraire
Skim/reduced-fat milk	0.731	-0.188	0.273	-0.206	-1.103
Whole milk	-0.364	0.142	0.330	-0.180	2.449
Whole grain cereal	-0.577	0.462	-1.380	-1.217	3.013
Other cereal	0.066	-0.083	0.427	2.370	-2.143
Whole grains	-0.661	-0.048	-1.064	-0.420	1.714
Refined grains	-1.349	0.065	-0.621	2.811	-0.966
100% juice	0.100	-1.030	-0.488	0.115	1.284
Juice drink	-0.299	-0.243	-1.827	-1.548	3.369
Carbonated beverage	1.115	0.035	-1.224	-2.736	1.330
Numeraire	-0.009	0.002	0.037	0.017	-1.083

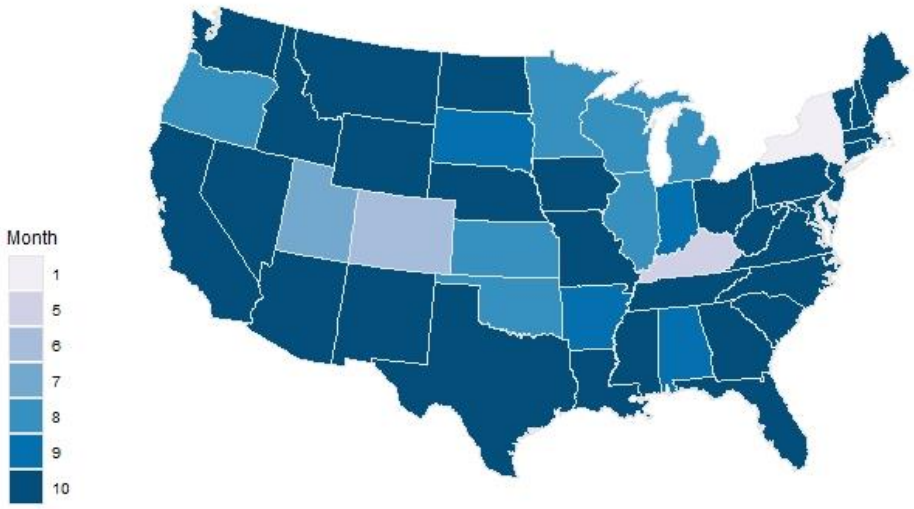

Figure 1: Month of implementation of the 2009 WIC food package revision