Rational Addiction and other Purchasing Dynamics Across Obesity Status Groups

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Abstract: The prevalence of obesity in the United States in 2017–2018 was 42.4 percent among adults aged 20 and over, and it has increased from 30.5 percent in 1999–2000. Policies that tax a particular food or beverage (such as soda) or a particular nutrient (such as added sugar) have been implements or discussed in an attempt to reduce consumption. However, the overall effectiveness of food taxes may need to account for a deeper understanding of purchasing behavior dynamics, including stockpiling as well as rational addiction. This study estimates a reduced form economic model of nutrient-specific food addiction using consumer-level food purchase data in the U.S.. Specifically, our model investigates addictive behavior for a wider range of unhealthy foods and investigates whether addictive behaviors vary across subsamples defined by obesity status. We find substantial evidence that addiction plays a role in consumers' purchase decisions for certain products including salty snacks and sweet beverages. We find substantial evidence that addiction plays a role in consumers' purchase decisions for certain products including salty snacks and sweet beverages and we observe some differential effects across consumers of different obesity status.

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I. Introduction and Motivation

The prevalence of obesity in the United States in 2017–2018 was 42.4 percent among adults aged 20 and over, and it has increased from 30.5 percent in 1999–2000 (CDC, 2021; Alston and Okrent, 2017; Ogden et al., 2015). Relying on models of rational addiction (e.g., Becker and Murphy, 1988; Richards and Hamilton, 2012), recent studies look for evidence of addictive behavior among certain foods, and explore the associated policy implications (e.g., Richards, Patterson, and Tegene, 2007, Zhen et al., 2011; Liu and Lopez, 2012). There is evidence to suggest that policies aimed at rationally addicted consumers can be effective if they increase future costs associated with addiction, so consumers become rationally incentivized against the addictive behavior. With respect to food addiction and obesity, this lesson implies that policies that tax a particular food or beverage (such as soda) or a particular nutrient (such as added sugar) might be effective in reducing consumption. However, we argue that the overall effectiveness of food taxes may need to account for a deeper understanding of purchasing-behavior dynamics, including stockpiling as well as rational addiction.

Researchers have extended the rational addiction literature to investigate several closely related topics. For example, some studies have begun to examine if consumers behave differently depending on their health or obesity status; and another group of studies investigates whether obese consumers have some time inconsistencies in their preferences so that they may appear to not behave rationally. These studies typically rely on quantifying the correlation between a proxy for the discount factor that is measured with a survey question and a measure of an individual's BMI. This study estimates a reduced form economic model of nutrient-specific food addiction using consumer-level food purchase data in the U.S.. Specifically, our model investigates addictive behavior for a wider range of unhealthy foods and investigates whether addictive behaviors vary across subsamples defined by obesity status. We find substantial evidence that addiction plays a role in consumers' purchase decisions for certain products including salty snacks and sweet beverages.

Additionally, we investigate another dynamic aspect of consumers' rational decisions, stockpiling behavior, which can be common in shelf-stable foods, including sodas, that are often sold on price promotions (Wang, 2015). We see some evidence of stockpiling behavior that will be accounted for with further research.

Becker and Murphy's (1988) seminal work on rational addiction describes many behaviors commonly associated with addiction in a highly tractable model. The term rational addiction may seem at first an oxymoron, how indeed could the erratic and self-destructive behaviors of the alcoholic, heroin user, or the overeater be described as rational? However, Becker and Murphy's model describes forward-looking utility maximizing individuals with stable preferences that economists would describe as rational. The process of addiction is described where past consumption affects future consumption in a process of "learning by doing", addiction is thus inherently a dynamic process. A necessary condition for addiction is that past consumption of a good raises the marginal utility of present consumption; therefore, consumption increases with a reinforcing effect over time. Therefore, the model predicts a strong correlation between past consumption and future consumption known as adjacent complementarity. Additionally, as the model predicts forward-looking, utility maximizing behavior it also predicts that current consumption will be sensitive to future prices (Becker and Murphy, 1988). Therefore, when empirically estimating rational addiction researchers are generally looking for A) significant positive effects of past consumption on current consumption and B) significant effects of future prices on current consumption.

Since the publication of Becker and Murphy's model there have been numerous attempts to empirically estimate demand for addictive products in this framework. Some early and well received examples estimate addictive demand using equations derived from utility maximization in Becker and Murphy's model, this class of models is referred to as AR(2) (Chaloupka, 1991; Becker and Murphy, 1994; Dragone and Raggi, 2021). These models show that demand for cigarettes can be explained under a framework of rational addiction.

However, later research has also shown that these same models could be used to show rational addiction in many non-addictive product categories, like dairy milk (Dragone and Raggi, 2021). Recently this issue has been addressed, Dragone and Raggi (2021) show that AR(2) leads to explosive consumption paths while their updated AR(1) model does not. Using this model Dragone and Raggi show evidence of addictive demand for cigarettes but not for non-addictive products like oranges, eggs, and milk. Taking insights from both AR(1) and AR(2) models we estimate a reduced form model of addictive demand which we apply to various classes of food products.

While reduced form estimates have been effective at showing evidence for rational addiction there have also been attempts to estimate truly dynamic structural models of rational addiction. An important contribution to the modern rational addiction literature comes from Gordon and Sun (2015) who present a dynamic structural model taking into account both addiction and stockpiling behaviors effects on consumption. This allows for a dynamic structural analysis of consumption patterns related to both stockpiling and addiction without making overly burdensome assumptions on consumer expectations and the exogeneity of price changes. They find evidence not only that addiction plays a substantial role in consumers' purchase decisions for cigarettes but also that the evidence supporting addiction is stronger after controlling for stockpiling behavior. Furthermore, when this model is applied to non-addictive products such as crackers or butter, they see evidence of stockpiling but not of addiction. With this model they can assess the impact of three policies on cigarette purchases: a tax on premium tier cigarettes, a category-wide cigarette tax, and a ban on the sale of cigarette cartons. While Gordon and Sun (2015) focus on cigarette purchases their model could be used to assess a broader class of addictive products, including common grocery items.

A structural demand model as presented in Gordon and Sun (2015) would in many ways be an effective way to assess rational addiction with respect to food and beverages. It would be possible to disaggregate the effects of stockpiling and addiction and more accurately quantify the extent to which addiction plays a role in purchase decisions. Additionally, if our results replicated Gordon and Sun's analysis we would observe more evidence of rational addiction when accounting for stockpiling. Indeed, a goal of this project is to estimate a dynamic demand model of addiction as in Gordon and Sun (2015). Nevertheless, our current reduced form model provides many important insights with respect to addictive demand.

We asses rational addiction and stockpiling dynamics using both qualitative evidence and a reduced form model of addictive demand over a broad category of salty snacks and beverages. While the evidence of stockpiling behavior is thus far weak we have seen some results that indicate that a dynamic estimate of both addiction and stockpiling as in Gordon and Sun (2015) would be a productive goal. We do, however, find substantial evidence that addiction plays a role in consumers' purchase decisions for certain products including salty snacks and sweet beverages and we observe some differential effects across consumers of different obesity status. Our reduced form addictive demand estimates show that regular soda exhibits strong evidence of rational addiction in the demand for regular soda and weaker evidence for addictive behavior in the demand for diet soda, apple juice, potato chips, tortilla chips, and pretzels. Corroborating Dragone and Raggi (2021) we do not see evidence of rational addiction in products like whole milk and orange juice when using a modification of their AR(1) model where we do when we use the AR(2) model. We also see the strongest evidence of rational addiction in the "overweight" BMI group and not in the higher BMI "obese" group as we might expect, it is unclear at this point if this pattern is persistent across a broader class of grocery items. Further research will refine the current reduced form model, estimate a dynamic structural model of rational addiction and stockpiling like Gordon and Sun (2015), and estimate welfare impacts of policy interventions with respect to rationally addictive behavior in a broad class of grocery items.

II. Data

Data from this project were collected by Information Resources Inc. (IRI) and provided through the United States' Department of Agriculture, Economic Research Service (details on data can be found in ERS, 2021). Data include household level data and store level data on food purchases. This dataset is comparable to the Nielsen scanner dataset. This project focuses on data collected between 2013 and 2018, although data from between 2008 and 2012 is also available. This project so far focuses on a specific group of beverages and salty snacks: regular soda, diet soda, apple juice, orange juice, milk, potato chips, tortilla chips, and pretzels. Because the dataset remains quite large we are able to use a consistent panel including only households which: A) are in the sample for the entire 6 years and B) are consistent consumers of each product, i.e. they purchase the product more than four times a year.

Household level data includes both the IRI Consumer Network household scanner data and supplemental Medprofiler data, these data were compiled for the entire U.S.. The Consumer

Network household scanner data includes information on purchase quantities, spending, and product attributes for each grocery trip a consumer makes throughout their participation in the survey. We aggregate this data by household and product categories monthly to estimate monthly purchases and spending, in the case of beverages purchase units are listed in fluid ounces and in the case of salty snacks they are listed in ounces. Average monthly price is calculated simply by dividing monthly spending by monthly purchases; therefore, our price estimate reflects price per fluid ounce and price per ounce in the cases of beverages and salty snacks, respectively. These data also include demographic information for households including the number of household members and the household's income.

At the consumer level we also have access to the Medprofiler survey which surveyed a subsample of consumers in the broader Consumer Network survey. This data crucially includes data for all household members including not only their height and weight but also qualitative descriptions of a variety of physical and mental health conditions including diabetes, heart disease, anxiety, and depression. This project so far uses only the information for height and weight to calculate body mass index (BMI). Aggregating BMI to the household level is quite problematic as it is difficult to assess an individual's contribution to the household's collective health. Thus, we chose to use average adult BMI in the household as the least problematic and simplest to implement method of aggregation. BMI categories are assigned consistently with CDC's methods where average household adult BMI<25 is assigned to the "normal" category (our analysis is mostly focused on obesity so we include households in the "underweight" category in the "normal" category), average household BMI>30 is assigned to the "obese" category and anything in-between is assigned to the "overweight" category (CDC, 2020). Medprofiler data are available annually for participating households.

We also use store level data, although in the current project their use is limited due to technical complications. In theory, prices at the chain-region level should heavily correlate with observed prices at a given store of that chain in that region. In practice, there is some difficulty in linking the store level data and consumer level data due to a difference in naming conventions across the two datasets. As a result, these data are only available at the Chicago level, where the issue was easier to deal with due to the smaller scale, and not the entire U.S. as with the rest of the data. It is planned to expand the store level data to the entire U.S. which will require matching of all the chains in the U.S. across the two datasets.

III. Qualitative Evidence of Rational Addiction and Stockpiling

Rationally addicted individuals would be expected to increase their purchases of given products over time as they become further addicted to them. As an illustrative example, we examine IRI data on soda purchases in the retail stores in and around Chicago, Illinois. Table 1 shows the average quantity purchased per adult equivalent household member in fluid ounces, as well as the proportion of consumers who increased, decreased, or did not change their purchase quantity from the previous week. These statistics are presented separately by BMI group based on IRI MedProfiler data. The results suggest evidence of rational addictive behavior in soda consumers: that is, consumers in general were more likely to increase their purchase quantity of soda, as compared to the other two possibilities. There is also evidence of differential rational addictive behavior across BMI groups. Table 1 shows that not only do obese consumers consume more soda, they also exhibit a slightly higher propensity to increase their soda purchases. This descriptive analysis is reminiscent of Gordon and Sun (2015) who compare rational addictive behavior between a known addictive product, cigarettes, and a known non-addictive product, crackers. The behavior consumers exhibit in soda purchases is remarkably similar to (if not slightly stronger than) the behavior exhibited in cigarette purchases and not similar to the behavior exhibited in cracker purchases which are mostly constant over time (Gordon and Sun, 2015). Descriptive analysis of the soda market shows substantial evidence that rational addiction is a relevant dynamic in the soda market and potentially other similar markets.

Another dynamic process that we examine with respect to obesity is stockpiling; however, for our Chicago-based soda-purchasing example, we observe less evidence of stockpiling than addiction. Descriptively, stockpiling could be observed if consumers buy a larger than usual quantity on sale, earlier than normal, then wait longer until their next purchase as they deplete their stockpile. Table 2 describes the average quantity purchased in fluid ounces, the average unit price, the average weeks since the previous purchase, and the average weeks until the next purchase. In addition to the BMI groups, this table differentiates these statistics by whether the product was on sale or not at time *t*. As in Hendel and Nevo (2006), a product is defined as being on-sale if it is sold at less than 95% of the modal price for that product in a particular retailer for a given week. The results of Table 2 suggest that while consumers buy a larger quantity of soda on sale they do not make the purchase earlier or indeed wait longer until their next purchase, indicating that stockpiling may not be an appropriate way to describe this behavior. Additionally, we do not see substantial variation in stockpiling across BMI groups. While this particular example does not show substantial evidence for stockpiling, we have seen some evidence in other analyses, including analyses of specific soda packaging.

Our preliminary results for the soda market in and around Chicago provide empirical evidence that rational addiction and stockpiling are likely to play strong and weak roles, respectively, in consumers' purchasing behaviors. Our research team has begun to find similar (and sometimes stronger) evidence of rational addiction and stockpiling for other product categories, including energy drinks and salty snacks.

IV. Modelling Rational Addiction

We estimate a reduced form model of demand to assess evidence of rational addiction following from a well-established literature of empirically estimating such a model (Chaloupka, 1991; Becker et al., 1994) taking into account more modern findings with respect to such models (Dragone and Raggi, 2021). With this estimation we show that, when using a modification of the AR(1) model of Dragone and Raggi, products like soda and sugary drinks show some evidence of rational addiction where products like dairy milk do not show any evidence of rational addiction. Additionally, we show rational addiction in a broad class of salty snacks: potato chips, tortilla chips and pretzels. This preliminary evidence is very encouraging in support of the hypothesis that the consumption of certain classes of grocery products is driven by addictive behavior similar to the demand for commonly accepted addictive products, like cigarettes.

An early example of empirical estimation of rational addiction comes from Chaloupka (1991). As in other early empirical estimations of rational addiction (such as Becker et al., 1994) the following quadratic utility function represents consumers' utility:

$$U_t = b_Y Y_t + b_c C(t) + b_A A_t + \frac{1}{2} U_{YY} Y_t^2 + \frac{1}{2} U_{cc} C_t^2 \qquad (1)$$

$$+\frac{1}{2} U_{AA} A_t^2 + U_{YA} Y_t A_t + U_{CA} C_t A_t + U_{YC} Y_t C_t$$

where Y_t is a vector including the inputs to the composite good and health in time t, C_t consumption of the addictive good. Additionally, A_t is estimated to be the addictive stock where:

$$A_t = \sum_{i=0}^{t-1} (1 - \delta) C_i \qquad (2)$$

Maximizing (1) subject to a budget constraint with respect to Y_t, converting to discrete time, and using the resulting first-order conditions for C_t and A_t, the following demand equations are derived where P_t is the price of the addictive good in time t:

$$C_t = \beta_0 + \beta_1 P_t + \beta_2 P_{t-1} + \beta_3 P_{t+1} + \beta_4 C_{t-1} + \beta_5 C_{t+1} \quad (3)$$

and

$$C_t = \phi_0 + \phi_1 \mathrm{P_t} + \phi_2 \mathrm{P_{t+1}} + \phi_3 \mathrm{C_{t+1}} + \phi_4 \mathrm{A_t} \quad (4)$$

From these demand equations Chaloupka (1991) econometrically estimates demand for cigarettes in a rational addiction framework. Where A_t must be estimated he assumes different values of the depreciation rate δ including 100%, 80% and 60% annually. However, addictive demand can also be estimated without assuming a depreciation rate using (3). This model is referred to in modern literature as AR(2) (Dragone and Raggi, 2021). Models like this including Chaloupka (1991) and Becker et al. (1994) produced a lot of empirical support for Becker and Murphy's (1988) model of rational addiction.

More recently, this method of estimating rational addiction has come under scrutiny as it tends to predict addictive behavior in a variety of goods not generally thought to be addictive such as dairy milk (Dragone and Raggi, 2021). The Euler equation associated with the demand for addictive consumption (Chaloupka, 1991; Becker et al., 1994) has been shown to often lead to explosive consumption paths (Dragone and Raggi, 2021). Instead, Dragone and Raggi (2021) present the saddle path solution to the infinite time-horizon dynamic optimization problem which smoothly converges to a steady state level of consumption (see Dragone and Raggi, 2018 for details). Dragone and Raggi (2021), following the saddle path solution estimate demand for addictive goods as follows:

$$C_t = \rho C_{t-1} + \gamma_1 P_{t-1} + \gamma_2 P_t + \gamma_3 P_{t+1} + \gamma_0 \quad (5)$$

The crucial difference between this model and the model presented in (3) is that this model does not contain consumption in the next period C_{t+1}, this model is referred to as AR(1). As a result, Dragone and Raggi's model shows evidence of rational addiction in consumption of addictive products, such as cigarettes, but not in consumption of non-addictive products: oranges, eggs, and milk. AR(2) on the other hand, shows evidence of rational addiction in the consumption of all these products (Dragone and Raggi, 2021).

Model

Our model attempts to estimate (4), Chaloupka's (1991) model including the addictive stock, taking account of Dragone and Raggi's (2021) findings with respect to the saddle path solution, i.e., removing C_{t+1} , thus we estimate:

$$C_t = \zeta A_t + \psi_0 + \psi_1 P_t + \psi_2 P_{t+1} \qquad (6)$$

Where:

$$A_t = (1 - \delta)(C_{t-1} + A_{t-1}) \qquad (7)$$

Is equivalent to (2) and we assume a depreciation rate of .05 because our data is monthly, this depreciation rate is consistent with prior literature.

Showing that this model can be derived from utility maximization will require further research. Nevertheless, this model is highly intuitive and provides some very compelling results. Some crucial assumptions of this model which should be verified through robustness checks and data collection are the degree of monthly depreciation of the addictive stock and the assumption that the next price observed is the next price the consumer chooses to purchase at. The issue of the monthly depreciation rate can be assessed in the reduced form structure by performing a sensitivity analysis. In a structural model this parameter could be estimated through a maximum likelihood method. The issue of future prices comes from the structure of the data, we only observe price in the consumer data when the consumer makes a purchase, thus we assume that the consumers next purchase price is the next price they observe. This issue could be addressed through store level data where price could be calculated at the chain-region level. These issues notwithstanding our model provides some very intriguing results with respect to rational addiction indicating further research will be a fruitful endeavor.

There are three properties of rational addiction that can be observed with this model: adjacent complementarity, the law of demand, and forward-looking behavior (Dragone and Raggi, 2018). First, adjacent complementarity implies that current consumption is increasing with past consumption, thus we would expect a significant and positive coefficient for depreciated past consumption, A_t, $\zeta > 0$. Second the law of demand, we expect current consumption to be significantly negatively associated with current price $\psi_2 < 0$. The final property of rational addiction is forward-looking behavior, we expect the coefficient on future price to be significant. $\psi_3 < 0$ implies that the good is “strongly addictive” while $\psi_3 < 0$ implies that the product is “weakly addictive”.

In order to investigate evidence of rational addiction we estimate (6) using IRI data and standard OLS estimates. Additionally, we control for household level variables including the number of household members and household income levels. We also control for time fixed effects using year and month dummy variables.

Results

First we see evidence in support of Dragone and Raggi's (2021) hypothesis and the weakness of some of the older models (Chaloupka, 1991; Becker et al., 1994). Table 3. shows the results of a similar model to AR(2) as presented in Chaloupka (1991) and described in this paper by equation (4) which includes future consumption and the addictive stock. Those three pieces of evidence being that demand effects are significantly negative in current price, significantly positive in lagged past consumption, and significant in future price. When evidence of rational addiction is assessed using these metrics many products which one would not consider addictive show evidence of rational addiction such as whole milk and orange juice.

The model presented in table 4 shows the reduced form demand estimates using the modified AR(1) model i.e., the model presented by equation (6) of this paper. Using this model instead we show strong evidence for rational addiction in regular soda while showing weaker evidence in diet soda and apple juice and no evidence of rational addiction in orange juice and whole milk. This is consistent with a hypothesis that sweet beverages can be addictive in a broad population where dairy milk is unlikely to be addictive to most people.

Additionally, we show some evidence in table 5. that salty snacks are addictive to a similar degree as diet soda and apple juice. As one might expect, the strongest evidence for rational addiction is observed in potato chips, then tortilla chips, we see the weakest evidence of rational addiction in the plainer pretzels. It would be interesting to see if the effects of flavor could be disaggregated in this analysis, we might expect to see more evidence of rational addiction in flavored salty snacks which also tend to include significant amounts of sugar.

Table 6 shows the reduced form demand analysis performed separately across BMI groups for beverage consumption and observe somewhat of a differential impact. We observe evidence of rational addiction across all three BMI classes with respect to their consumption of regular soda and we observe no evidence of rational addiction for orange juice in consumers of orange juice or whole milk. Curiously however, it is only the "overweight" class where evidence of rational addiction is observed for products like apple juice and diet soda instead of the higher BMI "obese" group. Further exploration will assess if this pattern is common across other products or if different groups are more likely to show signs of addiction to different products.

V. Discussion

A crucial aspect to Becker and Murphy's (1988) theory of rational addiction is that products are not addictive in and of themselves. In fact, it is the specific juncture of individuals, circumstance, and product where the conditions for addiction are met. We show substantial evidence that these conditions are met in innocuous seeming sugary beverages and salty snacks, not only by commonly recognized addictive products, like cigarettes as previous work has shown (Chaloupka, 1991; Becker et al., 1994; Gordon and Sun, 2015; Dragone and Raggi, 2021).

Further research on this topic has three primary goals. First, to assess the robustness of existing reduced form evidence of rational addiction and to quantify patterns across different product categories. Second, to disaggregate the dynamic processes of addiction and stockpiling similarly to Gordon and Sun (2015). And finally, to estimate welfare impacts of policy interventions with respect to rationally addictive behavior in a broad class of grocery items.

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Table 1. Descriptive Analysis of Addiction, Soda Purchases Chicago Il. 2013-2018					
BMI Group	**Normal**	**Overweight**	**Obese**	**Morbidly Obese**	**Total**
Quantity Purchased	125.1 fl. oz.	139.4 fl. oz.	150.2 fl. oz.	145.6 fl. oz.	135.1 fl. oz.
Increase	37.6%	37.4%	37.7%	38.6%	37.6%
Constant	34.1%	34.3%	34.9%	31.1%	34.0%
Decrease	28.3%	28.3%	27.4%	30.2%	28.4%

Table 2. Descriptive Analysis of Stockpiling, Soda Purchases Chicago 2013-2018						
	BMI Group	**Normal**	**Overweight**	**Obese**	**Morbidly Obese**	**Total**
Off Sale	Quantity	106.4 fl.oz.	115.2 fl.oz.	120.7 fl.oz.	123.0 fl.oz.	112.8 fl.oz.
	Average Price	$3.09	$2.91	$3.06	$2.86	$2.98
	Weeks Since	4.32	4.16	4.67	4.08	4.24
	Weeks Until	4.52	4.22	4.89	4.42	4.40
On Sale	Quantity	138.0 fl.oz.	155.9 fl.oz.	170.6 fl.oz.	160.9 fl.oz.	150.5 fl.oz.
	Average Price	$2.77	$2.73	$2.72	$2.79	$2.75
	Weeks Since	4.32	4.19	4.69	4.48	4.29
	Weeks Until	4.48	4.38	4.76	4.52	4.45

Table 3. Reduced Form Addictive Demand for Beverages AR(2) U.S. 2013-2018					
Dependent Variable: $ln(C_t)$	Regular Soda	Diet Soda	Apple Juice	Orange Juice	Whole Milk
$ln(A_t)$	0.5181*** (0.0056)	0.4028*** (0.0080)	0.1793*** (0.0123)	0.2121*** (0.0062)	0.2358*** (0.0059)
$ln(C_{t+1})$	0.2382*** (0.0052)	0.3222*** (0.0087)	0.4331*** (0.0196)	0.4012*** (0.0091)	0.4687*** (0.0076)
$ln(P_t)$	-0.7227*** (0.0108)	-0.7028*** (0.0204)	-0.3201*** (0.0473)	-0.2911*** (0.0235)	-0.6659*** (0.0234)
$ln(P_{t+1})$	0.3315*** (0.0113)	0.3393*** (0.0213)	0.1951*** (0.0481)	0.0868*** (0.0237)	0.3414*** (0.0240)
Rational Addiction	Yes	Yes	Yes	Yes	Yes

Notes: Estimation of demand for regular soda, diet soda, apple juice, orange juice, whole milk data from IRI consumer panel using the AR(2) model (4) where A_t is calculated using (7) assuming $\delta = 0.05$. Dependent variable = $ln(C_t)$; * p<0.10, **p<0.05, ***p<0.001. All quantities in per-household terms and all regressions control for household size, household income, and year and month fixed effects. Rational addiction predicts the coefficient of A_t to be positive and less than one, P_t to be negative, and P_{t+1} to be significantly different from zero. All products show persistence in consumption and forward-looking behavior and thus rational addiction.

Table 4. Reduced Form Addictive Demand for Beverages AR(1) U.S. 2013-2018					
Dependent Variable: $ln(C_t)$	Regular Soda	Diet Soda	Apple Juice	Orange Juice	Whole Milk
$ln(A_t)$	0.6358*** (0.0038)	0.4908*** (0.0049)	0.3076*** (0.1083)	0.3029*** (0.0040)	0.3748*** (0.0041)
$ln(P_t)$	-0.6947*** (0.0090)	-0.6330*** (0.0171)	0.0945*** (0.1095)	-0.3676*** (0.0170)	-0.6911*** (0.0199)
$ln(P_{t+1})$	0.1361*** (0.0089)	0.0474*** (0.0170)	0.1610** (0.0829)	-0.0063 (0.0169)	0.0056 (0.0196)
Rational Addiction	Yes	Yes	Yes	No	No

Notes: Estimation of demand for regular soda, diet soda, apple juice, orange juice, whole milk data from IRI consumer panel using the modified AR(1) model (6) where A_t is calculated using (7) assuming $\delta = 0.05$. Dependent variable = $ln(C_t)$; * p<0.10, **p<0.05, ***p<0.001. All quantities in per-household terms and all regressions control for household size, household income, and year and month fixed effects. Rational addiction predicts the coefficient of A_t to be positive and less than one, P_t to be negative, and P_{t+1} to be significantly different from zero. Regular soda, diet soda, and apple juice show persistence in consumption and forward-looking behavior and thus rational addiction where orange juice and whole milk do not show forward-looking behavior and thus do not show rational addiction.

Table 5. Reduced Form Addictive Demand for Salty Snacks AR(1) U.S. 2013-2018			
Dependent Variable: $ln(C_t)$	Potato Chips	Tortilla Chips	Pretzels
$ln(A_t)$	0.3669*** (0.0046)	0.2486*** (0.0048)	0.2188*** (0.0057)
$ln(P_t)$	-0.5554*** (0.0133)	-0.4405*** (0.0126)	-0.3675*** (0.0160)
$ln(P_{t+1})$	0.0446*** (0.0131)	0.0326** (0.0125)	0.0400*** (0.0159)
Rational Addiction	Yes	Yes	Yes

Notes: Estimation of demand for potato chips, tortilla chips, and pretzels data from IRI consumer panel using the modified AR(1) model (6) where A_t is calculated using (7) assuming $\delta = 0.05$. Dependent variable = $ln(C_t)$; * p<0.10, **p<0.05, ***p<0.001. All quantities in per-household terms and all regressions control for household size, household income, and year and month fixed effects. Rational addiction predicts the coefficient of A_t to be positive and less than one, P_t to be negative, and P_{t+1} to be significantly different from zero. All products show persistence in consumption and forward-looking behavior and thus rational addiction.

Table 6. Reduced Form Addictive Demand for Beverages AR(1) U.S. 2013-2018 By Obesity Status						
Dependent Variable: $ln(C_t)$		Regular Soda	Diet Soda	Apple Juice	Orange Juice	Whole Milk
Normal BMI<25	$ln(A_t)$	0.6449*** (0.0077)	0.4833*** (0.0105)	0.1904*** (0.0148)	0.3211*** (0.0082)	0.3890*** (0.0083)
	$ln(P_t)$	-0.5714*** (0.0185)	-0.4130*** (0.0420)	-0.3745*** (0.0595)	-0.4195*** (0.0350)	-0.7221*** (0.0388)
	$ln(P_{t+1})$	0.1121*** (0.0184)	0.0095 (0.0418)	0.0251 (0.0590)	-0.0113 (0.0345)	0.0050 (0.0380)
	Rational Addiction	Yes	No	No	No	No
Overweight BMI 25-30	$ln(A_t)$	0.6298*** (0.0062)	0.5004*** (0.0079)	0.2569*** (0.0121)	0.3214*** (0.0063)	0.3881*** (0.0068)
	$ln(P_t)$	-0.6948*** (0.0148)	-0.5421*** (0.0296)	-0.4026*** (0.0473)	-0.3469*** (0.0271)	-0.6849*** (0.0335)
	$ln(P_{t+1})$	0.1577*** (0.0146)	0.0653** (0.0295)	0.1359*** (0.0455)	0.0040 (0.0270)	0.0338 (0.0329)
	Rational Addiction	Yes	Yes	Yes	No	No
Obese BMI>30	$ln(A_t)$	0.6324*** (0.0063)	0.4700*** (0.0079)	0.2242*** (0.2242)	0.2639*** (0.0071)	0.3490*** (0.0067)
	$ln(P_t)$	-0.7647*** (0.0142)	-0.7631*** (0.0241)	-0.4025*** -(0.4025)	-0.3620*** (0.0282)	-0.6761*** (0.0322)
	$ln(P_{t+1})$	0.1254*** (0.0142)	0.0399 (0.0240)	0.0043 (0.0043)	-0.0131 (0.0279)	-0.0250 (0.0320)
	Rational Addiction	Yes	No	No	No	No

Notes: Estimation of demand for regular soda, diet soda, apple juice, orange juice, whole milk data from IRI consumer panel using the modified AR(1) model (6) where A_t is calculated using (7) assuming $\delta = 0.05$. Dependent variable = $ln(C_t)$; * p<0.10, **p<0.05, ***p<0.001. All quantities in per-household terms and all regressions control for household size, household income, and year and month fixed effects. Average adult BMI is calculated per-household and obesity groups are assigned consistently with individual level BMI groups (CDC, 2020). Rational addiction predicts the coefficient of A_t to be positive and less than one, P_t to be negative, and P_{t+1} to be significantly different from zero. Regular soda, diet soda, and apple juice show persistence in consumption and forward-looking behavior and thus rational addiction however for diet soda and apple juice it is only in the "overweight" group. Orange juice and whole milk do not show forward-looking behavior and thus do not show rational addiction in any BMI group.