Applied Economic Perspectives and Policy (2015) volume 37, number 3, pp. 437–458.
doi:10.1093/aepp/ppu039
Advance Access publication on 26 November 2014.

Submitted Article

Revisiting the Supplemental Nutrition Assistance Program cycle of food intake: Investigating heterogeneity, diet quality, and a large boost in benefit amounts

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Submitted 31 December 2013; accepted 1 November 2014.

Abstract *The monthly cycle of daily food intake among adult participants in the Supplemental Nutrition Assistance Program is examined using data from the 2007–10 National Health and Nutrition Examination Survey. Exogenous variation in interview and benefit receipt dates provides means for identification, and a difference-in-differences specification is used to account for the large boost in benefits that began in April 2009 via the American Recovery and Reinvestment Act (ARRA). Caloric intake declined as much as 25% at the end of the month prior to ARRA, but not after implementation. Few differences were observed for diet quality measures or among subgroups. Increases in SNAP benefit amounts may help smooth food intake over the benefit month.*

Key words: SNAP cycle, Adults, Caloric intake, Diet quality, ARRA, NHANES.

JEL codes: D12, E21, I38.

Recent news articles have highlighted the idea that some participants in the Supplemental Nutrition Assistance Program (SNAP) have difficulty obtaining enough food over the benefit month. For example, midnight lines in supermarkets at the end of the month and all-day rushes on the first of the month have been described in Woonsocket, Rhode Island (Saslow 2013), North Bergen, New Jersey (Farzad 2011), and in the states of Idaho (Hopper 2011), and Virginia (Kennedy 2012). While such monthly surges in demand can be difficult for retailers to manage, a public health concern is whether such cyclic spending causes individuals to experience food insecurity or declines in diet quality near the end of the benefit month. Previous research found that from 1989–91, some SNAP participants experienced a decline in caloric intake at the end of the benefit month (Wilde and Ranney 2000;

Shapiro 2005). No previous studies have focused exclusively on adults, who may have different intake patterns than children within households, or have explored the impacts on diet quality using reported intake data.

The objective of this paper is to revisit the question of whether SNAP participants experience a cyclic pattern of food intake that is linked to when they receive their benefits; focus is placed on adults, and expanding the set of outcomes to include measures of diet quality. The SNAP program has undergone many changes since 1989–91, warranting a reexamination of the issue using more recent data. Changes in caloric intake and diet quality over the benefit month among adults aged 20 and older between 2007 and 2010 are examined. Identifying the effect of time since SNAP benefits were received is achieved by exploiting exogenous variation in the time between the day of an individual's reported food intake and the day SNAP benefits were last received. Complicating the analysis is the American Recovery and Reinvestment Act (ARRA), which increased SNAP benefits by 14% beginning in April 2009. This benefit change was immediate, and affected all SNAP households beginning on their first benefit transfer on or after April 1, 2009. This abrupt change in benefit level is modeled using a double-difference estimator, allowing the relationship between time since SNAP receipt and food intake to vary depending on whether benefits were received before or after ARRA's implementation.

Heterogeneity is explored by estimating the effect of time since SNAP was received on two subgroups of adults who may have more difficulty smoothing food intake: those with no high school degree or GED, and those living with children. The next section describes reasons for cyclicity in consumption and is followed by an overview of the SNAP program and a summary of previous research on the SNAP cycle of food intake. The data, identification strategy, and empirical approach are then presented, followed by the results. A discussion of the results and their implications conclude the paper.

Reasons for Cyclicity in Consumption

Mainstream economic theory assumes that consumers are rational, have perfect information, and have access to credit. When managing resources over time, this means that consumers will account for future needs when deciding what to consume today, and will incorporate future expected income and the interest rate into their budget constraint. This means that consumption will track average lifetime (permanent) income because individuals will borrow against future higher income during the early part of their working years, will save when income is highest, and will draw down that savings in old age. In short, consumption will be unrelated to when expected income is actually received (Friedman 1957; Hall 1978).

Empirical evidence indicates however, that in many cases individuals fail to smooth consumption over their lifetimes, and even over shorter periods of time. Of course, having income below the level necessary to meet their basic needs is one reason why households may face food shortages. Other factors include unexpected expenses, credit market failures (Zeldes 1989), and being present-biased (Hurst 2003; Aguiar and Hurst 2005; Mastrobouni and Weinberg 2009).

Factors specifically related to food shopping and consumption further complicate a household's ability to smooth intake. Grocery shopping incurs time and transportation costs, in addition to the cost of food. Also, SNAP

households may incur stigma costs when redeeming benefits. Thus, a household can reduce the total cost of food by making infrequent trips and buying in bulk to lower average unit costs to acquire food that can be stored for longer periods of time (e.g., canned, frozen, or dry foods). The increase in supercenters and club stores likely made it easier for households to purchase in bulk and shop less frequently. However, evidence suggests that having larger quantities or packages on hand may actually increase the amount consumed (Wansink 1996). Consequently, infrequent shoppers may be more likely to be low on food and money at the end of the month. Individuals with more present-biased preferences may also find it hard to manage food resources over the month. Feelings of depravation or want may then in turn affect purchase decisions upon receipt of income, which reinforces the cycle (Townsend et al. 2001).

Overview of the SNAP Program and Changes since 1989–91

The SNAP program provides a monthly benefit that can be used to purchase food that can be prepared at home.[1] Among other eligibility criteria, households must have a gross monthly income below 130% of the official poverty guideline for their family size and have a net income (income after allowable deductions) that falls below the poverty guideline.[2] Since 2005, all benefits are distributed once per month onto an Electronic Benefit Transfer (EBT) card that can be used like a debit card in retail outlets.[3] Participation in SNAP generally follows the business cycle, with a rise in the unemployment rate leading to an increase in the caseload, while improving economic conditions lead to a decline in the caseload (Klerman and Danielson 2011; Hanson and Oliveira 2012). The most recent recession is no exception—between 2006 and 2012, the number of SNAP participants increased from 26.5 million to 46.6 million people (FNS/USDA 2013). Although changes in many administrative rules have focused on increasing eligibility and access to the program, this large increase in the program caseload can mainly be explained by the sustained high unemployment rate that followed the 2007–09 recession (Ganong and Liebman 2013).

The maximum SNAP benefit is set in October, at the start of each fiscal year (FY), based on the cost of the USDA Thrifty Food Plan (TFP) in June of the same calendar year (Hanson and Andrews 2008). As food prices rise over the year, the benefit level covers less and less of the TFP food basket. Even at the start of a fiscal year, the maximum benefit is unlikely to cover the cost of the TFP, as the adjustment that occurs in October is based on June price levels. The gap between food costs and SNAP benefit amounts (or monthly shortfall) became particularly large in 2008 when food prices rose dramatically. In response to rising food prices and increased unemployment during the recession of 2007–09, the U.S. Congress included a 14% increase in the maximum SNAP benefit in ARRA, beginning in April

[1] *Most foods from grocery stores are allowable purchases, but ready-to-eat hot deli items, such as a hot rotisserie chicken, are excluded.*

[2] *Allowable deductions include 20% of earned income, a fixed standard deduction per household, dependent care, medical expenses, child support payments, and a deduction for shelter costs that exceed half of the remaining net household income.*

[3] *Prior to EBT, benefits were delivered in the form of paper coupons that could be used as tender at authorized venders. The transition to EBT began in the late 1980s, but was not complete until the end of 2005. The 2008 Farm Bill set the expiration date for any remaining paper coupons as June 17, 2009.*

2009—the start of the 3rd quarter of fiscal year (FY) 2009. The ARRA also removed annual adjustments to the maximum benefit until inflation raised the cost of the TFP to this higher benefit level. Later legislation ended the boost at the end of October 2013 (ERS 2012).

Thus, between 2007 and April 2009, SNAP benefits were below food needs (as measured by the TFP), with the gap increasing over the fiscal year as inflation reduced the real value of benefit levels. Starting in April 2009, SNAP benefit levels were, on average, above Thrifty Food Plan costs, with 1% average annual inflation during 2009 and 2010 reducing the real value slightly. This suggests that, all else being equal, a SNAP cycle in food intake would be more likely prior to April 2009, when benefit levels were lower, and less likely thereafter. Recent findings related to food security are consistent with this hypothesis. Nord and Prell (2011) found that between December 2008 and December 2009 (before and after ARRA), food spending increased and food insecurity declined in households that were income-eligible for SNAP, but among households with slightly higher income the increase in food expenditures was smaller and there was no change in food insecurity.

Since 1989–91, there have been many changes to SNAP administrative rules as well as the landscape of other assistance programs that SNAP participants are eligible to receive. The use of online applications, reduced frequency for recertification for some groups, and waiving the need for face-to-face interviews make it easier for many households to participate, which may have changed the composition of the SNAP caseload. Prior to the 1996 Personal Responsibility and Work Opportunity Act, most SNAP households contained children and also received benefits from some other means-tested cash assistance program (Klerman and Danielson 2011). However, by 2009, less than 25% of SNAP households contained children and were receiving means-tested cash assistance. Cash assistance payments are also made on a regular schedule, and depending on their alignment with SNAP payments, may either exacerbate cyclic consumption or help to smooth resource availability over the month. Thus, a reduction in the share of the SNAP caseload that also receives cash assistance may alter how intake relates to the timing of SNAP receipt.

Analysis of SNAP redemptions during FY 2009 (October 2008–September 2009) indicate that the vast majority of SNAP benefits are redeemed early in the benefit month (Castner and Henke 2011). The study found that over 50% of all benefits are redeemed by day seven in the benefit month, and less than 40% of all SNAP households have more than $1 in benefits remaining by day 21 after issuance. Comparing patterns before and after ARRA indicates that redemptions were smoother over the benefit month and participants had more SNAP transactions per month after ARRA. Thus, not only did the increase in benefits lead to a slower depletion of SNAP benefits over the benefit month, SNAP households also shopped more frequently.

Previous Research on the SNAP Cycle

Two previous empirical studies of the SNAP cycle in food intake both used data from the 1989–91 Continuing Survey of Food Intake by Individuals (CSFII) and pooled children and adults in their analyses. Wilde and Ranney (2000) found that average caloric intake, as a percentage of the Recommended Dietary Allowance, was significantly lower in the fourth week after benefits were received, but only among individuals in

households that conducted major grocery shopping once per month. They also observed that SNAP recipients were more likely to shop only once per month (42%) than low-income nonparticipants (16%). Employing an endogenous switching model where the consumer chooses both shopping frequency and food intake levels in each half of the month, Wilde and Ranney (2000) found that shopping frequency had the greatest impact on total caloric intake and its evolution over the month among SNAP recipients. These authors argued that the stigma associated with redeeming the old paper food stamps and longer distances to grocery stores reduced shopping frequency among recipients. Wilde and Ranney suggested that the transition to EBT cards, which was underway in 1989–91 but not yet complete, would lessen the stigma associated with redeeming benefits, likely increasing shopping frequency and reducing the cyclicity of daily caloric intake.

Shapiro (2005) used a different approach with the same CSFII data to examine how the time since benefit receipt affects caloric intake. He regressed the log and level of caloric intake on the number of days since SNAP benefits were received and found that each additional day since receipt decreased caloric intake between 0.3–0.4% (about 8 calories per day). Shapiro also used data from the 1987–88 Nationwide Food Consumption Survey to investigate how the time since receipt of benefits affected the total value of food consumed, and found that the dollar value of intake declined by 0.7% each day after benefits were received. He thus concluded that recipients switched from higher quality/cost foods early in the month to lower quality/cost foods later in the benefit month. Shapiro also estimated the relationship between time since SNAP receipt and caloric intake separately for weekly, biweekly, and monthly shoppers. In contrast to Wilde and Ranney, Shapiro found that declines in caloric intake were greater among those that shopped once per week or more frequently compared to those that shopped biweekly or monthly. Overall, Shapiro estimated that the monthly food consumption path was consistent with quasi-hyperbolic discounting, and that since such cyclic consumption is sub-optimal, the consumer's utility would be increased if he/she could prevent overconsumption at the beginning of the month.

Revisiting the question of whether or which SNAP participants experience cyclic food intake related to when they receive their benefits is warranted given that these two studies used data from a much earlier period—when SNAP was operating under much different rules—and that their findings somewhat contrasted. Both studies only compared estimates across households with different frequencies of major grocery shopping and neither study examined the effect on diet quality.

Data and Identification

The National Health and Nutrition Examination Survey (NHANES) is a continuous survey that collects detailed information about individual health outcomes and other individual and household characteristics. The data are released in two-year cycles, and each two-year data release is weighted to be nationally representative. The data are collected through a number of instruments, generally in the following order: a household survey, a physical exam and questionnaire in a Mobile Examination Center (MEC), and various follow-up phone questionnaires. The time between each of these components varies across individuals.

One day of dietary intake is collected via a recall survey at the time of the physical exam in the MEC. A second day of dietary intake is collected through a follow-up phone survey, usually within 10 days of the MEC exam.[4] Individuals report the type and amount of food consumed the previous day, at what time it was consumed, and from where each food was obtained. The public release data include the total quantity (in grams), caloric value, and the quantity of other micro and macro nutrients for each food, as well as totals for the day. A supplementary data file, the Food Patterns Equivalents Database (FPED), provides the quantity of food groups, such as cup or ounce equivalents of fruit, vegetables, protein, and other food groups contained in each food item reported in NHANES. Merging the FPED to the NHANES dietary intake data allows for the construction of the 2010 Healthy Eating Index (HEI-2010) score, which measures how well individuals meet the *2010 Dietary Guidelines* recommendations (Guenther, Casavale, Reedy, et al. 2013).

Information about SNAP participation is collected at the time of the household interview. Beginning with the 2007–08 cycle, the Flexible Consumer Behavior Survey (a supplementary set of questions included in NHANES) asked households when they last received SNAP benefits.[5] Because SNAP benefits are distributed at the same time each month to participant households, households that report having received SNAP within 30 days of the household interview are classified as current SNAP households. The sample is restricted to adults (age 20 and older) in current SNAP households. Individuals that did not provide reliable day-one intake data, women that are pregnant or lactating, as well as those with incomplete data on household income, body size, or activity level are also excluded. The final sample consists of 1,480 individuals.

Identification

Identifying the effect of time since SNAP benefits were received requires exogenous variation in this measure. Each SNAP household[6] receives the monthly SNAP benefit on the same day each month. The SNAP program rules allow states to set their own distribution schedule. Some states deliver benefits to all program participants on the same day each month, but many states have elected to stagger distribution. Staggering entails dividing the roster into groups (e.g., by the first letter of the last name) and distributing benefits to only one group of beneficiaries each day. The result is that distribution schedules vary across states, and across SNAP recipient households within most states. Moreover, distribution schedules have changed over time within states, most notably in recent years. The SNAP distribution schedules between 2007 and 2010 are reported in table A.1. More than half of all states staggered distribution over a period of seven days or more, while 7 or 8 states distributed over a period of 3 to 5 days, and 9 or 10 distributed on a single day each month.

[4]*Beginning in 2002, the dietary intake component of the CSFII was merged with NHANES.*

[5]*These data were released with the food security module data, measured as the days since receipt to prevent disclosing NHANES interview dates in the public-use file.*

[6]*Some households contain multiple SNAP units, where eligibility and benefits amounts are determined separately for subgroups of the household. However, multiple SNAP units are not identified in NHANES and only one receipt date is collected.*

This variation in SNAP distribution schedules both across and within states, paired with variation in interview dates in NHANES, allows for identification of the effect of time since benefits were received. Shapiro (2005) employs a similar identification method to study the effect of time since SNAP was received on consumption. Even if everyone reported dietary intake for the exact same day each month, the across and within-state variation in benefit delivery would provide some exogenous variation in time since benefits were received to identify the effect. Since selection into the NHANES sample and interview dates are not related when a household receives SNAP, there is also exogenous variation in interview dates, thus strengthening the identification approach.

To determine the time since SNAP benefits were received for each individual in the sample, access to actual interview dates—for the household interview and for each of the dietary intake days—was obtained through a restricted access agreement with the National Center for Health Statistics (NCHS), which merged data compiled from the Food and Nutrition Service on the state SNAP distribution schedules for the year and month of each household interview. The date that SNAP was last reported received for each individual's household was determined using the household interview date and the reported time since SNAP was last received. This calculated receipt date was cross-checked with the known SNAP distribution schedule. More than 85% of the SNAP receipt dates match with the known distribution schedule, which indicates that individuals report this information fairly accurately.

The calculated SNAP receipt date is used to determine the number of days between when SNAP was last received and the first day of dietary intake. There are some cases where the time between SNAP receipt and the intake day is greater than 30 days. When this occurs, it is assumed that they remained a SNAP participant and received SNAP on the same date the following month before calculating the number of days between last SNAP receipt and the dietary intake day. For example, if a household responded to the household interview on June 20th and reported having received SNAP 15 days before the household interview, SNAP is first calculated as being last received on June 5th. If the individual reported the first day of intake for July 10th (more than 30 days after June 5th), it is assumed they also received SNAP on July 5th and the time since SNAP was last received is calculated to be five days. Such calculated SNAP days are noted as being "adjusted" and as a robustness check (discussed below) the model is estimated when these observations are excluded. The SNAP receipt dates on or after April 2009 are considered to be in the ARRA period.

Sample Characteristics and Dependent Variables

Table 1 reports the means of individual and household characteristics, variables describing the time since SNAP was last received, and whether the last SNAP receipt was in the ARRA period. Mean age is 41 years, 59% are female, 47% identify themselves as non-Hispanic white, 25% as non-Hispanic Black, and 22% as Hispanic. Less than half (44%) are married, 46% did not complete high school or a GED, 26% report having at least some college education, and 7% report being on a low-calorie or weight-loss diet. Mean body weight is 84.8 kg (187 lbs) and average height is 167 cm (or 5′ 6″); an individual with that height and weight would have a BMI of 30.2,

Table 1 Summary of Demographic Characteristics and Dependent Variables, Current SNAP Recipients, Adults (age 20+), 2007–2010 NHANES

	Mean/share	SE
Age	41.52	(0.58)
Male	0.41	(0.01)
White	0.47	(0.06)
Black	0.25	(0.03)
Hispanic	0.22	(0.04)
Other race	0.05	(0.01)
Married†	0.44	(0.02)
no High School diploma or GED	0.46	(0.02)
High school education	0.28	(0.02)
Some college or more	0.26	(0.02)
On low-calorie or weight-loss diet	0.07	(0.01)
Weight (kg)	84.84	(1.07)
Height (cm)	166.77	(0.39)
Usual minutes of moderate exercise per day†	140.46	(7.92)
HH size	3.75	(0.10)
HH income to poverty ratio	1.04	(0.04)
HH received WIC in past 12 months	0.27	(0.02)
Major food shopping weekly or more frequent	0.42	(0.03)
Major food shopping biweekly	0.27	(0.02)
Major food shopping monthly	0.31	(0.02)
Days since SNAP received	13.76	(0.41)
Intake day was in first 2 days since SNAP received	0.09	(0.01)
Intake day was in last 2 days since SNAP received	0.04	(0.01)
Last SNAP received was after ARRA implementation	0.48	(0.07)
Dependent variables		
Calories consumed on intake day	2,094.69	(35.26)
Calories as a percentage of EER	87.39	(1.61)
Calories a percentage of EER<50	0.17	(0.01)
Reported eating more than usual	0.07	(0.01)
Reported eating less than usual	0.27	(0.02)
Number of eating occasions	4.66	(0.06)
HEI-2010 score	44.77	(0.71)
Total cups of vegetables consumed	1.43	(0.05)
Total cups of whole fruit consumed	0.46	(0.03)
Total ounces of protein foods consumed	6.29	(0.19)
Observations	1480	

Notes: Weighted means reported; † indicates vigorous activity converted to moderate activity by multiplying by 2; EER = Estimated Energy Requirement, calculated using formula from formulae for men and women in Dietary Reference Intakes *(IOM 2006) using height, weight, age, and usual physical activity collected in the Physical Activity questionnaire in NHANES.*

which is above the obesity threshold. Individuals report about 140 minutes of moderate exercise per day (which includes work-related activities). Mean household size is 3.75 members and average income is just above the poverty line. Less than one-third of the households receive WIC. Grocery shopping is conducted biweekly or more often in 69% of the households, and 31% report that major grocery shopping occurs only once per month (less than the 42% found by Wilde and Ranney (2000) in the 1989–91 CSFII).

Mean time since SNAP was last received is about 14 days, with 9% having received their benefits 2 or fewer days prior to the dietary intake

day, and 4% are expected to receive SNAP within 2 days of the dietary intake day. To confirm the exogeneity of the days since SNAP was received, each of the characteristics in table 1, and indicators for whether the intake day was a Friday or a weekend (Saturday/Sunday) were regressed on the days since SNAP was received. None of the characteristics was statistically significant at conventional levels ($p < 0.05$, results available upon request).

The means of the dependent variables are also reported in table 1. Average daily intake is 2,094 calories, corresponding to 87% of Estimated Energy Requirements (EER). Each individual's EER was calculated according to the formulae for men and women in *Dietary Reference Intakes* (IOM 2006) using height, weight, age, and usual physical activity collected in the Physical Activity questionnaire. The fact that caloric intake is below EER among adults may be due to underreporting (Briefel et al. 1997), but also in part because 7% report being on a low-calorie or weight-loss diet. In addition, 7% of adults reported that their intake on the day was more than usual, while 27% reported that it was less than usual, and 17% of individuals had reported intake that was less than 50% of EER on the intake day. Adults reported an average of 4.7 eating occasions (defined uniquely by time of consumption). Zizza et al. (2008) found that although caloric intake was not lower among food insecure adults, eating patterns were different. Overall diet quality is measured by the HEI–2010, with a sample mean of 45. For the whole population, adults and children combined, the mean HEI–2010 score was 53.5 in 2007–08 (Guenther, Casavale, Kirkpatrick, et al. 2013). Because the HEI score is a density measure in which intake is normalized by caloric intake, total intake of three food groups—vegetables, fruit, and protein—are also examined. The first two are measured as cup-equivalents, and protein is measured in ounce-equivalents, corresponding to quantity unit recommendations in the Dietary Guidelines.

Empirical Approach

The empirical approach is straightforward. Individuals are assumed to consume food at a level that meets their caloric needs over time (which is determined by body size, activity level, and weight-change goals), as well as social norms and customs associated with food intake, subject to available resources for food. For example, food intake may be higher than average on weekends or holidays because the food becomes part of the activities or customs of that day. Because food stocks must be replenished periodically, available resources may vary over the course of the month. For example, unexpected expenses or lower income (due to illness or unemployment) may reduce available resources at some point in the month.

Previous research on the SNAP cycle has focused on whether there is a decline in intake over the course of the month, or only at the end of the month. This is done by estimating the linear relationship between caloric intake and time since benefits were received, or testing for whether intake in the last week of the month is significantly lower than the rest of the month (Parke and Wilde 2000; Shapiro 2005). Surges in consumption at the beginning of the month, which would be consistent with a feast and famine cycle, are also tested for.

Specifically, the model below is estimated for each of the dependent variables:

$$y_i = \beta_1 * SNAPdays_i + \beta_2 * ARRA_i + \beta_3 * (SNAPdays_i * ARRA_i), + \theta \mathbf{X}_i + \alpha \mathbf{D}_i + \delta \mathbf{Y}_i + \varepsilon_i \quad (1)$$

where SNAPdays is the number of days since SNAP was received for individual *i*, and ARRA indicates whether the last SNAP benefit was received on or after April, 1, 2009. Further, β_1 estimates the effect of an additional day since SNAP was received on the outcome variable, β_2 estimates the difference in means of the outcome between the periods before and during the ARRA boost in benefits, and β_3 estimates the additional effect of SNAPdays on the outcome in the ARRA period. Thus, the net effect of SNAP days in the ARRA period is given by $\beta_1 + \beta_3$. The full set of individual and household characteristics listed in table 1 is included in X, D is a set of indicators specific to the intake day (including whether the day was a Friday, or a weekend day (Saturday or Sunday)[7], Y is a set of year dummies, and ε is an individual error term. Although the SNAPdays measure is exogenous to the dependent variables, including control variables associated with intake can improve precision.

Two other specifications are also estimated. First, SNAPdays and its interaction with the ARRA indicator are replaced by two indicators for being in the first or last two days of the benefit month (first2, last2) and their respective interactions with the ARRA indicator. The indicator for whether SNAP was received on or the day before the dietary intake allows for testing for the presence of SNAP receipt feast days. A third specification replaces last2 and its interaction with ARRA with an indicator for the last week (the final 7 days) of the SNAP benefit (lastweek), and its interaction with the ARRA indicator.

For log calories, calories as a percentage of EER, the number of eating occasions in the day, and the HEI-2010 score, the models are estimated using OLS. For the binary indicators (ate more or less than usual, and intake was less than 50% of EER), probit regressions are used, and for the dietary components (vegetables, whole fruit, and protein), negative binomial regressions are used. Weights are used in all regressions, and standard errors are adjusted to account for the complex sampling design.

Results

The results for total calories, calories as a percentage of EER, the number of eating occasions in the day, and the HEI-2010 score are reported in table 2. The three specifications described above are reported (full results for the linear model are available in the appendix), and an additional specification (the linear model with no additional controls) is presented first for log calories. Each outcome variable is discussed in turn.

In the first specification for log calories (linear with no controls), the coefficient on SNAPdays is negative, but not statistically significant, while the coefficients on the ARRA indicator and its interaction with SNAPdays are positive, but also not statistically significant. Including the demographic and other controls has no effect on the estimated coefficient for SNAPdays

[7] *Indicators for the intake day being a holiday were also tested, but there were too few holidays observed in the data to make this empirically feasible.*

Table 2 Estimated Effect of Time since SNAP Received on Log Daily Calories, Daily Calories as a Percentage of EER, Number of Eating Occasions per Day, and Daily HEI-2010 Score, Adults

	log calories		% EER	# eating occasions	HEI-2010
(1)	no controls	w/ controls	w/controls	w/controls	w/ controls
SNAP days	−0.004	−0.003	−0.192	−0.017**	−0.090**
	(0.003)	(0.003)	(0.189)	(0.006)	(0.033)
ARRA	0.018	−0.084	−6.382	−0.033	2.075
	(0.066)	(0.062)	(5.750)	(0.154)	(1.861)
ARRA*SNAP days	0.006	0.005	0.435	0.018	0.028
	(0.005)	(0.005)	(0.454)	(0.011)	(0.073)
SNAP days + (Post *SNAP days)		0.003	0.243	0.001	−0.062
R-squared	0.013	0.177	0.114	0.057	0.118
(2)					
First 2 days in SNAP month		−0.047	−3.925	−0.132	2.159
		(0.090)	(7.658)	(0.277)	(2.009)
Last 2 days in SNAP month		−0.384***	−25.793***	−0.467	3.927
		(0.091)	(5.976)	(0.288)	(2.804)
ARRA		−0.036	−2.891	0.126	2.817
		(0.054)	(5.724)	(0.204)	(1.836)
ARRA*first 2		0.061	12.515	0.241	−4.753
		(0.149)	(13.261)	(0.401)	(2.948)
ARRA*last 2		0.525***	40.549***	0.320	−7.626**
		(0.103)	(9.237)	(0.378)	(3.376)
Last 2 + (post*last 2)		0.142**	14.756*	−0.147	−3.699**
R-squared		0.188	0.123	0.055	0.120
(3)					
First 2 days in SNAP month		−0.032	−3.199	−0.212	1.862
		(0.088)	(7.793)	(0.272)	(2.083)
Last 7 days in SNAP month		−0.013	−2.319	−0.458***	−0.453
		(0.044)	(4.043)	(0.130)	(1.204)
ARRA		−0.055	−5.254	0.055	3.311*
		(0.046)	(4.961)	(0.191)	(1.942)
ARRA*first 2		0.065	13.791	0.344	−4.943
		(0.140)	(12.754)	(0.396)	(2.982)
ARRA* last 7		0.170*	19.770**	0.584**	−3.864*
		(0.086)	(7.302)	(0.274)	(2.134)
Last 7 + (post*last 7)		0.157**	17.451***	0.126	−4.317***
R-squared		0.181	0.123	0.059	0.123
Observations	1480	1480	1480	1480	1480

*Notes: Complex survey design accounted for in regressions. Additional controls include individual and household characteristics listed in table 1 and indicators for whether the intake day was a Friday or a weekend (Saturday or Sunday), and year dummies. Asterisk * indicates $p < 0.10$, ** indicate $p < 0.05$, and *** indicate $p < 0.01$.*

or the interaction of ARRA with SNAPdays. The estimated coefficient on the ARRA indicator changes sign when the controls are added (but remains statistically insignificant), likely reflecting the fact that the composition of the SNAP caseload changed slightly as a result of the recession and the ARRA boost to benefit levels (USDA/FNS 2012; Wolkwitz and Leftin 2008). Because including the additional controls can improve efficiency and reduce standard errors, the rest of the results reported are from models where the control variables are included.

The model that tests for two-day feast and famine periods (specification 2) shows that prior to ARRA, caloric intake declined by about 38% relative to the rest of the month, but that in the ARRA period, intake may have risen by about 14% in the final two days of the benefit month. This ARRA drop in intake appears to be concentrated in the final days of the month, as the estimated decline in intake for the last seven days of the month (specification 3) falls to 1.3%, and is no longer statistically significant. However, the boost in caloric intake in the ARRA period is observed for the entire last week of the month.

The estimated effects for caloric intake as a percentage of EER are similar to those for log calories. Intake measured as a percentage of EER is 25 percentage points lower in the last 2 days of the month in the pre-ARRA period (but not in the final week of the benefit month), and 14 percentage points higher in the ARRA period. Intake is also higher in the last week of the month in the ARRA period, by about 17 percentage points.

In contrast to caloric intake, the number of eating occasions declines with each day since SNAP was received (by 0.02 per day) or about 0.5 per day in the last week of the benefit month, but only prior to ARRA. The HEI-2010 score also declines over the benefit month in the pre-ARRA period, by about 0.09 points per day. Although the linear model does not show a significant decline in HEI score during the ARRA period, the score is 3.7 points lower in the final two days of the benefit month and 4.3 points lower in the last week of the benefit month during ARRA—declines of 8% and 10% relative the mean score in the sample, respectively.

The estimated marginal effects at the sample mean for the binary indicators (ate more or less than usual and intake $<$50% of EER) and the quantity of fruit, vegetables, and protein consumed, from specification 2 are presented in table 3. The effect on the self-reported evaluations of intake are consistent with the estimated effects on total calories and percentage of EER. The probability of eating less than usual is nearly 17 percentage points higher in the final days of the SNAP benefit month prior to ARRA, but not during the ARRA periods. Moreover, the probability that intake is less than 50% of EER was nearly 29 percentage points higher in the final two days of the benefit month before ARRA, and this was cut in half during the ARRA period. There appears to be no cyclic intake in quantity of vegetables or fruit consumed, but protein declined an average of 2.2 ounces per day in the final two days of the benefit month prior to ARRA. This drop does not occur after ARRA, and intake appears to even increase at the end of the month, which is consistent with research that finds low-income mothers with children prioritize meat when food shopping (Wiig and Smith 2009).

Robustness Checks

To test the robustness of the results, specification 2 is estimated when those on a weight-loss or low-calorie diet are excluded, and also when

Table 3 Estimated Marginal Effects on Binary Intake Outcomes and Components of Diet Quality, Estimated at Sample Means

	Ate more than usual	Ate less than usual	Caloric intake <50% EER	Total cups of vegetables	Total cups of whole fruit	Total ounces of protein
First 2 days in SNAP month	−0.00003	0.01885	0.04069	0.00244	0.19276	−0.45007
	(0.052)	(0.086)	(0.042)	(0.154)	(0.232)	(0.886)
Last 2 days in SNAP month	−0.02238	0.16847**	0.28750***	−0.15006	−0.07268	−2.1696***
	(0.026)	(0.085)	(0.087)	(0.285)	(0.087)	(0.785)
ARRA	−0.05334	0.03261	0.00059	−0.10633	0.32553***	−1.3156**
	(0.037)	(0.059)	(0.029)	(0.126)	(0.104)	(0.624)
ARRA*first 2	0.03451	0.00485	0.02527	−0.22641	−0.24040***	0.97989
	(0.099)	(0.105)	(0.071)	(0.202)	(0.081)	(1.530)
ARRA * last 2	−0.00145	−0.21052***	−0.13590***	0.98100	−0.01603	4.73850*
	(0.063)	(0.059)	(0.017)	(0.689)	(0.210)	(2.791)
Observations	1,480	1,480	1,480	1,480	1,480	1,480

*Notes: Complex survey design accounted for in regressions. Probit regression used for binary outcomes, negative binomial regression used for diet quality measures. Additional controls include individual and household characteristics listed in table 1 and indicators for whether the intake day was a Friday or a weekend (Saturday or Sunday), and year dummies; EER = Estimated Energy Requirement. Asterisk * indicates $p < 0.10$, ** indicate $p < 0.05$, and *** indicate $p < 0.01$.*

excluding those with an adjusted SNAPdays measure (table 4). When excluding weight-loss dieters from the sample, the decline in the number of eating occasions in the last two days of the benefit month is statistically significant, at 0.6 fewer occasions per day before ARRA. All other effects are similar in magnitude and significance. When excluding all observations with an adjusted SNAPdays measure, all estimated effects become larger in magnitude, but significance levels remain the same. This suggests that measurement error in SNAPdays biased the estimated effects from the full sample downward.

Subgroup Analyses

Individuals with present-biased preferences may have more difficulty smoothing consumption over the benefit month. Since the NHANES survey does not collect any information than can be used to estimate or measure time preferences directly, education level is used as a proxy, since education and patience tend to be correlated, in part because obtaining education requires some patience, but also that education may teach patience (Becker and Mulligan 1997). Specification 2 is estimated on the subgroup of adults that have not completed high school or a GED (table 5, upper panel). Just as with the full sample, caloric intake (logged and percentage of EER) is estimated to decline in the last two days of the month in the pre-ARRA period. However, there is no significant boost in caloric intake at the end of the benefit month in the ARRA period, instead the decline in intake is no longer statistically significant. There is no significant effect on the number of eating occasions or on the HEI score for this subgroup.

The food insecurity literature suggests that in households with children, adults will protect the food consumption of children by cutting back on their own intake (Coleman-Jensen et al. 2013). Specification 2 is estimated for the subgroup of adults that live with children aged under 18 (table 5, lower panel).[8] Similar to the low-education sample, caloric intake declines in the last two days of the benefit month prior to ARRA, and there is no boost to intake in the ARRA period. One difference with this group is that diet quality was higher in the first two days of the benefit month prior to ARRA.

Discussion and Implications

Previous research found that SNAP participants experience cyclic food intake, with rather large declines in caloric intake over the course of the benefit month, or sharply at the end of the month. The conversion to EBT cards to deliver and redeem benefits was expected to help reduce cyclic consumption, perhaps by reducing the level of stigma associated with the program and encouraging more frequent shopping. Although this paper did not directly test the effect of the change from paper coupons to EBT redemptions, the results indicate that SNAP participants continue to experience cyclic food intake despite the national use of EBT cards. The decline in intake is concentrated in the final days of the benefit month, rather than occurring over a week or spread evenly over the month, and many SNAP-participating adults consume well below their energy requirements

[8] *There is no direct measure of the presence of children in the household in the NHANES survey. Households with children under age 18 are identified using the child food insecurity measure, which is missing for all individuals that do not live with children under age 18.*

Table 4 Robustness Checks on Calories, Eating Occasions, and Diet Quality

	Log daily calories	Calories as percentage of EER	Number of eating occasions	HEI-2010
Excluding weight-loss dieters				
First 2 days in SNAP month	−0.079	−6.466	−0.294	1.252
	(0.099)	(8.627)	(0.261)	(2.021)
Last 2 days in SNAP month	−0.405***	−27.496***	−0.600**	3.127
	(0.097)	(6.465)	(0.284)	(2.909)
ARRA	−0.043	−3.061	0.165	2.796
	(0.058)	(6.090)	(0.209)	(2.026)
ARRA*first 2	0.147	18.688	0.339	−4.807
	(0.149)	(14.426)	(0.337)	(3.004)
ARRA*last 2	0.565***	43.227***	0.495	−6.917*
	(0.104)	(9.790)	(0.381)	(3.751)
Last 2 + (post*last 2)	0.160***	15.731**	−0.105	−3.791*
R-squared	0.180	0.111	0.057	0.103
Observations	1,377	1,377	1,377	1377
Unadjusted SNAP days				
First 2 days in SNAP month	0.115	9.355	−0.451	−0.654
	(0.150)	(11.608)	(0.479)	(3.825)
Last 2 days in SNAP month	−0.481***	−34.437***	−0.699**	4.348
	(0.095)	(6.802)	(0.259)	(3.531)
ARRA	−0.062	−7.328	−0.358	−1.309
	(0.084)	(7.978)	(0.330)	(2.485)
ARRA*first 2	0.059	9.291	−0.120	−2.679
	(0.228)	(24.286)	(0.564)	(4.727)
ARRA*last 2	0.622***	48.215***	0.505	−8.257*
	(0.112)	(10.542)	(0.387)	(4.130)
Last 2 + (post*last 2)	0.140**	13.778	−0.194	−3.909**
R-squared	0.216	0.169	0.065	0.120
Observations	753	753	753	753

*Notes: Complex survey design accounted for in regressions. Additional controls include individual and household characteristics listed in table 1 and indicators for whether the intake day was a Friday or a weekend day (Saturday or Sunday), and year dummies; EER = Estimated Energy Requirement. Asterisk * indicates $p < 0.10$, ** indicate $p < 0.05$, and *** indicate $p < 0.01$.*

at the end of the benefit month. The 14% increase in benefits from ARRA eliminated the end-of-the month decline in caloric intake for the full sample. This suggests that resources, and/or the ability to budget those resources appropriately, are major factors affecting SNAP participants' ability to meet their food needs. There is some evidence that those with present-biased time preferences may still struggle to manage their food resources over the month.

The slight decline in the number of eating occasions suggests that part of the decline in intake could be from skipping meals, but is most likely due to lower overall intake at each eating occasion. There is also some evidence of a decline in diet quality at the end of the benefit month, but this is mainly

Table 5 Estimated Effects on Calories, Eating Occasions, and Diet Quality for Low-education Adults and Adults Living with Children

	Log daily calories	Calories as percentage of EER	Number of eating occasions	HEI-2010
No High School degree or GED				
First 2 days in SNAP month	0.098	5.553	−0.076	4.863
	(0.117)	(8.643)	(0.532)	(3.182)
Last 2 days in SNAP month	−0.336**	−24.750**	−0.310	6.856
	(0.155)	(10.465)	(0.438)	(4.965)
ARRA	0.063	0.333	0.375	3.792
	(0.062)	(4.743)	(0.281)	(2.506)
ARRA*first 2	−0.016	12.869	−0.107	−4.198
	(0.218)	(22.823)	(0.596)	(4.355)
ARRA*last 2	0.149	18.491	−0.425	−9.650*
	(0.268)	(22.010)	(0.725)	(5.453)
Last 2 + (post*last 2)	−0.186	−6.259	−0.735	−2.794
R-squared	0.187	0.156	0.059	0.174
Observations	723	723	723	723
Living with children				
First 2 days in SNAP month	−0.006	−3.060	0.092	3.864*
	(0.068)	(5.321)	(0.281)	(2.000)
Last 2 days in SNAP month	−0.410***	−24.977***	−0.110	3.699
	(0.110)	(7.429)	(0.354)	(3.118)
ARRA	0.024	2.332	0.149	3.121*
	(0.065)	(6.124)	(0.236)	(1.835)
ARRA*first 2	0.128	18.244	0.198	−7.547**
	(0.130)	(12.579)	(0.457)	(3.269)
ARRA*last 2	0.452***	29.224**	0.199	−5.398
	(0.137)	(11.564)	(0.384)	(3.510)
Last 2 + (post*last 2)	0.042	4.247	0.088	−1.699
R-squared	0.206	0.122	0.053	0.124
Observations	921	921	921	921

*Notes: Complex survey design accounted for in regressions. Additional controls include individual and household characteristics listed in table 1 and indicators for whether the intake day was a Friday or a weekend day (Saturday or Sunday), and year dummies; EER = Estimated Energy Requirement. Asterisk * indicates $p < 0.10$, ** indicate $p < 0.05$, and *** indicate $p < 0.01$.*

observed in the ARRA period, when caloric intake is not falling. Thus, despite greater benefits, SNAP participants may still have difficulty smoothing consumption over the benefit month, substituting calories for quality when resources are limited. Consistent with other research that suggests that low-income households prioritize meat consumption, a 35% decline in protein intake in the final two days of the benefit month was observed in the pre-ARRA period. During ARRA, protein intake was not lower at the end of the month, lending further support to the fact that low-income consumers prioritize meat intake.

The results are robust to the sample composition, but measurement error in the time since SNAP was last received likely biased the estimates downward. Subgroup analysis suggests that the effects are similar across education levels and households with and without children. More precise estimates for subgroups could be obtained once more cycles of the NHANES data become available with measures of time since SNAP was received.

Now that the ARRA-induced benefit boost has been eliminated, it is likely that SNAP recipients are again experiencing a monthly cycle in caloric intake. Nord (2013) found that the decline in the real value of SNAP benefits between 2009 and 2011 leads to an increase in food insecurity among SNAP-recipient households. Given that food prices are positively correlated with demand throughout the month (Hastings and Washington 2010), the increase in the number of states that are choosing to stagger distribution and do so over a longer period should help lower food prices for consumers at the time that they receive their benefits. However, if household budgeting and an overall shortfall in resources are the main reasons for cyclic intake, changes in distribution schedules will have little effect.

Splitting benefit payments to households in a month—a policy expressly limited in the 2008 Farm Bill—could help some households to smooth their food resources and intake. Allowing SNAP participants to choose whether to receive a single payment each month or to receive split payments could improve smoothing for those that have difficulties while limiting negative effects on those households that are able to smooth consumption well given the current system. Shapiro (2005) estimated that the benefit to participants of split payments would not cover the increased program costs. However, his calculations used costs from Maryland in 1993, the first year that EBT cards were used statewide to deliver SNAP benefits. Technological changes over the past 20 years may have lowered the costs associated with delivering benefits through EBT cards. The feasibility of splitting the monthly benefit, accounting for the value to participants and the increased administrative costs, could be revisited.

Regardless of whether or not a change in payment frequency occurs, the results suggest that SNAP participants may benefit from receiving help in household budgeting, particularly with respect to food, a suggestion also made by the IOM and NRC (IOM and NRC 2013). The nutrition education component of SNAP (SNAP-Ed) covers such topics and has been expanding in recent years. In 1992, the program operated in only seven states, with federal outlays totaling just over $661,000. All 50 states had dedicated SNAP-Ed budgets by 2007, and in fiscal year 2009, total federal funding was $341 million (half of SNAP-Ed expenditures). Future research could investigate whether SNAP-Ed helps households manage their SNAP benefit—and other resources—better to smooth consumption over the benefit month.

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Appendix

Table A.1 State-level SNAP Distribution Schedules, 2007–2010

	2007		2008		2009		2010	
State	**First day**	**Last day**	**First day**	**Last day**	**First day**	**Last day**	**First day**	**Last day**
Alabama	4	18	4	18	4	18	4	18
Alaska	1	1	1	1	1	1	1	1
Arizona	1	13	1	13	1	13	1	13
Arkansas	4	13	4	13	4	13	4	13
California	1	10	1	10	1	10	1	10
Colorado	1	10	1	10	1	10	1	10

Continued

Table A.1 *Continued*

State	2007		2008		2009		2010	
	First day	Last day	First day	Last day	First day	Last day	First day	Last day
Connecticut	1	3	1	3	1	3	1	3
Delaware	5	11	5	11	5	11	5	11
District of Columbia	1	10	1	10	1	10	1	10
Florida	1	15	1	15	1	15	1	15
Georgia	5	14	5	14	5	14	5	14
Hawaii	1	5	1	5	1	5	1	5
Idaho	1	5	1	5	1	1	1	1
Illinois	1	23	1	23	1	23	1	23
Indiana	1	10	1	10	1	10	1	10
Iowa	1	10	1	10	1	10	1	10
Kansas	1	10	1	10	1	10	1	10
Kentucky	1	10	1	10	1	10	1	10
Louisiana	5	14	5	14	5	14	5	14
Maine	10	14	10	14	10	14	10	14
Maryland	6	15	6	15	6	15	6	15
Massachusetts	1	14	1	14	1	14	1	14
Michigan	1	9	1	9	1	9	3	21
Minnesota	4	13	4	13	4	13	4	13
Mississippi	5	19	5	19	5	19	5	19
Missouri	1	22	1	22	1	22	1	22
Montana	2	6	2	6	2	6	2	6
Nebraska	1	5	1	5	1	5	1	5
Nevada	1	1	1	1	1	1	1	1
New Hampshire	5	5	5	5	5	5	5	5
New Jersey	1	5	1	5	1	5	1	5
New Mexico	1	20	1	20	1	20	1	20
New York Upstate	1	9	1	9	1	9	1	9
New York City	1	15	1	15	1	15	1	15
North Carolina	3	12	3	12	3	12	3	12
North Dakota	1	1	1	1	1	1	1	1
Ohio	1	10	1	10	1	10	1	10
Oklahoma	1	1	1	1	1	1	1	10
Oregon	1	9	1	9	1	9	1	9
Pennsylvania	4	17	2	12	2	14	1	14
Rhode Island	1	1	1	1	1	1	1	1
South Carolina	1	10	1	10	1	10	1	10
South Dakota	10	10	10	10	10	10	10	10
Tennessee	1	10	1	10	1	10	1	10
Texas	1	15	1	15	1	15	1	15
Utah	5	15	5	15	5	15	5	15
Vermont	1	1	1	1	1	1	1	1
Virginia	1	1	1	1	1	1	1	1
Washington	1	10	1	10	1	10	1	10
West Virginia	1	9	1	9	1	9	1	9
Wisconsin	2	15	2	15	2	15	2	15
Wyoming	1	4	1	4	1	4	1	4

Notes: Highlighted rows indicate a change at some point between 2007 and 2010.

Table A.2 Full Results from Linear Model, Reported in Table 2, Panel (1) with Controls

	Log calories	Calories as % EER	Eating occasions	HEI-2010
SNAP days	−0.003	−0.192	−0.017**	−0.090**
	(0.003)	(0.189)	(0.006)	(0.033)
ARRA	−0.084	−6.382	−0.033	2.075
	(0.062)	(5.750)	(0.154)	(1.861)
ARRA*SNAP days	0.005	0.435	0.018	0.028
	(0.005)	(0.454)	(0.011)	(0.073)
Age	−0.005***	−0.142*	0.006	0.216***
	(0.001)	(0.080)	(0.004)	(0.025)
Male	0.246***	0.099	−0.415***	−0.238
	(0.031)	(3.621)	(0.145)	(1.118)
Black	0.023	4.011	−0.463***	1.242
	(0.038)	(3.628)	(0.160)	(1.010)
Hispanic	0.018	0.244	−0.051	4.637***
	(0.037)	(2.999)	(0.146)	(1.471)
Other race/ethnicity	0.047	5.670	0.087	3.448*
	(0.083)	(8.997)	(0.345)	(1.746)
On weight-loss diet	−0.230***	−16.629***	−0.079	4.451**
	(0.049)	(3.024)	(0.165)	(2.037)
Weight (kg)	−0.000	−0.486***	−0.006***	−0.013
	(0.001)	(0.080)	(0.002)	(0.016)
Height (cm)	0.004	0.161	0.023**	−0.094
	(0.002)	(0.232)	(0.010)	(0.070)
Minutes of moderate exercise	0.000***	−0.004	0.000	0.002
	(0.000)	(0.004)	(0.000)	(0.002)
Household income to poverty	0.055***	1.684	0.239***	0.483
	(0.019)	(1.804)	(0.064)	(0.606)
Household size	−0.008	−1.162	−0.036	0.170
	(0.010)	(0.852)	(0.046)	(0.343)
Children <18 in household	−0.010	−3.673	0.246	0.212
	(0.044)	(3.909)	(0.180)	(1.014)
Married	−0.026	0.261	0.021	−0.225
	(0.025)	(2.820)	(0.104)	(0.937)
Completed high school	0.085*	7.309*	0.017	0.652
	(0.045)	(3.923)	(0.156)	(0.902)
Complete some college or more	0.037	2.620	0.239	3.974***
	(0.036)	(3.304)	(0.158)	(0.821)
Received WIC in past 12 months	0.015	2.663	−0.106	−0.186
	(0.035)	(2.723)	(0.133)	(0.850)
Intake day was a Friday	0.045	5.613	0.006	0.578
	(0.035)	(3.933)	(0.128)	(1.125)
Intake day was a Saturday or Sunday	0.028	2.603	−0.164	−1.329
	(0.034)	(3.027)	(0.126)	(1.042)
Intake was in 2008	−0.048	−6.581	−0.054	−1.492
	(0.063)	(4.876)	(0.145)	(1.473)
Intake was in 2009	0.103*	4.434	−0.178	−1.229
	(0.058)	(4.741)	(0.141)	(1.588)

Continued

Table A.2 *Continued*

	Log calories	Calories as % EER	Eating occasions	HEI-2010
Intake was in 2010	0.079	−0.446	−0.419	−2.314
	(0.068)	(6.398)	(0.251)	(2.148)
Constant	6.951***	111.386***	1.397	49.902***
	(0.384)	(34.584)	(1.598)	(11.755)
Observations	1480	1480	1480	1480
R-squared	0.177	0.114	0.057	0.118

Notes: Survey weights applied in estimation and standard errors adjusted to account for complex survey design.