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HETEROGENEITY IN INTRA-MONTHLY CONSUMPTION PATTERNS, SELF-CONTROL, AND SAVINGS AT RETIREMENT

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Heterogeneity in Intra-Monthly Consumption Patterns, Self-Control, and Savings at Retirement*

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Abstract

Using data from the Continuing Survey of Food Intake by Individuals, this paper describes the shape of consumption profiles over the month for Social Security benefit recipients. Individuals with income mostly made up of Social Security benefits and who have some savings smooth consumption over the pay period, while individuals with little savings consume 25 percent fewer calories the week before checks are received relative to the week after checks are received. The findings for individuals with little savings are inconsistent with the Permanent Income/Lifecycle Hypothesis, but are consistent with hyperbolic discounting.

Keywords: hyperbolic consumption, caloric consumption, paychecks, Continuing Survey of Food Intake by Individuals.

JEL classification codes: D01,D12, D91

1 Introduction

A large number of U.S. citizens are saving too little for retirement. The long-term deficit of Social Security makes this fact particularly troubling. One explanation for individuals saving too little is that these same individuals are unable to resist the temptation of immediate gratification (Laibson, Repetto & Tobacman 1998). The tempted consumer indulges in high consumption today while promising herself that she will reduce her consumption and begin saving for retirement at a future date, yet when that future date finally arrives she caves in to the temptation of immediate gratification again. Such individuals will reach an old age with little savings.

In this paper, we provide evidence that elderly individuals with little savings suffer from self-control problems. We use data from the Continuing Survey of Food Intake by Individuals (CSFII) to study differences in the shapes of consumption profiles over the pay-cycle for the elderly with different levels of savings. Our empirical analysis uses the fact that Social Security benefits payments are essentially made on the third of the month. This information allows us to study the difference in how consumption varies with time since checks were received between two groups: people with liquid savings above and below $5000. The changes in the difference between the consumption profiles of these two groups and the changes within groups reveal patterns that are at odds with the standard consumer theory.

Individuals with little savings have consumption that is very responsive to Social Security payments. People with less than $5000 in savings have consumption that is 25 percent lower during the final few days of the pay-cycle than it is during the first week. If shopping is costly and food rots, this decline would not have to be related to self-control problems. However, the extent to which consumption declines due to food depreciation is likely to be common to both groups.

Individuals with little savings have consumption that decreases over the month even more dramatically when compared to the consumption of individuals with savings. Also, the rate of the decline in relative consumption of non-savers is increasing over the Social Security payment cycle. Caloric intake is 11 percent lower for individuals without substantial savings relative to those who have saved two weeks before the end of the pay cycle than it is during the week after checks are received, and 35 percent lower during the last three days of the pay-cycle.

Our findings are difficult to explain using the standard Life Cycle/Permanent Income Hypothesis and exponential discounting. Hall (1978) shows that exponential discounters with rational expectations and the ability to transfer income from periods in which it is high to periods in which it is low ought to have unpredictable changes in consumption around a linear trend. The elderly are perhaps the most likely individuals to satisfy Hall's assumptions, particularly when forming expectations is easy because their primary source of income is paid on predictable dates in predictable amounts. The elderly are both experienced in budgeting and, because they do not have much future income, are unlikely to face credit constraints. For these reasons, we conclude from our empirical results that individuals with low savings have short run impatience.[1] We check the robustness of this result by considering and ruling out alternative explanations. The quasi-hyperbolic discounting model introduced by Phelps & Pollak (1968) and popularized by Laibson (1997) (1998) provides a parsimonious framework for modelling short run impatience.[2] Quasi-hyperbolic discounters discount the consumption between today and tomorrow at a higher rate than than consumption between adjacent days further in the future, and this generates time inconsistency. In laboratory and field studies of time preferences, individuals (as well as animals) appear to have discount rates that decrease as the time horizon increases (Ainslie 1992, Thaler & Loewenstein 1989). In their survey of the literature, Frederick, Loewenstein & O'Donoghue (2002) provide evidence that long and

[1] An early formulation of dynamic inconsistency is Strotz (1955).

[2] For an axiomatic model of temptation and self-control in which there is no dynamic inconsistency see Gul & Pesendorfer (2001).

short-run discount rates differ in general with a meta-analysis of discount rate estimates across studies where choices were made over different time-horizons. We simulate the quasi-hyperbolic discounting model to show that, unlike exponential discounting, it generates consumption profiles that decrease at an increasing rate over the pay-cycle, which is similar to those actually observed for the group with low savings in our data.

A growing number of papers demonstrate that individuals suffer from self-control problems (Frederick, Loewenstein & O'Donoghue 2002). Our paper contributes to this literature by linking behavior within the month to savings behavior over the entire life cycle and by providing evidence that possibly not all individuals struggle with self-control equally. In related research, Ameriks, Caplin, Leahy & Tyler (2004) find that individuals differ in their propensity to plan and that this can dramatically influence wealth accumulation over the lifecycle.

Shapiro (2005) uses the 1989-91 CSFII data to study consumption profiles of food stamp recipients and concludes that their behavior is best reconciled with quasi-hyperbolic discounting. He does not consider heterogeneity though, probably because to be eligible for food stamps individuals need to be poor. Moreover, it is unclear whether his results are valid for non-food stamps recipients. Our sample, in contrast, represents almost half of all elderly Social Security recipients, of which only around 8 percent receive food stamps.

Della Vigna & Malmendier (2006) find that people over-estimate the number of times they will use the gym when choosing membership packages.[3].

A larger literature directly focuses on testing the Life Cycle/Permanent Income Hypothesis. Stephens Jr. (2003) uses Consumer Expenditure Data and the predictability of Social Security receipts to study the response of household expenditures to payments and finds that the amount of money spent increases immediately after checks are received. Stephens Jr. (2006) studies payday effects using U.K. Family Expenditure Survey data

[3] Huffman & Barenstein (2005) use U.K. Family Expenditure Survey data to show that expenditures decline between pay periods and conclude this is largely due to costly decision making when budgeting.

and again finds that expenditures tend to spike soon after the paycheck receipt. In Appendix B we show that when food rots and individuals cannot shop continuously it is optimal to purchase food on payday. By using measures of actual food consumption we avoid the possible discrepancy between expenditures and consumption, while by focusing exclusively on people at least 62 years old we know that they should have saved for retirement.

2 Consumption Profiles with Quasi-Hyperbolic Discounting ($\beta\delta - model$)

In this section we simulate the consumption profiles of exponential and quasi-hyperbolic discounters to highlight the differences. The quasi-hyperbolic discounter has a discount rate between immediate consumption and consumption one period later of $\frac{1-\beta\delta}{\beta\delta}$ and a smaller discount rate between consumption in any two future periods equal to $\frac{1-\delta}{\delta}$. We obtain a closed form solution for consumption for the case when the consumer is perfectly patient in the long run ($\delta = 1$) but has a preference for consumption today over consumption tomorrow ($\beta < 1$). When individuals aren't perfectly patient in the long run and $\delta < 1$ we solve for the optimal consumption profile numerically.

In order to calibrate the quasi-hyperbolic consumption model, it is convenient to work in discrete time. Consumers allocate y to finance their monthly food consumption $\{c_t^0\}_{t=0,..,T}$, $y = \sum_{t=0}^{T} c_t^0$.

Disregarding food depreciation and shopping (we deal with these issues empirically) consumers maximize

$$max_{\{c_t^0\}} u\left(c_0^0\right) + \beta \sum_{t=1}^{T} \delta^t u\left(c_t^0\right) \ ,$$

where δ is the exponential discount factor and β is the quasi-hyperbolic discount factor. Social Security checks are paid at perfectly predictable times and known amounts, which is why there is no uncertainty in our model. These checks are not reinvested. Since quasi-hyperbolic discounters ($\beta < 1$) make dynamically inconsistent choices, consumption profiles are superscripted. At time 0, the consumer "0" chooses a consumption profile $\{c_t^0\}_{t=1,..,T}$ that is going to be different then the one he chooses a day later $\{c_t^1\}_{t=1,..,T}$.[4]

The Euler equations are

$$\begin{aligned} t &= 0 : u'\left(c_0^0\right) = \beta\delta u'\left(c_1^0\right) = \lambda \ , \\ t &> 0 : u'\left(c_t^0\right) = \delta u'\left(c_{t+1}^0\right) = \lambda \ . \end{aligned}$$

We assume Constant Relative Risk Aversion,

$$\begin{aligned} t &= 0 : c_1^0 = (\beta\delta)^{\frac{1}{\rho}} c_0^0 \ , \\ t &> 0 : c_t^0 = \delta^{\frac{1}{\rho}} c_{t-1}^0 = \delta^{\frac{s}{\rho}} c_{t-s}^0 = \beta^{\frac{1}{\rho}} \delta^{\frac{t}{\rho}} c_0^0 \ . \end{aligned}$$

In the appendix we show that when $\delta = 1$, log consumption chosen at time t will be given by the expression:

$$\log c_t^t = \log y_0 + \frac{1}{\rho} \log \beta + \log\left(T - t + 1\right) - \sum_{s=0}^{t} \log\left[1 + \beta^{\frac{1}{\rho}}\left(T - s\right)\right]$$

The decrease in log consumption over time is given by

$$\frac{\partial \log c_t^t}{\partial t} = \frac{-1}{T - t + 1} + \frac{1}{T - t + \beta^{\frac{-1}{\rho}}} < 0 \ ,$$

and it is easy to verify that this decrease is increasing over the pay-cycle. Patterns of log-consumption for a yearly discount rate of 0.97 and different values of daily β are shown

[4] We assume that ex ante consumers do not realize the inconsistency of their behavior, they are "naive." If consumers are "sophisticated," meaning that they are aware of their time inconsistent behavior, the drop in consumption is the same as "naive" individuals if utility is logarithmic ($\rho = 1$), and is be smaller (bigger) for $\rho > 1$ ($\rho < 1$) (Pollak 1968). In the case of $\rho > 1$, as in the case with uncertainty, our estimated β represents an upper bound on the true instantaneous discount factor.

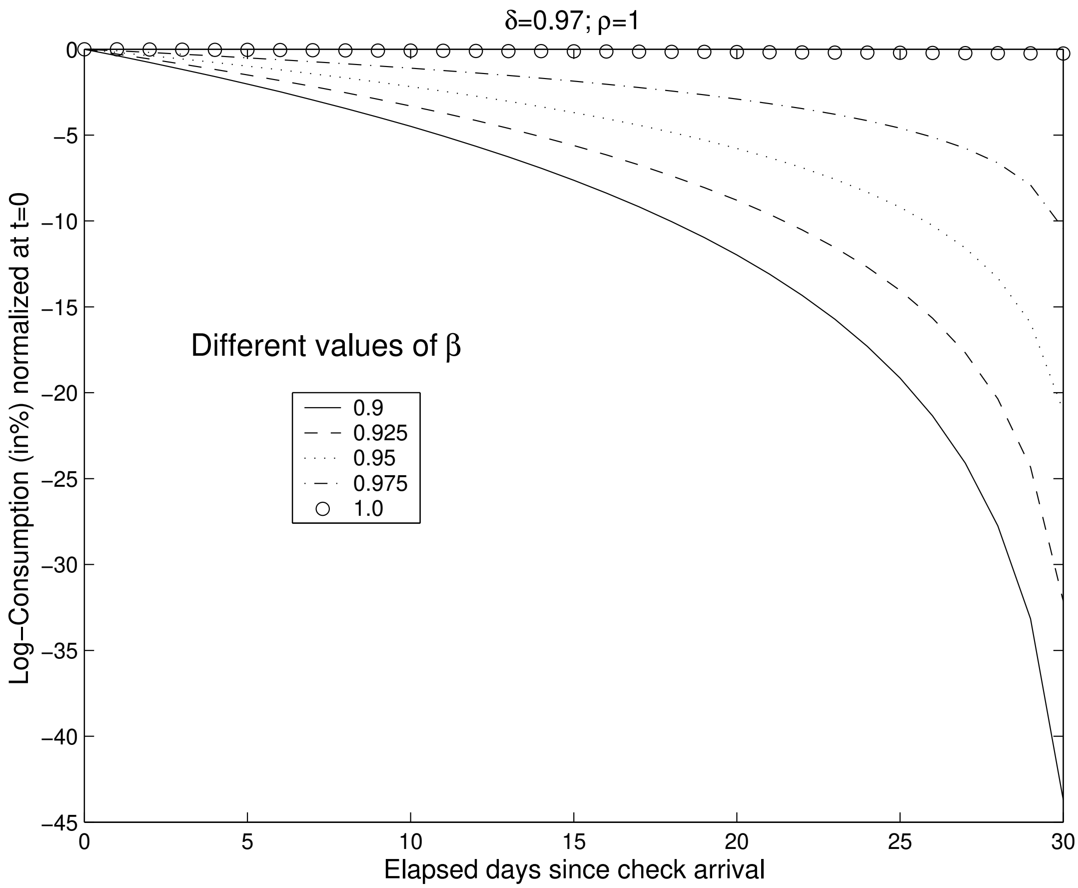

Figure 1: Monthly consumption pattern

in Figure 1. Log-consumption has been normalized to 0 at time 0 in order to ease the interpretation of the empirical results that are shown later.

The key qualitative features of the graph is that log-consumption declines at an increasing rate for quasi-hyperbolic discounters, while it can be easily seen that for exponential discounters with $\delta \leq 1$ the decline follows a straight line with a slope of $log(\delta)/\rho$. A 20 percent drop in consumption over the pay period can be explained using the following combination of ρ and δ, $-0.20 = 30\log(\delta)/\rho$. The yearly discount factor, $[\exp(-\rho.2/30)]^{365}$, is 8 percent for $\rho = 1$, and basically zero for $\rho = 4$.

3 Data and Sample Restrictions

We use data from the Continuing Survey of Food Intake by Individuals, 1994-1996 to explore the consumption behavior of households containing individuals that receive Social Security benefits and a member older than 62 years. The CSFII is randomly administered by the U.S. Department of Agriculture to individuals over the month. During the time period covered by our data, Social Security benefits were paid out on the third of the month if that date was neither a holiday or on the weekend and otherwise on the first day prior to the third of the month that was not a holiday or on the weekend. Between 1994 and 1996, on average 60 percent of Social Security recipients received their checks via direct deposit and would therefore have access to their benefits on pay dates ("So 1989-96).[5] The exogenous variation in interview date and knowledge of pay dates allows us to identify the effect of time elapsed since checks were received on consumption. Survey respondents were asked to recall everything they ate over the last 24 hours, and the USDA implemented procedures and prompts developed by the Census Bureau's Center for Survey Methods Research that would improve response accuracy (USDA 1997). Households were to be interviewed a second time between 3 and 10 days after initially interviewed. The attrition rate between the first and second interview is 10 percent and 22 percent of second interview dates actually occurred outside the planned window of between 3 and 10 days after the initial interview. For these reasons we use only the initial interviews.[6] We also exclude individuals that did not know if they were receiving Social Security benefits. The over-all response rate for the first interview was 80 percent.

Using actual consumption data allows us to more directly test for consumption smoothing against quasi-hyperbolic discounting than would be possible if only expenditure data were available. In the appendix we show that it is in fact optimal for consumers to shop

[5]Between 1989 and 1992 only 51.5 percent of recipients used direct deposit, which makes the CSFII, 1989-1992 less appropriate for our analysis.

[6]Given the detailed nature of these surveys, survey fatigue may be an issue as well. Our results are qualitatively similar, though somewhat dampened when both interview dates are used.

on payday when food depreciates. The intuition is that immediate consumption is preferred to later consumption and shopping early matches the fresher food with immediate consumption.

The CSFII data contains observations on 12,364 households of which 2,332 receive Social Security benefits. This yields 3,600 first day surveys.[7] Social security pays disability on a date different than the date on which it pays benefits, so we restrict our sample to those older than 62 which leaves 1897 individual surveys. It is possible that by focusing on households dependent on Social Security with a member older than 62 we have included multi-person households with Social Security Disability Benefits, which are paid on the first of the month. Since disability benefits become old-age benefits at age 65, this measurement error is likely to be small and would make our findings a lower bound on the true effect. We focus on individuals from households in which Social Security income makes up at least 80 percent of total income, and these individuals make up 41 percent of our sample. Each household in the CSFII data identified if they have cash, savings or checking accounts, stocks, bonds, mutual funds, and certificates of deposit valued at more than $5,000. Unfortunately, no information on the exact level of savings is available. Because in our sample 94 percent of household incomes lie above $5,000, we simply call those who answered "yes" savers and those who answered "no" non-savers. Our sample is roughly divided in half between savers and non-savers.

Table 1 presents regressions of various demographic characteristics on dummies indicating if individuals were interviewed two, three, four, or five weeks after pay was received. Most of the dummies are not statistically significant and are small in magnitude, and this suggests that the timing of interview date is exogenous. At a five percent significance level, we would expect five percent of the coefficients to be significant even if the true effect were zero.

[7] There are more first day surveys than households that receive Social Security because of large households.

Table 2 presents descriptive statistics for savers and non-savers. These two groups are very different from each other. Individuals with savings have higher benefits than non-savers, which implies that savers had higher labor earnings over their careers. Respondents with savings are also more likely to be in good health, male, white, and have on average two more years of education than those without savings.

4 Consumption over the Pay-Cycle

4.1 Graphical Evidence

Figure 4.1 contains plots of the logarithm of consumption against time since a benefit check was received for respondents whose Social Security income comprised at least 80 percent of total income. All results are qualitatively similar when the sample is broadened to include households with Social Security income at least 70 percent of total income[8]. We first look at consumption in terms of caloric intake and the probability of eating a meal out. The graphs are locally weighted regressions of both weighted daily average and weighted daily residual consumption measures on time elapsed since pay was issued. Residual log consumption and the residual probability of eating out were obtained by first partialling out with a linear model other factors that influence food consumption including usual monthly food expenditures, gender, household size, age, an age-gender interaction, health indicators, highest year of schooling completed (with a dummy variable for missing values), height, race, retirement status, self-reported, a dummy indicating whether the respondent receives food stamps, and additional dummy variables indicating month, day of the week, survey year, region, typical shopping frequency, and MSA status. Interview date is not thought to be correlated with determinants of consumption aside from duration since paycheck, but controlling for other determinants will increase precision. The solid graphs

[8]Including household with lower levels of relative Social Security income increases the sample size, but decreases the precision of our instrument.

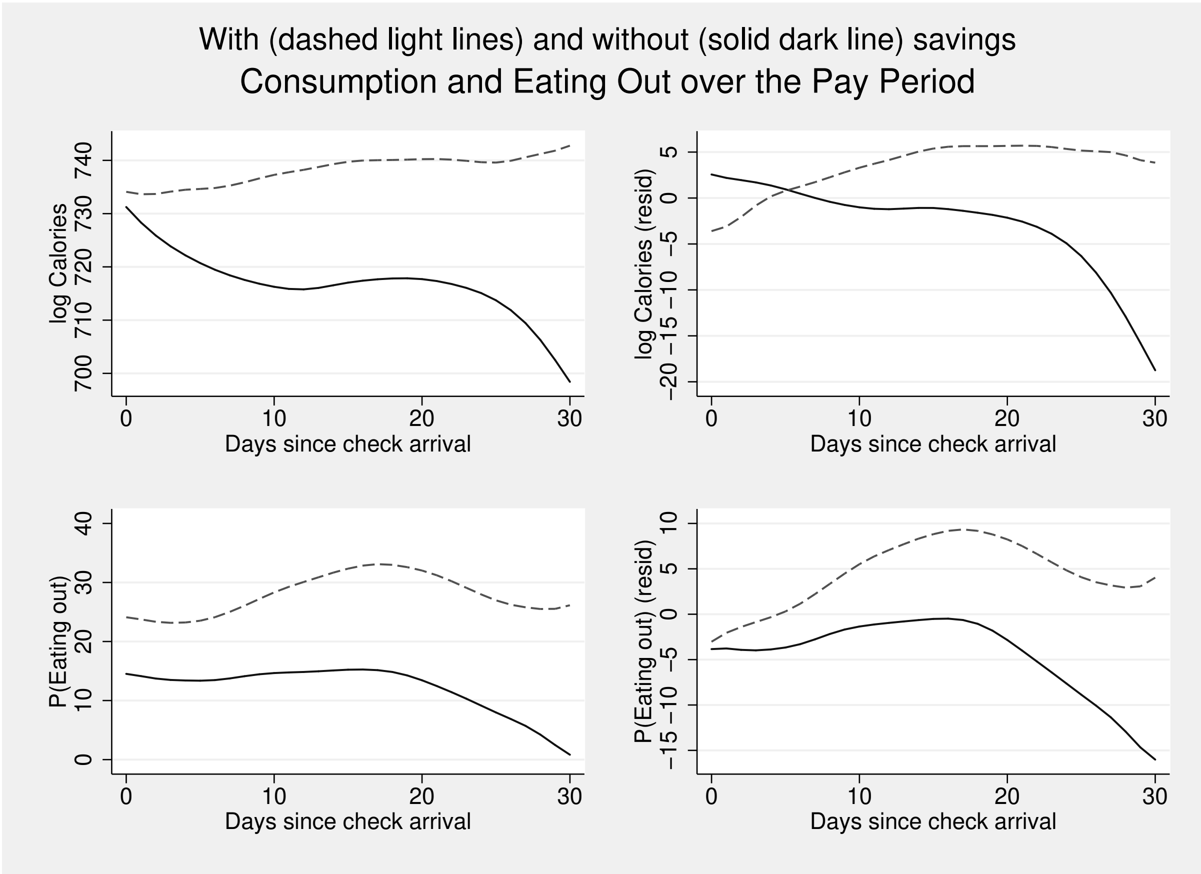

Figure 2: Log-Consumption

Notes: Figures are locally weighted regression plots of weighted daily average log consumption and weighted daily average residual log consumption and the probability of eating out and residual probability of eating out over the Social Security pay-cycle for households with benefits that are at least 80 percent of total income.

are for individuals with assets valued at less than five-thousand dollars, and the dashed graphs are for individuals with assets of a value more than five-thousand dollars. We use the CSFII provided survey weights throughout to insure that our sample is representative of the U.S. population.

The consumption of households with higher valued liquid assets is fairly flat. In contrast, caloric intake for those with little savings is decreasing. Initially caloric intake is roughly the same for low savings individuals than for high savings individuals, though this changes not long after checks are received. Caloric intake drops dramatically for low

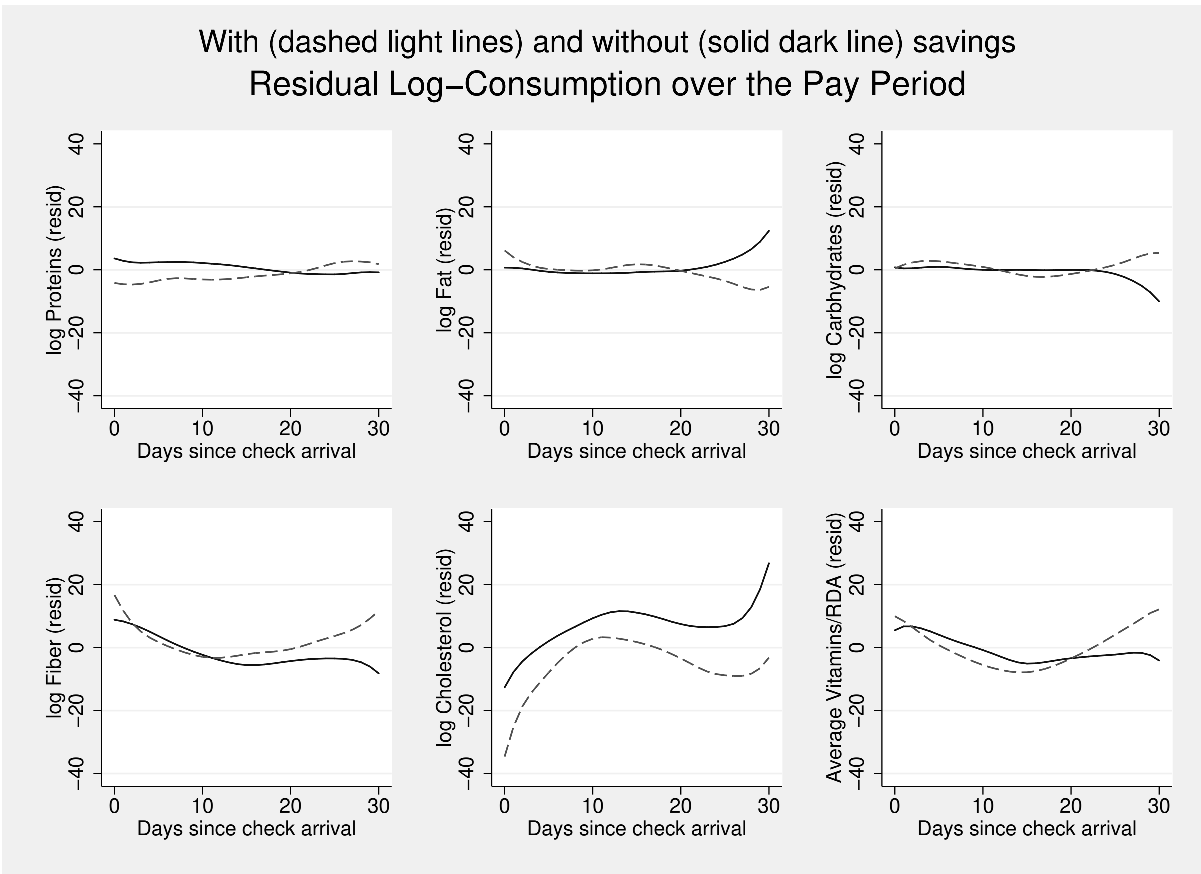

Figure 3: Log-Consumption

Notes: Figures are locally weighted regression plots of daily average residual log consumption over the Social Security pay-cycle for households with benefits that are at least 80 percent of total income where total log calories are controlled for along with determinants of consumption described in text.

savings individuals during the last five days of the pay-cycle. Caloric intake is almost 20% lower than average thirty days after pay is received for individuals without substantial savings. A comparison of this pattern with the simulated ones of Figure 1, reveals that assuming an intertemporal rate of substitution of 1 and a yearly discount rate of 0.03 implies that the instantaneous discount factor β is close to 0.95. Reducing the intertemporal rate of substitution to 1/4, so that a 10 percent rise in relative prices causes a 2 percent reduction in relative consumption, gives β=0.8. Households with low savings also consume a larger proportion of meals they eat out soon after their paycheck than households with higher savings.

Total caloric intake falls over the pay-cycle for individuals with little savings. We next explore how the content of the typical diet for savers and non-savers changes over the pay-cycle. Figure 4.1 contains plots of locally weighted regressions of log residual consumption measures. The residuals were obtained by regressing the log of grams of protein, fat, and carbohydrates, fiber, cholesterol, and an average of 10 vitamins[9] on the log of caloric intake and the same additional controls used to construct Figure 4.1. The figures imply non-savers diets contain more fat and cholesterol towards the end of the pay-period. If poor quality foods are high in fat and cholesterol, this implies that the quality of consumption declines over the paycycle for households with Social Security benefits recipients that have little savings. Households with Social Security benefits recipients that did not save do not smooth consumption because of the sharp declines in consumption during the last week of the pay-cycle. The non-linear decrease in log-calories is more in line with quasi-hyperbolic discounting and rules out heterogeneity in either exponential discount rates or intertemporal rates of substitution.

The sudden drop in food consumption, in terms of both quantity and quality, for the elderly without savings also has implications for health. Figure 4.1 contains plots of the

[9]Vitamin A, E, C, B6, B12, thiamin, riboflavin, niacin, and folate, expressed as a percentage of recommended daily amount.

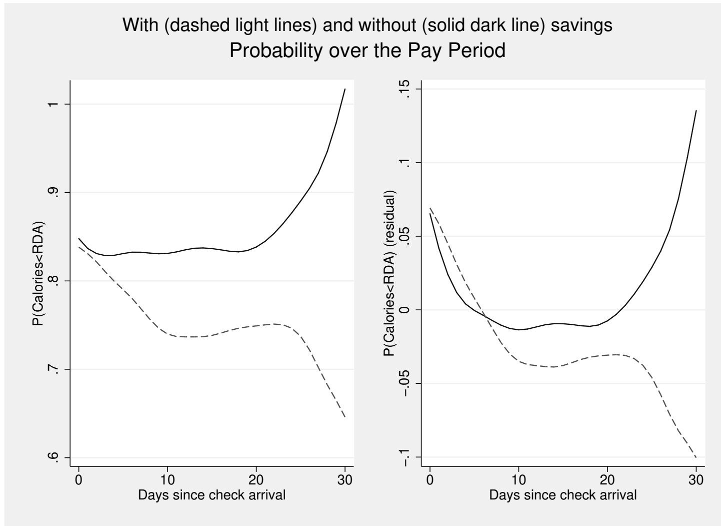

Figure 4: Probability of eating less than RDA over the pay period

Notes: These figures are locally weighted regression plots of the probability of consuming calories less than recommended daily amount and its residual over the Social Security pay-cycle for households with benefits that are at least 80 percent of total income.

probability of consuming less than the USDA recommended consumption level for total calories. During the final week of the pay-period the likelihood of not consuming enough calories increases by nearly 15 percent for individuals without savings.

4.2 Regression Estimates

We carry out inference by estimating how consumption of non-savers changes over each of the weeks after Social Security is received relative to savers. The following model is fitted to the data:

$$\begin{aligned} \ln c_i &= \alpha + \psi_{fe} + \gamma Nosave_i + \sum_{t=2}^{5} \phi_t Week\_t_i + \sum_{t=2}^{5} \pi_t Nosave_i \times Week\_t_i + X_i'\theta + \varepsilon_i \\ \psi_{fe} &= \eta_m + \eta_y + \xi_d + \nu_r \end{aligned}$$

where $\ln c_i$ denotes the natural log of consumption for household i, $Nosave_i$ is a dummy equal to one if household i has less than \$5,000 in liquid assets, $Week\_t_i$ is a dummy equal to one if household i most recently received Social Security benefits t weeks ago, and X_i' is a vector of characteristics for household i. We include the same characteristics used to produce the graphs.[10] The term ψ_{fe} is the vector of fixed-effects in the model, including month fixed effects η_m, year fixed effects η_y, day of the week fixed effects ξ_d and region fixed effects ν_r.

The OLS estimated coefficients $\widehat{\phi}_t$ measure the average percentage change in consumption common to savers and non-savers. The estimates $\widehat{\pi}_t$ on the interaction measure the percentage change in consumption of non-savers between the first and t^{th} week after receiving pay relative to savers. If discounting is exponential then log-consumption would depend linearly on time elapsed since checks were received (this is true even if households are unable to transfer income across months), and this would give rise to linearly decreasing coefficients. The slope of log consumption would be $\log(\delta)/\rho$. For reasonable values of daily discount rates and intertemporal rates of substitution[11] the ϕ_t's would be close to zero and the π_t's would be zero. Savers and non-savers would consume different levels, but the slope would always be the same. If instead the heterogeneity was in terms of δ or ρ the slopes of the consumption profiles across the two groups would be different but still linear, that is the π_t's would be on a straight line as would the ϕ_t's.

Although for our sample the consumption drop does not appear to be linear, in order to compare our results to those of Shapiro (2005), we also estimate a version of the model

[10]We include usual food expenditure, gender, household size, age, an age-gender interaction, health indicators, highest year of schooling completed (with a dummy variable for missing values), height, race, retirement status, a dummy indicating whether the respondent receives food stamps, and additional dummy variables indicating month, year, day of the week, region, shopping frequency, and MSA status.

[11]ρ is believed to be around 4 and typically not smaller than one.

where the change over time in consumption is restricted to be linear:

$$\begin{aligned}\ln c_i &= \alpha + \psi_{fe} + \gamma * Nosave_i + \phi t_i + \pi t_i \times Nosave_i + X_i'\theta + \varepsilon_i \\ \psi_{fe} &= \eta_m + \xi_d + \nu_r\end{aligned}$$

where here t_i is the number of days since checks were received. The average daily percentage change in consumption common to savers and non-savers is given by the coefficient ϕ and the average daily percentage decline in consumption of non-savers relative to savers is given by π.

Table 3 contains the results of estimating the unconstrained model for various consumption measures. Column (1) reports the relative change in energy (total caloric intake) over the pay cycle. The estimates in column (1) imply that the difference in caloric intake between savers and non-savers is insignificantly different from zero during the week immediately after checks are received, with a t-statistic on the difference of 0.56. The changes in consumption for the savers relative to their first week consumption are positive and insignificantly different from zero for each period. The consumption for non-savers drops dramatically relative to savers, particularly during the final few days of the pay period. During the third week the difference increases to -11 percent. During the last few days of the pay period this difference increases to -35 percent (significantly different from zero at the .05 level).

Columns (2) through (4) present the results of estimating the unrestricted model for caloric intake decomposed into grams of protein, fat, and carbohydrates[12]. Though insignificant at conventional levels, the point estimates imply that non-savers consume 6.21 percent more grams of protein than savers and 5.15 percent more grams of fat during the week after checks are received. These measures of consumption also fall dramatically relative to savers during the final days before checks are received. The differences in

[12] Here we do not control for calories, as opposed to the plots in Figure 4.1.

proteins and carbohydrates consumed between the final two or three days of the pay period and the first seven days of the period for non-savers relative to savers are -32 and -42 percent, respectively. Column (6) presents the results for cholesterol. This measure of consumption declines relatively little with respect to our other measures.

Table 4 contains the results of estimating the linear model. Caloric intake rises by an insignificantly different from zero .26 percent per day for savers and falls by -.70 percent per day for non-savers relative to savers on average. Taken together these estimates imply that caloric intake falls by .44 percent per day for households without savings. The estimate of the daily decline in consumption for non-savers is in line with Shapiro's (2005) study of food stamp recipients. He finds consumption declines of .40 percent per day for recipients after they receive their stamps.

4.3 Alternative Explanations and Additional Evidence

Table 5 presents the results of estimating the unconstrained model for different subsamples of the data. Column 1 reports the results for the full sample for ease of reference. An alternative explanation for declining consumption over the month is intra-household competition for resources. Columns 2 and 3 present results from separately estimating the model for single and multi-person households. Doing so significantly reduces the sample size, and the results are mixed for single person households. While consumption does fall in the final days of the pay-period for single people, this estimate is not precisely estimated and an imprecisely estimated small increase in consumption for non-savers relative to savers was found in the fourth week. The results for multi-person households are much more similar to the results from the full sample. In two separate questions the CSFII asks respondents whether they are meal planners for their household and whether they do the major food shopping. If individuals were competing for food, then respondents who do the shopping would have an obvious strategic advantage over those who don't. In columns

6 and 7 we find no strong differences in consumption patterns across these groups, casting doubt on the explanation based on uncooperative behavior among household members.

Households that have little savings and heavy dependence on Social Security may be more susceptible to unexpected expenses than those with savings. Households with savings can draw down their savings and continue their usual consumption, while those without savings may be forced to go with little food if they are liquidity constrained. CSFII respondents were asked if they had enough food over the past three months. As long as past shocks are correlated with current shocks we can test the importance of uncertainty. Column 4 presents estimates of the model for the subsample of respondents that did not recently run out of food and column 5 presents estimates for those that did. Curiously, consumption falls dramatically for non-savers who did have enough food over the past three months and remains constant for non-savers who did not have enough food sometime over the past three months. Consumption slightly rises over the month for savers who have not ran out of food recently and falls for those who had run out. This evidence suggests that for consumers who face larger uncertainties the precautionary motives that give rise to an increasing consumption pattern dominate the present-bias. It also suggests that greater vulnerability to negative shocks does not entirely explain the shape of consumption profiles.

Alternatively, in the presence of expenditure shocks some consumers may be more willing to risk being subject to drastic reductions in consumption. In this case, the significant drop of those hit by negative shocks would drive all the results. Since shocks can be more easily absorbed at the beginning of the payperiod than at the end, this model would generate heteroskedasticity with respect to elapsed time since check arrival. To test for heteroskedasticity we first run a median regression. If the results were driven by a few outliers, the median effects would be lower. What we find instead is a significant 43 percent drop between week 5 and week 1 for non-savers compared to savers. We also can reject heteroskedasticity using the Breush-Pagan test (at the 28 percent level).[13]

Individuals with time preferences that display short-run impatience will want to procrastinate when deciding when to undertake costly activities aside from saving for future consumption (i.e. Akerlof 1991, O'Donoghue & Rabin 1999, DellaVigna & Paserman 2005). We further document the importance of short run impatience by estimating the shape of consumption profiles over the month separately for respondents with different observable indicators of present bias. Results are reported in Table 6 and are not, in general, very precisely estimated. Column 1 presents results for people who do and do not consume vitamin supplements. Column 2 distinguishes between smokers and non-smokers, columns 3 and 4 between drinkers and non-drinkers and heavy drinkers and non-heavy drinkers, respectively, column 5 by whether the respondent currently rents their home, and column 6 by whether the respondent shops more than 3 times a month. Taking vitamins indicates smoother consumption and smoking indicates less smooth consumption, as expected. Individuals who shop more frequently have consumption profiles that drop while those who do not have smoother consumption.

5 Conclusions

We provide evidence of quasi-hyperbolic discounting amongst the elderly that are reliant upon Social Security income. Individuals with low savings have consumption profiles over the month that decline dramatically, particularly in the final week of the pay period. We cannot prove that individuals with savings are not quasi-hyperbolic discounters, even though their food consumption profiles do not decline over the month. Individuals who have saved may have knowledge of and access to commitment devices such as illiquid investments that individuals without savings do not (Bertrand, Mullainathan & Shafir

[13] We regress the squared residuals of non-savers on the elapsed weeks dummies. R2 times the number of observations has a chi-squared distribution with 5 degrees of freedom.

2004).

More frequent issuance of paychecks would limit the quasi-hyperbolic discounters ability to indulge in high current consumption at the expense of later consumption. With the small cost of issuing checks through direct deposit, allowing Social Security benefits recipients the ability to choose more frequent payments would result in a Pareto improvement upon the monthly schedule. This will be true even if the direct utility benefits are small given the small cost of sending money via direct deposit and the negative externalities of medical costs that may result from hyperbolic discounters not eating enough at the end of the month.

Our results also help justify legislation such as the Pension Reform Bill of 2006 which encourages employers to enroll employees into 401(k) plans by default and commitment devices such as the "Save More Tomorrow" plan proposed by Benartzi & Thaler (2004). Madrian & Shea (2001) show that changing default rules to automatic enrollment in 401(k) plans dramatically increased enrollment rates of new hires by about 30 percent. The "Save More Tomorrow" plan gave employees at a medium sized company the ability to commit in advance to putting portions of their future earnings towards retirement savings. 78 percent of the employees that were offered this plan used it.

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Table 1: Check for Randomization of Interview Dates: Regression of Demographic Characteristics on Weeks Since Pay Received

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Food Exp.	Benefits	MW	SO	WE	Good Health	Poor H.	Age	Male	Black	Years educ	Retired	Food stamps	HH size	Height
							Panel A: Savers								
Delap2	31.27	-131.29	-0.07	-0.06	0.01	-0.08	0.00	-0.96	-0.05	0.02	-0.36	-0.00	-0.00	-0.10	-0.77
	(48.94)	(121.21)	(0.09)	(0.09)	(0.05)	(0.09)	(0.03)	(1.44)	(0.07)	(0.03)	(0.60)	(0.09)	(0.00)	(0.13)	(0.67)
Delap3	112.49	100.20	-0.13	-0.16	0.13	-0.00	-0.04	-2.02	0.01	0.02	-0.69	0.09	0.01	0.17	-0.37
	(71.06)	(188.28)	(0.10)	(0.10)	(0.08)	(0.10)	(0.02)*	(1.31)	(0.07)	(0.03)	(0.65)	(0.09)	(0.01)	(0.17)	(0.77)
Delap4	19.78	-22.32	0.09	-0.19	0.04	-0.13	0.02	0.40	-0.01	-0.02	-0.18	0.06	-0.00	0.18	-0.09
	(51.66)	(135.88)	(0.10)	(0.09)**	(0.05)	(0.08)*	(0.03)	(1.71)	(0.07)	(0.02)	(0.65)	(0.09)	(0.00)	(0.17)	(0.89)
Delap5	70.51	374.90	-0.03	-0.24	0.11	0.02	0.01	-2.58	0.07	-0.02	-0.05	0.07	-0.00	0.04	0.57
	(70.74)	(364.20)	(0.20)	(0.12)*	(0.11)	(0.12)	(0.05)	(1.66)	(0.09)	(0.02)	(0.68)	(0.11)	(0.00)	(0.22)	(0.80)
Constant	305.78	1,167.24	0.41	0.40	0.09	0.44	0.04	75.53	0.42	0.02	11.82	0.73	0.00	1.70	66.24
	(32.91)***	(93.61)***	(0.11)***	(0.11)***	(0.04)**	(0.07)***	(0.02)*	(1.01)***	(0.05)***	(0.02)	(0.49)***	(0.07)***	(0.00)**	(0.10)***	(0.50)***
Observations	346	346	346	346	346	346	346	346	346	346	346	346	346	346	346
R-squared	0.02	0.04	0.03	0.03	0.02	0.01	0.01	0.02	0.00	0.01	0.00	0.01	0.01	0.02	0.01
							Panel A: Non-Savers								
Delap2	-6.49	3.89	0.06	-0.10	0.04	-0.10	0.03	0.48	-0.02	0.08	-0.84	-0.07	-0.09	0.03	-0.72
	(35.44)	(83.80)	(0.08)	(0.10)	(0.07)	(0.09)	(0.05)	(1.27)	(0.07)	(0.07)	(0.64)	(0.07)	(0.06)	(0.18)	(1.21)
Delap3	-25.02	-69.47	0.05	-0.03	-0.01	-0.07	0.03	-0.13	-0.05	0.07	-1.01	-0.01	0.05	-0.03	-1.51
	(36.55)	(86.49)	(0.07)	(0.10)	(0.06)	(0.09)	(0.07)	(1.38)	(0.05)	(0.07)	(0.70)	(0.07)	(0.08)	(0.19)	(1.09)
Delap4	-40.53	-94.66	0.22	-0.16	0.02	-0.07	-0.00	2.03	0.04	-0.04	-1.45	-0.04	-0.09	-0.16	-1.28
	(29.02)	(72.03)	(0.08)***	(0.09)*	(0.07)	(0.09)	(0.04)	(1.24)	(0.07)	(0.07)	(0.66)**	(0.07)	(0.08)	(0.15)	(1.13)
Delap5	38.72	25.67	0.15	-0.25	-0.10	-0.13	0.00	1.28	-0.01	0.13	-0.83	-0.14	-0.18	0.20	-0.23
	(50.15)	(91.55)	(0.10)	(0.11)**	(0.05)*	(0.11)	(0.07)	(1.25)	(0.11)	(0.13)	(0.58)	(0.12)	(0.05)***	(0.21)	(1.93)
Constant	245.60	805.41	0.14	0.49	0.11	0.35	0.11	72.48	0.28	0.17	9.92	0.80	0.22	1.69	65.87
	(23.88)***	(70.82)***	(0.07)**	(0.10)***	(0.05)**	(0.07)***	(0.04)***	(0.97)***	(0.05)***	(0.05)***	(0.42)***	(0.04)***	(0.06)***	(0.13)***	(1.02)***
Observations	399	399	399	399	399	399	399	399	399	399	399	399	399	399	399
R-squared	0.02	0.02	0.04	0.03	0.01	0.01	0.00	0.01	0.00	0.02	0.02	0.01	0.03	0.01	0.01

Notes: Estimated on CSFII data restricted to households with individuals older than 62 obtaining Social Security income that is at least 80 percent of total income. Savings is defined as having cash, savings or checking accounts, stocks, bonds, mutual funds and certificates of deposit worth at least $5,000. Standard errors clustered by survey stratum in parenthesis.

Table 2: Descriptive Statistics for Households with Savings Above and Below $5000

	Low savings	High savings	Difference
Food expenditures	233.120	347.557	-114.437
	(12.149)	(28.850)	(26.586)
Social Sec. benefits	772.938	1181.711	-408.773
	(26.335)	(57.516)	(61.313)
Mid-West	0.220	0.378	-0.158
	(0.083)	(0.116)	(0.066)
South	0.401	0.283	0.118
	(0.104)	(0.091)	(0.048)
West	0.112	0.142	-0.030
	(0.044)	(0.066)	(0.040)
Rural	0.309	0.347	-0.038
	(0.106)	(0.116)	(0.059)
Good health	0.284	0.390	-0.105
	(0.023)	(0.025)	(0.031)
Poor health	0.128	0.042	0.087
	(0.022)	(0.012)	(0.025)
Age	73.090	74.738	-1.648
	(0.507)	(0.431)	(0.719)
Male	0.273	0.418	-0.145
	(0.023)	(0.021)	(0.034)
Black	0.204	0.020	0.185
	(0.035)	(0.013)	(0.033)
Years of education	9.117	11.539	-2.422
	(0.236)	(0.280)	(0.320)
Fraction retired	0.757	0.773	-0.016
	(0.031)	(0.030)	(0.040)
Food stamps	0.172	0.003	0.169
	(0.024)	(0.003)	(0.024)
Household size	1.675	1.750	-0.076
	(0.072)	(0.060)	(0.089)
Hight (inches)	65.068	65.997	-0.929
	(0.328)	(0.278)	(0.419)
Observations	399	346	

Notes: CSFII data restricted to households older than 62 obtaining Social Security income that is at least 80 percent of total income. Savings is defined as having cash, savings or checking accounts, stocks, bonds, mutual funds and certificates of deposit worth at least $5,000. Standard errors along with sample size reported instead of standard deviations.

Table 3: Consumption Over the Pay-cycle by Savings Categories

	(1) *log* Energy	(2) *log* Proteins	(3) *log* Fat	(4) *log* Carbh.	(5) *log* Fiber	(6) *log* Cholest.	(7) *log* Vitamins	(8) *calories* Out/Tot energy
No savings	2.76	6.21	5.15	-0.98	0.43	12.26	4.21	-6.15
	(6.95)	(7.48)	(9.28)	(7.42)	(13.02)	(27.69)	(11.42)	(8.94)
Week 2	5.82	9.76	8.59	1.79	-8.28	14.18	-12.89	0.96
	(7.54)	(8.77)	(11.21)	(7.13)	(9.51)	(24.89)	(8.81)	(8.01)
Week 3	8.05	7.16	15.98	-0.25	-1.89	18.59	-6.57	8.74
	(7.82)	(7.83)	(11.43)	(7.66)	(12.24)	(16.94)	(9.30)	(8.40)
Week 4	6.03	11.40	3.67	1.70	-1.44	-0.69	2.47	-2.11
	(7.00)	(7.72)	(11.03)	(6.42)	(9.81)	(24.75)	(8.34)	(7.08)
Week 5	15.25	16.90	16.48	13.17	17.77	24.99	13.66	8.33
	(9.45)	(10.20)	(11.99)	(9.38)	(14.74)	(25.19)	(14.33)	(13.26)
NSxWeek 2	-9.37	-8.35	-16.55	-3.61	-9.45	-1.98	-7.46	-1.88
	(10.21)	(10.89)	(16.22)	(10.19)	(14.66)	(31.52)	(13.77)	(10.31)
NSxWeek 3	-11.31	-12.16	-17.66	-7.45	-21.22	-8.13	-16.71	-11.95
	(10.25)	(11.72)	(15.70)	(11.28)	(19.05)	(27.84)	(15.80)	(10.76)
NSxWeek 4	-10.62	-13.15	-12.51	-6.90	-16.45	1.86	-14.73	-3.15
	(10.08)	(11.02)	(15.09)	(9.44)	(16.19)	(30.72)	(14.07)	(9.40)
NSxWeek 5	-35.26	-31.96	-29.18	-42.30	-48.78	-21.90	-46.30	-19.77
	(14.12)**	(15.29)**	(17.78)	(15.30)***	(19.57)**	(33.43)	(18.77)**	(15.86)
Observations	745	745	745	745	745	742	745	745
R-squared	0.26	0.23	0.20	0.24	0.23	0.13	0.18	0.11

Notes: Estimated on CSFII data restricted to households with individuals older than 62 obtaining Social Security income that is at least 80 percent of total income. Savings is defined as having cash, savings or checking accounts, stocks, bonds, mutual funds and certificates of deposit worth at least $5,000. Standard errors clustered by survey stratum in parenthesis.

Table 4: Consumption Over the Pay-cycle by Savings Categories: Linear Model

	(1) *log* Energy	(2) *log* Proteins	(3) *log* Fat	(4) *log* Carbh.	(5) *log* Fiber	(6) *log* Cholest.	(7) *log* Vitamins	(8) *calories* Out/Tot energy
Time	0.26	0.42	0.17	0.17	0.20	0.30	0.33	0.13
	(0.27)	(0.29)	(0.36)	(0.28)	(0.42)	(0.82)	(0.38)	(0.30)
No savings	2.78	8.20	-0.27	2.75	1.66	11.76	8.25	-4.02
	(6.03)	(6.52)	(7.81)	(6.77)	(10.50)	(22.83)	(9.55)	(7.78)
Time x No Savings	-0.70	-0.86	-0.54	-0.77	-1.05	-0.24	-1.08	-0.51
	(0.37)*	(0.40)**	(0.49)	(0.41)*	(0.61)*	(1.10)	(0.54)**	(0.38)
Observations	745	745	745	745	745	742	745	745
R-squared	0.26	0.23	0.19	0.23	0.22	0.12	0.17	0.11

Notes: Estimated on CSFII data restricted to households with individuals older than 62 obtaining Social Security income that is at least 80 percent of total income. Savings is defined as having cash, savings or checking accounts, stocks, bonds, mutual funds and certificates of deposit worth at least $5,000. Standard errors clustered by survey stratum in parenthesis.

Table 5: Consumption Over the Pay-cycle by Savings Categories for Subgroups

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Full sample	Household size		Enough food	Not enough food	Meal Planner	
		=1	>1	Yes	No	Yes	No
No savings	2.76	-2.72	7.99	6.65	-27.08	3.95	13.43
	(6.95)	(10.34)	(8.16)	(7.43)	(12.03)**	(8.90)	(12.26)
Week 2	5.82	12.64	-1.23	8.20	-31.58	6.28	9.23
	(7.54)	(10.65)	(6.50)	(8.36)	(14.01)**	(9.32)	(9.72)
Week 3	8.05	10.47	6.46	5.34	10.24	8.32	12.44
	(7.82)	(11.81)	(10.41)	(8.34)	(12.70)	(9.20)	(12.82)
Week 4	6.03	-6.28	6.79	5.45	3.65	10.36	0.41
	(7.00)	(16.90)	(7.94)	(7.45)	(15.47)	(8.61)	(7.81)
Week 5	15.25	3.46	11.15	18.68	-54.43	20.46	3.62
	(9.45)	(17.92)	(10.52)	(9.48)*	(26.70)**	(11.98)*	(13.32)
NSxWeek 2	-9.37	-22.77	-0.81	-17.76	32.07	-13.60	-12.72
	(10.21)	(12.73)*	(11.77)	(11.21)	(19.53)	(12.03)	(14.82)
NSxWeek 3	-11.31	-2.95	-16.61	-19.16	11.15	-10.60	-23.91
	(10.25)	(15.55)	(12.41)	(11.46)*	(16.49)	(12.27)	(17.28)
NSxWeek 4	-10.62	17.07	-33.45	-12.11	9.01	-11.70	-28.40
	(10.08)	(19.30)	(14.85)**	(10.70)	(19.66)	(12.14)	(19.34)
NSxWeek 5	-35.26	-15.65	-36.12	-43.74	51.47	-39.44	-43.77
	(14.12)**	(21.66)	(14.03)**	(13.61)***	(31.32)	(17.10)**	(22.07)*
Observations	745	304	441	569	176	523	221
R-squared	0.26	0.30	0.37	0.28	0.49	0.25	0.38

Notes: Estimated on CSFII data restricted to households with individuals older than 62 obtaining Social Security income that is at least 80 percent of total income. Savings is defined as having cash, savings or checking accounts, stocks, bonds, mutual funds and certificates of deposit worth at least $5,000. Standard errors clustered by survey stratum in parenthesis.

Table 6: Consumption Over the Pay-cycle by Savings Categories: Linear Model using different "treatments."

	(1)	(2)	(3)	(4)	(5)	(6)
			"Distinguishing variable"			
	No supplements	Smoker	Drinker	Heavy Drinker	Home renter	Frequent shopper
Fraction	54%	17%	36%	2.5%	29%	64%
"Distinguishing variable"	4.53	16.24	0.12	63.96	5.82	11.36
	(7.52)	(9.37)*	(5.99)	(46.68)	(7.70)	(8.29)
Week 2	2.72	1.30	-2.88	1.19	5.65	-3.06
	(6.44)	(5.77)	(6.00)	(5.48)	(5.68)	(7.13)
Week 3	4.16	2.78	-2.85	0.78	1.06	3.15
	(6.89)	(5.81)	(6.55)	(5.64)	(6.40)	(8.98)
Week 4	3.27	2.57	-5.78	1.09	0.00	7.17
	(5.86)	(5.38)	(5.83)	(5.29)	(5.03)	(9.69)
Week 5	4.97	2.65	-1.80	-2.34	-3.83	4.08
	(7.47)	(7.74)	(7.55)	(6.86)	(7.94)	(14.80)
DVxWeek 2	-5.53	-1.99	9.70	-29.63	-15.75	3.87
	(11.45)	(12.58)	(7.09)	(48.23)	(9.74)	(9.52)
DVxWeek 3	-5.95	-2.99	12.51	-14.37	3.06	-3.26
	(9.77)	(12.12)	(8.58)	(48.98)	(11.09)	(12.05)
DVxWeek 4	-6.23	-11.03	17.41	-66.47	1.33	-11.45
	(9.26)	(12.39)	(8.34)**	(49.31)	(9.72)	(10.94)
DVxWeek 5	-21.28	-17.52	3.43	-37.16	10.23	-8.76
	(12.10)*	(13.79)	(15.65)	(49.22)	(14.31)	(19.05)
Observations	759	773	775	775	777	742
R-squared	0.25	0.26	0.26	0.26	0.25	0.25

Notes: Estimated on CSFII data restricted to households with individuals older than 62 obtaining Social Security income that is at least 80 percent of total income. Savings is defined as having cash, savings or checking accounts, stocks, bonds, mutual funds and certificates of deposit worth at least $5,000. Standard errors clustered by survey stratum in parenthesis.

A Derivation of Optimal Consumption Profile

Here we solve for the time t consumer's consumption sequence. Assuming constant relative risk averse utility, the Euler equations can be written as

$$\begin{aligned} t &= 0 : c_1^0 = (\beta\delta)^{\frac{1}{\rho}} c_0^0 \\ t &> 0 : c_t^0 = \delta^{\frac{1}{\rho}} c_{t-1}^0 = \delta^{\frac{s}{\rho}} c_{t-s}^0 = \beta^{\frac{1}{\rho}} \delta^{\frac{t}{\rho}} c_0^0 \ . \end{aligned}$$

Using this expression for initially planned time t consumption in the budget constraint gives

$$y_0 = c_0^0 \left[1 + \beta\delta^{\frac{1}{\rho}} \frac{1-\delta^{\frac{T}{\rho}}}{1-\delta^{\frac{1}{\rho}}} \right] = c_0^0 \left[\frac{1 + \left(\beta^{\frac{1}{\rho}} - 1\right)\delta^{\frac{1}{\rho}} - \beta^{\frac{1}{\rho}}\delta^{\frac{T+1}{\rho}}}{1-\delta^{\frac{1}{\rho}}} \right]$$

and $c_0^0 = y_0 \frac{1-\delta^{\frac{1}{\rho}}}{1+\left(\beta^{\frac{1}{\rho}}-1\right)\delta^{\frac{1}{\rho}}-\beta^{\frac{1}{\rho}}\delta^{\frac{T+1}{\rho}}}$.

Similarly a time t consumer will set $c_0^t = y_t \frac{1-\delta^{\frac{1}{\rho}}}{1+\left(\beta^{\frac{1}{\rho}}-1\right)\delta^{\frac{1}{\rho}}-\beta^{\frac{1}{\rho}}\delta^{\frac{T+1-t}{\rho}}}$,

where $y_t = y_0 - \sum_{s=0}^{t-1} c_s^s$.

Setting $\delta = 1$ the budget constraint simplifies to

$$\sum_{t=0}^{T} c_t^0 = \left(1 + \beta^{\frac{1}{\rho}} T\right) c_0^0 = y_0 \ ,$$

and we get closed form solutions for c_t^t:

$$\begin{aligned} c_0^0 &= \frac{y_0}{\left(1+\beta^{\frac{1}{\rho}}T\right)} \\ c_t^t &= \frac{y_0\beta^{\frac{1}{\rho}}\left(T-t+1\right)}{\prod_{s=0}^{t}\left[1+\beta^{\frac{1}{\rho}}\left(T-s\right)\right]} \end{aligned}$$

Taking logs gives

$$\log c_t^t = \log y_0 + \frac{1}{\rho}\log\beta + \log(T-t+1) - \sum_{s=0}^{t}\log\left[1+\beta^{\frac{1}{\rho}}(T-s)\right]$$

B Optimal Shopping Time

During each pay period the consumer maximizes her utility from food consumption. The pay period is normalized to have length 1. Without loss of generality, we assume that consumers shop only once every pay period. Food depreciates after it is bought according to the function $f(t-s), f' < 0, 0 \leq s \leq 1$, where t represents time and s represents the shopping date. Consumers have a positive discount rate δ[14] and receive income y_0 every month with certainty. Consumers do not save and are not allowed to borrow. The consumer's problem takes the following form:

$$max_{c_t^1 c_t^2,,s} U(c) = \int_0^s e^{-\delta t} f(t-s+1)\, u\left(c_t^1\right) dt + \int_s^1 e^{-\delta t} f(t-s)\, u\left(c_t^2\right) dt$$

s.t.

$$y_0 = \int_0^s c_t^1 dt + \int_s^1 c_t^2 dt\ .$$

The Euler equations are (FOC_c)

$$\begin{aligned}
\partial c_t, t &< s : e^{-\delta t} f(t-s+1)\, u'\left(c_t^1\right) = \lambda \\
\partial c_t, t &= s : f(1)\, u'\left(c_s^1\right) = f(0)\, u'\left(c_s^2\right) = \lambda \\
\partial c_t, t &> s : e^{-\delta t} f(t-s)\, u'\left(c_t^2\right) = \lambda\ ,
\end{aligned}$$

[14]Assuming quasi-hyperbolic discounting would only reinforce the results.

while the first order condition with respect to s is (FOC_s)

$$\partial s : e^{-\delta s} f\left(1\right) u\left(c_s^1\right) - e^{-\delta s} f\left(0\right) u\left(c_s^2\right) - \int_0^s e^{-\delta t} f'\left(t-s+1\right) u\left(c_t^1\right) dt$$
$$- \int_s^1 e^{-\delta t} f'\left(t-s\right) u\left(c_t^2\right) dt - \lambda\left(c_s^1 - c_s^2\right) = 0 \; .$$

In order to show that it is optimal to shop at time 0, when the pay check is received, first we show that at the solution of FOC_s the second order condition with respect to s is positive, which means that one of the two bounds 0 and 1 represents the solution. Using integration by parts and FOC_c, FOC_s can be rewritten as

$$f\left(1-s\right) u\left(c_1^2\right)\left(1-e^{-\delta}\right) - \delta \int_0^s e^{-\delta t} f\left(t-s+1\right) u\left(c_t^1\right) dt$$
$$-\delta \int_s^1 e^{-\delta t} f\left(t-s\right) u\left(c_t^2\right) dt = 0 \; .$$

The second order condition (SOC) is

$$-f'\left(1-s\right) u\left(c_1^2\right)\left(1-e^{-\delta}\right) - \delta e^{-\delta s} f\left(1\right) u\left(c_s^1\right) + \delta e^{-\delta s} f\left(0\right) u\left(c_s^2\right)$$
$$+\delta \int \_0^s e^{-\delta t} f'\left(t-s+1\right) u\left(c_t^1\right) dt + \delta \int \_s^1 e^{-\delta t} f'\left(t-s\right) u\left(c_t^2\right) dt \; .$$

Using again integration by parts we get that

$$-f'\left(1-s\right)\left(1-e^{-\delta}\right) u\left(c_1^2\right) - f\left(1-s\right)\delta\left(1-e^{-\delta}\right) u\left(c_1^2\right) - \delta\lambda\left(c_s^1 - c_s^2\right)$$
$$+\delta\delta \int_0^s e^{-\delta t} f\left(t-s+1\right) u\left(c_t^1\right) dt + \delta\delta \int_s^1 e^{-\delta t} f\left(t-s\right) u\left(c_t^2\right) dt \; .$$

Using FOC_s the SOC simplifies to

$$-f'(1-s)\left(1-e^{-\delta}\right)u\left(c_1^2\right)-\delta\lambda\left(c_s^1-c_s^2\right)>0$$

which, given FOC_c, is positive .

FOC_s evaluated at 0 is negative since

$$\begin{aligned}
& f(1)\,u\left(c_1^2\right)\left(1-e^{-\delta}\right)-\delta\int 0^1 e^{-\delta t} f(t)\,u\left(c_t^2\right)dt \\
< \; & f(1)\left(1-e^{-\delta}\right)u\left(c_1^2\right)-\delta\int_0^1 e^{-\delta t} f(1)\,u\left(c_1^2\right)dt \\
= \; & f(1)\left(1-e^{-\delta}\right)u\left(c_1^2\right)-f(1)\,u\left(c_1^2\right)\delta\frac{-1}{\delta}\left[e^{-\delta}-1\right]dt=0\;.
\end{aligned}$$

Similarly FOC_s evaluated at 1 is positive, but 1 represents next pay check's 0. The optimum is therefore to shop as soon as the pay check has been received. Introducing more shopping days does not change this result. It is therefore not surprising if expenditures spike on the pay day. It is important to to look at consumption instead of expenditures, and to control for food depreciation, and for shopping frequency.

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