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The Ronald O. Perelman Center for Political Science and Economics (PCPSE)
133 South 36th Street
Philadelphia, PA 19104-6297

pier@econ.upenn.edu
http://economics.sas.upenn.edu/pier

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RONG HAI
University of Miami

DIRK KRUEGER
University of Pennsylvania

ANDREW POSTLEWAITE
University of Pennsylvania

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Rong Hai
University of Miami

Dirk Krueger
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Andrew Postlewaite
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Abstract

We propose a new category of consumption goods, memorable goods, that generate a utility flow even after physical consumption. Empirically, memorable goods expenditures exhibit frequent zero monthly purchases and lumpy expenditure spikes. Memorable goods expenditures are 20% the size of nondurable expenditures, but twice as volatile. We then develop a consumption-savings model with borrowing constraints and income risk that formalizes the notion of memorable goods and distinguishes them from other nondurable goods. We show that consumers optimally choose lumpy consumption of memorable goods. We then measure the welfare cost of consumption fluctuations using our calibrated model and empirically evaluate our calibrated model's predictions for the consumption response to predictable income changes. We find that the welfare cost of household-level consumption fluctuations induced by income shocks fall from 20.4 to 12.3 percentage points if memorable goods are accounted for, and that empirical estimates of excess sensitivity of consumption may significantly be driven by memorable goods expenditures.

Keywords: Memorable Goods, Consumption Volatility, Welfare Cost of Income Risk
JEL Codes: D91, E21

*Rong Hai: Department of Economics, University of Miami, Jenkins Building, Coral Gables, FL 33146, email rxh515@miami.edu. Dirk Krueger: Department of Economics, University of Pennsylvania, 3718 Locust Walk, Philadelphia, PA 19104, email dkrueger@upenn.edu. Andrew Postlewaite: Department of Economics, University of Pennsylvania, 3718 Locust Walk, Philadelphia, PA 19104, email apostlew@econ.upenn.edu. We thank Hanming Fang, Eric Hurst, Larry Samuelson, Nick Souleles and seminar participants at the University of Pennsylvania and the University of Miami for useful comments. We also thank Jeffrey Crilley from the Bureau of Labor Statistics for his help with CEX data. Krueger and Postlewaite thank the National Science Foundation for continued support.

We can entertain ourselves with memories of past pleasures (Adam Smith [1759])

Much of the pleasure and pain we experience in daily life arises not from direct experience - that is, "consumption" - but from contemplation of our own past or future or from a comparison of the present against the past or future. The fact that experiences are carried forward in time through memory enables them to affect welfare at later times. (Loewenstein and Elster [1992])

1 Introduction

In this paper we propose to augment the canonical distinction of consumption goods into nondurable and durable goods by a third category which we call memorable goods. Conceptually, a good is *memorable* if a consumer draws utility from her past consumption experience, that is, through memory. A large vacation once in a while will be enjoyed for months, possibly years, afterwards.[1] In addition to generating immediate utility, the vacation contributes to a stock of memories that may depreciate over time but generates utility in the meantime. However, traditionally, goods are differentiated only according to whether or not they have a physical durable component, and memorable goods are typically classified as part of the nondurable goods category.

Based on this idea we construct a structural consumption-savings model of nondurable and memorable goods.[2] As in the example, memorable goods consumption impacts future utility through the accumulation of the stock of memory. A key ingredient of our model is that only "unusual" memorable goods consumption experiences add to the consumer's stock of memory and thus increase her future utility. In contrast to the consumption smoothing motive for standard non-

[1]Work in psychology and marketing finds evidence of utility from memories. Using fMRI Speer et al. (2014) show that the same neural circuitry that responds to monetary rewards is stimulated by positive memories. They also find that participants were willing to sacrifice monetary rewards to activate positive memories. Zauberman et al. (2009) find a connection between recall of positive memories and responses to monetary rewards; participants were willing to sacrifice more tangible rewards in order to activate positive memories: "When people make decisions about experiences to consume over time, they treat their memories of previous experiences as assets to be protected."

[2]We abstract from durable goods in the model because incorporating them is not needed for our applications. It is conceptually straightforward to augment the model to include these goods in exactly the same way the sizeable literature on consumer durables has done.

durables, memorable goods create an incentive to let consumption expenditures fluctuate, to do something out of the ordinary in order to create memory. We demonstrate that households optimally choose a non-smooth profile of memorable goods expenditures even in a perfect-certainty world without frictions or transaction costs. Compared to nondurable goods, memorable goods consumption in the model exhibits high volatility, high incidence of zero expenditures, and consumption spikes. Thus, the model captures the salient empirical features of memorable consumption goods: the timing of the physical act of consumption and the utility this act generates are decoupled, and both expenditures and physical consumption occur infrequently as part of the *optimal* household consumption plan, and in lumps when they occur.

Based on our heuristic definition of memorable goods we turn to the Consumer Expenditure data (CEX) and reclassify some of the traditionally defined nondurable goods as memorable goods. The set of memorable goods (MG) is meant to comprise goods for which the timing of the physical act of consumption and the utility this act generates are typically decoupled, and for which both expenditures as well as physical consumption occur infrequently. A memorable good is often *infrequently purchased and infrequently consumed* (as implied by consumers' optimal choices in our model), while nondurable goods are frequently purchased and frequently consumed.[3] See Figure 1 for a representation of expenditure and consumption patterns implied by our classification. Therefore, in our empirical classification, we look for traditionally classified nondurable goods (see Lusardi (1996), Parker (1999), Krueger and Perri (2006), and Aguiar and Hurst (2013)) that exhibit both infrequent zero purchases and expenditure spikes.[4]

Goods we classify as memorable include trips and vacations, entertainment excluding on trips and vacations, food and alcohol consumed outside the home excluding on trips and vacations, photographic services and rental, charitable giving, clothing services, clothing and shoes, and jewelry and watches. These goods are typically classified as nondurables, see, e.g., Cutler and Katz (1992) or Souleles (1999). We also define *strictly memorable goods* to be memorable goods excluding

[3] A luxurious dinner on a trip, e.g., occurs infrequently while an ordinary dinner at home happens on a daily basis.

[4] We emphasize that the categorization of a good as memorable does not imply that a specific consumer will necessarily have memorable consumption from this good; whether or not she does will depend on the pattern of her consumption of the good.

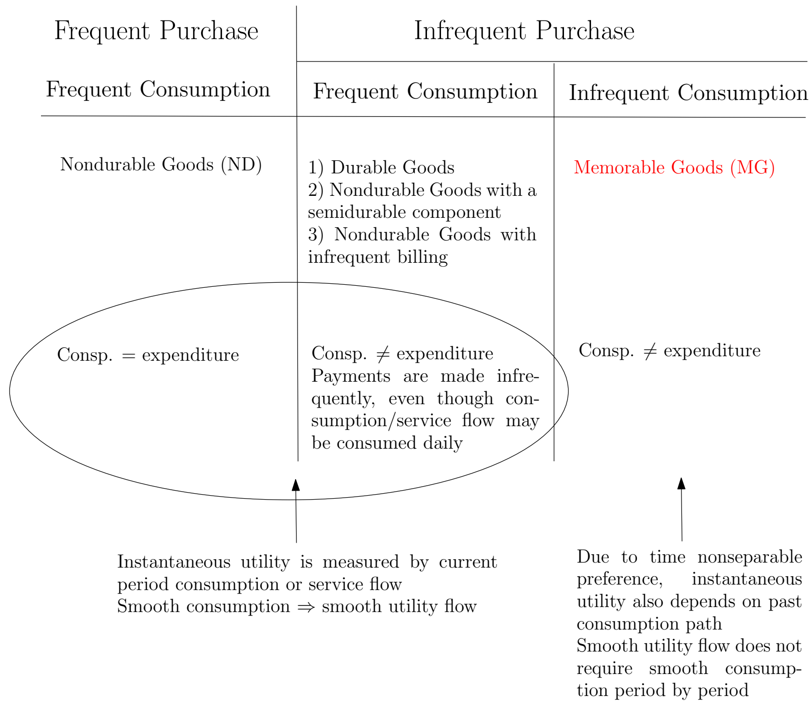


Figure 1: Purchase and Consumption Patterns

clothing and shoes and jewelry and watches. Trips and vacations, entertainment, and food and alcohol outside the home are the three largest components of strictly memorable goods. In total, strictly memorable goods expenditure accounts for 13.1% of total outlay and our broadly defined memorable goods expenditure accounts for 18.6% of total outlays.

About 6.5% of the households had at least one incidence of zero expenditure on memorable goods during the 12 month reference period, and about 7.5% of the households had at least one zero expenditure of strictly memorable goods. In comparison, nondurable goods expenditures are always positive for all households across all reference periods. Furthermore, across the 12 month period, about 97.6% of households had at least one spike of memorable goods consumption and 91.7% of households had at least one spike of strictly memorable goods consumption. In comparison, the fraction of households who had at least one consumption spike of nondurable goods consumption and strictly nondurable goods consumption is 44.6% and 41.8%, respectively. Finally, the expenditures on memorable goods as well as on strictly memorable goods are three times as volatile as nondurable goods expenditures.

Using the aforementioned data, we introduce and calibrate a fully specified model of memorable goods and discuss key quantitative implications. In our quantitative model of memory goods, households face income risk and choose expenditures on nondurable and memorable goods, subject to a borrowing constraint. However, we want to emphasize that our model can generate lumpy and infrequent memorable goods even in the absence of market frictions or transaction costs, stemming entirely from the preference side of the model. We calibrate the model's preference parameters to match the expenditure patterns of nondurable goods and memorable goods in the data. Our calibrated model not only matches the share and volatility of memorable goods, but also the patterns of spikes and inactivity of memorable goods expenditures. We then use calibrated model for two applied questions.

First, we investigate our model's implications for the welfare cost of consumption fluctuations. An immediate implication of our model is that although expenditures on memorable goods are volatile, the associated utility flow that they generate is not. This property of the theory has profound consequences for the calculation of the welfare cost of consumption expenditure fluctuations because the infrequent and lumpy expenditure profile of memorable goods, as implied by the optimal choices of households, might contribute little, if anything, to the welfare losses associated with volatile consumption expenditures for risk-averse households.[5] When we use our quantitative model with memorable goods to quantify the welfare losses of consumption fluctuations induced by uninsurable idiosyncratic income risk, we find that relative to the benchmark in which memorable goods are lumped together with nondurable goods, the presence of memorable goods reduces this welfare cost by 8.1 percentage points, from 20.4% to 12.3%. This finding stems directly from the facts that a) strictly memorable goods expenditure constitutes a significant share (16.6%) of total expenditure, b) expenditures on strictly memorable goods are very volatile over time, and c)

[5]One prominent example is the expenditure on weddings. Web sites focusing on wedding finance show that the average budget for a wedding amounts to about $20,000, whereas average household income of a newly married couple is $55,000 annually. Many expenditures, such as those for the honeymoon, the reception site rental, outlays for photography and video services or the rehearsal dinner are commonly categorized as nondurable consumption expenditures. We suggest that due to the memorable component in wedding consumption, there is no significant welfare loss associated with the fluctuations of household consumption expenditures for a wedding.

according to our model this volatility in expenditures is not associated with a significant welfare loss, relative to a smooth consumption profile. Indeed, according to our model a smooth consumption expenditure profile of memorable goods is pointedly suboptimal.[6]

Second, we investigate the potential importance of memorable goods in interpreting the empirical evidence on the consumption expenditure response to expected income changes. Specifically, we show that the rejection of the permanent income hypothesis (PIH) based on the excess sensitivity of consumption to expected tax refund receipts documented in the important empirical study by Souleles (1999) might primarily be driven by the adjustment of memorable goods expenditure. After separating memorable goods from traditionally defined nondurable goods, the latter does not significantly respond to predictable federal income tax refunds, just as the standard PIH theory predicts. However, as we show through simulations of our model, a lumpy change in expenditures on memorable goods associated with an expected income change is fully consistent with our theoretical model, which we view as a natural extension of the standard PIH style consumption-savings model to incorporate memorable goods. This result also suggests that memorable goods could play an important role for the empirically documented response of consumption to other anticipated income changes, such as the government stimulus programs from 2001, 2008 and 2020.

The paper is organized as follows. In the next subsection we briefly relate our work to the existing literature before turning to a description of our conceptual framework in Section 2. In that section we lay out a simple example that illustrates households' incentive to incur lumpy and infrequent consumption of memorable goods in order to create memory which increases later life utility. Section 3 contains the results of a descriptive empirical analysis using CEX consumption data. There we empirically distinguish memorable goods from traditionally defined nondurable goods and document that memorable goods account for a sizable fraction of a typical household's spending and exhibit different expenditure patterns from nondurable goods, as predicted by our

[6]For some memorable goods such as vacations, one might worry that there are alternative explanations for the infrequency of purchases. For example, one could imagine a fixed cost to going to Greece, hence it may be optimal to go one time for a long period rather than make frequent trips. The existence of motivations beyond memory formation for the infrequency doesn't preclude the expenditure being memorable, however. Our basic notion is that pleasurable out-of-the-ordinary consumption adds to memory stock. The thrust of our welfare analysis would be unaffected, subject to the good generating memories as the model assumes.

model in Section 2. Section 4 calibrates a fully specified model of memorable goods and discusses key quantitative implications of our model. The remainder of the paper is devoted to the two applications. In Section 5, we analyze the welfare cost of consumption fluctuations in the presence of memorable goods. In Section 6, we revisit Souleles's (1999) empirical evidence against the permanent income hypothesis in the presence of memorable goods. Section 7 concludes. Details about the theoretical properties of the model, the numerical solution procedure and the CEX data used in the empirical analysis are relegated to a separate appendix.

Relation to the Literature

Our paper contributes to the literature on modeling household dynamic consumption and savings choices, by proposing and analyzing a novel consumption-savings model with memorable goods. Our paper therefore complements the large literature, starting from Friedman (1957) and Modigliani and Brumberg (1954), that models nondurable consumption choices, as well as the literature on modeling expenditures and consumption on durable goods (see e.g. Mankiw (1982)) and the work that proposes non-time-separable preferences over streams of consumption (see, e.g., the habit persistence models of Abel (1990), Campbell and Cochrane (1999), and Hotz et al. (1988), or models with recursive preferences as in Epstein and Zin (1989) or the rational addiction model of Becker and Murphy (1988)). There are both similarities and differences between our memorable goods model and standard internal habit formation model. The stock of memories is like a habit, although the memory stock in our model is not a substance stock but a durable goods stock that provides a service flow and substitute for current consumption expenditure. Therefore, compared to an internal habit formation model where consumers have stronger desire to smooth consumption over time,[7] our model creates incentives for consumers to optimally consume in spikes. Recent contributions in this literature have introduced transaction cost into households' consumption and savings choices. Chetty and Szeidl (2016) demonstrate that consumption commitments can ex-

[7] In the internal habit formation model, any increase in current consumption raises the habit stock (i.e., the substance level) and reduces future utility for a given consumption level.

plain both excess sensitivity and excess smoothness of consumption response and that the welfare cost of large shocks is smaller in the commitments model than in the habit formation model. Finally, Kaplan and Violante (2014) show that a two-asset model, with a low-return liquid asset and a high-return illiquid asset that carries a transaction cost, can rationalize well the empirically observed excess sensitivity of consumption to an anticipated fiscal stimulus.

We build on the literature stressing that individuals may care about past consumption because of the memories associated with it. See, for example, the quotations of Smith (1759) and Loewenstein and Elster (1992) at the beginning. The formal incorporation of utility derived from past consumption dates (at least) back to Strotz's classic paper on dynamic consistency (Strotz (1955)). His formulation incorporated utility from past consumption to allow for "the possibility that a person is not indifferent to his consumption history but enjoys his memories of it". We view as one advantage of our approach that our model is a straightforward extension of standard consumption-savings models, which allows a clear understanding of the role memories play for optimal dynamic consumption decisions. Hayashi (1985) distinguishes explicitly between consumption and expenditures, and postulates that the consumption of every good is a distributed lag function of current and past expenditures. Using Japanese household panel data he then estimates the durability, defined as the persistence of the distributed lag, of each consumption good, and finds that even goods such as food and services have a significant durable component. He then shows that once this durability of consumption is accounted for, consumption is well-approximated by a martingale, as the standard PIH implies. Our work builds on the basic idea of Hayashi (1985), but extends it both empirically and theoretically. Empirically, we provide a classification that distinguishes memorable goods from traditionally defined nondurable goods categories, using detailed U.S. consumption expenditure data, rather than estimate the durability of each of these goods. Theoretically, we postulate that only extraordinary expenditure adds to the memory stock and we formalize this idea in an otherwise standard consumption-savings model. We show that our model generates optimal memorable goods expenditure spikes, and inaction in other periods (the latter is harder to generate in Hayashi (1985)'s distributed lag model). Finally, in addition to drawing out the empirical implications for the excess sensitivity literature, a focus we share with Hayashi (1985), we also quantify the implications of our theory for the welfare costs of consumption fluctuations.

Our paper contributes to the literature that measures the welfare cost of consumption fluctuations. Using aggregate consumption data, Lucas (1987) calculates that the welfare gain from eliminating all aggregate consumption fluctuations over the business cycle is less than one-hundredth of one percent of consumption when preferences are logarithmic. However, using micro-level consumption data, the welfare losses of *idiosyncratic* consumption fluctuations are orders of magnitude larger, following the same Lucas (1987) approach. Gorbachev (2011) argues, based on PSID expenditures on food, that consumption has become more volatile over time, and thus that the welfare cost of these fluctuations, with log-preferences preferences, has risen from 4.35% in the 1970's to 7.35% by 2004. Our welfare cost estimates are somewhat larger since we base our calculations on total nondurable consumption rather than food consumption. Similar to this paper, Karahan and Ozkan (2013) and Wu and Krueger (2020) assess the welfare cost of uninsurable idiosyncratic income risk, but abstract from the distinction between nondurable and memorable goods. Their estimates line up very well with our numbers when memorable goods are subsumed in nondurables.

When we revisit Souleles's (1999) empirical test of the permanent income hypothesis using income tax return data, we contribute to the literature that estimates the extent to which consumption responds to expected changes in income (starting with Hall (1978)) as well as income shocks.[8] Souleles (1999) produces strong evidence of excess sensitivity in the response of households' nondurable consumption to their income tax refunds. Jermann and Baxter (1999) show that a quantitative equilibrium model of household production can generate excess sensitivity of consumption because market consumption responds to predictable income growth. This literature also documented that there is substantial heterogeneity in the profiles of individual consumption sub-components (see Aguiar and Hurst (2013), Hamermesh (1982), Nelson (1994), and Browning and Crossley (2000)) and in the response to income shocks and economic fluctuations (see Zeldes

[8] See Hall and Mishkin (1982) for a seminal contribution and Jappelli and Pistaferri (2010) for a recent survey.

(1989), Parker (1999), Browning and Crossley (2009), Charles and Stephens (2006)).

Finally, within the excess sensitivity literature a set of recent papers estimates to what extent private consumption expenditures respond to government stimulus programs implemented in economic downturns. Johnson et al. (2006) and Parker et al. (2013) estimate the consumption expenditure in response to 2001 and 2008 tax rebates and find that households increase their nondurable consumption during the three-month period of rebate receipt. Misra and Surico (2014) document that there is substantial heterogeneity in consumption responses to 2001 and 2008 rebates. Broda and Parker (2014) use Nielsen data on selected consumption goods to argue that in response to 2008 Economic stimulus payment, the average household's spending rose by 10 percent the week it received a payment. Overall, this evidence suggests that anticipated income increases (due to government transfers) in the midst of a recession induce significant private spending responses, and that these responses may be especially large for households close to their borrowing constraint. We think of lumpy expenditures on memorable goods as a complementary mechanism for rationalizing a positive expenditure response of nondurables (broadly defined) to predictable income increases. In fact, we show in Section 6 that these two mechanisms interact in our model, with excess sensitivity of expenditure on memorable goods being especially pronounced in the presence of tight borrowing constraints.

2 A Simple Example

We now sketch a conceptual framework of memorable goods. In this section, we illustrate that the optimal expenditure of memorable goods may exhibit infrequent purchase and lumpiness even in a world without income risk and credit frictions. Denote by C_{mt} and C_{nt} the current consumption expenditures on memorable and on nondurable goods, respectively. In each period the new memorable goods expenditure augments the household's stock of memories if the expenditure is higher than a preference threshold N_t. The stock of memory M_t then evolves according to:

$$M_{t+1} = (1-\delta_m)M_t + \max\{C_{m,t} - N_t, 0\}, \quad \delta_m \in (0,1) \tag{1}$$

where the household's preference threshold N_t is given by:

$$N_t = C_{m,t-1}. \tag{2}$$

This formulation of memory stock implies that the household consumer uses her $t-1$ memorable goods consumption level as a threshold value and considers the period t memorable goods consumption to be *indeed memorable* if $C_{m,t} > C_{m,t-1}$. In this case the current memorable goods stock M_t (net of depreciation) is increased by the amount $(C_{m,t} - C_{m,t-1})$.

Households have preferences over consumption C_{mt} and C_{nt}, and the stock of memory M_t from past memorable consumption expenditures, represented by a period utility function of the form

$$U(C_{nt}, C_{mt}, M_t) = u(C_{nt}, C_{mt} + \zeta M_t), \quad \zeta > 0. \tag{3}$$

We assume that the utility function u is strictly increasing and concave in both arguments and satisfies the Inada conditions. Note that if we set $\zeta = 0$, memorable goods become standard nondurable goods. Therefore, in the analysis below, we focus on the case $\zeta > 0$.

At this point, there is no need to take a strong stand on the nature of the income process or capital market frictions that agents face, but we will do so in the fully specified model of Section 4. To demonstrate how the model works most clearly, here we focus on a 3-period model without income risk and asset market frictions. At time 0, given an initial memory stock $M_0 > 0$, preference threshold $N_0 = C_{m,-1}$, and initial assets S_0 (all possibly inherited from the time individuals lived with their parents) each household chooses nondurable- and memorable goods expenditure, C_{nt}

and C_{mt}, respectively, to maximize period 0 lifetime (3-period) utility given as follows:

$$u(C_{n0}, C_{m0} + \zeta M_0) + u(C_{n1}, C_{m1} + \zeta M_1) + u(C_{n2}, C_{m2} + \zeta M_2), \tag{4}$$

subject to (1) and the intertemporal budget constraint

$$\sum_{t=0}^{2} (C_{n,t} + C_{m,t}) = \sum_{t=0}^{2} Y + S_0. \tag{5}$$

where Y is the household's income in each period.

Let λ be the multiplier on the agent's budget constraint and let u_k be the derivative of the utility function with respect to its kth argument. Optimal nondurable goods expenditure is characterized by the first order condition:

$$u_1(C_{nt}, C_{mt} + \zeta M_t) = \lambda, \quad t = 0, 1, 2. \tag{6}$$

The Inada condition ensures that optimal nondurable goods expenditures are always positive because as nondurable goods expenditure approaches zero, marginal utility tends to infinity. However, this is not the case for memorable goods due to the presence of the stock of memory. The first order conditions for expenditure on memorable goods are characterized by the following three inequalities, which are strict if and only if $C_{mt} = 0$:

$$\underbrace{u_2(C_{n0}, C_{m0} + \zeta M_0)}_{\text{marginal gains in period 0}} + \underbrace{\zeta \cdot \mathbf{1}_{C_{m0} > C_{m,-1}} \cdot (u_2(C_{n1}, C_{m1} + \zeta M_1) + (1-\delta_m) u_2(C_{n2}, C_{m2} + \zeta M_2))}_{\text{marginal gains in future periods due to changes in memory stock}} \tag{7}$$

$$- \underbrace{\zeta \cdot \mathbf{1}_{C_{m1} > C_{m0}} \cdot \mathbf{1}_{C_{m0} > 0} \cdot u_2(C_{n2}, C_{m2} + \zeta M_2)}_{\text{marginal cost in future period due to changes in preference threshold}} \leq \lambda$$

$$u_2(C_{n1}, C_{m1} + \zeta M_1) + \zeta \cdot \mathbf{1}_{C_{m1} > C_{m0}} \cdot u_2(C_{n2}, C_{m2} + \zeta M_2) \leq \lambda \tag{8}$$

$$u_2(C_{n2}, C_{m2} + \zeta M_2) \leq \lambda, \tag{9}$$

where $\mathbf{1}_{C_{mt} > C_{m,t-1}}$ is an indicator function that is equal to 1 if and only if $C_{mt} > C_{m,t-1}$.

If households' preferences over nondurable goods and memorable goods are additively separable, i.e., $u_{12} = 0$, the Euler equation of nondurable goods consumption (Equation 6) implies that the optimal nondurable goods expenditures C_n^* are smooth over time.[9] The next two propositions characterize the optimal time path of memorable goods expenditures.

Proposition 1 ***[Fluctuations are Optimal]:*** *If $M_0 > 0$, $u_{12} = 0$, $\zeta > 0$, and $\delta_m \in (0,1)$, a smooth path of positive memorable goods expenditure is never optimal.*

Proof. We prove this proposition by contradiction. Assume that the optimal memorable goods expenditure is smooth and given by $C_{m,t} = C_m^* > 0$, then the stock of memory at time t is $M_t = (1-\delta)^t M_0$ for $t = 1,2$. The following two equations must hold:

$$u_2(C_n^*, C_m^* + \zeta(1-\delta_m)M_0) = \lambda$$
$$u_2(C_n^*, C_m^* + \zeta(1-\delta_m)^2 M_0) = \lambda,$$

If $M_0 > 0$ and $C_m^* > 0$, these two equations cannot hold at the same time, a contradiction. *Q.E.D.*

Proposition 2 ***[Optimal Zero Purchase]:*** *Define $\overline{M}(C_n^*)$ such that $u_2(C_n^*, \zeta\overline{M}(C_n^*)) = \lambda$, thus a household's optimal new expenditure of memorable goods at period 0 is zero if $M_0 > \overline{M}(C_n^*)$. Note that $\overline{M}(C_n^*)$ is not a constant, but rather is a function of C_n^*.*

Proof. Follows directly from the first order condition of memorable goods expenditure (Eq. 7). *Q.E.D.*

Thus, even in this basic version of the model with certainty, each household optimally chooses time-varying memorable goods expenditures. Memorable goods consumption expenditure is intermittent, even in the absence of non-convex adjustment costs and indivisibilities.

[9] However, if $u_{12} \neq 0$, the marginal utility of nondurable goods also depends on the consumption of memorable goods. In this case, optimal consumption of nondurable goods varies over time with memorable goods in this perfect-certainty model. In the following analysis, we focus on the the case where the preferences over nondurable goods and memorable goods are additively separable to obtain the clearest intuition what is driving optimal fluctuations of memorable goods consumption.

3 Data and Empirical Strategy

We now describe the US Consumer Expenditure Survey (CEX) used in our empirical analysis.

3.1 Consumer Expenditure Survey (CEX)

The data is obtained from the Consumer Expenditure Survey (CEX) for the period 1980-2003.[10] The CEX, constructed by the Bureau of Labor Statistics (BLS) contains comprehensive measures of consumption expenditures and earnings for a large cross section of households. In addition, and crucially for our purposes, it has a limited panel dimension.[11] The CEX is a rotating panel of households that are selected to be representative of the U.S. population. Each household is interviewed every three months over five calendar quarters, and in every quarter 20 percent of the sample is replaced by new households. In the first preliminary interview the CEX procedures are explained to the members of the household, and they are asked to keep track of their expenditures for future interviews. After this first interview, each household is subsequently interviewed for a maximum of four more times, once every three months. In each of these interviews, detailed information is collected on household consumption expenditures for the last three months. In the second and fifth interviews, demographic and income data are collected for each household, including earnings and income information for the previous 12 months.

We deflate all consumption goods category expenditures using the relevant consumer price index (CPI). Income categories are deflated by monthly CPI for all urban consumers and all items. All the data in the paper are expressed in 1982-1984 dollars.

We include in our sample only households that are classified as complete income reporters in the CEX. We also drop observations that report zero food expenditures, and those who report only food expenditures. In addition, we exclude all observations of households for which the

[10] Starting in 2004 the CEX introduced many changes in both income and consumption expenditure variables that reduce the comparability with the data from the earlier period.

[11] The Panel Study of Income Dynamics (PSID) has extended its coverage of consumption in recent years, but the higher frequency of observations in the CEX (as well as the longer overall sample with comprehensive consumption data) makes the CEX preferable to the PSID consumption data for this study.

household reference person is below 21 or above 64, and those households with negative or zero disposable income.[12] Finally, we exclude households classified as rural, and those households who do not have consecutive 12 months of consumption expenditure reports. Our final sample consists of 28,969 households with the full 12 months of consecutive consumption expenditure observations.[13]

3.2 Frequency of Consumption Expenditure Observations in the CEX

Since we are interested in how households change expenditures in different consumption categories over time, a panel dimension with a reasonably high frequency of observations is desirable. Although the CEX interview is conducted at quarterly frequency, the highest frequency for consumption data is monthly. Specifically, each expenditure reported by a household is identified by Universal Classification Code (UCC) and the month in which the expenditure occurred in CEX Monthly Expenditure (MTAB) file. The algorithm that BLS uses to construct MTAB files for each interview quarter is called the Time Adjustment (TA henceforth) process. It maps each UCC into a monthly time frame. Whenever the reference month information is available, the TA algorithm maps the UCC to the exact month in which the expenditure occurred (e.g. trip related expenditures, expenditures on jewelry, and cars). If only quarterly information is available, the TA algorithm converts monthly expenditure by dividing quarterly expenditure by 3 (e.g. food at home).

The TA algorithm is based on the detailed UCCs. There are more than 600 UCCs in the CEX data. When we aggregate these UCCs into relative aggregate consumption categories, many of these consumption categories contain "mixed" frequency information.[14] Based on the 2006 TA mapping algorithm,[15] we report the underlying frequencies of our consumption expenditure categories as an illustration (Table A.III). We say a consumption category contains monthly infor-

[12] The definition of disposable income is described in the Appendix.
[13] Table A.I and Table A.II report selected summary statistics of our sample.
[14] The mapping between CEX UCCs and detailed consumption and income categories is available upon request.
[15] We thank Jeffrey Crilley from BLS for providing us with the file.

mation, if any of the UCCs contained in this category has information on a specific expenditure month in CEX data. As seen from Table A.III, most consumption categories contain monthly information.[16] In addition, as a robustness check, in Section 3.4 we conduct our empirical analysis both for data at monthly frequency (our preferred data) and for data at quarterly frequency.

3.3 Descriptive Statistics and Detailed Consumption Categories

In this subsection, we document descriptive statistics for expenditures on 28 detailed consumption goods, and discuss how we classify these 28 detailed consumption goods into three consumption categories: memorable goods, nondurable goods, and durable goods. We document that memorable goods expenditure accounts for a significant share (18.6% for memorable goods and 13.1% for strictly memorable goods) of a typical households' budget and exhibits substantially larger fluctuations at a monthly (and quarterly) frequency than our defined nondurable goods.

We investigate four descriptive statistics for each consumption good: average expenditure share as a percentage of total outlays, the fraction of households who had at least one zero purchase, the fraction of households who had at least one expenditure spike, and average volatility. To calculate the average share of a consumption category as a percentage of total outlays, we first calculate the expenditure share for each household in every reference period and then average across 12 months to obtain household-level expenditure share, we then average the household expenditure share across all households weighted using average Consumer Unit (CU) replicate weight in CEX data. We say that a consumer h had a consumption spike if the consumer's expenditure is higher than $\kappa = 1.5$ times her average expenditure[17], i.e., $\sum_{l=1}^{12} \mathbf{1}\{l : E_{i,l}^h > \kappa \cdot \bar{E}_i^h\} \geq 1$, where $E_{i,l}^h$ denotes household h's expenditure on good i in month l, and $\bar{E}_i^h$ is the average consumption expenditure for household h over the 12 months for that good i. We then calculate the fraction of households who had at least one consumption spike for each consumption category using average CU replicate weight. We measure the monthly consumption expenditure volatility of good i for household h

[16] This is especially true for memorable goods and durable goods expenditures which will be defined in Section 3.3.

[17] Choosing a threshold of $\kappa = 2$ gives very similar results, and we settled for a value of $\kappa = 1.5$ since the empirical results are not sensitive to small variations of κ around that value.

as the standard deviation of household h's consumption expenditures over 12 months, divided by the household-specific 12 month average consumption expenditure.[18] If household h's average expenditure on good i is zero, which only occurs if household h has zero expenditure on good i over the entire 12 month reference period, we assign the household h's expenditure volatility of good i to be zero.[19] The average volatility is calculated as the weighted average volatility across all households using average CU replicate weight. Table 1 reports the four statistics for 28 detailed consumption categories. We discuss below how we classify these detailed consumption categories into memorable goods, nondurable goods, and durable goods, based on these descriptive statistics, physical durability, existing literature, and intuition.

We start with the durable goods category, which is easiest to identify based on its physical durability and on existing literature. As discussed in the introduction, we do not intend to reclassify durable goods, and the discussion of durable goods here is mainly for the purpose of completeness and comparison. Durable goods include durable household furnishing and equipment (3.5% of total outlays), new and used motor vehicles (1.93%), tires, tubes, accessories, and other parts (0.83%), and recreation and sports equipment (1.61%). The durable goods expenditure does not include expenditures on housing assets, since we will include a measure of the service flow from housing assets (i.e., the rental equivalent) in our nondurable goods category. As seen in Table 1, durable goods expenditure is indeed infrequent as more than 90% of households had at least one zero expenditure on each of these detailed durable goods categories. At the same time, durable goods expenditure is also lumpy due to its physical indivisibility. More than 30% of households had at least one expenditure spike of size 1.5 during the 12 month reference period. In total, durable goods expenditure accounts for 7.9% of total outlays (see Table 2).

We turn next to the classification of memorable goods. The set of memorable goods (MG)

[18] Our measure is analogous to that of Davis and Kahn (2008). They measure volatility of consumption as the absolute value of the log change in 6 month consumption expenditures for each household, and then average over households. However, because we need to allow for zero expenditures in some consumption categories for our analysis, instead of taking log changes for each household we calculate the coefficient of variation.

[19] Our volatility measure is a conservative measure of consumption volatility for memorable and durable goods with infrequent expenditures because we underestimated the expenditure volatility for households for which we do not observe any positive expenditure during the 12 month observation period (inactive households).

Table 1: Purchase and Consumption Patterns of Detailed Consumption Categories

Frequent Purchase — Frequent Consumption

	(1) Share %Outlays	(2) Had Zeros	(3) Had Spikes	(4) Ave Vol.
Strictly Nondurable Goods				
1. Food & Alcohol at Home	18.93	0.006	0.194	0.259
2. Food at School	0.37	0.930	0.239	0.338
3. Meals Received as Pay	0.18	0.993	0.069	0.106
4. Tobacco Products	1.26	0.699	0.220	0.279
5. Housing	12.64	0.037	0.143	0.194
6. Household Operations & Utilities	17.61	0.051	0.741	0.482
7. Transportation Services Excl. on Trips/Vacations	10.06	0.078	0.772	0.592
8. Business Services	1.32	0.761	0.811	1.400
9. Personal Care Services	1.23	0.386	0.502	0.552
10. Gambling	0.02	0.994	0.036	0.071

Infrequent Purchase — Frequent Consumption

	(1) Share %Outlays	(2) Had Zeros	(3) Had Spikes	(4) Ave Vol.
Durable Goods				
1. Durable Household Furnishing & Equipment	3.50	0.994	0.899	2.042
2. New & Used Motor Vehicles (Net Outlay)	1.93	1.000	0.297	0.989
3. Tires, Tubes, Accessories, and Other Parts	0.83	1.000	0.639	1.813
4. Recreation & Sports Equipment	1.61	0.895	0.821	1.774
Nondurable Goods with a semidurable component				
1. Health	4.31	0.487	0.847	1.302
2. Education	0.82	0.997	0.418	1.100
3. Reading	0.75	0.444	0.626	0.663
Strictly Nondurable Goods with infrequent billing				
1. Vehicle Registration	0.39	1.000	0.766	2.224
2. Life and other Personal Insurance	1.56	0.996	0.595	1.017
3. Auto Insurance	2.10	1.000	0.799	1.667

Infrequent Purchase — Infrequent Consumption

	(1) Share %Outlays	(2) Had Zeros	(3) Had Spikes	(4) Ave Vol.
Strictly Memorable Goods				
1. Trips & Vacations	2.92	0.996	0.759	1.850
2. Entertainment Excl. on Trips/Vacations	3.83	0.302	0.854	0.875
3. Food & Alcohol out Excl. on Trips/Vacations	4.82	0.302	0.595	0.601
4. Photographic Services & Rental	0.25	0.851	0.616	0.793
5. Charitable Giving	0.69	0.980	0.576	1.040
6. Clothing Services	0.57	0.696	0.673	0.948
Memorable Goods with a semidurable component				
1. Clothing and Shoes	5.1	0.901	0.980	1.490
2. Jewelry and Watches	0.4	1.000	0.544	1.596

(1) To calculate the average share as percentage of total outlays, we first calculate the expenditure share for each household in every reference period and then average across 12 months to obtain household-level shares, we then average the household expenditure share across all households weighted using average CU replicate weights in CEX data.

(2) We calculate the fraction of households who had at least one zero expenditure on the good, which we term as inactivity. All the across households calculation is weighed using the average CU replicate weight.

(3) We say that a consumer h had a consumption spike of size κ, if the consumer's expenditure is higher than κ times her average expenditure, i.e., $\sum_{l=1}^{12} \mathbf{1}\{l : E_{i,l}^h > \kappa \cdot \bar{E}_i^h\} \geq 1$, where $E_{i,l}^h$ denotes household h's expenditure on good i in month l, and $\bar{E}_i^h$ is the average consumption expenditure for household h over the 12 months for that good i. We then calculate the fraction of households who had at least one consumption spike for this consumption category using average CU replicate weights. Here we set $\kappa = 1.5$.

(4) The average volatility is calculated as follows. First, for each household h, we calculate the household's expenditure on good i as $\text{vol}_i^h = \sqrt{\sum_l (E_{i,l}^h - \bar{E}_i^h)^2/12}/\bar{E}_i^h = \text{standard deviation}_i^h/\text{mean}_i^h$, where $E_{i,l}^h$ denotes household h's expenditure on good i in month l, and $\bar{E}_i^h$ is the average consumption expenditure for household h over the 12 months for that good i. If $\bar{E}_i^h = 0$, household h has zero expenditure over 12 months in category i, and we assign $\text{vol}_i^h = 0$. The average volatility is calculated as the weighted average across all households using average CU replicate weights.

is meant to comprise goods for which the timing of the physical act of consumption and the utility this act generates are typically decoupled, and for which both expenditures and physical consumption occur infrequently. As illustrated by our model, households prefer infrequent and lumpy consumption of memorable goods because consumers have an incentive to consume something out of ordinary in order to generate memory. Therefore, in our empirical classification, we look for traditionally classified nondurable goods, see Lusardi (1996), Parker (1999), Krueger and Perri (2006), and Aguiar and Hurst (2013)) that exhibit both infrequent purchases and lumpy purchases.[20] Among these goods we use our judgment to decide whether such patterns are due to households' preferences or other reasons such as billing frequency.

We classify as memorable goods trips and vacations (2.92% of total outlays), entertainment excluding on trips and vacations (3.83%), food and alcohol out excluding on trips and vacations (4.82%), photographic services and rental (0.25%), charitable giving (0.69%), clothing services (0.57%), clothing and shoes (5.1%), and jewelry and watches (0.4%) (see Table 1). As recognized by many existing studies (e.g., Lusardi (1996) and Souleles (1999)), clothing and shoes and jewelry and watches have a semi-durable component. We therefore define strictly memorable goods to be memorable goods excluding clothing and shoes and jewelry and watches. Trips and vacations, entertainment excluding on trips and vacations, and food and alcohol out excluding on trips and vacations are the three largest components of strictly memorable goods. In total, strictly memorable goods expenditure accounts for 13.1% of total outlays and our broadly defined memorable goods expenditure accounts for 18.6% of total outlays (see Table 2).

As seen in Table 1, all these detailed memorable goods categories exhibit infrequent and lumpy purchases.[21] For trips and vacations, over 99% households had at least one zero expenditure and more than 75% of the households had at least one consumption spike. For entertainment excluding on trips and vacations and for food and alcohol out excluding trips and vacations, the fractions

[20] We emphasize that the categorization of a good as memorable does not imply that a specific consumer necessarily has memorable consumption from this good; whether she does depends on the pattern of her consumption of the good.

[21] Appendix Figure 5 documents the frequency of zero expenditures for the following detailed memorable goods categories: total expenditure on trips and vacations, clothes and shoes, jewelry and watches. We also report the inactivity patterns for two durable goods categories, new and used vehicles (net outlay), and tires, tubes, accessories and other parts, as a comparison with memorable goods in Figure 5.

of households with zero expenditures are 30%, and the fractions of households with at least one spike are 85.4% and 59.5%, respectively. For clothing and shoes, and jewelry and watches, the fraction of households with zero purchases are 90% and 100%, respectively, and the fractions of households with spikes are 98% and 54.4%, respectively. Last but not least, the average volatility of memorable goods is as high as those of the durable goods categories. Specifically, the average expenditure volatility of trips and vacations is about 2 times the volatility of that of new and used motor vehicles and is about the same magnitude as that of tires, tubes, accessories and other parts.

Lastly, our definition of nondurable goods (ND) encompasses the rest, except those defined as memorable goods, of the goods traditionally classified as nondurable goods (see Lusardi (1996), Parker (1999)), Krueger and Perri (2006), and Aguiar and Hurst (2013)). We include in nondurables food and alcohol at home (18.9% of total outlay), food at school (0.37%), meals received as pay (0.18%), tobacco products (1.26%), housing (12.64%), household operations and utilities (17.61%), transportation services excluding on trips and vacations (10.06%), business services (1.32%), personal care services (1.23%), gambling (0.02%), vehicle registration (0.39%), life and other personal insurance (1.56%), auto insurance (2.1%), health (4.31%), education (0.82%), and reading (0.75%). As discussed by Lusardi (1996) and Souleles (1999), the consumption of health, education, and reading has a semi-durable component, we therefore define a subset of nondurables, "strictly nondurables" (Strictly ND) to be all nondurable goods, but excluding health, education and reading. Thus our definition of nondurable and memorable goods combined is equivalent to Souleles (1999)'s nondurable goods, and our definition of strictly nondurable and strictly memorable goods combined equals Souleles (1999)'s definition of strictly nondurable goods. In total, strictly nondurable goods expenditure accounts for 67.7% of total outlays and our broadly defined nondurable goods expenditure accounts for 73.5% of total outlays.

As seen in Table 1, the majority of our defined strictly nondurable goods do not exhibit infrequent purchase and lumpy expenditure at the same time. In particular, the largest component of strictly nondurables is food and alcohol at home. As seen in Table 1, less than 1% of households had zero expenditures on food at home, and only 19.4% of them experienced a consumption

Table 2: Consumption Expenditure Shares (Monthly Frequency)

	Outlays (%)	(ND+MG) (%)	Strictly (ND+MG) (%)
Outlays	100.0		
Durables	7.9		
ND+MG	92.1	100.0	
Memorables	18.6	20.4	
Nondurables	73.5	79.6	
Strictly (ND+MG)	80.7	87.4	100.0
Strictly Memorables	13.1	14.3	16.6
Strictly Nondurables	67.7	73.1	83.4

spike of size 1.5 during the 12 month reference period. The next largest component of strictly nondurables is household operations and utilities, where only 5% of households had zero expenditures. For expenditure on housing (including both rents and rental equivalent of owned home), only 3.7% of households had zero purchases and 14% of households had spikes. Similarly, only 7.8% of households had zero expenditure on transportation services excluding on trips and vacations. There are a few exceptions, however, among our strictly nondurable goods category, which exhibit both infrequent and lumpy expenditure. These exceptions are food at school, business services, vehicle registration, life and other personal insurance, and auto insurance. We do not consider food at school and business services as memorable goods because they are business and school related and the lumpiness of their expenditure does not stem from memory creation which consumers can enjoy later on. The expenditures on vehicle registration, life and other personal insurance, and auto insurance are also infrequent and lumpy due to infrequent billings. Finally, as seen in Table 1, the expenditure on nondurable goods with a semi-durable component (i.e., health, education, readings) are infrequent and lumpy.

3.4 Memorable Goods, Nondurable Goods, and Durable Goods

In this section, we document the summary statistics for our defined three aggregate consumption categories: memorable goods, nondurable goods, and durable goods.

As seen in Table 2, memorable goods expenditure accounts for 18.6% of total outlay and strictly

Table 3: Consumption Expenditure Patterns (Monthly Frequency)

	Had Zeros	Had Spikes	Ave Vol.
Outlays	0.000	0.747	0.525
Durables	0.842	0.961	2.048
ND+MG	0.000	0.563	0.313
Memorables	0.065	0.976	0.828
Nondurables	0.000	0.446	0.287
Strictly (ND+MG)	0.000	0.503	0.294
Strictly Memorables	0.075	0.917	0.810
Strictly Nondurables	0.000	0.418	0.272

Note: Ave Vol. is the average household-specific 12-month consumption volatility. The calculation is the same as in Table 1.

memorable goods expenditure accounts for 13.1% of total outlays.[22] Of the combined expenditure that households allocated towards memorable goods and nondurable goods, the average expenditure share of memorable goods is 20.4%. Of the combined expenditure that households allocated toward strictly memorable goods and strictly nondurable goods, the average expenditure share of strictly memorable goods is 16.6%.

As seen in Table 3, for memorable goods, 6.5% of households had at least one zero purchase and 97.6% of households had at least an expenditure spike of size 1.5. For strictly memorable goods, 7.5% of households had at least one zero purchase, and the percentage of households with at least one consumption spike is 91.7%. In comparison, for nondurable goods and strictly nondurable goods, the fraction of households with zero expenditures is zero and the fraction of households with at least one consumption spike is below 45%; for durable goods, the fraction of zero purchases is 84% and the fraction with spikes is 96%.

The last column of Table 3 reports the average volatility of different consumption categories. Strictly memorable goods are 3 times as volatile as strictly nondurable goods. Durable goods expenditures are 7.5 times as volatile as strictly nondurable goods. We also report the measured expenditure volatilities based on data at quarterly frequency (Table A.V). As one can see from

[22] Measured at a quarterly level, Memorable Goods expenditure accounts for 18.6% of total outlays and strictly memorable goods expenditure accounts for 12.9% of total outlays (see Table A.IV in the appendix).

Table 3 above and Table A.V (in the appendix), the relative magnitudes of the volatility measures of these consumption goods groups do not change as we move from monthly to quarterly frequency.[23]

4 A Quantitative Model with Borrowing Constraint and Income Uncertainty

In this section, we now turn to a fully parameterized quantitative model and calibrate our model parameters using the CEX data described in the data section above.

4.1 The Setup

As seen in the simple example in Section 2, we need to take a stance on how memory stock is updated over time as well as how instantaneous utility function depends on it. In order to capture the idea proposed in the introduction that only an unusual consumption experience contributes to the stock of memory, we assume that the memorable goods expenditure $C_{m,t}$ augments the household's stock of memory tomorrow, M_{t+1}, only if it exceeds a preference threshold N_t of being memorable. Specifically, the law of motion of the memory stock M_t is characterized by

$$M_{t+1} = (1-\delta_m)M_t + \max\{C_{m,t} - N_t, 0\}, \quad \delta_m \in (0,1) \tag{10}$$

where N_t is the household's preference threshold given by:

$$N_t = (1-\rho)N_{t-1} + \rho C_{m,t-1}, \quad \rho \in (0,1]. \tag{11}$$

The threshold value N_t itself could in principle depend on the individual's complete history of past consumption experience, Equation 11 provides a parsimonious way of modeling N_t recursively. With equation 11, we can rewrite the memory threshold as a sum of all past memorable goods

[23] Quarterly strictly memorable goods expenditures are 2.9 times as volatile as strictly nondurable goods, and durable goods expenditures are 6 times as volatile as expenditures on nondurable goods (see Appendix Table A.V).

consumption: $N_t = \rho C_{m,t-1} + \rho(1-\rho)C_{m,t-2} + \rho(1-\rho)^2 C_{m,t-3} + \ldots$. If $\rho = 1$, $N_t = C_{m,t-1}$, a consumer uses her $t-1$ memorable goods consumption level as the threshold value, and we return to the special case where the evolution of preference threshold is as specified in Section 2 Equation 2. If $\rho < 1$, the preference threshold of being memorable is a weighted average of the consumer's own past memorable consumption choices.

Households have preferences defined over contemporaneous consumption C_{mt} and C_{nt}, and the stock of memory M_t from past memorable consumption expenditures, represented by a period utility function of the form

$$U(C_{nt}, C_{mt}, M_t) = \xi \frac{C_{nt}^{1-\gamma}}{1-\gamma} + (1-\xi)\frac{(C_{mt} + \zeta M_t)^{1-\gamma}}{1-\gamma}. \tag{12}$$

with the weight parameter $\xi \in [0,1]$ governing the relative expenditure shares of nondurable goods consumption and memorable goods consumption. We intentionally impose within period additivity (between nondurables and memorables) and homotheticity to eliminate complementarity and "luxury" effects. The utility from memorable goods consumption is the weighted sum of the direct utility obtained from the act of consumption C_{mt} from current new expenditure and the stock of memory M_t from past memorable goods consumption, with weight ζ controlling the importance of immediate memorable goods consumption C_{mt} relative to the stock of memory M_t. When $\zeta = 0$, memorable goods become standard nondurable goods. Notice that if $1-\gamma < 0$, our utility specification implies that households always choose positive nondurable goods consumption because $\lim_{C_n \to 0} U = -\infty$, but the same statement is not true for memorable goods expenditure. Households may find it optimal to have zero memorable goods expenditure if $M_t > 0$.

Given the period utility function, the intertemporal household consumption-savings problem is standard. The household faces a stochastic income process $\{Y_t\}$ and chooses levels of contemporaneous nondurable goods and memorable goods expenditure, C_{nt}, and C_{mt}, respectively, to maximize time zero expected lifetime utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_{nt}, C_{mt}, M_t). \tag{13}$$

The household faces a sequence of budget constraints and borrowing constraints

$$C_{mt} + C_{nt} + S_{t+1} \leq Y_t + (1+r)S_t \tag{14}$$

$$S_{t+1} \geq 0 \tag{15}$$

where $\{Y_t\}$ is the household's stochastic income at time t and S_t is the beginning of the period holding of riskless assets. The exogenous net return r on these assets is assumed to be constant. We assume that $(1+r)\beta \leq 1$.

For the stochastic process governing monthly income, we assume that Y_t is determined as the sum of a permanent component $\bar{y}$ and an income shock z_t that follows an $AR(1)$ process

$$\ln Y_t = \bar{y} + z_t \tag{16}$$

$$z_t = \rho_z z_{t-1} + \varepsilon_t \tag{17}$$

where $\bar{y}$ is the average log-income of the household, ρ_z measures the persistence of the income shock, and the shock itself is distributed normally with variance σ_ε^2, that is $\varepsilon_t \overset{iid}{\sim} N(0, \sigma_\varepsilon^2)$.[24]

4.2 Household Optimization & Model Solution

Households optimally choose their consumption and savings, fully taking into account the stochastic feature of their maximization problem. The dynamic programming problem of the household

[24]Thus, the conditional distribution of z_t is given by $z_t \sim N(\rho_z z_{t-1}, \sigma_\varepsilon^2)$, and the unconditional distribution of z_t by $z_t \sim N(0, \frac{\sigma_\varepsilon^2}{1-\rho_z^2})$. Moreover, unconditional expected income is given by $\mathbb{E}(Y_t) = \mathbb{E}(\exp(\bar{y} + z_t)) = \exp(\bar{y} + \frac{1}{2}\frac{\sigma_\varepsilon^2}{1-\rho_z^2})$.

has state variables (M, N, S, z) and is given by

$$V(M,N,S,z) = \max_{C_m, S' \geq 0} \left\{ U(C_n, C_m, M) + \beta \mathbb{E}[V(M', N', S', z')|z] \right\} \qquad s.t. \tag{18}$$

$$C_n = Y + (1+r)S - C_m - S' \tag{19}$$

$$M' = (1-\delta_m)M + \max\{C_m - N, 0\} \tag{20}$$

$$N' = (1-\rho)N + \rho C_m \tag{21}$$

$$\ln Y = \bar{y} + z \tag{22}$$

$$z' = \rho_z z + \varepsilon \tag{23}$$

Our model departs from traditional consumption models in the dynamics of the memory stock M_t (Equation 20) and the endogenous evolution of preference threshold N_t (Equation 21). Memorable goods consumption C_{mt} adds to the stock of memory M_{t+1} to the extent that it exceeds an endogenous threshold N_t that is determined by past expenditures. This threshold property is the key mechanism that generates the intermittent spikes of memorable goods consumption even in the *absence* of non-convex adjustment costs and indivisibilities.[25]

The model does not have an analytical solution, so we solve it numerically. The challenge is that with 4 continuous state variables (M, N, S, z) the state space is large. In addition, our specification of memorable good results in a maximization that is not a convex problem, and the resulting policy functions (especially for C_m) are not continuous in the state variables, especially the memory stock M and the memorable threshold N. To deal with the large state space we use a Smolyak sparse grid collocation algorithm and approximate the *value function* (but not the policy functions) by a linear combination of polynomials at each grid point.[26] Note that although the decision vari-

[25]This feature of the model also implies that a consumer may have higher utility if she postponed further expenditures to a later period since by doing so she may obtain a greater increment to her memory stock. In addition, making this consumer a gift of a memorable good in a period just prior to an unusually large memorable goods purchase may make her *worse off*; this cannot happen in a standard model with durable goods.

[26]See Barthelmann et al. (2000) and Malin et al. (2007) for the details of Smolyak's algorithm.

ables exhibit jumps, it is convenient to iterate on the value function, which is continuous due to the theorem of the maximum. Details on the solution algorithm are provided in Appendix C.

4.3 Calibration of the Model Parameters

We use an annual real interest rate of 4%, and thus the monthly real interest rate in our model is set to be $r = 0.33\%$. We set the deterministic component of log income to $\bar{y} = -0.5\frac{\sigma_\varepsilon^2}{(1-\rho_z^2)}$ so that the unconditional expectation of an individual's monthly income is normalized to 1.

We match moments to calibrate the preference parameters $(\beta, \xi, \zeta, \delta_m, \rho, \gamma)$, and the income process parameter $(\rho_z, \sigma_\varepsilon)$. The target moments include an average liquid assets to annual income ratio of 1.231,[27] average share of strictly memorable goods as a fraction of combined strictly memorable goods and strictly nondurable goods of 0.166, fraction of households that had at least one spike in memorable goods consumption, relative size of strictly memorable goods spikes, fraction of households that had at least one zero expenditure in strictly memorable goods, and average volatility of strictly memorable goods, strictly nondurable goods and both goods combined. We report the cross-sectional variance of the log of strictly nondurables, and the cross-sectional variance of the log of strictly nondurables and strictly memorables combined as untargeted moments.

The calibrated values of model parameters are reported in Table 4. The relative importance of nondurable goods is fairly large, $\xi = 0.8679$, relative to the weight $1 - \xi = 0.1321$ on memorable goods. Although immediate memorable consumption C_m constitutes the most important component of the utility flow from memorable goods consumption ($\zeta = 0.1090$), the memory stock M_t is also significant. The weight of current memorable goods consumption on future memory threshold N is moderate ($\rho = 0.2486$). Last, after one year $2/3$ of the memorable shock is depreciated, absent spending, and thus only $1/3 \approx (1 - 0.0839)^{12}$ remains. We also report the values of targeted moments and the simulated moments under the parameter estimates[28] in Table 5.

[27]The average ratio of liquid assets to annual income is 1.231 in PSID data from 1989 to 2003 among households with non-negative financial assets.

[28]Although the fit of the moments is satisfactory, it is not perfect, due to the inability of the model to generate both a sufficiently volatile nondurable consumption and sufficiently smooth memorable consumption expenditures in the model, relative to the data. However, that household consumption in the CEX is likely measured with substantial error

Table 4: Internally Calibrated Parameters

	Interpretation	Value
ξ	Weight on C_n in U	0.8679
ζ	Weight on M in U	0.1090
δ_m	Deprec. of Memory	0.0839
ρ	Weight on C_m in N	0.2486
γ	Relative risk aversion coefficient	1.4173
ρ_z	Persistence of log income process	0.9420
σ_ε	S.D. of log income process	0.2600
β	Subjective discount factor	0.9911

Table 5: Model Fit

Moments	Data	Model
Panel A: Targeted Moments		
Average Share of Strictly Memorables	0.166	0.178
Had Spikes: Strictly Memorables	0.917	0.996
Had Zeros: Strictly Memorables	0.075	0.047
Relative Size of Strictly Memorable Spikes	2.555	2.031
Average Volatility: Strictly (Memorables+Nondurables)	0.294	0.215
Average Volatility: Strictly Nondurables	0.272	0.128
Average Volatility: Strictly Memorables	0.810	0.793
Mean Liquid Assets/Annual Income	1.231	1.364
Panel B: Untargeted Moments		
Cross-Sectional Variance: Log strictly Nondurables	0.254[a]	0.317
Cross-Sectional Variance: Log strictly (Memorables+Nondurables)	0.289	0.332

[a]The cross-sectional variance of log consumption in the data is calculated via a regression analysis, controlling for a time trend, household head's age, age^2, age^3, number of children, number of adults, dummy variables for household head's marital status, gender, and race, dummy variables for education categories, and dummy variables for regions.

5 The Welfare Cost of Income Fluctuations Revisited

One implication of our model with memorable goods is that the observed large consumption expenditure fluctuations of memorable goods do not necessarily lead to welfare losses from volatile consumption. A household's underlying utility flow from memorable goods is smoother than the

which might overstate the empirical expenditure volatility for a given household over a twelve month interval.

per-period memorable goods consumption expenditure because current memorable goods consumption and the stock of memory accumulated in the past are substitutes in the utility function. Optimal consumption of memorable goods depends on both the stock of memory and the preference threshold of being memorable (i.e. the average of past memorable goods consumption). Hence, households adjust their memorable goods consumption over time based on their memory stock and average past memorable goods consumption. This is the case even in the *absence* of income risk and incomplete financial markets, as shown in the simple example of section 2.

We use our calibrated quantitative model with income risks and borrowing constraints developed in Section 4 to measure by how much the welfare loss of consumption fluctuations is overstated by not accounting for the fact that memorable goods expenditure fluctuations are part of optimal household consumption choices, even in the absence of uninsurable shocks (to income, say) that may make consumption volatile.

In our model the only source of suboptimal consumption fluctuations is uninsurable idiosyncratic *labor income* risk; recall that households can only self-insure through building up and drawing down their balance of risk free assets.[29] We now ask, in the context of the model, how large are the welfare losses from consumption fluctuations induced by idiosyncratic income shocks, and how are these losses affected by explicitly modeling memorable goods? To do this, we compare (both in the model with, and in the model without memorable goods) household welfare in two scenarios: one in which households in the model face a stochastic income process and one in which households receive deterministic incomes with the same mean as in the stochastic world.

5.1 Welfare Cost Calculation

Equipped with the structurally estimated model we now calculate the welfare losses from uninsurable income shocks, both in the presence and absence of memorable goods. Denoting by Φ the

[29] In Lucas' (1987) representative agent endowment economy income and consumption fluctuations are identical.

normal cdf with zero mean and variance σ_ε^2, we can rewrite the value function, equation (18) as:

$$V(M,N,S,z) = \max_{C_n,C_m,S'\geq 0} \left\{ \xi \frac{C_n^{1-\gamma}}{1-\gamma} + (1-\xi)\frac{(C_m+\zeta M)^{1-\gamma}}{1-\gamma} + \beta \int V(M',N',S',\rho_z z+\varepsilon')d\Phi(\varepsilon') \right\}$$

subject to equations (19) to (22). This dynamic programming problem yields value and policy functions $V(M,N,S,z)$, $C_n(M,N,S,z)$, $C_m(M,N,S,z)$, $S'(M,N,S,z)$. Similarly, define the dynamic programming problem for a household facing no income risk as

$$\bar{V}(M,N,S) = \max_{C_n,C_m,S'} \left\{ \xi \frac{C_n^{1-\gamma}}{1-\gamma} + (1-\xi)\frac{(C_m+\zeta M)^{1-\gamma}}{1-\gamma} + \beta \bar{V}(M',N',S') \right\}$$

subject to equations (19) to (21), and with income

$$\ln Y = \bar{y} + \frac{1}{2}\frac{\sigma_\varepsilon^2}{(1-\rho_z^2)}. \tag{24}$$

The last term ensures that the household faces the same expected income as with income risk. Denote value and policy functions from this dynamic program as $\bar{V}(M,N,S)$, $\bar{C}_n(M,N,S)$, $\bar{C}_m(M,N,S)$, $\bar{S}'(M,N,S)$. Further define

$$W(S,z) = \max_{C_n,S'\geq 0} \left\{ \frac{C_n^{1-\gamma}}{1-\gamma} + \beta \int W(S',\rho_z z+\varepsilon')d\Phi(\varepsilon') \right\}$$

subject to equation (19) and (22) as the dynamic programming problem in the presence of income risk, but *absent* memorable goods, with value and policy functions $W(S,z), C_n^W(S,z), S^{W\prime}(S,z)$. Finally, in the absence of both income risk and memorable goods the dynamic program reads as

$$\bar{W}(S) = \max_{C_n,S'\geq 0} \left\{ \frac{C_n^{1-\gamma}}{1-\gamma} + \beta \bar{W}(S') \right\}$$

subject to equation (19) and (24), with associated value and policy functions $\bar{W}(S), \bar{C}_n^W(S), \bar{S}^{W\prime}(S)$.

For each state (M,N,S), we define the welfare cost of consumption fluctuations induced by uninsurable income shock as the permanent percent reduction in consumption that would make a household living in a world without income risk indifferent to living in a world with income risk. As Appendix B shows, these numbers can be calculated from the value functions alone as[30]

$$
\begin{aligned}
1-g(M,N,S) &= \left[\frac{V(M,N,S,z=0)}{\bar{V}(M,N,S)}\right]^{\frac{1}{1-\gamma}} \\
1-g^W(S) &= \left(\frac{W(S,z=0)}{\bar{W}(S)}\right)^{\frac{1}{1-\gamma}}.
\end{aligned}
$$

5.2 Results

By construction, the welfare cost function $g(M,N,S)$ in the model with memorable goods depends on the state variables M, N and S. Let $F(M,N,S)$ denote the invariant marginal distribution over state variables (M,N,S) in the model with memorable goods and income risk. Similarly, let $F^W(S)$ denote the invariant marginal distribution over wealth in the model with income risk but without memorable goods. Therefore,

$$
\begin{aligned}
F(M,N,S) &= \int H(M,N,S,z)d\Phi^z(z) \\
F^W(S) &= \int H^W(S,z)d\Phi^z(z)
\end{aligned}
$$

where $H(M,N,S,z)$ and $H^W(S,z)$ are the invariant distributions over the states in models with and without memorable goods, respectively, and Φ^z is the normal cdf with zero mean and variance $\sigma_\varepsilon^2/(1-\rho^2)$. We can then calculate two aggregate welfare cost measures as follows:

$$
\begin{aligned}
\bar{g} &= \int g(M,N,S)dF(M,N,S) \\
\bar{g}^W &= \int g^W(S)dF^W(S).
\end{aligned}
$$

[30]For $\gamma = 1$, a similar derivation yields

$$
\begin{aligned}
1-g(M,N,S) &= \exp\left[(1-\beta)(V(M,N,S,z=0)-\bar{V}(M,N,S))\right] \\
1-g^W(S) &= \exp\left[(1-\beta)(W(S,z=0)-\bar{W}(S))\right].
\end{aligned}
$$

Table 6: Aggregate Welfare Cost

	Interpretation	Estimated Value
$\bar{g}$	Welfare cost with memorable goods	12.3%
$\bar{g}^W$	Welfare cost without memorable goods	20.4%

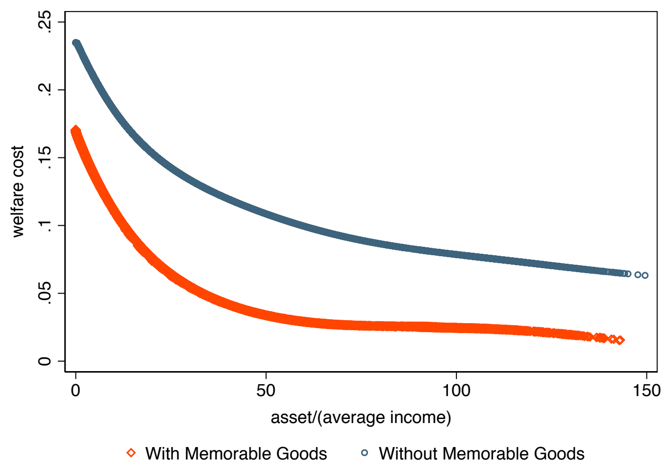


Figure 2: Welfare Cost Comparison

The difference between the welfare costs $\bar{g}^W - \bar{g}$, is our measure of the overstatement of the welfare cost of consumption fluctuations that results from ignoring memorable goods. Table 6 reports the estimated aggregate welfare cost measures $\bar{g}$ and $\bar{g}^W$ from the structurally estimated model. The reduction in the welfare cost of consumption fluctuations amounts to a very substantial 8.1 percentage points, from 20.4% to 12.3%. Figure 2 compares the welfare cost in the model with memorable goods to that in the model without memorable goods at each asset level (S) averaged across states M and N. We observe that the magnitude of the welfare costs of consumption fluctuations, is significantly smaller in the model with memorable goods than in the model without memorable goods, at *each* asset level. In the presence of income risk and borrowing constraints, both the model with memorable and without memorable goods have a non-degenerate invariant distribution over their respective state variables. In the model with uninsurable income risk but without memorable goods, households can only smooth consumption through asset accumulation. However, in the model with memorable goods in which memories depreciate at low rates, these goods serve as an alternative buffer to insure against income shocks. When faced with such a shock, households can access their internal capital market by delaying expenditure spikes of memorable goods and letting the stock of memories depreciate. [31]

6 The Excess Sensitivity of Consumption Revisited

In the previous section we demonstrated that accounting for and explicitly modeling memorable consumption goods significantly changes our quantitative assessment of the welfare cost of consumption fluctuations induced by uninsurable income shocks. In this section, we argue that the presence of memorable consumption goods may warrant a reinterpretation of empirical findings uncovering excess sensitivity of consumption to expected income changes. Our goal here is not to rewrite the massive empirical literature on the excess sensitivity of consumption. We simply want to demonstrate that one important piece of this evidence, stemming from the consumption response to predictable receipts of federal income tax refunds, as documented in the important paper by Souleles (1999), could potentially be due to the rational response of memorable consumption expenditures to these tax refunds.

The idea of empirical consumption excess sensitivity tests is to ask whether household consumption expenditures respond to predictable changes in disposable income at the time of the income receipt. The basic test for excess sensitivity of nondurable consumption to predictable income changes is conducted by estimating the specification:

$$C_{n,0} - C_{n,-1} = \beta_0 + \beta_2 \Delta Y_0 + \text{other terms} \tag{25}$$

where ΔY_0 is the predictable income change realized at period 0 but announced before period 0.

[31] Thus, on one hand, precautionary savings are smaller in the presence of memorable goods, while on the other hand, the presence of memorable goods creates an incentive to save for planned future memorable consumption spikes.

The standard consumption-savings model predicts that, absent borrowing constraints, consumption should not respond to predictable changes in income, i.e. $\beta_2 = 0$. If it does, consumption exhibits excess sensitivity (to predictable income changes), and is viewed as evidence against optimal intertemporal consumption choice behavior. In Appendix B, we show that in the absence of binding borrowing constraints our model predicts $\beta_2 = 0$ for nondurable goods consumption.[32]

However, this argument does not apply for expenditures on memorable goods.[33] Using model simulations we demonstrate below that even asset-abundant households may find it optimal to adjust their memorable goods expenditures $C_{m,0} - C_{m,-1}$ at the time of receiving income increases that were anticipated in advance. That is, our model generates a significantly positive coefficient $\tilde{\beta}$ when regressing the change of memorable consumption expenditures on expected income changes:

$$C_{m,0} - C_{m,-1} = \tilde{\beta}_0 + \tilde{\beta}_2 \Delta Y_0 + \text{other terms}. \tag{26}$$

In the next subsection we provide intuition for the response of memorable expenditures to expected income changes in our model and then run regressions (25) and (26) on model-simulated data. In Section 6.2, we then show empirically that the excess sensitivity of nondurable goods consumption to predictable federal income tax refunds, as documented in the important paper by Souleles (1999), is mainly driven by the response of memorable consumption expenditures to these refunds.

6.1 Model-Predicted Consumption Response to Expected Income Changes

To model anticipated income changes we now assume that the household learns the stochastic part z of income $T+1 \geq 1$ periods in advance. The current information set now contains future incomes

[32] The analysis is based on the linearization of the Euler equation for nondurable consumption expenditures. See Parker and Preston (2005) and Parker (1999) for similar analyses.

[33] See the linear approximation of the Euler equation for memorable consumption goods in appendix B.

T periods ahead, and the state space includes $(z, z_{+1}, \dots, z_{+T})$. The dynamic program becomes

$$\begin{aligned} V(M,N,S,z,z_{+1},z_{+2},\dots,z_{+T}) &= \max_{C_m,S'\geq 0} \left\{ U(C_n,C_m,M) + \beta \mathbb{E}_{\hat{\varepsilon}'}[V(M',N',S',z',z'_{+1},z'_{+2},\dots,z'_{+T})] \right\} \\ z' &= z_{+1} \quad z'_{+1} = z_{+2} \quad \dots \quad z'_{+T-1} = z_{+T} \\ z'_{+T} &= \rho_z z_{+T} + \hat{\varepsilon}' \end{aligned}$$

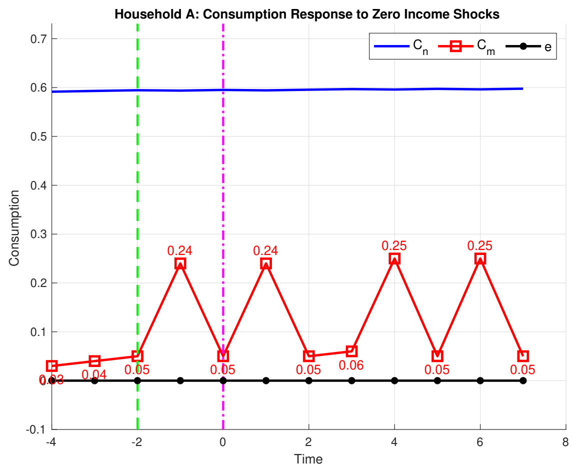
subject to Equations (19)-(22).

We now simulate income, consumption and asset data for a large panel of households over a 12-month period, consistent with the structure of the CEX data. Our goal is to mimic the receipt of information about the annual federal income tax refund, as well as the actual receipt, on average two months later. Thus, for each household the model simulation starts in month -4, and in month -2 households learn about a non-negative (but potentially zero) income shock that materializes at the beginning of month 0. There are no further income shocks after that month.[34] A gap of two months between learning the income shock and it materializing is an empirically plausible assumption for the tax rebate application below. Figure 3 displays income and consumption paths for two ex ante identical households A and B with the same initial assets (3.7 times average income) in $t = -4$. Figure 3(a) shows the paths of household A who does not experience any increase in income (i.e. receives no refund); Figure 3(b) does the same for household B who learns in $t = -2$ about a positive income shock in period 0. Figure 3(c) plots the cross-sectional relationship between income and consumption changes in period 0, the period the income change materializes.

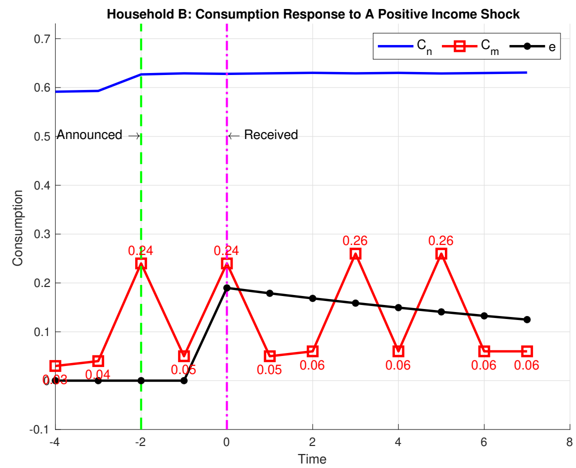
The key observations are two-fold. First, the model's predicted path for nondurable goods expenditures is the same as in the standard consumption-savings model.[35] These expenditures respond to the income shock as soon as information about it is received, that is, in period -2. In the period in which the income shock (in our application, the tax refund) actually materializes

[34] Specifically, we set $\varepsilon_t = 0$ for all $t \neq 0$. The period zero shock ε_0 is drawn from the empirical distribution $N(0, \sigma_\varepsilon^2)$. If the randomly drawn ε_0 is less than 0, we modify ε_0 to 0 to ensure the income shock is non-negative.

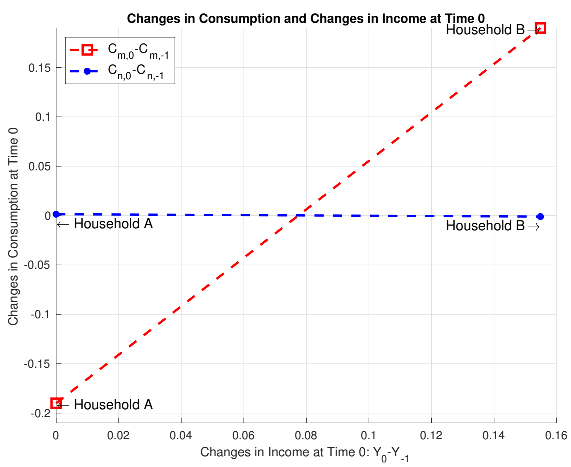
[35] For households with exactly zero wealth, even nondurable consumption responds to predictable income changes (as in the standard model), and for very wealthy households the expected income change leaves expenditures of both categories essentially unchanged.



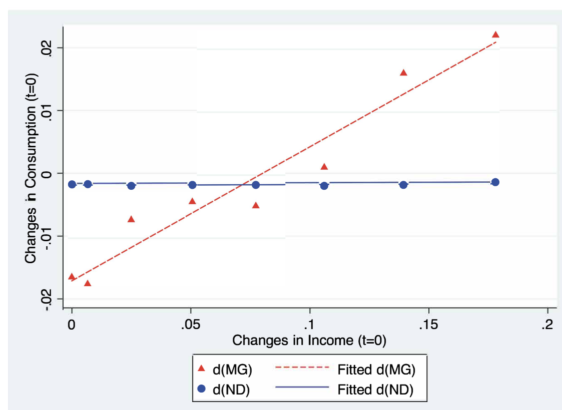
(a) Household A: Zero Income Shock



(b) Household B: Positive Income Shock



(c) Relationship of Changes in Consumption and Changes in Income (Example)



(d) Relationship of Changes in Consumption and Changes in Income (Entire Simulation; 8 Bin Scatter)

Figure 3: Model: Changes in Consumption and Income (Learning 2 Periods in Advance)

(period 0) nondurable consumption displays no further response. Thus, as seen in Figure 3(c), the gradient of nondurable goods expenditure changes with respect to income changes in period 0 is zero. This is of course exactly what standard permanent income theory predicts: there is no excess nondurable consumption sensitivity to an expected income increase in period 0.

Second, the situation is distinctly different for memorable consumption expenditures. Expected household lifetime income increases with the income shock, and as with nondurables the household wants to consume more memorable goods *at some point*. But as we have argued in Section 2, it is optimal to spend on memorable goods in spikes. The income innovation thus potentially triggers a change both in the timing of the spikes as well as their magnitude. Comparing figures 3(a) and 3(b) demonstrates the first effect. The news of a positive income shock induces the household to increase his memorable goods expenditure immediately in period -2. This shift is more likely to occur the larger is the income shock. But moving the spike to $t = -2$ results in low expenditures on memory goods in period $t = -1$, therefore a relatively low stock of memories M at the beginning of $t = 0$, and thus to a memorable goods expenditure spike in period 0. Without a positive income shock (Figure 3(a)), the household optimally chooses a memorable goods expenditure spike in period -1 and lower expenditures in period 0. As illustrated in Figure 3(c), the gradient between changes in memorable goods expenditures and expected income changes in period 0 is positive. This is simple evidence of excess sensitivity of memorable goods expenditures in this example with two households. That this finding is not an artifact of a very peculiarly chosen example with two households is demonstrated in Figure 3(d) which displays the relation between expected income changes and resulting consumption expenditure changes in a panel of 50,000 simulated households, grouped into eight income change bins.[36] It shows that the model implies a systematic positive relation between expected income changes and memorable goods expenditures, but no such relationship for expenditures on nondurables.

The positive excess sensitivity of memorable goods in Figure 3 is driven by the model property that households optimally choose to consume memorable goods in spikes, and that anticipated

[36] The full scatter plot with all 50,000 households displays the same relation, but is of course much more noisy.

income increases the chance that the spike will be brought forward in time to the period in which the income innovation is learned, the more so the larger is the expected income innovation. This in turn increases the chance households enter the period of the actual income gain with a low stock of memories M. Note that this argument does not at all depend on the presence of binding borrowing constraints (recall that the two households in the example are far away from the constraint).

In addition, households may also (or exclusively) respond to the expected income increase by changing the magnitude of the expenditure spike. A number of them planned to have a spike in period $t = 0$ even before learning about the positive income shock, but now optimally make that spike larger, especially if the initial spike was suboptimally small due to a binding liquidity constraint. Thus our model can rationalize a response of expenditures on memorable goods to expected income changes even in the absence of binding borrowing constraints, but expect that response to be larger in magnitude in its presence.

Table 7: The Marginal Propensity To Consume

This table displays the marginal propensity to consume from the following regression: $C_t^h - C_{t-1}^h = \beta_1 + \beta_2 * (\text{income}_t^h - \text{income}_{t-1}^h) + u_t^h$, where t is the time of receiving the positive income shock.

	Benchmark Model ($S' \geq 0$)		Model with Natural Borrowing Limit	
	ND	MG	ND	MG
β_2	0.0004	0.2086***	0.0003	0.0810***
	(0.0004)	(0.0218)	(0.0004)	(0.0230)
Observations	50,000	50,000	50,000	50,000

This intuition is confirmed in Table 7 which reports the results of running excess sensitivity regressions on model-simulated data of 50,000 households for our benchmark model with tight borrowing constraint and for an alternative model with a natural borrowing limit.[37] In either model, nondurable consumption does not significantly respond to expected changes in income such as an expected tax refund.[38] In contrast, the regressions display excess sensitivity of memorable

[37]The stationary distribution is derived based on the 2-period anticipation model with a tight borrowing constraint. We then draw 50,000 households from this distribution, simulate them each for 12 months, starting from $t = -4$ (corresponding to January), and with a non-negative income shock realized in period $t = 0$ (i.e. in May).

[38]Absent binding borrowing constraints this is to be expected, and in the model with tight constraints few households in our simulated data are at the constraint in period $t = 0$. Only 0.5% of households have zero assets at time 0. These 262 out of 50,000 households indeed display excess sensitivity behavior with respect to nondurables, with an average

goods expenditure to expected income changes (second and fourth column of the table), and this sensitivity is significantly larger if borrowing constraints are potentially binding ($\beta_2 = 0.21$ v/s $\beta_2 = 0.08$. These results not only conform to the intuition developed above, but also line up well with the empirical evidence from tax refund data, as we argue in the next section.

6.2 Empirical Test Using CEX Tax-Refund Data

Our empirical strategy, including variable definitions and sample selection choices, follows Souleles (1999) as much as possible. As discussed in Section 3, our definition of nondurable and memorable goods combined is equivalent to Souleles (1999)'s nondurable goods (ND+MG), and our definition of strictly nondurable and strictly memorable goods combined equals Souleles (1999)'s definition of strictly nondurable goods (Strictly (ND+MG)). The data used in this section are drawn from 1980 to 1991 CEX surveys, which cover exactly the same time period as Souleles (1999). A detailed discussion of sample selection can be found in the Appendix .

Souleles (1999) provides evidence for excess sensitivity in consumption by estimating two regressions, both of which we revisit here. The first specification is based on the general idea of excess sensitivity tests in equation 25:

$$C^h_{t,II} - C^h_{t,I} = \sum_t \beta_{0t} * \text{year}^h_t + \beta_1' X^h_t + \beta_2 * \text{refund}^h_t + u^h_t. \tag{27}$$

The dependent variable $C^h_{t,II} - C^h_{t,I}$ is the change in a given household h's real consumption expenditures (in levels) between quarter I (January to March) and quarter II (April to June) of a given year t. The variable year^h_t is the year dummy that is included to control for aggregate shocks and interest rates across time. The variable refund^h_t measures the tax refund received by household h in year t. As discussed in Appendix B, with $\beta_2 = 0$ equation (27) can be derived as a linearized version of the standard household consumption Euler equation; no linearization is necessary if the period utility function is quadratic. The vector X^h_t contains demographic variables (the age of the

MPC out of predicted income changes of 0.19. Given their small number they do not translate into statistically significant excess sensitivity in the overall model-based regression.

household head and changes in the number of adults and children) and is included in the regression to control for changes in household preferences. The refund variable in the CEX, refund_t^h, has a reference period of 12 months. To ensure that the refund reference period covers the consumption change period (quarter I and quarter II of year t), we restrict the interview month of the final interview to be either January or July-December, so that the refund_t^h regressor, which records the real value of refunds that household h received in the past 12 months before the final interview, covers the first two quarters of year t (when about 90 percent of the refunds are received).[39] This sample restriction ensures that the refund_t^h regressor is predetermined, and thus under the permanent income hypothesis β_2 should be zero.

An alternative to the standard frictionless intertemporal consumption model is a theory proposed by Campbell and Mankiw (1990) and adopted by Souleles (1999) in which households simply consume a fraction μ of their tax refunds upon the receipt of the refund check. The number μ can be interpreted as the marginal propensity to consume (MPC) out of tax refunds. One could estimate μ by replacing $\beta_2 * \text{refund}_t^h$ in equation (27) with $\mu * \Delta\text{refund}_t^h$, where $\Delta\text{refund}_t^h = \text{refund}_{t,II}^h - \text{refund}_{t,I}^h$, the value of refunds received in quarter II of year t minus the value of refunds received in quarter I of year t. The CEX however, does not record refunds at quarterly frequency. Therefore following Souleles (1999), we use the information on the distribution of aggregate refund disbursement to account for the difference between refund_t^h and Δrefund_t^h.

Specifically, we calculate an 'attenuation factor' π from the distribution of aggregate refund disbursements: $\pi_t^h = p_h^{t,II} - p_h^{t,I}$, where $p_h^{t,II}$ and $p_h^{t,I}$ are the proportions of the refunds disbursed during h's refund reference period that were disbursed in quarter I and quarter II of year t. Multiplying the regressor refund_t^h by these factors to correct for the probability that some refunds have been received in the second quarter of the reference year rather than the first, we essentially approximate $\Delta(\text{refund}_t^h) \approx \text{refund}_t^h * \pi_t^h$. The attenuation factors used are taken directly from Souleles

[39] With this sample restriction, our final sample size is larger than that of Souleles (1999) because we use monthly reference periods whereas Souleles (1999) uses quarterly reference periods. For example, a consumption record that covers Dec. 1996 to Feb. 1997, is dropped by Souleles (1999) because it does not exactly cover the calendar quarter I, whereas in our sample, we use 12 months consumption data to construct the consumption record in quarters I and II.

(1999) and reported in Table 9. The equation for estimating the MPC is then given by

$$C^h_{t,II} - C^h_{t,I} = \sum_t \beta_{0t} * \text{year}^h_t + \beta_1' X^h_t + \beta_2 * \text{refund}^h_t * \pi^h_t + u^h_t. \tag{28}$$

6.2.1 Results

Equation (27) is estimated by ordinary least squares (OLS), with standard errors corrected for heteroskedasticity. The estimation is undertaken including households that report no refund. A statistically significant and positive coefficient β_2 indicates, using the terminology of the literature, that consumption is excessively sensitive to changes in after-tax incomes due to the tax rebates that could have been anticipated by households. The results are reported in Table 8. As a comparison, we also report the results from Souleles (1999) for the same consumption categories in Table 8.

Table 8, panel A, displays the impact of federal income tax refunds on consumption categories that do not differentiate between memorable goods and nondurable goods. For consumption defined as the sum of strictly nondurable and memorable goods (corresponding to the definition of strictly nondurable consumption used in Souleles (1999)), the coefficient of the refund variable refund^h_t is 0.023 and is statistically significant.

However, once we exclude memorable goods from this consumption measure in panel B of Table 8, the excess sensitivity of strictly nondurable goods and nondurable goods consumption to tax refunds becomes economically small and statistically insignificant. Furthermore, we find that the coefficients on the refund variable for strictly memorable goods and memorable goods are both economically and statistically significant, 0.019 and 0.026, respectively. Thus, we conclude that the excess sensitivity of strictly nondurable consumption expenditure found in Souleles (1999) is primarily due to the response of strictly memorable consumption expenditure.[40]

The OLS estimation results of equations (28) are reported in Table 9, with standard errors corrected for heteroskedasticity. We first report, in panel A, the estimated MPC for consumption categories that do not differentiate between nondurable and memorable goods. In panel B we then

[40] We cannot reject the null hypothesis that the responses of strictly nondurable goods and strictly memorable goods are the same. This is because the estimated response of strictly nondurable goods has relatively large standard errors.

Table 8: Excess Sensitivity Tests

This table shows results for the excess sensitivity of consumption to tax refund by estimating the following regression model: $C^h_{t,II} - C^h_{t,I} = \sum_t \beta_{0t} * \text{year}^h_t + \beta_1' X^h_t + \beta_2 * \text{refund}^h_t + u^h_t$, where $C^{II} - C^I$ is the change in consumption between the first and second quarter.

Panel A: without Memorable Goods

	Strictly (ND+MG)		ND+MG		Total consumption	
	Souleles (1999)	Our Sample	Souleles (1999)	Our Sample	Souleles (1999)	Our Sample
Refund	0.024**	0.023*	0.025	0.024	0.184**	0.158**
	(0.012)	(0.014)	(0.018)	(0.017)	(0.067)	(0.065)
Age	1.12	1.211	1.43	1.873	2.07	2.147
	(0.77)	(1.056)	(1.21)	(1.224)	(3.43)	(3.011)
d(adults)	164.4**	102.798**	145.7*	113.054**	323.9**	293.923**
	(45.7)	(35.970)	(62.4)	(43.115)	(134.9)	(107.969)
d(kids)	51.9	65.685*	14.3	101.207**	116.2	339.047**
	(45.5)	(37.009)	(103.6)	(48.981)	(207.6)	(140.693)
Observations	7622	9399	7525	9399	7525	9399

Panel B: with Memorable Goods

	Strictly ND	ND	Strictly MG	MG	Durables
Refund	0.005	-0.002	0.019**	0.026**	0.134**
	(0.011)	(0.013)	(0.009)	(0.012)	(0.065)
Age	0.073	0.769	1.138*	1.104	0.273
	(0.821)	(0.960)	(0.643)	(0.741)	(2.725)
d(adults)	65.565**	57.933*	37.234	55.120*	180.870*
	(27.811)	(34.112)	(25.072)	(28.811)	(96.328)
d(kids)	60.451*	85.427**	5.234	15.780	237.839*
	(31.691)	(40.193)	(21.086)	(28.197)	(126.651)
Observations	9399	9399	9399	9399	9399

Our definition of consumption categories is consistent with Souleles (1999). Specifically, our definition of nondurable and memorable goods combined is equivalent to Souleles (1999)'s nondurable goods (ND+MG), and our definition of strictly nondurable and strictly memorable goods combined equals Souleles (1999)'s definition of strictly nondurable goods (Strictly (ND+MG)).

Coefficients on time dummies are not reported. The sample includes the households not receiving refunds (the control group). Heteroskedasticity-corrected standard errors are in parentheses.

* $p < 0.10$, ** $p < 0.05$

Table 9: The Marginal Propensity To Consume

This table shows results for the marginal propensity to consume by estimating the following model: $C^h_{t,II} - C^h_{t,I} = \sum_t \beta_{0t} * \text{year}^h_t + \beta'_1 X^h_t + \beta_2 * \text{refund}^h_t * \pi^h_t + u^h_t$, where $C^{II} - C^I$ is the change in consumption between the first and second quarters.

Panel A: without Memorable Goods

	Strictly (ND+MG)		Total consumption		Total consumption-Strictly (ND+MG)	
	Souleles (1999)	Our Sample	Souleles (1999)	Our Sample	Souleles (1999)	Our Sample
Refund*π	0.093**	0.094**	0.640**	0.577**	0.537**	0.482**
	(0.037)	(0.046)	(0.224)	(0.216)	(0.225)	(0.209)
Observations	7622	9399	7525	9399	7525	9399
Refund*$\pi_{2\text{ week}}$	0.045**	0.044*	0.344**	0.301**	0.294**	0.257**
	(0.021)	(0.025)	(0.116)	(0.114)	(0.122)	(0.114)
Observations	7622	9399	7525	9399	7525	9399

Panel B: with Memorable Goods

	Strictly ND	ND	Strictly MG	MG	Durables
Refund*π	0.023	0.016	0.072**	0.094**	0.467**
	(0.036)	(0.042)	(0.030)	(0.037)	(0.211)
Observations	9399	9399	9399	9399	9399
Refund*$\pi_{2\text{ week}}$	0.010	0.001	0.034**	0.047**	0.253**
	(0.019)	(0.022)	(0.016)	(0.021)	(0.115)
Observations	9399	9399	9399	9399	9399

The attenuation factors π and $\pi_{2\text{ week}}$ represent the probability the refund came in April-June minus the probability the refund came in January-March, as described in the text. $\pi_{2\text{ week}}$ allows for a two-week delay before the refund is received and spent. The average of the π's across households by year, for 1980-1991 respectively, are: 0.13, 0.16, 0.20, 0.36, 0.34, 0.55, 0.32, 0.28, 0.30, 0.21, 0.15, 0.16. For $\pi_{2\text{ week}}$ the respective averages are: 0.42, 0.45, 0.47, 0.56, 0.60, 0.73, 0.57, 0.57, 0.56, 0.55, 0.50, 0.50. $\pi_{2\text{ week}}$ were computed allowing for a two-week delay after the disbursement of refunds. This should conservatively accommodate any delay while refund checks were in the mail and before households cashed them.

Our definition of consumption categories is consistent with Souleles (1999). Specifically, our definition of nondurable and memorable goods combined is equivalent to Souleles (1999)'s nondurable goods (ND+MG), and our definition of strictly nondurable and strictly memorable goods combined equals Souleles (1999)'s definition of strictly nondurable goods (Strictly (ND+MG)).

Coefficients on time dummies and demographic variables are not reported. The sample includes the households not receiving refunds (the control group). Heteroskedasticity-corrected standard errors are in parentheses.

* $p < 0.10$, ** $p < 0.05$

display results if memorable goods are treated as a separate consumption category. The MPC of strictly nondurable consumption, including memorable goods, is positive and significant, as Souleles (1999) finds. However, once memorable goods are excluded from the definition of nondurable goods, the MPC of both strictly nondurable and nondurable goods again turns statistically insignificant. Moreover, as before both strictly memorable goods and memorable goods display a significantly positive and large MPC (0.072 and 0.094 respectively) out of the tax refunds.

To summarize, our results show that nondurable, memorable, and durable goods have distinct responses to income tax refunds. After excluding memorable goods from the nondurable goods category, this category does not respond to the refunds in an economically and statistically significant way, whereas memorable goods consumption displays a sizeable response.

7 Conclusion

In this paper we propose a novel consumption model that augments the canonical categorization of consumption goods into nondurable and durable goods by a third category which we call memorable goods. Memorable goods consumption impacts future utility through the accumulation process of the memory stock. We show that households optimally choose a non-smooth consumption profile of memorable goods. We then estimate the welfare costs associated with consumption fluctuations, and find that relative to a model in which all nondurable consumption is lumped together, the distinction and modeling of memorable goods reduces the estimated welfare costs significantly. We further argue that the rejection of optimal intertemporal choice behavior based on the excess sensitivity of consumption to predictable income changes documented in the literature might primarily be due to the presence of memorable goods.

With the development of our theory we hope to have laid the foundations for other applied work, beyond the two applications presented in this paper, using the concept of memorable goods. For example, it is sometimes suggested that people under-save for retirement, as evidenced by a decline in consumption when they are old. To the extent that early-life consumption includes goods with long-lasting memories, models that ignore such memory formation will overstate the decline in utility accompanying decreased consumption later in life. Breaking the direct link between consumption expenditures on memorable goods and the marginal utility of consumption from such expenditures may also have additional implications for asset prices.

Finally, as pointed out in the introduction, we restrict attention to positive memories in this work. However, it seems obvious that out-of-the-ordinary negative experiences can result in unpleasant memories, the consequences of which affect future welfare. While positive memories can generate expenditures that seem anomalous from the perspective of the standard model (e.g. infrequent expenditure spikes), negative memories would more likely be linked to avoiding certain expenditures. Although outside the scope of this paper, we think that an analysis of the impact of negative memories on consumption-savings dynamics is an interesting research area for the future.

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Appendix: For Review and Online Publication Only

A Data

Income Categories: We define disposable income as income before tax minus reported federal, state and local income taxes payments, property tax not reported elsewhere and other tax (net of tax refunds), deductions for social security and pension plans. Household income before tax includes wages and salaries, net business income, net farm income, rents income, dividend income, interest income, pension income, social security and railroad retirement income, supplemental security income, unemployment compensation, workers' compensation and veterans benefits, welfare received, scholarship, food stamps, contributions received from others with alimony/child support, meals received as pay, rent received as pay, and lump sum receipts and lump sum child support payment.

Table A.I: Average Monthly Income and Consumption Expenditures - Sample

	Disp Income	Total Outlays	ND+Memorables	ND	Memorables	Durables
mean	1972.32	1484.61	1193.87	905.54	288.33	290.74

Table A.II: Average Demographic Characteristics - Sample

	Age of Head	Male Head	White Head	Married	High School Above	Family Size
mean	41.14	0.65	0.84	0.59	0.85	2.87

Table A.III: Underlying Frequencies of CEX Expenditure Categories

	Nondurable Goods			**Memorable Goods**	
Number	Categories	Frequency	Number	Categories	Frequency
1	Food At Home	Quarterly	1	Food Away from Home Excl. on Trips	Quarterly
2	Food at School	Monthly	2	Food for Catered Affairs	Monthly
3	Meals Received as Pay	Quarterly	3	Food on Trips/Vacations	Monthly
4	Tobacco Products	Quarterly	4	Alcohol Out Excl. on Trips/Vacations	Quarterly
5	Alcohol Home	Quarterly	5	Alcohol on Trips	Monthly
6	Personal Care Services	Quarterly	6	Entertainment Fees and Admissions	Monthly
7	Maintenance, Insurance etc - Owned Housing	Monthly	7	Entertainment Fees and Admissions on Trips/Vacations	Monthly
8	Tenant-Occupied Nonfarm Dwelling – Rent	Monthly	8	Other Entertainment Services and Rental	Monthly
9	Rental Equivalence of Owned Home	Annually	9	Other Entertainment Services and Rental on Trips	Monthly
10	Rent Received as Pay	Quarterly	10	Lodging on Trips/Vacations	Monthly
11	Lodging at School	Monthly	11	Vehicle Maintenance, Rental etc on Trips/Vacations	Monthly
12	Electricity	Monthly	12	Gasoline and Oil on Trips/Vacations	Monthly
13	Gas	Monthly	13	Public Transportation on Trips/Vacations Excl. Airline	Monthly
14	Water and other sanitary services	Monthly	14	Airline Fares	Monthly
15	Fuel Oil and Coal	Monthly	15	Photographic Services and Rental	Monthly
16	Telephone Service	Monthly	16	Charitable Giving	Monthly
17	Domestic Service	Monthly	17	Clothing and Shoes	Monthly
18	Other Household Operation	Monthly	18	Jewelry and Watches	Monthly
19	Vehicle Registration	Monthly	19	Clothing Services, including watch and jewelry repair	Monthly
20	Vehicle Maintenance, Rental etc	Monthly			
21	Gasoline and Oil	Monthly			
22	Auto Insurance	Monthly			
23	Local Public Transportation	Monthly		**Durable Goods**	
24	Reading	Monthly	Number	Categories	Informative Frequency
25	Business Services	Monthly	1	Durable Household Furnishing and Equipment	Monthly
26	Gambling	Monthly	2	New and Used Motor Vehicles (Net Outlay)	Monthly
27	Life and other Personal Insurance	Monthly	3	Tires, Tubes, Accessories, and Other parts	Monthly
28	Prescription Drugs (Net Outlay)	Monthly	4	Recreation and Sports Equipment	Monthly
29	Medical Supplies (Net Outlay)	Monthly			
30	Medical Services (Net Outlay)	Monthly			
31	Health Insurance	Monthly			
32	College Tuition and Fees	Monthly			
33	Nursery, Elementary, and Other School Tuition and Fees	Monthly			
34	Educational books and supplies	Monthly			

Table A.IV: Consumption Expenditure Shares (Quarterly Frequency)

	Outlays (%)	(ND+MG) (%)	Strictly (ND+MG) (%)
Outlays	100.0		
Durables	10.9		
ND+MG	89.1	100.0	
Memorables	18.6	21.2	
Nondurables	70.5	78.8	
Strictly (ND+MG)	77.0	86.4	100.0
Strictly Memorables	12.9	14.6	17.1
Strictly Nondurables	64.1	71.7	82.9

Table A.V: Consumption Expenditure Volatility (Quarterly Frequency)

	Had Zeros	Had Spikes	Ave Vol.
Outlays	0.000	0.274	0.321
Durables	0.419	0.911	1.184
ND+MG	0.000	0.084	0.208
Memorables	0.028	0.554	0.515
Nondurables	0.000	0.080	0.199
Strictly (ND+MG)	0.000	0.088	0.206
Strictly Memorables	0.053	0.609	0.569
Strictly Nondurables	0.000	0.078	0.195

A.1 Expenditure Spikes and Inactivity for Selected Detailed Goods Categories

In this section, we document the frequency of expenditure spikes and zero purchases for selected memorable goods categories: total expenditure on trips and vacations, clothes and shoes, jewelry and watches. We also report the expenditure spikes and zero purchase patterns for two durable goods categories, new and used vehicles (net outlay), and tires, tubes, accessories and other parts, as a comparison with memorable goods. Figure 4 shows that most households have at least one consumption expenditure spike within a 12 month period for these selected memorable and durable goods, and the expenditure on these goods tends to be quite lumpy. From Figure 5 we observe that indeed, memorable goods, as well as durable goods, display infrequent monthly expenditures.

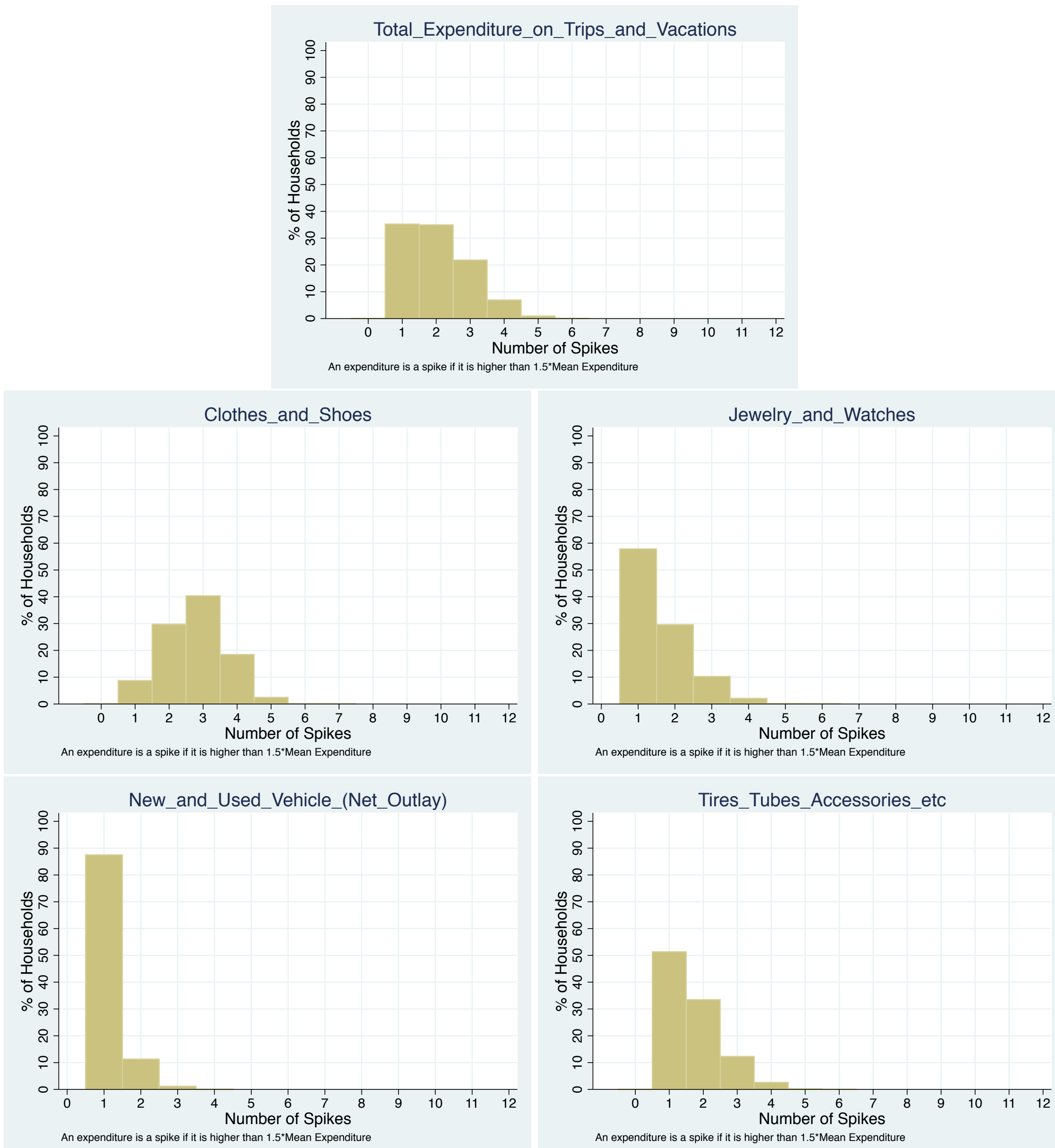

Figure 4: Number of Months with Expenditure Spikes ($\kappa = 1.5$)

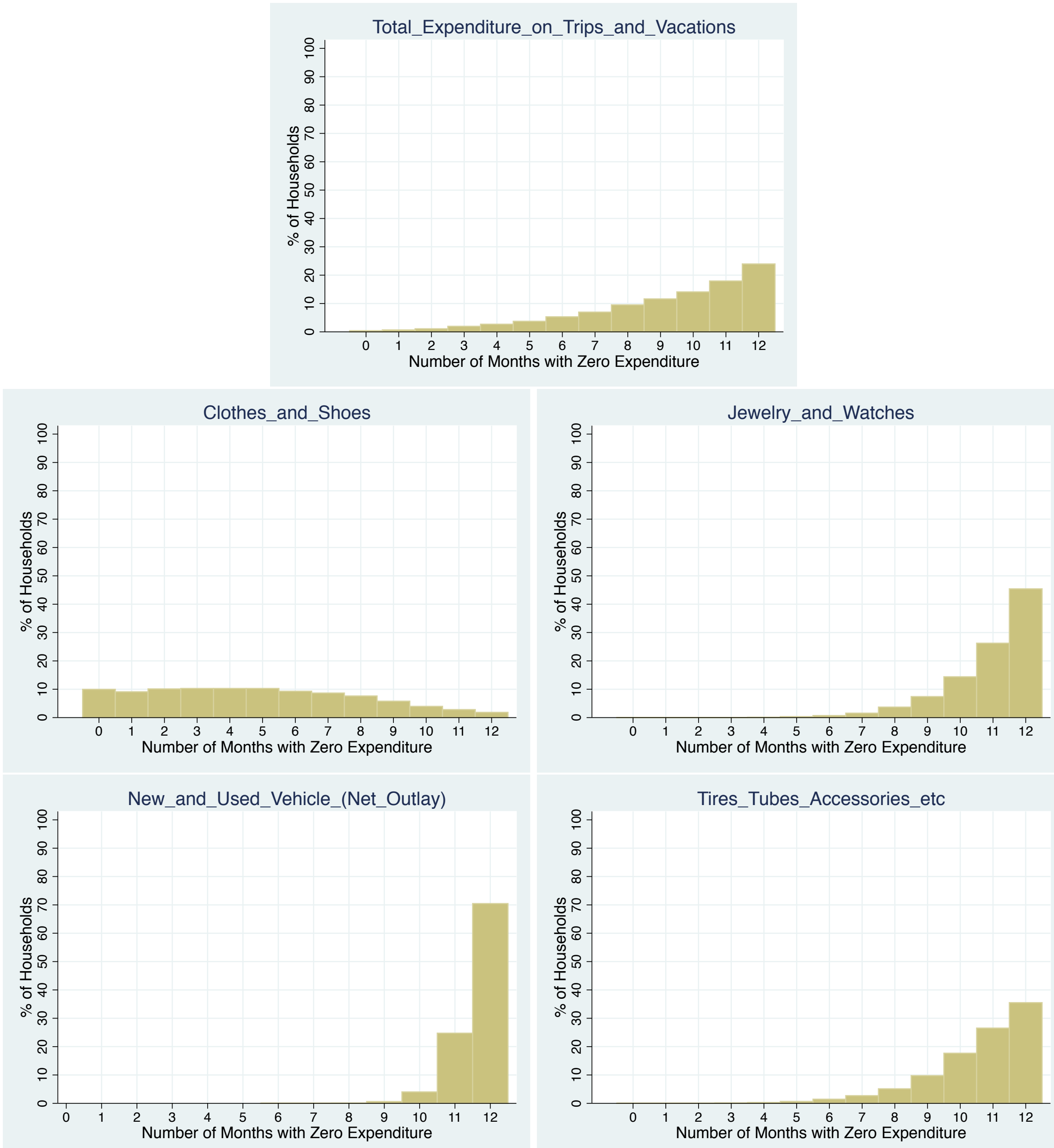

Figure 5: Number of Months with Zero Purchases

B Quantitative Model Derivations

Derivation of Euler Equations. The household's maximization problem is given by

$$
\begin{aligned}
V(M,N,S,z) &= \max_{C_m,S'} \left\{U(C_n,C_m,M)+\beta\mathbb{E}V(M',N',S',z')|z\right\} \\
& \quad s.t. \\
C_n &= Y+(1+r)S-C_m-S' \\
M' &= (1-\delta_m)M+\max\{C_m-N,0\} \\
N' &= (1-\rho)N+\rho C_m \\
S' &\geq 0 \\
\ln Y &= \bar{y}+z \\
z' &= \rho_z z+\varepsilon.
\end{aligned}
$$

We could rewrite the household's maximization problem as

$$
\begin{aligned}
V(M,N,S,z) &= \max_{N',S'} \left\{U(C_n,(N'-(1-\rho)N)/\rho,M)+\beta\mathbb{E}V(M',N',S',z')|z\right\} \\
& \quad s.t. \\
C_n &= Y+(1+r)S-S'-\frac{1}{\rho}(N'-(1-\rho)N) \\
M' &= (1-\delta_m)M+\frac{1}{\rho}\max\{N'-N,0\} \\
S' &\geq 0 \\
\ln Y &= \bar{y}+z \\
z' &= \rho_z z+\varepsilon.
\end{aligned}
$$

The first order conditions imply that the following two equations must hold at optimum,

$$
\begin{aligned}
\frac{\partial U}{\partial C_n}(C_n, C_m, M) &= \beta \mathbb{E} \frac{\partial V}{\partial S}(M', N', S', z') + \lambda_{S'} \\
\frac{\partial U}{\partial C_n}(C_n, C_m, M) - \frac{\partial U}{\partial C_m}(C_n, C_m, M) &= \mathbf{1}_{C_m > N} \cdot \beta \mathbb{E} \frac{\partial V}{\partial M}(M', N', S', z') + \rho \beta \mathbb{E} \frac{\partial V}{\partial N}(M', N', S', z')
\end{aligned}
$$

where $C_n = Y + (1+r)S - C_m - S'$, $\lambda_{S'}$ is the Lagrange multiplier associated with the borrowing constraint $S' \geq 0$, and $\mathbf{1}_{C_m > N}$ is an indicator function that equals 1 if and only if $C_m > N$.

The envelope theorem implies that the following conditions hold at the optimum,

$$
\begin{aligned}
\frac{\partial V}{\partial M}(M, N, S, z) &= \frac{\partial U}{\partial M}(C_n, C_m, M) + (1 - \delta_m) \beta \mathbb{E} \frac{\partial V}{\partial M}(M', N', S', z') \\
\frac{\partial V}{\partial N}(M, N, S, z) &= \frac{1-\rho}{\rho} \frac{\partial U}{\partial C_n}(C_n, C_m, M) - \frac{1-\rho}{\rho} \frac{\partial U}{\partial C_m}(C_n, C_m, M) - \mathbf{1}_{C_m > N} \cdot \beta \mathbb{E} \frac{\partial V}{\partial M}(M', N', S', z') \\
\frac{\partial V}{\partial S}(M, N, S, z) &= (1+r) \frac{\partial U}{\partial C_n}(C_n, C_m, M).
\end{aligned}
$$

The Euler equation for the optimal consumption path of nondurable goods C_n is standard,

$$
\frac{\partial U}{\partial C_n}(C_n, C_m, M) - (1+r) \beta \mathbb{E} \frac{\partial U}{\partial C_n}(C_n', C_m', M') = \lambda_{S'}
$$

where $\lambda_{S'}$ is the Lagrange multiplier associated with the borrowing constraint $S' \geq 0$.

Under our utility specification, the Euler equation of $C_{n,t}$ is given by the following equation

$$
C_{n,t}^{-\gamma} - (1+r) \beta \mathbb{E}_t C_{n,t+1}^{-\gamma} = \frac{\lambda_{S_{t+1}}}{\xi}.
$$

The optimal consumption path of memorable goods C_m rely on not only the borrowing constraint and the interest rate but also the memory stock M and the past experience level of memorable goods consumption N,

$$
\begin{aligned}
&\frac{\partial U}{\partial C_n}(C_n,C_m,M)-\frac{\partial U}{\partial C_m}(C_n,C_m,M)\\
=&(1-\rho)\beta\mathbb{E}(\frac{\partial U}{\partial C_n}(C_n',C_m',M')-\frac{\partial U}{\partial C_m}(C_n',C_m',M'))\\
&+\mathbf{1}_{C_m>N}\cdot\beta\mathbb{E}\frac{\partial V}{\partial M}(M',N',S',z')-\rho\beta^2\mathbb{E}(\mathbf{1}_{C_m'>N'}\cdot\mathbb{E}\frac{\partial V}{\partial M}(M'',N'',S'',z''))\\
=&(1-\rho)\beta\mathbb{E}(\frac{\partial U}{\partial C_n}(C_n',C_m',M')-\frac{\partial U}{\partial C_m}(C_n',C_m',M'))\\
&+\mathbf{1}_{C_m>N}\cdot\beta\mathbb{E}\frac{\partial U}{\partial M}(C_n',C_m',M')\\
&+\mathbf{1}_{C_m>N}\cdot\beta^2(1-\delta_m)\mathbb{E}\frac{\partial V}{\partial M}(M'',N'',S'',z'')-\rho\beta^2\mathbb{E}(\mathbf{1}_{C_m'>N'}\cdot\mathbb{E}\frac{\partial V}{\partial M}(M'',N'',S'',z'')).
\end{aligned}
$$

Under our current utility specification, the above equation can be rewritten as

$$
\begin{aligned}
C_{n,t}^{-\gamma}-\frac{1-\xi}{\xi}K_t^{-\gamma}=(1-\rho)\beta\mathbb{E}(C_{n,t+1}^{-\gamma}-\frac{1-\xi}{\xi}K_{t+1}^{-\gamma})+\mathbf{1}_{C_m>N}\cdot\beta\zeta\frac{1-\xi}{\xi}\mathbb{E}K_{t+1}^{-\gamma}\\
+\frac{1}{\xi}\mathbf{1}_{C_m>N}\cdot\beta^2(1-\delta_m)\mathbb{E}\frac{\partial V}{\partial M}(M_{t+2},N_{t+2},S_{t+2},z_{t+2})\\
-\frac{1}{\xi}\rho\beta^2\mathbb{E}(\mathbf{1}_{C_{m,t+1}>N_{t+1}}\cdot\frac{\partial V}{\partial M}(M_{t+2},N_{t+2},S_{t+2},z_{t+2}))
\end{aligned}
$$

where $K_t=C_{m,t}+\zeta M_t$. ■

Derivation of Euler Equations. Define

$$
\begin{aligned}
\lambda_{n,t} &= \frac{\lambda_{S_{t+1}}}{\xi(1+r)\beta\mathbb{E}_t C_{n,t+1}^{-\gamma}}\\
\lambda_{m,t} &= \frac{\left(\begin{array}{l}(1-\frac{(1-\rho)}{1+r})\xi C_{n,t}^{-\gamma}-\xi\frac{(1-\rho)}{1+r}\lambda_{S_{t+1}}-\mathbf{1}_{C_{m,t}>N_t}\cdot\beta\mathbb{E}_t\frac{\partial V}{\partial M}(M_{t+1},N_{t+1},S_{t+1},z_{t+1})\\ +\rho\beta^2\mathbb{E}_t(\mathbf{1}_{C_{m,t+1}>N_{t+1}}\cdot\mathbb{E}\frac{\partial V}{\partial M}(M_{t+2},N_{t+2},S_{t+2},z_{t+2}))\end{array}\right)}{(1-\xi)(1-\rho)\beta\mathbb{E}_t((C_{m,t+1}+\zeta M_{t+1})^{-\gamma})}
\end{aligned}
$$

Rational expectations implies that at optimum the following equation must be true[41]:

$$\frac{(1+r)\beta C_{n,t+1}^{-\gamma}}{C_{n,t}^{-\gamma}}(1+\lambda_{n,t}) = 1 + e_{n,t+1} \tag{29}$$

$$\frac{(1-\rho)\beta[(C_{m,t+1}+\zeta M_{t+1})^{-\gamma}]}{(C_{m,t}+\zeta M_t)^{-\gamma}}(1+\lambda_{m,t}) = 1 + e_{m,t+1} \tag{30}$$

where $e_{n,t+1}$ and $e_{m,t+1}$ can be interpreted as the expectation error, and by construction $e_{n,t+1}$ and $e_{m,t+1}$ are uncorrelated with information known at time t. Taking logs on both side and taking a linear approximation[42] of equation 29, we obtain the linearized Euler equation for nondurable consumption:

$$C_{n,t+1} - C_{n,t} = \frac{1}{\tilde{\gamma}}[\log((1+r)\beta) + \log(1+\lambda_{n,t}) - \log(1+e_{n,t+1}))]. \tag{31}$$

Note that when the borrowing constraint is not binding at period t ($\lambda_{S_{t+1}} = 0$) $\lambda_{n,t} = 0$.

Doing the same with equation 30 yields

$$C_{m,t+1} - C_{m,t} = \frac{1}{\gamma'}[\log((1-\rho)\beta) + \log(1+\lambda_{m,t}) - \log(1+e_{n,t+1}))] - \zeta(M_{t+1} - M_t)$$

and plugging in the law of motion for M_{t+1} delivers the linearized Euler equation for memorable consumption expenditures:

$$C_{m,t+1} - C_{m,t} = \frac{1}{\gamma'}[\log((1-\rho)\beta) + \log(1+\lambda_{m,t}) - \log(1+e_{n,t+1}))] - \zeta(-\delta_m M_t + \max\{C_{m,t} - N_t, 0\}) \tag{32}$$

In these equations the constants $\tilde{\gamma}, \hat{\gamma}$ are products of the risk aversion coefficient γ and approximation constants. ■

[41] See Parker and Preston (2005) and Parker (1999) for similar analyses for nondurable goods expenditure.

[42] The linear approximation used here is $\log y_{t+1} - \log y_t = (y_{t+1} - y_t)/\bar{y}$ for some $\bar{y}$.

C Model Solution Algorithm

The model solution algorithm is as follows:

Step 1. Guess an initial value of value function $V^{(0)}$ at each grid point of the state space, use OLS regression to calculate the Smolyak coefficients associated with value function $V^{(0)}$.

Step 2. At each state space grid point, value function at the i-th iteration, $V^{(i)}$, is maximized by searching memorable goods consumption C_m over a discrete grid

$$V^{(i)}(M,N,S,z) = \max_{C_m \in \text{Grid of } C_m} \{W^{(i)}(M,N,S,z,C_m)\}$$

where $W^{(i)}(M,N,S,z,C_m)$ is the value function associated with memorable goods consumption C_m for given state space variables (M,N,S,z), i.e.,

$$W^{(i)}(M,N,S,z,C_m) = \max_{S'} \left\{ U(C_n,C_m,M) + \beta \mathbb{E}[V^{(i-1)}(M',N',S',z')|z] \right\}.$$

The solution of optimal savings S'^* associated with memorable goods consumption C_m is characterized by the following equation

$$-\frac{\partial U(Y+(1+r)S-C_m-S'^*,C_m,M)}{\partial C_n} + \beta \frac{\partial \mathbb{E}[V^{(i-1)}(M',N',S'^*,z')|z]}{\partial S'} = 0$$

and $S'^* = 0$ if $-\frac{\partial U(Y+(1+r)S-C_m,C_m,M)}{\partial C_n} + \beta \frac{\partial \mathbb{E}[V^{(i-1)}(M',N',0,z')|z]}{\partial S'} \leq 0$.

For (M',N',S',z') outside the state space grid, the value of value function $V^{(i-1)}(M',N',S',z')$ is calculated via interpolation using Smolyak coefficients. Furthermore, $\mathbb{E}[V^{(i-1)}(M',N',S'^*,z')|z]$ is calculated using quadratic rule numerical integration method.

Step 3. Update Smolyak coefficients associated with value function $V^{(i)}$.

Step 4. Repeat Step 2 to 3 until the value of value function at each state space grid point and associated Smolyak coefficients converge.

D Computation of Stationary Distribution

Our model predicts that there is a cross-sectional stationary distribution of state variables. There is no analytical solution to the household's consumption-savings problem, so we characterize the cross-sectional distribution of (M_t, N_t, S_t, z_t) numerically using Markov chain Monte Carlo (MCMC) simulation method. Specifically our procedure is as follows:

Step 1: At period $t = 0$, we randomly simulate state variables (M_0, N_0, S_0) for each household $h \in \{1, \ldots, H\}$ from an arbitrary initial distribution $F^{(0)}(M, N, S)$, and draw z_0 from the distribution $N(0, \sigma^2/(1-\rho^2))$ for each household.

Step 2: At period $t = 0$, for given state variables (M_t, N_t, S_t, z_t), households optimally make their current memorable goods consumption $C^*_{m,t}$ and period $t+1$ savings decisions S^*_{t+1}. Households' period $t+1$ state variables M^*_{t+1} and N^*_{t+1} are updated according to Equations 20 and 11 respectively. Households' period $t+1$ income shock z_{t+1} is randomly drawn according to the conditional distribution $N(\rho_z z_t, \sigma^2)$. The updated state variables $(M^*_{t+1}, M^*_{t+1}, M^*_{t+1})$ for H households yield the numerical distribution $F^{(1)}(M, N, S)$.

Step 3: Check if distribution $F^{(1)}(M, N, S)$ converges to $F^{(0)}(M, N, S)$ by checking whether the mean and variance of the state variable M, N, S are the same under these two distributions. If the distribution has not converged, repeat step 2 for $t = 2, \ldots$.

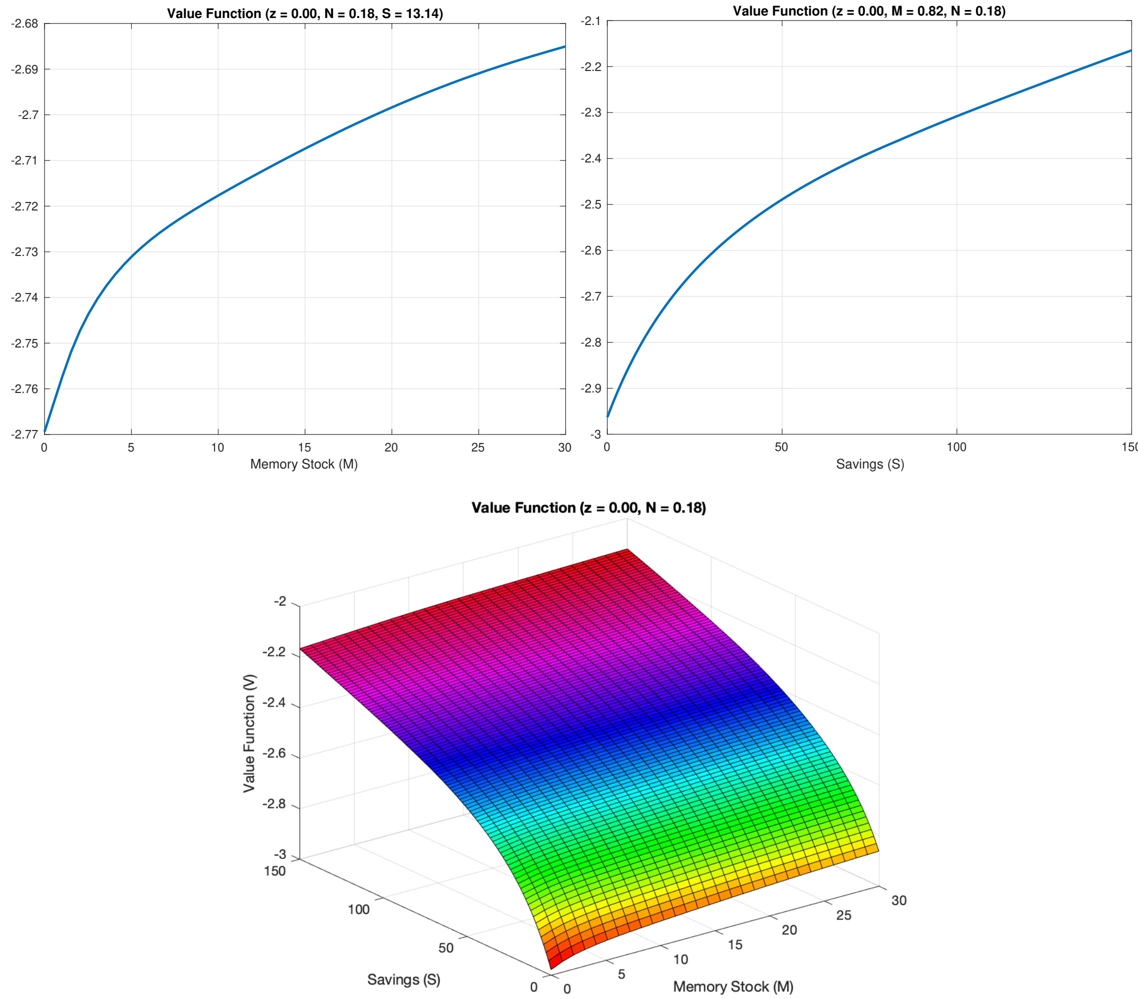

Figure 6: Value Function

E Welfare Cost Analysis

Derivation of Equation 25. Define as

$$\begin{aligned}\bar{V}(M,N,S;g) &= \xi\frac{\left[(1-g)\bar{C}_n(M,N,S)\right]^{1-\gamma}}{1-\gamma}+(1-\xi)\frac{((1-g)\bar{C}_m(M,N,S)+\zeta(1-g)M)^{1-\gamma}}{1-\gamma}\\ &\quad +\beta\bar{V}(\bar{M}',\bar{N}'(M,N,S),\bar{S}'(M,N,S);g).\end{aligned}$$

Note that

$$\bar{V}(M,N,S;g)=(1-g)^{1-\gamma}\bar{V}(M,N,S;g=0)=(1-g)^{1-\gamma}\bar{V}(M,N,S). \tag{33}$$

As for $\bar{V}$, we can define $\bar{W}(S;g)$ by

$$\bar{W}(S;g)=\frac{\left((1-g)\bar{C}_n^W(S)\right)^{1-\gamma}}{1-\gamma}+\beta\bar{W}(\bar{S}^{W\prime}(S);g).$$

Note that

$$\bar{W}(S;g)=(1-g)^{1-\gamma}\bar{W}(S;g=0)=(1-g)^{1-\gamma}\bar{W}(S). \tag{34}$$

$\bar{V}(M,N,S;g)$ is lifetime utility in the no-risk economy with memorable goods, but with non-durable and memorable consumption scaled up by a factor g at all future dates. The function $\bar{W}(S;g)$ has a similar interpretation.

For $\gamma=1$, a similar calculation yields

$$\begin{aligned}\bar{V}(M,N,S;g) &= \frac{\log(1-g)}{1-\beta}+\bar{V}(M,N,S;g=0)=\frac{\log(1-g)}{1-\beta}+\bar{V}(M,N,S)\\ \bar{W}(S;g) &= \frac{\log(1-g)}{1-\beta}+\bar{W}(S;g=0)=\frac{\log(1-g)}{1-\beta}+\bar{W}(S).\end{aligned}$$

The welfare cost of consumption fluctuations for a household in state (M,N,S) is then defined (in the model with and without memorable goods, respectively) as the solution to

$$\begin{aligned}\bar{V}(M,N,S;g(M,N,S)) &= V(M,N,S,z=0)\\ \bar{W}(S;g^W(S)) &= W(S,z=0)\end{aligned}$$

where setting $z=0$ in the model with risk again assures that households have the same income today and same expected income from tomorrow on in both worlds. Solving for $g(M,N,S)$ and $g^W(S)$ gives, exploiting equations (33) and (34),

$$\begin{aligned}1-g(M,N,S) &= \left[\frac{V(M,N,S,z=0)}{\bar{V}(M,N,S)}\right]^{\frac{1}{1-\gamma}}\\ 1-g^W(S) &= \left(\frac{W(S,z=0)}{\bar{W}(S)}\right)^{\frac{1}{1-\gamma}}.\end{aligned}$$

■

F Revisiting an Excess Sensitivity Test of Consumption: Data and Sample Selection

To insure comparability with Souleles (1999) our empirical strategy, as well as crucial sample selection choices and variable definitions, follows his as much as possible. Our definition of non-durable and memorable goods is the same as in previous sections. As discussed in Section 3, our definition of nondurable and memorable goods combined is equivalent to Souleles (1999)'s non-durable goods (ND+MG), and our definition of strictly nondurable and strictly memorable goods combined equals Souleles (1999)'s definition of strictly nondurable goods (Strictly (ND+MG)). [43]

The sample was selected in a way that closely follows the selection criteria provided in Souleles

[43]The major components of strictly nondurables, defined in Souleles (1999), are food; household operations, including monthly utilities and small-scale rentals; apparel services and rentals; transportation fuel and services; personal services; and entertainment services and high-frequency fees. We further break down the above consumption groups into two consumption categories: strictly nondurable and strictly memorable goods by introducing memorable goods.

(1999).[44] The CEX asks about tax refunds twice, in a household's first and final interview. Each time what is recorded is the value of federal tax refunds received by the households in the 12 months before the interview month. Thus the refund variable in the CEX has a reference period of 12 months. About 80 percent of the refunds were mailed in March, April and May during the years 1980-1991,[45] and thus following Souleles (1999), we deflate refunds by the average of the monthly CPI for all items averaged over March, April, and May. All nominal variables were deflated to 1982-1984 dollars.

[44] A household was dropped from the sample if there were multiple consumer units in the household, or if the household lived in student housing or the head of household was a farmer; a household quarter was dropped if the household lacked basic food expenditure for any month of the quarter, or if any food was received as pay in the quarter. A household quarter is dropped if the age of household head increased by more than one or decreased moving into next quarter. The sample was restricted to households with heads aged 24-64. Finally, a household is dropped if the income report is incomplete or any of the income or financial records are invalid. We thank Nick Souleles for sharing the data appendix of Souleles (1999).

[45] Refer to Table 2 in Souleles (1999).