Durables, Non-Durables, and a Structural Test of Fungibility

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Abstract

In his 1999 summary of all things mental accounting (see Thaler [21]), Richard Thaler describes one of the primary components of mental accounting as the budgeting of specific utility-providing activities which can depend, but does not have to, on the resources used to fund those activities. The analysis presented in this paper focusses specifically on household expenditure of durable and non-durable goods and the liquidity sources used to fund these different expenditures. Specifically, we exploit a linked dataset of credit and debit card users to examine consumer purchasing patterns of durable and non-durable consumption commodities under both methods of payment. Our findings suggest that on average durable purchases are more sensitive to increases in available credit than non-durable purchases, and most consumers are more likely to increase total consumption due to increases in available credit than increases in available checking account balances. We empirically show that the standard neo-classical consumption/savings model, the equilibrium conditions of which implicitly assume that the household's available resources (liquidity and investments) are perfectly fungible, fails to rationalize our data for the median/modal consumer in our sample. However, our results are rich because we also show that the behavioral distribution of consumers includes both households which treat liquidity as fungible and those that do not. Given the heterogeneity we find, future work should test whether these results would matter on aggregate.

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JEL Classification: D01, D11, D90

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1 Introduction

It has been well-established that consumers[1] appear to use credit cards in ways inconsistent with the permanent income hypothesis (PIH) (see for example Prelec and Loewenstein [14], Prelec and Simester [15], Gross and Souleles [8], Huffman and Barenstein [12], and Quispe-Torreblanca et al. [17]). There exists strong empirical evidence that consumers treat other sources of liquidity as non-fungible too.[2] Yet despite these previous findings, the distribution of these behavioral tendencies has not been thoroughly investigated, an important undertaking if economists are to understand how violations of fungibility could affect broad economic outcomes. We add to the literature by showing that a dynamic, neo-classical consumption/savings model of the household can be modified to construct a household-level test of fungibility.[3] Allowing for heterogeneity in consumer preferences, we partially confirm the results outlined above, showing that the median/modal household in our sample behaves as if the resources from different liquidity categories are non-fungible both generally and within durable and non-durable consumption expenditure. Our estimates however also show that the distribution of this behavior across households is disperse: some households treat liquidity as extremely non-fungible while others essentially treat it as fungible.

[1]Throughout the paper we will use the words "consumer," "individual consumer", and "household" interchangeably. In our data analysis, the unit of measure is "household," though some households consist of multiple individual persons with one account and some of a single individual person with multiple accounts. These different entities are observationally equivalent, so we extrapolate from potential person-level differences and consider the behavior of all persons within one household together, as a collective.

[2]Heath and Soll [11] wrote one of the first papers to empirically show that consumers behave as if liquidity were non-fungible across different commodity groups. Souleles [19] shows that non-durable consumption expenditure is excessively sensitive to tax refunds, as opposed to durable consumption expenditure. Hastings and Shapiro [9] exploit variation in the prices of different grades of gasoline to show that households behave as if budgets for gasoline consumption are non-fungible. Hastings and Shapiro [10] reject the hypothesis that households respect the fungibility of money by comparing food expenditure using food stamps verses other payment methods.

[3]We use the term "neo-classical" in its broadest sense to encompass any kind of dynamic household consumption/savings model of the form:

$$V_t(w_t) = \max_{\boldsymbol{c}_t, s_t} \quad u_t(\boldsymbol{c}_t) + \beta \cdot \mathbb{E}_t V_{t+1}(w_{t+1}) \tag{1}$$

$$\text{s.t.} \quad \boldsymbol{p}_t \cdot \boldsymbol{c}_t + s_t \leq w_t \quad \forall t \tag{2}$$

where $\boldsymbol{c}_t$ is a vector of real consumption commodities, $\boldsymbol{p}_t$ is a vector of market prices, s_t is savings, and w_t is available net resources (wealth plus credit). Further, $u_t(\boldsymbol{c}_t)$ is a strictly increasing, strictly concave, at least twice-continuously-differentiable cardinal utility function which takes as its argument *only* the vector of real consumption, but not savings, wealth, or available liquidity. β is the geometric rate of time preference and $V_t(w_t)$ is the agent's optimal value function. Consumers choose sequences of consumption $\boldsymbol{c}_t$ and savings s_t to maximize their period-t utility from consumption plus the discounted expected future value of all future consumption.

Despite the degree of heterogeneity, our results affirm that most households treat credit availability and cash as non-fungible, suggesting they make decisions under some degree of mental accounting. Under mental accounting, consumers to care not simply about the sum of their available resources when making consumption expenditure decisions, but the various *components* of these resources (e.g., credit, cash, savings). A consumer who spends as if his available resources were perfectly fungible, absent any liquifying constraints, would respond to the marginal change in one specific class of resources, say the credit limit on his credit card, the same as if a different class of resource, say the balance on his checking account, had experienced the same marginal change. Non-fungibility, by definition, is the result of the disobedience of this stricture. The best theoretical explanation for this behavioral phenomenon was first explained in Thaler [20] and extended in Shefrin and Thaler [18] and Thaler [22, 21]. Yet, few studies have attempted to understand the non-fungibility of liquidity in terms of its broader economic implications. One of the most impactful which comes to mind is Richard Thaler's 1995 paper with Shlomo Benartzi entitled "Myopic Loss Aversion and the Equity Premium Puzzle" where the authors show that the puzzle can be reconciled by a model with mental accounting features (see Benartzi and Thaler [2]).[4]

Another important paper which models the interaction between method of payment and consumption utility is that of Prelec and Loewenstein [14]. This work is our main anchoring point, as the authors explore how the relative durability of a specific product impacts a consumer's willingness to hold credit card debt after purchasing that product. The authors hypothesize that consumers will be more likely to hold and pay interest on credit card debt for commodities which generate a dynamic flow of utility as opposed to commodities the utility from which is fully experienced at the moment of first consumption. Durable goods, such as furniture, produce a stream of utility over many periods, while non-durable goods like a box of candy are essentially consumed once and thereafter useless.[5] Under the authors' theory, a consumer should be less likely to purchase the candy on credit, and even if they did, they should be less likely to hold debt, and thus have to pay interest, on that credit card purchase. Using their word choices (though the example is our own), paying \$1 in interest on a box of candy one has already consumed is "more painful" than \$1 in interest on a desk one uses every day. This is because, in the latter situation, as with all durable goods, the pain of paying is offset by the pleasure one gets from continuing usage of the product. Higher levels of durable goods purchases should

[4]More work is needed to explore the broader economic impacts when consumers and investors engage in mental accounting. In the concluding section of this paper, we discuss potential avenues forward exploring potential broader impacts associated with our analysis.

[5]The empty box, of course we must assume, is garbage with no intrinsic value.

lead to larger proportions of monthly credit card balances carried forward to the next period, thus accruing interest. This result is empirically confirmed by analyses on U.K. credit card data in Quispe-Torreblanca et al. [17] who find that consumers are approximately 9% less likely to pay down their full credit card statement balance after making a durable purchase.[6]

Prelec and Loewenstein [14] provides the springboard for our main analysis where we compare marginal propensities for real consumption out of changes to both available credit and available checking account balances. We do this for both durable and non-durable consumption to argue that the data appear to suggest that the method of payment is coupled with the commodity class within the consumer's decision process. Why focus on the distinction between durables and non-durables? Durables are purchased in the same way as non-durable goods, yet function more like an investment asset so the dynamics behind durable good accumulation are important. Fernández-Villaverde and Krueger [5] show in fact that durable good expenditure is skewed over the life-cycle toward younger households. In a fairly standard neo-classical model with geometric discounting, Fernández-Villaverde and Krueger [5] can match the observed hump-shaped profile of durable expenditure along with the tendency of middle-aged households to accumulate more traditional financial assets rather than durable goods. We demonstrate that consumers appear to increase durable consumption out of increases to credit at a faster rate than checking account balance increases, yet durable goods consumption appears less sensitive across consumers to balance changes than that of non-durable goods (see Figure 1). The life-cycle effects of durable consumption may be due to younger households' being more likely to be borrowing or liquidity constrained [6, 23, 5]. Unfortunately we lack data on household members' ages, yet our findings complement those of Fernández-Villaverde and Krueger [6], Yang [23], and Fernández-Villaverde and Krueger [5], since liquidity-constrained households can engage in consumption expenditure out of credit, yet it is more difficult to turn available credit card credit into financial assets.

Our goal is not to explain a specific puzzle, nor show that *all* consumers behave one way or another. Rather we show that the neo-classical model can be used, with only slight modifications, to assess fungibility at the household level. We do not explicitly construct a model of mental accounting, but instead use the neo-classical economic consumption/savings model to empirically test the null hypothesis implied by that model, specifically that credit card and checking account balances are equally fungible when controlling for their different rates of interest and return. The main structural result demon-

[6]We reproduce the main analyses in Quispe-Torreblanca et al. [17] and find similar tendencies amongst U.S. consumers. For discussion and results see Appendix B.

strates that for the median/modal consumer the null hypothesis can be rejected with $> 99\%$ certainty. This result is a repudiation of fungibility for some consumers within the neo-classical construction, however it is not an absolute repudiation of the neo-classical consumption/savings construction entirely.

The main result we present says that: 1) given individuals face a standard, concave, monotone, at least twice differentiable utility function that is strongly separable over broad commodity groups, *and* 2) that this utility function takes as its arguments consumption commodities *only* and not methods of payment for said commodities, *and* 3) that individual consumers discount the future at a geometric rate, the neo-classical consumption/savings model cannot rationalize, for every consumer, the observed variation in expenditure out of credit cards and checking accounts, absent additional gimmicks. This should be read as evidence in support of alternative models of consumer behavior, foremost mental accounting which allows for consumers to consider the method of payment when making expenditures. The heterogeneity we observe with respect to the degree to which households treat liquidity as fungible opens the door to broader questions which we do not attempt to answer here but address in the concluding section.

This paper proceeds as follows: in Section 2 we present some important features of our dataset and discuss their implications for assessment of household-level behavior under mental accounting; in Section 3 we specify and estimate the structural model used to assess the degree to which households treat available credit and available checking balances as fungible; in Section 4 we conclude and outline potential ways forward.

2 Data

We obtain anonymized data from a large U.S. bank which contains credit card, debit card, and checking account transactions (including deposits), matched by household. Our main analysis operates on a subset of this dataset featuring households that use both credit and debit cards. The dataset subsample we use for this analysis and the analyses in the next section features $10,690$ household units each with at least 2 consecutive months of debit/checking account and credit card account transactions and income observations. This gives us a total of $123,112$ unique account/month combinations. The mean household has approximately 11.5 months of observations with a median of 10 observations. The maximal household features 66 consecutive months of observations. The time frame of our data ranges from January 2007 to October 2014. We classify consumption expenditure into durable or non-durable categories by using the descriptions associated with the 4-digit Visa card merchant code and manually matching these descriptions to those for the U.K. credit card data used by Quispe-Torreblanca et al. [17]. These classifications are presented in Table 4 in Appendix A.

Before proceeding to the structural model where we show directly that our data fails to reconcile standard fungibility requirements, we first examine differences in marginal propensity to consume from changes in available credit verses changes in checking account balances. Let nd_{it} denote real non-durable consumption expenditure by the i^{th} household in period t and equivalently denote d_{it} for real durable consumption expenditure. Let c_{it} denote total non-durable plus durable real consumption expenditure. Define the variable $MPND_{it}(j)$ as the change in total non-durable consumption due to a change in the balance of liquidity source j where $j = m$ for credit and $j = z$ for checking account balances, and equivalently $MPD_{it}(j)$ for the change in total durable consumption. The marginal propensity to consume for total non-durable plus durable consumption is $MPC_{it}(j)$. We define available credit as the credit limit b (borrowing limit) less any debts. Since our data are denominated in nominal terms, we deflate non-durable expenditure using the core personal consumption expenditure index (PCE) from the Bureau of Economic Analysis (BEA) and deflate durable expenditure using the PCE for durable goods. Both indices are normalized so that 2009-dollars are the numeraire. The marginal propensities to consume can then be approximated using finite differences where Δ denotes the finite difference operator:

$$MPC_{it}(j) = \frac{\Delta c_{it}}{\Delta j_{it}} \tag{3}$$

$$MPND_{it}(j) = \frac{\Delta nd_{it}}{\Delta j_{it}} \tag{4}$$

$$MPD_{it}(j) = \frac{\Delta d_{it}}{\Delta j_{it}} \tag{5}$$

j_{it} denotes the available balance to consumer i in liquidity-category j entering period t.

Let T_i denote the total number of months of observations for consumer-unit i. For each consumer, we compute the average marginal propensity to consume out of changes in m_{it}

and z_{it} for both non-durables, durables, and total consumption which is denoted by C_{it}:

$$\overline{MPC}_i(j) = \frac{1}{T_i}\sum_{t=1}^{T_i} MPC_{it}(j) \tag{6}$$

$$\overline{MPND}_i(j) = \frac{1}{T_i}\sum_{t=1}^{T_i} MPND_{it}(j) \tag{7}$$

$$\overline{MPD}_i(j) = \frac{1}{T_i}\sum_{t=1}^{T_i} MPD_{it}(j) \tag{8}$$

We present summary statistics for these marginal propensities in Appendix A, Table 5.

Figure 1 shows a grid of plots featuring the distribution of individual means from (6) to (8) with both credit and debit card denominators. The distributions in Figure 1 have fat tails and a near point-mass at 0. If we difference the consumer-level average marginal propensity to consume from credit cards with the marginal propensity to consume from debit cards within category we get the same shape of distribution. Figure 2 shows distributions over consumers of the following differences in means, which we denote with $\mathcal{D}G_i$ where G is some commodity category:

$$\mathcal{D}C_i = \overline{MPC}_i(m) - \overline{MPC}_i(z) \tag{9}$$

$$\mathcal{D}ND_i = \overline{MPND}_i(m) - \overline{MPND}_i(z) \tag{10}$$

$$\mathcal{D}D_i = \overline{MPD}_i(m) - \overline{MPD}_i(z) \tag{11}$$

The distributions in Figure 2 appear to have fat tails and be symmetric. If these distributions are centered at 0 then that would tell us that the modal or median consumer treats increases to available credit as equally fungible to increases in cash. Neo-classical theory would suggest that an increase in available credit should actually lead to relatively less consumption than an equivalent increase in available cash, since a rational consumer maximizing expected lifetime utility would rather consume out of cash and avoid high interest payments in the future. On the other hand, a consumer who is more responsive to credit increases than cash increases is borrowing from the future to fund consumption in the present.

To better understand which story fits our data, we assume that each of (9) thru (11) is distributed according to the fat-tailed, symmetric Cauchy distribution:

$$\mathcal{D}G_i \sim \text{Cauchy}(\mu_G, \sigma_G) \tag{12}$$

In the above μ_G is the distribution's location parameter for good G. This parameter is associated with the distribution's median and mode (the Cauchy distribution does not have finite first and second moments and thus does not have a mean). To understand whether the median/modal consumer is more likely to increase consumption due to a credit increase verses a cash increase, we test the following null hypothesis:

$$H_0 : \ \mu_G = 0, \quad \forall G \in \{C, ND, D\} \tag{13}$$

The results of maximum likelihood estimation on (12) for each of total consumption, non-durable, and durable consumption, along with the results of the associated hypothesis tests on (13) are presented below in Table 1. The column marked "Wald" tests the hypotheses in (13) against a χ^2_1 random variable. All of the median/modal parameters μ_G are significantly different from 0. For each good, the median/modal consumer thus consumes more due to an increase in credit than an increase in cash, though the effect is more pronounced for durable goods than non-durable goods, consistent with the theory of Prelec and Loewenstein [14] and empirical results of Quispe-Torreblanca et al. [17].

Table 1: MLE Results for Differences

Model	σ_G	μ_G	Wald	p-value
$\mathcal{D}C_i$	2.212	0.185	42.975	5.545e-11
	(0.033)	(0.028)		
$\mathcal{D}ND_i$	0.734	0.048	28.741	8.273e-08
	(0.012)	(0.009)		
$\mathcal{D}D_i$	2.884	0.315	72.103	0
	(0.042)	(0.037)		

For most consumers, consumption appears to be excessively unresponsive to balance changes and thus excessively smooth over time. Excess smoothness of consumption has been used to justify the PIH (see Campbell and Deaton [3], Quah [16], Flavin [7], Ludvigson and Michaelides [13], and Attanasio and Pavoni [1]). However, if individuals engage in two-stage mental accounting and strongly anchor their expenditure on a preset budget, then excess consumption smoothness would result. In the former case (PIH), consumers are taken to be *incredibly* forward-looking. In the latter case, consumers are assumed more myopic in terms of dynamic outcomes, instead using rule-of-thumb budgeting to regulate consumption. Observationally, if we look only at marginal propensities, these outcomes are equivalent. Thus, a structural test of fungibility is needed since in the case where PIH holds, we would expect fungibility to also hold. For this, we must take a more rigorous, decision-theoretic approach.

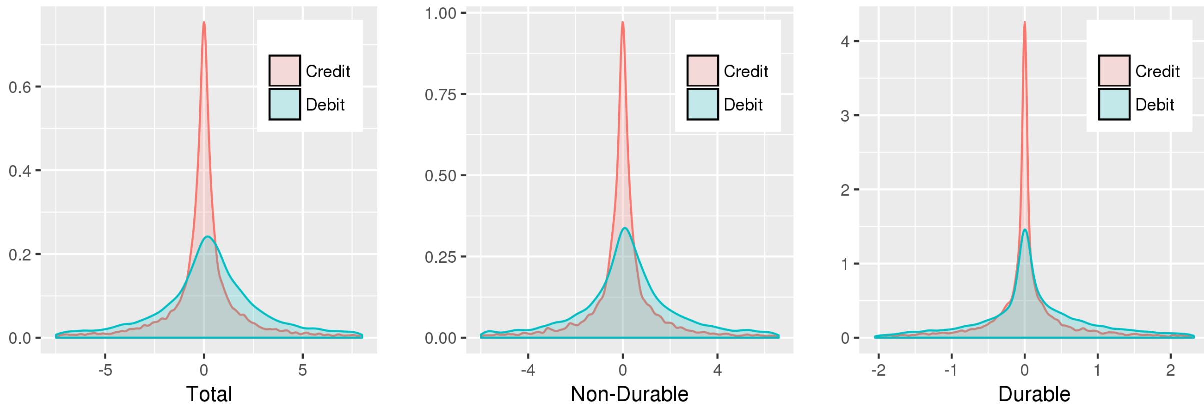

Figure 1: Notice that total consumption (left panel) and non-durable consumption (center panel) are such that the distribution of individual average marginal propensities to consume out of checking account increases appears to dominate the same marginal propensity to consume out of credit increases. This relationship does not appear, at first glance, to hold for durable goods, suggesting consumers again are more comfortable holding credit card debt on durable purchases. (All plots truncated at bottom and top 0.10 quartile.)

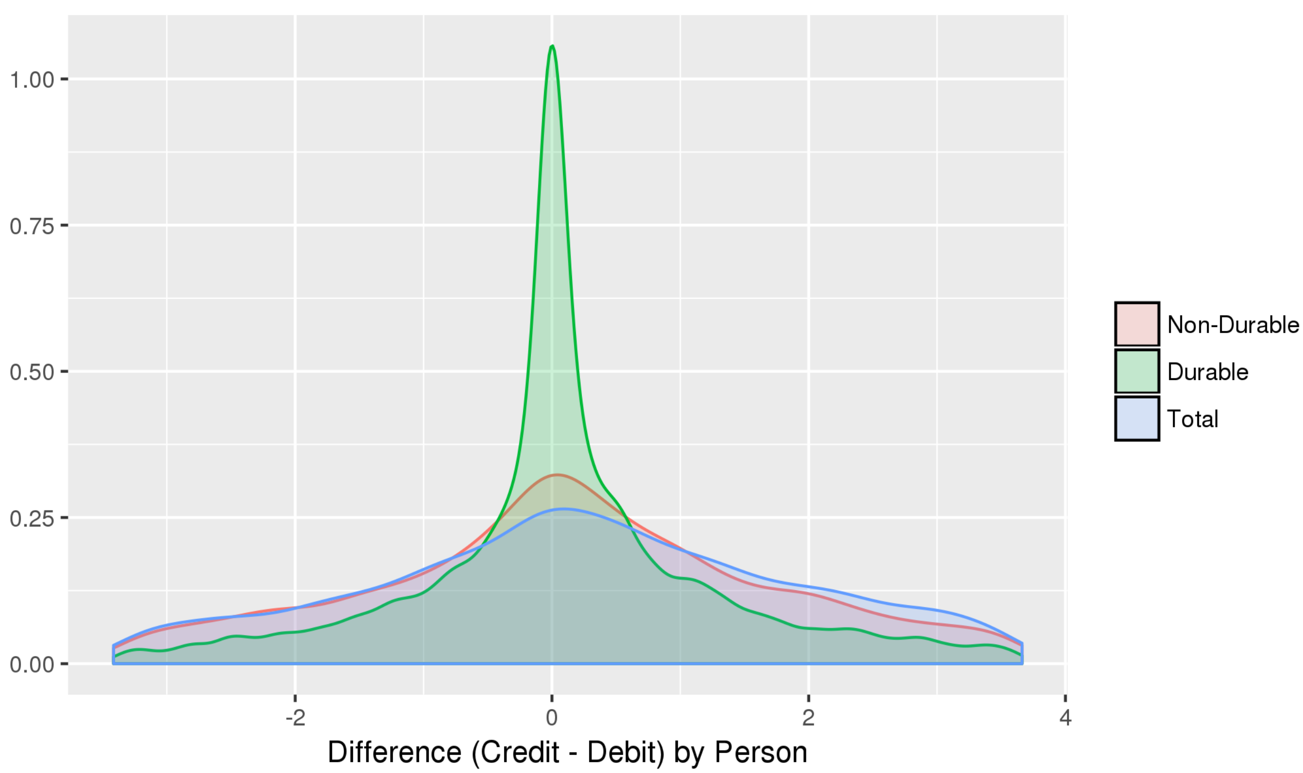

Figure 2: Consumers to the right of the origin increase consumption spending due to a credit increase more than due to a cash increase, while consumers to the left increase consumption spending due to a cash increase more than due to a credit increase. Table 1 shows that the modes/medians of these distributions, if we assume a Cauchy specification, are significantly positive and different from 0. (All plots truncated at bottom and top 0.10 quartile.)

3 Structural Model

In this section we first define the household's problem in terms of the neo-classical formulation commonly found in consumption/savings models with perfect information, exponential/geometric discounting, and rational expectations. In this initial formulation found in Section 3.1, we describe the important features of this model in which consumers are assumed to treat liquidity as perfectly fungible. In Section 3.2 we modify the model to accommodate some of the features of mental accounting by partitioning the budget constraint. We accomplish this without adjusting the preference structure. Finally, we exploit the equilibrium conditions of the mental accounting modification to perform the main, structural fungibility test in Section 3.3.

3.1 Classical Formulation

Consider a consumer who derives utility from consumption of a non-durable good nd_t and the stock of available durable goods k_t each period. Utility is some strictly increasing, strictly concave, twice-differentiable function $u_t(nd_t, k_t)$ that admits the gross substitutes property. The usefulness of durable goods declines each period due to wear and tear with this depreciation denoted by δ. Each period the consumer chooses how much of his wealth w_t to consume in non-durable goods nd_t, invest in savings s_t, and invest in durable goods d_t by solving the dynamic programming problem

$$V_t(w_t, k_t) = \max_{nd_t, d_t, s_t} \quad u_t(nd_t, k_t) + \beta \cdot \mathbb{E}_t V_{t+1}(w_{t+1}, k_{t+1}) \tag{14}$$

$$\text{s.t.} \quad p_t^{nd} \cdot nd_t + p_t^d \cdot d_t + s_t \leq w_t \tag{15}$$

$$k_{t+1} \leq (1-\delta)k_t + d_t \tag{16}$$

Here, k_t and w_t are stock variables and nd_t, d_t, and s_t are flow variables. Equation (16) describes how the total stock of durable goods in the household evolves from period to period. $V_t(w_t, k_t)$ is a function that describes the value a consumer derives from making an optimal decision, p_t^{nd} is the period t price level for non-durable consumption, p_t^d is the period t price level for durable consumption, and β is a parameter governing the consumer's rate of time preference. In the budget constraint, wealth w_t is a function of the consumer's net assets a_t and his labor income l_t:

$$w_t = r_t \cdot a_t + l_t \tag{17}$$

In the above, r_t is the net rate of return on saved assets. Thus in this formulation the consumer values \$1 held in assets the same as \$1 earned from labor income. In the standard formulation, one assumes that asset holdings must satisfy some borrowing limit b_t which usually does not bind:

$$a_{t+1} \geq -b_t \tag{18}$$

with $b_t \geq 0$. Thus in this formulation consumers can choose to borrow to finance present consumption but cannot choose to both borrow and save simultaneously. This allows us to express the law of motion for net assets as

$$a_{t+1} \leq a_t + s_t \tag{19}$$

Let R_t be the gross rate of return on assets. Now, using (19) and (17), the budget constraint can be written strictly as a function of asset holdings and labor income:

$$p_t^{nd} \cdot nd_t + p_t^d \cdot d_t + a_{t+1} \leq R_t \cdot a_t + l_t \tag{20}$$

The linear structure of the consumer's budget constraint implies that, absent liquidation costs, wealth from investments is perfectly substitutable with wealth derived from labor income. In the forthcoming analysis, we will refer to the linear constraint of (20) and assume, for now, that (18) does not bind.

To characterize the consumer's optimal decision in period t, let us write out the Lagrangian function using the collapsed budget constraint. Call this function $\mathcal{L}_t(a_t, k_t)$ for the problem described by (14) through (16) with (20) substituting for (15). In this formulation agents choose nd_t, d_t, and a_{t+1}, and the state variables are a_t and k_t with l_t introduced as an additional flow variable. Letting λ_t denote the Lagrangian multiplier on (20) and η_t the multiplier on (16), the period t Lagrangian is:

$$\begin{aligned} \mathcal{L}_t(a_t, k_t) = {} & u_t(nd_t, k_t) + \beta \cdot \mathbb{E}_t V_{t+1}(a_{t+1}, k_{t+1}) \\ & + \lambda_t \cdot (R_t \cdot a_t + l_t - p_t^{nd} \cdot nd_t - p_t^d \cdot d_t - a_{t+1}) \\ & + \eta_t \cdot \big((1-\delta)k_t + d_t - k_{t+1}\big) \end{aligned} \tag{21}$$

Differentiating the Lagrangian yields three first-order conditions (plus the budget constraint and law of motion for durable goods) so long as $a_{t+1} > -b_t$:

$$\frac{\partial u_t}{\partial nd_t} = \lambda_t p_t^{nd} \tag{22}$$

$$\eta_t = \lambda_t p_t^d \tag{23}$$

$$\lambda_t = \beta \cdot \mathbb{E}_t \frac{\partial V_{t+1}}{\partial a_{t+1}} \tag{24}$$

The three conditions describe the intratemporal rate of substitution between durable and non-durable consumption and the intertemporal consumption/savings tradeoff a consumer faces. λ_t links the marginal utilities between goods with the discounted expected future marginal value an individual will accrue from his savings. Thus λ_t stands in for the marginal value of period t resources. η_t stands in for the marginal value of an additional unit of durable goods. In equilibrium, the internal household marketplace for present and expected future consumption is cleared when the marginal utilities from present non-durable consumption, present durable consumption, and the expected marginal value of investments next period are both exactly equal to the marginal value of period t wealth. Using the Envelope Theorem, (24) can be rewritten:

$$\lambda_t = \beta \cdot \mathbb{E}_t R_{t+1} \lambda_{t+1} \tag{25}$$

This condition says that today's marginal value of wealth must equal the discounted expected gross marginal value of resources next period.

Implicitly, this problem says nothing about how consumers value different forms of liquidity, instead focussing on net available resources. Suppose we now allow consumers to choose which forms of available liquidity, such as wealth or credit, out of which to consume and save. Rather than folding borrowing into a single asset-holding decision a_{t+1} where $a_{t+1} < 0$ if a consumer holds net debt, we will now formulate the model to allow consumers to choose the specific forms of available liquidity out of which to consume and invest. Let m_t denote the amount of credit available to the consumer in period t. Let q_t denote the interest rate the consumer must pay if he carries debts into the next period, with Q_t denoting the gross rate associated with q_t. Consumers can choose to pay off, out of assets or labor income, the debts they accrued prior to incurring interest on the balance. Let e_t denote net outlay (expenditures less payments) associated with the debt instrument and denote the credit limit (effective borrowing limit) by b_t. Then available debt evolves according to the law of motion:

$$b_{t+1} - m_{t+1} \leq Q_t(b_t - m_t - e_t) \tag{26}$$

Under this formulation, all borrowing happens through choices of e_t not s_t. Thus we can rewrite (18) to force $a_{t+1} \geq 0$, so that savings must always be non-negative. This alters the budget constraint. Now consumers must choose s_t and e_t, but these choices depend on the relative rate of return between savings and borrowing. If $e_t > 0$ then the consumer paid down debts more than he borrowed, while if $e_t < 0$ he borrowed more than he paid down debts. Total consumption expenditure, investment, and debt payments must still satisfy the consumer's available net resources, though the budget constraint now additively separates investment from borrowing:

$$p_t^{nd} \cdot nd_t + p_t^d \cdot d_t + s_t + e_t \leq r_t \cdot a_t + l_t \tag{27}$$

We can use (26) in (27) to completely collapse the constraints into a single budget constraint but which now contains an explicit credit feature. The endogenous state variables for the consumer's optimization problem are now a_t, k_t, and m_t, and the recursive optimization problem is

$$V_t(a_t, k_t, m_t) = \max_{nd_t, d_t, a_{t+1}, m_{t+1}} \quad u_t(nd_t, k_t) + \beta \cdot \mathbb{E}_t V_{t+1}(a_{t+1}, k_{t+1}, m_{t+1}) \tag{28}$$

$$\text{s.t.} \quad p_t^{nd} \cdot nd_t + p_t^d \cdot d_t + a_{t+1} + \frac{m_{t+1} - b_{t+1}}{Q_t} \leq R_t \cdot a_t + m_t - b_t + l_t \tag{29}$$

$$k_{t+1} \leq (1-\delta)k_t + d_t \tag{30}$$

Here, the borrowing limits are incorporated directly into the budget constraint, eliminating the additional inequality constraint.

Denote the Lagrangian multiplier on (29) as μ_t and that on (30) as η_t. The new problem yields four first-order conditions (plus the budget constraint):

$$\frac{\partial u_t}{\partial nd_t} = \mu_t p_t^{nd} \tag{31}$$

$$\eta_t = \mu_t p_t^d \tag{32}$$

$$\mu_t = \beta \cdot \mathbb{E}_t \frac{\partial V_{t+1}}{\partial a_{t+1}} \tag{33}$$

$$\frac{\mu_t}{Q_t} = \beta \cdot \mathbb{E}_t \frac{\partial V_{t+1}}{\partial m_{t+1}} \tag{34}$$

Here, the interpretation of μ_t is slightly different than that of λ_t. Whereas λ_t stands in for the marginal value of period-t wealth, μ_t represents the marginal value of period t liquidity, i.e. wealth plus credit. We can combine (33) and (34) to show that the expected marginal value of having more available credit should equal the expected marginal value of assets weighted by the inverse gross rate of credit interest:

$$\mathbb{E}_t \frac{\partial V_{t+1}}{\partial m_{t+1}} = \left(\frac{1}{Q_t}\right) \cdot \mathbb{E}_t \frac{\partial V_{t+1}}{\partial a_{t+1}} \tag{35}$$

Thus as Q_t increases, a consumer can adjust his asset holdings down to offset the additional borrowing cost by paying back his debts faster. Similarly, as Q_t falls, the consumer will borrow more reducing his available credit and increasing his expected marginal value of available credit. These results are a direct consequence of the concavity of the value function inducing diminishing marginal utility.

Despite this small adjustment to the neo-classical consumption/savings model made by explicitly modeling the borrowing decision alongside the savings decision, the consumer by design has the same marginal value for liquidity regardless of the liquidity instrument. In other words, liquidity in this model is "perfectly fungible" across invested assets, income, and credit. This assumption fundamentally contradicts the theory of mental accounting specifically discussed in Shefrin and Thaler [18] and Thaler [22, 21]. Other authors like Prelec and Simester [15] have noted that consumer willingness-to-pay seems directly related to payment method: consumers are willing to spend more to purchase an item when using their credit cards as opposed to their checking accounts. Such a phenomenon could be explained by a liquidity or buffer-stock preference as modeled in Carroll [4]. Even so, a rational consumer who is constrained as described by the budget constraint in (29) should seek to ensure that his economic behavior befits the condition in (35), and thus price-weighted marginal value of wealth is independent of the liquidity type.

This leads to the natural question: do consumers behave as if the marginal value of liquidity is the same for all liquidity types? To answer it, we will consider consumer behavior under an alternative formulation of the above model where instead of choosing total consumption and investment levels consumers choose shares of liquidity sources out of which to allocate consumption. We will call this formulation the "mental accounting" formulation as it is consistent with the idea that consumers care about the source of funds used to engage in expenditure and/or savings. We accomplish the integration of this modeling feature into the standard, classical utility maximization problem without altering the consumer's preference structure, only his choice set.

3.2 Mental Accounting Formulation

Suppose now consumers behave according to the theory of Shefrin and Thaler [18] whereby ex-ante they set expenditure plans for themselves according to some optimization rule. Such behavior would be consistent with what is known as the "planner's" side of the problem. Consumers then go out and engage in expenditure — the "doer's" side of the problem. Here, we will explicitly focus on the planner's side particularly with respect to the method of payment consumers will use to engage in expenditure.

Consumers have preferences over durable and non-durable consumption given by $u_t(nd_t, k_t)$. Consumers have three sources of liquidity out of which they can consume — investment income $R_t \cdot a_t$, available cash z_t, and credit m_t. The choice process takes a two-step approach. First, consumers decide how much of their expenditure they want to come from the different liquidity sources by choosing goods-dependent shares $\theta_{at}(nd_t)$, $\theta_{zt}(nd_t)$, and $\theta_{mt}(nd_t)$ and $\theta_{at}(d_t)$, $\theta_{zt}(d_t)$, and $\theta_{mt}(d_t)$ where total expenditure of each good in the period is the weighted sum of these shares

$$p_t^{nd} \cdot nd_t = \theta_{at}(nd_t) R_t \cdot a_t + \theta_{zt}(nd_t) z_t + \theta_{mt}(nd_t) m_t \tag{36}$$

$$p_t^{d} \cdot d_t = \theta_{at}(d_t) R_t \cdot a_t + \theta_{zt}(d_t) z_t + \theta_{mt}(d_t) m_t \tag{37}$$

Here, for example, $\theta_{zt}(nd_t)$ is the fraction of available cash z_t the consumer chooses to spend on non-durable goods nd_t each period.

Given their expenditure choices, consumers then decide how much to save s_t and pay down their credit card debt with payments e_t. The laws of motion change slightly since the payment and savings decisions are fundamentally separate from the expenditure-share decisions. Here, we model the evolution of credit m_t and include an additional state variable z_t which corresponds to the evolution of cash or, equivalently, checking-account holdings[7]:

$$a_{t+1} \leq \big(1 - \theta_{at}(nd_t) - \theta_{at}(d_t)\big) R_t \cdot a_t + s_t \tag{38}$$

$$z_{t+1} \leq W_t\big(l_t + (1 - \theta_{zt}(nd_t) - \theta_{zt}(d_t)) z_t - e_t - s_t\big) \tag{39}$$

$$b_{t+1} - m_{t+1} \leq Q_t\big(b_t - m_t + (\theta_{mt}(nd_t) + \theta_{mt}(d_t)) m_t - e_t\big) \tag{40}$$

The value of cash next period z_{t+1} is the value of cash this period less expenditure, payments, and savings, appreciated at gross rate W_t. Total debt next period $b_{t+1} - m_{t+1}$ is debt this period plus expenditure out of credit this period less payment, appreciated at

[7] We use "cash", "debit", and "checking account balances" interchangeably.

rate Q_t.

Now assume the consumer chooses these shares $\theta_{at}(nd_t)$, $\theta_{zt}(nd_t)$, $\theta_{mt}(nd_t)$, $\theta_{at}(d_t)$, $\theta_{zt}(d_t)$, and $\theta_{mt}(d_t)$, savings s_t, and payments e_t so as to solve his recursive dynamic programming problem where utility is derived over consumption of non-durable and durable goods. The endogenous state variables for this problem are assets a_t, the stock of durables k_t, cash z_t, and credit m_t. Income l_t is thought to evolve exogenously. Credit lines b_t also evolve exogenously. For notational convenience, denote the vectors of shares where the individual components are the non-durable and durable-specific shares in bold face, (e.g. $\boldsymbol{\theta}_{at}$). The consumer's problem under this formulation is:

$$V_t(a_t, k_t, z_t, m_t) = \max_{\substack{\boldsymbol{\theta}_{at}, \boldsymbol{\theta}_{lt}, \boldsymbol{\theta}_{mt} \\ s_t, e_t}} \quad u_t(nd_t, k_t) + \beta \cdot \mathbb{E}_t V_{t+1}(a_{t+1}, k_{t+1}, z_{t+1}, m_{t+1}) \tag{41}$$

$$\text{s.t.} \quad a_{t+1} \leq \big(1 - \theta_{at}(nd_t) - \theta_{at}(d_t)\big) R_t \cdot a_t + s_t \tag{42}$$

$$z_{t+1} \leq W_t\big(l_t + (1 - \theta_{zt}(nd_t) - \theta_{zt}(d_t))z_t - e_t - s_t\big) \tag{43}$$

$$b_{t+1} - m_{t+1} \leq Q_t\big(b_t - m_t + (\theta_{mt}(nd_t) + \theta_{mt}(d_t))m_t - e_t\big) \tag{44}$$

$$k_{t+1} \leq (1-\delta)k_t + d_t \tag{45}$$

$$p_t^{nd} \cdot nd_t = \theta_{at}(nd_t) R_t \cdot a_t + \theta_{zt}(nd_t) z_t + \theta_{mt}(c_t) m_t \tag{46}$$

$$p_t^{d} \cdot d_t = \theta_{at}(d_t) R_t \cdot a_t + \theta_{zt}(d_t) z_t + \theta_{mt}(d_t) m_t \tag{47}$$

Denote the Lagrangian multipliers on (42), (43), and (44) as μ_{at}, μ_{zt}, and μ_{mt}. Let η_t be the multiplier on the durable goods law of motion again. When the agent chooses shares, the first order conditions are:

$$\frac{\partial u_t}{\partial nd_t} = \mu_{at} p_t^{nd} \tag{48}$$

$$\frac{\partial u_t}{\partial nd_t} = W_t \mu_{zt} p_t^{nd} \tag{49}$$

$$\frac{\partial u_t}{\partial nd_t} = Q_t \mu_{mt} p_t^{nd} \tag{50}$$

$$\eta_t = \mu_{at} p_t^{d} \tag{51}$$

$$\eta_t = W_t \mu_{at} p_t^{d} \tag{52}$$

$$\eta_t = Q_t \mu_{mt} p_t^{d} \tag{53}$$

Choices of s_t and e_t provide conditions on the Lagrange multipliers:

$$\mu_{at} = W_t \mu_{zt} \tag{54}$$

$$Q_t \mu_{mt} = W_t \mu_{zt} \tag{55}$$

Importantly, regardless of the functional form of the utility function chosen, the model says that marginal utility of non-durable consumption must equate with all price-weighted marginal values of liquidity for the different liquidity types. For durables, the marginal value of a one-unit increase to the durable stock η_t must equate with these price-weighted marginal values of liquidity also.

Conditions (54) and (55) provide natural restrictions to test the validity of this model. (54) says that the marginal value of an additional unit of assets is equal to the return-weighted marginal value of an additional unit of cash. Thus, individuals should maintain balances in all of these accounts, including available credit, so that they are roughly proportional to each other. The model thus predicts that individuals will take into consideration the relative interest rates across liquidity sources when making expenditure decisions and choose consumption expenditure in weighted proportions. Note that this is a *result* of the model which holds for all utility functions in which consumption utility is not separable across payment categories. Thus as long as consumers benefit from one unit of consumption from a credit card purchase the same as they benefit from one unit of consumption from a cash purchase, conditions (48) thru (55) will hold. (48) thru (55) constitute a system of identifiable simultaneous equations, but whose restrictions force the marginal utilities to relate via (54) and (55). We can test whether this is a reasonable assumption by empirically examining how the balances of these different liquidity sources covary over time.

3.3 A Test of Fungibility

The null hypotheses we are seeking to test is whether the conditions in (54) and (55) hold with equality. This will tell us whether or not individuals have consistent preferences over different liquidity sources and thus treat available liquidity as fungible, as predicted by the standard neo-classical consumption/savings problem outlined in (28) thru (30) and modified in (41) thru (47).

The primary focus of this exercise is to examine whether the classical model predicts that consumers will adjust their expenditure out of both checking and credit card sources at rates consistent with (55). Since our data primarily consists of debit card transactions from checking accounts and credit card transactions, we will focus on (55) and forego analysis of how individuals consume out of saved assets. Note that μ_{zt} and μ_{mt} denote the rate at which the individual Lagrangian function $\mathcal{L}_{it}$ changes with respect to unit changes in z and m respectively. Let i index individual consumers in our dataset. Using the finite differences operator Δ, we can thus write condition (55) at the consumer level:

$$Q_{it}\frac{\Delta\mathcal{L}_{it}}{\Delta m_{it}} = W_{it}\frac{\Delta\mathcal{L}_{it}}{\Delta z_{it}} \tag{56}$$

Canceling like terms, re-arranging the equation, then taking an expectation over time, provides us with a testable null hypothesis at the agent level:

$$H_0 : \ \mathbb{E}_i\left\{Q_{it}\frac{\Delta z_{it}}{\Delta m_{it}} - W_{it}\right\} = 0 \tag{57}$$

From Figure 3 it appears that the distribution of our test statistic is symmetric with fat tails, much like the distributions in Figure 2. Thus suppose (57) follows a Cauchy distribution with parameters μ and σ.[8]

$$\mathbb{E}_i\left\{Q_{it}\frac{\Delta z_{it}}{\Delta m_{it}} - W_{it}\right\} \sim \text{Cauchy}(\mu, \sigma) \tag{58}$$

Figure 3 shows that, even when weighted by the gross monthly interest rate Q_{it}, fluctuations in available credit dominate fluctuations in available cash. Note that available credit can change due to three factors: 1) changes in spending on the credit card, 2) payments made against the credit card balance, or 3) an exogenous increase in the credit limit by the bank. The latter rarely occurs. The fact that the distribution of (57) is centered to the left of the origin suggests that (55) does not hold with equality. We perform a formal test on this conjecture by estimating μ and σ using maximum likelihood estimation on (58). The results of the estimation and a Wald test on the hypothesis

$$H_0 : \ \mu = 0 \tag{59}$$

shows that $\mu < 0$ almost certainly. This implies that the median/mode of (57) is also less than 0, so that for the median/modal consumer in our sample, condition (55) does not hold. In fact, this test suggests that most consumers behave as if the marginal return to an additional unit of credit is *greater* than the marginal return to additional cash, a feature which would not be predicted by any standard parameterization of the neo-classical consumption/savings model. The full results of the MLE for (58) are presented in Table 2

[8] The distinction between these parameters from those in (12) is that we do not impose subscripts here.

below.

The units of the test statistic are real 2009 U.S. dollars. Essentially (57) represents on average how far away a household is from treating liquidity as perfectly fungible. A household with a test statistic value of 2, for example, will on average spend \$2 more on consumption due to a \$1 cash increase than if they had received a \$1 credit increase, while a household with a value of $-\$2$ will on average spend \$2 more on consumption due to a \$1 credit increase than if they had received a \$1 cash increase. Thus, the statistic measures the marginal rate at which households value additional cash verses additional credit.

While the median/modal consumer appears to violate fungibility, Figure 3 demonstrates that the distribution of this average behavior across individuals is rather disperse. In fact since the Cauchy distribution itself does not have a finite second moment, the asymptotic variance of (57) is effectively infinite. The variance of our sample test statistic, for example, is 225744954, suggesting that the Cauchy distribution may be a good fit. A small share of households appear to treat liquidity as fungible, though about 59% of households are clearly more sensitive to increases in available credit than increases in cash. To understand the relative shares of households who exhibit behavior "near" fungibility, in Table 3 we present estimates of the shares of households whose value of (57) resides within \$0.01, \$0.05, \$0.10, \$0.25, \$0.50, \$1, \$2, \$5, and \$10 of 0 for the MLE-fitted Cauchy distribution. About 16.9% of households, for example, reside within \$1 of fungibility, on average. This is not large, but it does suggest that further exploration may be needed to better understand what, if anything, sets more fungible households apart from their less fungible peers.

Whether all of this matters on aggregate remains to be explored. A generous interpretation of these results would say that the neo-classical formulation does not perform *too badly*: a significant share of consumers appear to treat liquidity as near fungible, depending on how one defines "near," and some are even more sensitive to cash increases than credit increases (about 41%). The test reveals what mental accounting theory would expect — most consumers are more sensitive to credit increases than cash increases — and yet the neo-classical model does not appear utterly terrible at reconciling these facts with only slight modifications, true testament to its durability and continuing utility for consumer scientists.

Table 2: Structural Test of Fungibility

σ	μ	Wald	p-value
3.388	-1.029	619.749	0
(0.054)	(0.041)		

Table 3: Shares of Households Within $$x$ from 0

Absolute $ From 0	0.010	0.050	0.100	0.250	0.500	1	2	5	10
Shares of HH	0.002	0.009	0.017	0.043	0.086	0.169	0.321	0.612	0.790

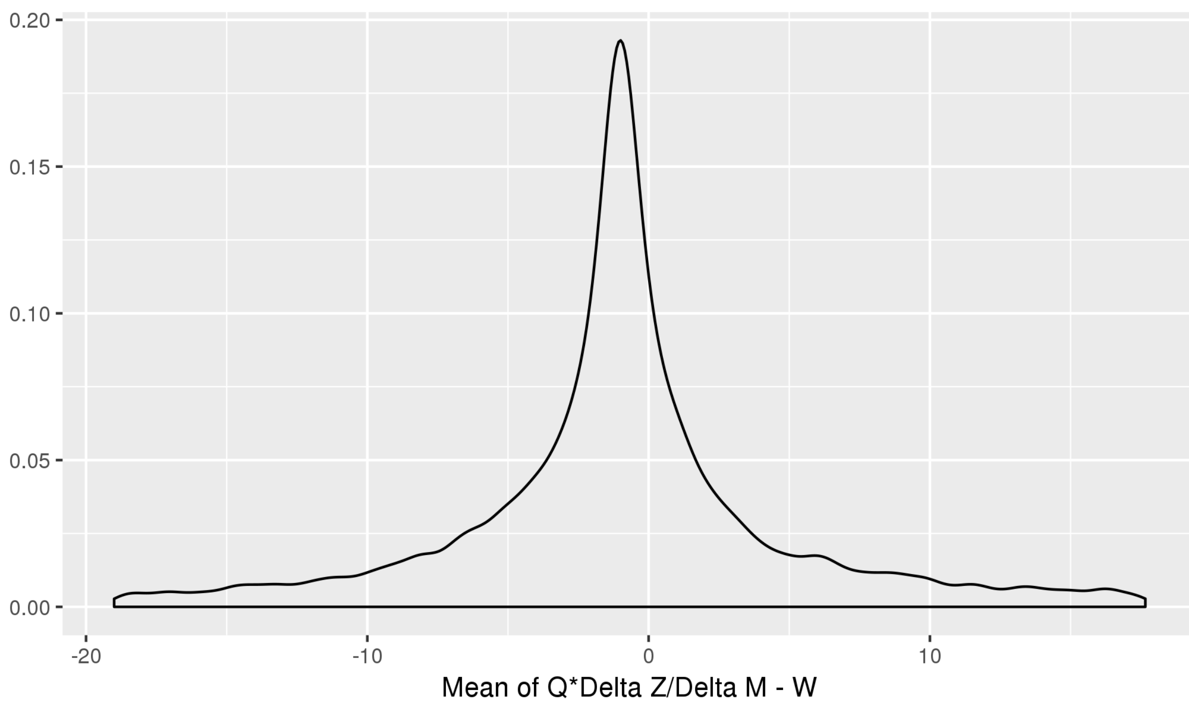

Figure 3: This is the distribution of the individual sample mean analogs of (57). Notice that the distribution is centered to the left of the origin, suggesting that the median/modal consumer exhibits behavior that is inconsistent with condition (55). (Truncated at bottom and top 0.10 quartile.)

4 Conclusion

We have shown that the neo-classical consumption/savings model can be used to perform a consistent, structural test of the fungibility of liquidity at the household level. Most households are credit hungry, increasing consumption more due to credit increases than cash increases, though there is significant heterogeneity in this behavior across households. Further, durable goods consumption exhibits patterns consistent with the theory of mental accounting in Prelec and Loewenstein [14], suggesting utility from consumption is coupled with method of payment. Broadly speaking, our results provide strong empirical support that consumers engage in various degrees of mental accounting.

But what does this mean for broader economic outcomes and societal impacts? More work is needed to uncover the economic and demographic profiles of households that exhibit highly non-fungible behavior. Understanding how credit hungriness under mental accounting is related on aggregate to broader fluctuations in liquidity and credit availability would be a daunting yet potentially groundbreaking endeavor. Thus our findings here should be used as a springboard for further research that examines how household-level mental accounting behaviors could affect broad economic aggregates, while better informing the design of policies and products that help encourage responsible consumer credit utilization.

A Data Miscellany

In this appendix we present two tables. Table 4 shows our broad classifications of durable and non-durable goods based on the 4-digit Visa merchant code descriptions. Table 5 presents summary statistics for the broad marginal propensities to consume and first differences used

Table 4: Merchant Category Classification

Category	Durable?
Other svcs. (vet, horticulture, agriculture)	Yes
General contractors	Yes
Contracting services (construction)	Yes
Misc. publishing and printing	No
Specialty cleaning	No
Air travel	No
Car rental	No
Hotels	No
Public transit	No
Freight and courier svcs.	No
Marine and boating svcs.	Yes
Air travel, airports, and air fields	No
Travel agencies and tourism	No
Cable and telephone equipment and svcs.	No
Utilities (electric, gas, sanitary, water)	No
Medical, motor vehicle, office furniture, hardware	Yes
Office supplies, uniforms, books, chemicals	Yes
Home supply warehouses and hardware stores	Yes
Wholesale clubs/dept. Stores	Yes
Groceries	No
Automotive and gasoline	No
Clothing	Yes
Furniture and home electronic sales	Yes
Restaurants, bars, liquor stores	No
Misc.religious products, tents, swimming pools, tobacco, flowers, etc. (day to day and hobbies)	No
Financial svcs.	Yes
Insurance	Yes
Misc. hotels and recreation	No
Misc. svcs. (laundry, dating, massage, escort, photography, health and beauty)	No
Misc. svcs. (advertising, computer prog., information retrieval, bus. Consulting, janitorial, secretarial)	Yes
Automotive repair and cleaning misc.	Yes
HVAC and furniture repair	Yes
Movie theaters and video rentals	No
Bowling, dance halls, golf, club memberships, video gaming, aquariums and other recreation svcs.	No
Medical and dental	Yes
Legal svcs.	Yes
Education (including colleges)	Yes
Child care and charitable svcs.	Yes
Civic, religious, and political organizations	No
Non-medical testing laboratories	Yes
Architectural, account'ing, plus misc. prof. Svcs.	Yes
Court costs, fines, bail and bonds	Yes
Taxes	Yes
Postal svcs. And intra-gov't transactions	No

Table 5: Summary Statistics: Marginal Propensities

Statistic	N	Mean	St. Dev.	Min	Max
$MPC_i(z)$	10,690	−0.922	104.359	−9,328.642	1,778.450
$MPND_i(z)$	10,690	0.101	49.516	−2,627.695	1,778.493
$MPD_i(z)$	10,690	−0.750	64.592	−6,222.867	1,039.497
$MPC_i(m)$	10,690	415.052	36,211.200	−259,806.000	3,601,747.000
$MPND_i(m)$	10,690	71.076	10,732.410	−220,949.500	1,074,203.000
$MPD_i(m)$	10,690	3.255	2,577.278	−173,748.800	183,706.500
$\mathcal{D}C_i$	10,690	415.975	36,211.030	−259,806.200	3,601,716.000
$\mathcal{D}ND_i$	10,690	70.975	10,732.540	−220,949.600	1,074,204.000
$\mathcal{D}D_i$	10,690	4.005	2,578.079	−173,749.000	183,704.900

B Quispe-Torreblanca et al. [17] Analysis

Here we replicate the durable/non-durable fungibility analysis in Quispe-Torreblanca et al. [17] and perform some additional tests. In the baseline exercise, we find U.S. consumer data possesses the same mental accounting signatures Quispe-Torreblanca et al. [17] find in U.K. We also consider the analyses of Quispe-Torreblanca et al. [17] on a broader dataset where we include the outliers that are precluded by their analysis.

For the baseline analysis we consider all credit card users in our dataset who have a positive (non-zero) merchant interest rate and have never recorded a balance transfer or cash advance on their credit card account. We then classify individual transactions by merchant category to mimic the durable/non-durable classifications in Quispe-Torreblanca et al. [17]. A summary of our classifications is presented in Table 4. The primary goal of this first analysis is to examine whether the period t payment to debt-balance ratio is related to the presence of durable good expenditure in any of the previous periods. Let i index individual households and t index time. Let $Prop_{it}$ be the payment to debt-balance ratio and $Full_{it}$ be an indicator which equals 1 if a consumer repaid his balance in full. Consistent with the methods employed by Quispe-Torreblanca et al. [17] we manually truncate our dataset so that $Prop_{it} \in [0, 1]$, dropping consumers who miss a payment or overpay. Let $Dur_{i\tau} = 1$ if a durable good was purchased in period τ. Let $\boldsymbol{X}_{it}$ be a vector of controls describing features of the consumer's credit card account, which includes the total credit line available, the merchant annual percentage rate, and the percent utilization of the credit line. Let $\boldsymbol{Z}_{it}$ be a vector of economic characteristics associated with the zip code of the account holder. We consider the following set of regressions using both individual κ_i and month/year γ_t fixed effects for lags of $\tau \in \{t-1, t-2, t-3, t-4\}$:

$$Prop_{it} = \beta \cdot Dur_{i\tau} + \boldsymbol{\theta}' \cdot \boldsymbol{X}_{it} + \boldsymbol{\eta}' \cdot \boldsymbol{Z}_i t + \kappa_i + \gamma_t + \epsilon_{it} \tag{60}$$

$$Full_{it} = \beta \cdot Dur_{i\tau} + \boldsymbol{\theta}' \cdot \boldsymbol{X}_{it} + \boldsymbol{\eta}' \cdot \boldsymbol{Z}_i t + \kappa_i + \gamma_t + \epsilon_{it} \tag{61}$$

The results of this analysis are consistent with those for British consumers in Quispe-Torreblanca et al. [17] and are presented in Tables 6 and 7. The presence of a durable goods transaction is associated with an percentage point drop in the proportion of balance repaid, so that consumers are more likely to hold positive, interest-bearing credit card balances when making a durable purchase. Table 8 thru 11 provide summary statistics for the different subsets used in the eight different linear regressions described by (60) and (61).

While performing the same analysis as Quispe-Torreblanca et al. [17] on our unique dataset yields the same mental accounting signature, when the analysis is extended to a non-truncated dataset which considers consumers who both prepay their balance or skip payments and features a continuous variable $DurExpend_{i\tau}$ which describes total monthly expenditure on durable goods, the significance of the linear model is compromised. We run the following regressions in the broader analysis for $\tau \in \{t-1, t-2, t-3, t-4\}$:

$$Prop_{it} = \beta \cdot DurExpend_{i\tau} + \boldsymbol{\theta}' \cdot \boldsymbol{X}_{it} + \boldsymbol{\eta}' \cdot \boldsymbol{Z}_i t + \kappa_i + \gamma_t + \epsilon_{it} \tag{62}$$

$$Full_{it} = \beta \cdot DurExpend_{i\tau} + \boldsymbol{\theta}' \cdot \boldsymbol{X}_{it} + \boldsymbol{\eta}' \cdot \boldsymbol{Z}_i t + \kappa_i + \gamma_t + \epsilon_{it} \tag{63}$$

In estimations of (62) and (63), we only exclude consumers who have never recorded a balance transfer or cash advance on their credit card account. This time, we keep consumers who have months with 0% APR, and for whom we observe both negative $Prop_{it}$ and $Prop_{it} > 1$. Both the magnitude and significance of the results in the first analysis is completely compromised when we make limited exclusions. Tables 12 and 13 show that with this larger dataset, the more a consumer spends on durables the more likely the consumer is to repay the month's full balance. This is contrary to the results in Tables 6 and 7, yet regressions (62) and (63) explain far less of the data variance than regressions on the truncated dataset. The summary statistics in Tables 14 thru 17 demonstrate that the credit limits of customers in our dataset is highly variable, ranging from a minimum of $200 to a high of $250,000. The proportion of balances repaid varies heavily in this regard as well, with consumers overpaying and skipping payments. Note that we cannot observe whether or not consumers receive balance transfers *to* their account from another credit card account: these transactions appear strictly as payments. Thus, our analysis could be biased and consumers may be transferring balances *off* of their credit card account to another account that is unobserved, and we have no direct way of identifying this.

We performed several additional analyses to better understand the relationships between durable expenditure and payments in the non-truncated dataset. Table 18 presents regressions of $Prop_{it}$ on the durable expenditure share of total consumption expenditure and the durable expenditure share of total available credit. While the share of total expenditure devoted to durables is negatively associated with the proportion of balances repaid as [14] would predict, the results are not statistically significant. Together the outcomes of these reduced-form regressions indicate that, while some consumers may exhibit a behavioral profile indicative of mental accounting, to better understand this phenomenon we seek to consumption expenditure in a more structural context.

Table 6: Regression (60): [17] Analysis

	Dependent variable:			
	Proportion of Balance Repaid After ...			
	1 Month	2 Months	3 Months	4 Months
Durable (= 1)	-0.079^{***}	-0.073^{***}	-0.072^{***}	-0.076^{***}
	(0.002)	(0.002)	(0.002)	(0.002)
APR ($\in (0,1)$)	-0.269^{***}	-0.371^{***}	-0.389^{***}	-0.416^{***}
	(0.018)	(0.019)	(0.020)	(0.021)
Credit Limit	-0.00000^{***}	0.00000^{***}	0.00000^{***}	0.00000^{***}
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Utilization (Bal/Credit Lim)	0.022^{***}	-0.104^{***}	-0.098^{***}	-0.101^{***}
	(0.002)	(0.002)	(0.002)	(0.002)
Controls?	Yes	Yes	Yes	Yes
Fixed Effects?	Yes	Yes	Yes	Yes
Observations	236,881	210,740	189,857	170,211
R^2	0.729	0.724	0.721	0.720
Adjusted R^2	0.729	0.724	0.721	0.720
Note:				$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 7: Regression (61): [17] Analysis

	Dependent variable:			
	(= 1) if Balance Fully Repaid After ...			
	1 Month	2 Months	3 Months	4 Months
Durable (= 1)	-0.820^{***}	-0.752^{***}	-0.716^{***}	-0.747^{***}
	(0.018)	(0.019)	(0.020)	(0.021)
APR ($\in (0,1)$)	-0.643^{***}	-1.560^{***}	-1.697^{***}	-2.127^{***}
	(0.193)	(0.223)	(0.240)	(0.257)
Credit Limit	-0.00001^{***}	0.00000^{***}	0.00000^{***}	0.00000^{***}
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Utilization (Bal/Credit Lim)	1.145^{***}	-0.064^{***}	-0.087^{***}	-0.132^{***}
	(0.023)	(0.024)	(0.025)	(0.027)
Controls?	Yes	Yes	Yes	Yes
Fixed Effects?	Yes	Yes	Yes	Yes
Observations	236,881	210,740	189,857	170,211
Log Likelihood	−86,115.360	−64,289.140	−56,384.720	−49,940.250
Akaike Inf. Crit.	172,298.700	128,644.300	112,833.400	99,942.500
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 8: First Analysis, Summary Statistics (One Lag)

Statistic	N	Mean	St. Dev.	Min	Max
Prop. Repaid (1 month)	236,881	0.491	0.302	0.000	1.000
Full Repay? (1 month)	236,881	0.124	0.329	0	1
Durable (= 1)	236,881	0.908	0.289	0	1
APR ($\in (0,1)$)	236,881	0.121	0.051	0.0003	0.290
Credit Limit	236,881	10,518.730	7,976.793	200	250,000
Utilization (Bal/Credit Lim)	236,881	0.690	0.335	0.000	1.000

Table 9: First Analysis, Summary Statistics (Two Lags)

Statistic	N	Mean	St. Dev.	Min	Max
Prop. Repaid (2 months)	210,740	0.466	0.292	0.000	1.000
Full Repay? (2 months)	210,740	0.093	0.290	0	1
Durable (= 1)	210,740	0.879	0.326	0	1
APR ($\in (0,1)$)	210,740	0.120	0.052	0.0003	0.290
Credit Limit	210,740	10,576.170	7,949.551	200	250,000
Utilization (Bal/Credit Lim)	210,740	0.707	0.329	0.000	1.000

Table 10: First Analysis, Summary Statistics (Three Lags)

Statistic	N	Mean	St. Dev.	Min	Max
Prop. Repaid (3 months)	189,857	0.461	0.291	0.000	1.000
Full Repay? (3 months)	189,857	0.089	0.285	0	1
Durable (= 1)	189,857	0.871	0.335	0	1
APR ($\in (0,1)$)	189,857	0.118	0.053	0.0003	0.290
Credit Limit	189,857	10,650.450	7,922.346	200	250,000
Utilization (Bal/Credit Lim)	189,857	0.708	0.330	0.000	1.000

Table 11: First Analysis, Summary Statistics (Four Lags)

Statistic	N	Mean	St. Dev.	Min	Max
Prop. Repaid (4 months)	170,211	0.460	0.291	0.000	1.000
Full Repay? (4 months)	170,211	0.088	0.283	0	1
Durable (= 1)	170,211	0.867	0.340	0	1
APR ($\in (0,1)$)	170,211	0.116	0.054	0.0003	0.290
Credit Limit	170,211	10,719.440	7,899.988	200	200,000
Utilization (Bal/Credit Lim)	170,211	0.711	0.329	0.000	1.000

Table 12: Regression (62): Non-Truncated Dataset

	Dependent variable:			
	Proportion of Balance Repaid After ...			
	1 Month	2 Months	3 Months	4 Months
Durable Expenditure	0.001**	0.0003	0.0001	−0.0001
	(0.0002)	(0.001)	(0.001)	(0.001)
APR	32.738***	109.231***	56.775	113.287***
	(11.109)	(31.911)	(43.912)	(33.884)
Credit Limit	−0.0001	0.0001	0.00002	0.0002
	(0.0001)	(0.0001)	(0.0002)	(0.0002)
Utilization	5.527***	−1.603	1.934	2.995
	(1.481)	(4.247)	(5.842)	(4.511)
Controls?	Yes	Yes	Yes	Yes
Fixed Effects?	Yes	Yes	Yes	Yes
Observations	507,707	466,607	427,646	390,500
R^2	0.0002	0.0001	0.0001	0.0001
Adjusted R^2	0.0001	0.00003	0.00002	0.00005
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 13: Regression (63): Non-Truncated Dataset

	Dependent variable:			
	(= 1) if Balance Fully Repaid After ...			
	1 Month	2 Months	3 Months	4 Months
Durable Expenditure	0.001***	0.001***	0.0003***	0.0002***
	(0.00001)	(0.00000)	(0.00000)	(0.00000)
APR	4.001***	3.879***	4.179***	4.098***
	(0.088)	(0.092)	(0.095)	(0.100)
Credit Limit	−0.00004***	−0.0001***	−0.00005***	−0.00005***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Utilization	4.927***	5.102***	4.821***	4.892***
	(0.016)	(0.021)	(0.021)	(0.023)
Controls?	Yes	Yes	Yes	Yes
Fixed Effects?	Yes	Yes	Yes	Yes
Observations	507,707	466,607	427,646	390,500
Log Likelihood	−259,225.000	−249,356.500	−234,590.900	−214,523.400
Akaike Inf. Crit.	518,529.900	498,788.900	469,253.800	429,116.900
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 14: Second Analysis, Summary Statistics (One Lag)

Statistic	N	Mean	St. Dev.	Min	Max
Prop. Repaid (1 month)	507,707	2.099	311.383	−88,234.290	117,770.000
Full Repay? (1 month)	507,707	0.589	0.492	0	1
Total Expenditure	507,707	1,072.796	2,850.744	−21,143.250	650,661.600
Durable Expenditure	507,707	406.028	2,080.070	−42,081	626,740
Credit Limit	507,707	11,736.170	9,608.041	200	250,000
APR	507,707	0.112	0.057	0.000	0.290
Last Stmt. Balance	507,707	2,363.081	3,884.139	−88,337.870	216,622.700
Last Stmt. Payment	507,707	1,045.675	2,982.071	0.000	524,520.500
Last Stmt. Billed	507,707	126.556	1,573.777	0.000	216,622.700
Utilization	507,707	0.737	0.308	−2.963	12.875

Table 15: Second Analysis, Summary Statistics (Two Lags)

Statistic	N	Mean	St. Dev.	Min	Max
Prop. Repaid (2 months)	466,607	−0.594	852.766	−357,639.000	216,366.000
Full Repay? (2 months)	466,607	0.375	0.484	0	1
Total Expenditure	466,607	1,076.562	2,874.685	−21,143.250	650,661.600
Durable Expenditure	466,607	407.788	2,110.806	−42,081	626,740
Credit Limit	466,607	11,798.880	9,617.044	200	250,000
APR	466,607	0.111	0.057	0.000	0.290
Last Stmt. Balance	466,607	2,361.919	3,885.395	−88,337.870	216,622.700
Last Stmt. Payment	466,607	1,051.232	2,999.824	0.000	524,520.500
Last Stmt. Billed	466,607	127.204	1,584.917	0.000	216,622.700
Utilization	466,607	0.739	0.306	−2.963	12.875

Table 16: Second Analysis, Summary Statistics (Three Lags)

Statistic	N	Mean	St. Dev.	Min	Max
Prop. Repaid (3 months)	427,646	0.683	1,118.235	−526,334.000	271,019.000
Full Repay? (3 months)	427,646	0.375	0.484	0	1
Total Expenditure	427,646	1,080.823	2,905.178	−21,143.250	650,661.600
Durable Expenditure	427,646	409.639	2,143.439	−42,081	626,740
Credit Limit	427,646	11,864.760	9,638.579	200	250,000
APR	427,646	0.110	0.058	0.000	0.290
Last Stmt. Balance	427,646	2,359.715	3,886.547	−88,337.870	216,622.700
Last Stmt. Payment	427,646	1,054.031	2,937.349	0.000	475,000.000
Last Stmt. Billed	427,646	127.938	1,589.664	0.000	216,622.700
Utilization	427,646	0.742	0.304	−2.963	12.875

Table 17: Second Analysis, Summary Statistics (Four Lags)

Statistic	N	Mean	St. Dev.	Min	Max
Prop. Repaid (4 months)	390,500	1.297	819.983	−357,639.000	265,422.000
Full Repay? (4 months)	390,500	0.376	0.484	0	1
Total Expenditure	390,500	1,080.808	2,761.589	−21,143.250	250,080.200
Durable Expenditure	390,500	409.601	1,952.871	−42,081	239,114
Credit Limit	390,500	11,927.920	9,648.585	200	250,000
APR	390,500	0.108	0.058	0.000	0.290
Last Stmt. Balance	390,500	2,359.653	3,897.069	−88,337.870	216,622.700
Last Stmt. Payment	390,500	1,057.577	2,933.676	0.000	475,000.000
Last Stmt. Billed	390,500	128.599	1,608.192	0.000	216,622.700
Utilization	390,500	0.744	0.303	−2.963	12.875

Table 18: Additional Regressions on Shares

	Dependent variable:		
	Proportion of Balance Repaid After 1 Month		
	(1)	(2)	(3)
Durable Share of Total Exp.	-1.874	-1.918	
	(1.783)	(1.782)	
Durable Share of Credit			18.573^{***}
			(4.473)
APR	40.067^{***}	41.851^{***}	34.154^{**}
	(13.538)	(13.348)	(13.617)
Credit Limit	-0.00004		-0.00002
	(0.0001)		(0.0001)
Utilization	8.112^{***}	7.828^{***}	8.531^{***}
	(1.934)	(1.900)	(1.933)
Controls?	Yes	Yes	Yes
Fixed Effects?	Yes	Yes	Yes
Observations	365,086	365,086	365,086
R^2	0.0003	0.0003	0.0003
Adjusted R^2	0.0002	0.0002	0.0002
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 19: Summary Statistics for Additional Share Regressions

Statistic	N	Mean	St. Dev.	Min	Max
Prop Repaid (1 month)	365,086	3.021	325.423	−45,833.330	117,770.000
Full Repay? (1 month)	365,086	0.635	0.482	0	1
Durable Share of Total Exp.	365,086	0.406	0.303	0.0001	1.000
Durable Share of Credit	365,086	0.062	0.123	−0.568	5.002
Total Expenditure	365,086	1,381.401	3,282.497	−3,302.000	650,661.600
Durable Expenditure	365,086	563.983	2,425.924	−3,302	626,740
Credit Line	365,086	12,408.890	10,231.480	200	250,000
APR	365,086	0.112	0.056	0.000	0.290
Last Stmt. Balance	365,086	2,468.353	4,040.862	−88,337.870	216,622.700
Last Stmt. Payment	365,086	1,296.954	3,434.025	0.000	524,520.500
Last Stmt. Billed	365,086	149.475	1,844.392	0.000	216,622.700
Utilization	365,086	0.753	0.286	−2.963	9.031

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