Consumers semi-intertemporally make intertemporal decisions: insights from the payday effects*

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Abstract

Analyzing the transaction data of a retail chain selling storable products and targeting upper-middle-class customers, we find that, besides making larger expenditures on a payday, even on a non-payday, customers make larger expenditures as long as it is their first trip to the retail chain since a payday. Thereafter, the per-trip expenditures decrease over trips within the monthly paycheck cycle until an upward jump on the first trip since the next payday. This pattern suggests that consumers without facing monthly liquidity constraints may self-impose a monthly mental budget. Their daily expenditure decisions follow a rule of thumb trying not to overspend beyond the mental budget. They renew the mental budget on paydays and the salience of paydays also causes overshoots in expenditures.

Keywords: Intertemporal Decision, Mental Accounting, Payday Effect, Projection Bias, Salience, Self-Control, Storable Products

JEL Codes: D12, D15, D91, L81, M31

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1. Introduction

Many traditional economic models assume that consumers rationally maximize long-horizon intertemporal utilities subject to an intertemporal budget constraint. In reality, however, on the one hand, consumers are neither capable of solving such complicated models nor completely naively myopic; on the other hand, they may neither be insusceptible to temptation for higher present consumption nor be fully impatient.

Analyzing the individual-level transaction data of the retail chain of a global cosmetic and personal-care brand targeting upper-middle-class customers, we find that, besides making larger expenditures on a payday, even on a non-payday, customers make larger expenditures as long as it is their first trip to the retail chain since a payday. Thereafter, the per-trip expenditures decrease over trips within the monthly paycheck cycle until an upward jump on the first trip since the next payday.

This empirical pattern suggests that consumers may have month-specific mental accounting. They budget their spending every month targeting a rule-of-thumb saving rate for their incomes in the month even if they do not face a monthly liquidity constraint. A paycheck receipt on a payday causes consumers to renew their monthly mental budgets and hence we observe an upward jump on the first trip since the payday even if the trip occurs on a non-payday. On later trips within the paycheck cycle, because they have already partially used the money in their monthly mental budget on the previous trips within the paycheck cycle, they cognitively turn up their intrinsic device of self-control and reduce expenditures to avoid overspending beyond the target saving rate of the paycheck.

One possible motive to follow this rule of thumb is to trade off between commitment and flexibility (Amador et al., 2006). Without facing an actual monthly liquidity constraint, solving the intertemporal utility maximization problem in a long horizon under an intertemporal budget constraint could generate a better consumption path than self-imposing a monthly mental budget constraint. However, if consumers suffer from temptation for higher present consumption, they need this rule of thumb as an internal device of self-control to counteract the overconsumption

from temptation. As implied by the theoretical model in Amador et al. (2006), an optimal commitment is imposing a minimum level of savings in each period.[1]

We also find that, given that it is the first trip since a payday, the expenditure is dramatically larger if the trip is on the payday than if the trip occurs one day after the payday. This empirical pattern suggests that paycheck receipt on paydays not only causes customers to renew their monthly mental budgets but also generates a salience effect leading to an excess downturn of the internal device of self-control and an overshoot in expenditures on paydays. On the one hand, salience of paydays may be necessary for enabling consumers to use paydays as milestones to decompose a long-horizon intertemporal problem into simpler periodical problems and renew their periodical mental budgets. On the other hand, salience of paydays causes overshoots in expenditures.

This study mainly contributes to four strands of literature. First, it contributes to the literature on self-control. Theoretical studies have illustrated the benefit of using external commitment devices to resolve the self-control problem. The external commitment devices either restrict consumers' choice sets (Amador et al., 2006) or alter the costs or benefits of their actions (Krusell et al., 2010; Hong and Huang, 2024). Many empirical studies have examined the effectiveness of external commitment devices.[2] In contrast, while many theoretical studies have proposed that consumers may use intrinsic commitment devices (e.g., cognitive control, self-signaling, creating memory biases, and strategically avoiding information) to overcome self-control problems,[3] little research has empirically examined intrinsic commitment devices because intrinsic devices are difficult to be observed.

[1] Another possible motive for following this rule of thumb is to avoid solving complicated models while still achieving suboptimal outcomes

[2] External commitment devices examined in the empirical literature include commitment savings products to increase financial responsibility and savings (Thaler and Benartzi, 2004; Ashraf et al., 2006; Beshears et al., 2015), deadlines established to tackle procrastination (Ariely and Wertenbroch, 2002), and commitment contracts to cease smoking (Gine et al., 2010), to reduce alcohol consumption (Schilbach, 2019), to promote exercise (Royer et al. 2015), to increase investments on preventive health (Bai et al., 2021), and to boost work effort (Kaur et al., 2015).

[3] See Benhabib and Bisin (2005) for cognitive control; Bénabou and Tirole (2004, 2011) and Hong et al. (2019) for self-signaling; Bénabou and Tirole (2002) and Chew et al. (2020) for creating memory biases; and Carrillo and Mariotti (2000) for avoiding information strategically.

Our empirical findings suggest that consumers not facing monthly budget constraints may have a monthly mental budget and follow a rule of thumb trying not to overspend within a month in their daily expenditure decisions. They use paydays as milestones to renew their monthly mental budgets. This intrinsic commitment device is analogous to the external device discussed in Amador et al. (2006) that restricts consumers' choice sets of consumption paths. They theoretically proved that the optimal commitment device trading off between maintaining flexibility and counteracting temptation should impose a minimum level of savings in each period.

The second strand of literature we contribute to is the literature on mental accounting. Most existing studies examined whether consumers have separate mental budgets across different product brackets (e.g., Heath and Soll, 1996; Hastings and Shapiro, 2013; Abeler and Marklein, 2017; Ma, 2021). In contrast, we provide evidence that consumers have separate mental budgets across periods and use regular paycheck receipts as the landmarks to separate these periods, instead of solving a complicated long-horizon intertemporal utility maximization problem under one intertemporal budget constraint. Our empirical results based on storable-product purchases indicate that consumers' month-specific mental accounts group expenditures made in a month instead of grouping consumption in a month because a storable product purchased in the current month will be partially consumed in later months.[4] [5] [6]

Our empirical findings also suggest that consumers may decompose a monthly mental budget into bracket-specific mental accounts within a month. We find that the expenditure on the first trip since a payday that occurs on a non-payday is roughly flat instead of monotonically decreasing in how many days the trip occurs after the payday. This result suggests that customers

[4] Rajagopal and Rha (2009) studied the mental accounts of time (not money) when people decide how to allocate time across different activities. In contrast, we study the mental accounts of money and the accounts are separated by time instead of by product brackets.

[5] Shafir and Thaler (2006) provided evidence that purchases to be consumed soon and purchases intended for a distant future consumption belong to separate mental accounts and hence follow different accounting rules. While that study on mental accounting was related to the time dimension, it was essentially a study of bracket-specific mental budgeting (e.g., instantaneous-consumption products vs. storable products) instead of period-specific mental budgeting.

[6] Huffman and Barenstein (2005) also proposed monthly mental budgeting, together with other theories (e.g., present bias), to explain their empirical findings that credit card users' consumption spending declines between paydays and jumps back to its initial level on the next payday. Our study differs from theirs in that, by examining whether consumers make a larger expenditure on the first trip since a payday even if the trip is on a non-payday, we conduct a direct test for monthly mental budgeting and identify it separately from present bias, projection bias, and salience.

allocate expenditures on this brand into a mental account separate from other expenditures. Although daily overall expenditures on other products (especially instantaneous-consumption products) will gradually exhaust a consumer's entire monthly mental budget over time, the unspent money for this specific brand in the consumer's monthly mental budget will not change until she makes an expenditure on this brand. Therefore, we only observe that the trip-level expenditure on this brand decreases over trips within a paycheck cycle (shown in Table 4) but do not observe that, from one day after a payday, the expenditure on the first trip of a paycheck cycle is decreasing in how many days after the payday.

The third strand of literature that our study contributes to is the literature on the payday effects. Most empirical studies examined only instantaneous-consumption brackets and found that consumers make larger expenditures only on paydays.[7] In contrast, we study a retail chain brand that sells storable products and find that, besides making larger expenditures on a payday, even on a non-payday, customers make larger expenditures as long as it is their first trip to the retail chain since a payday. Thereafter, the per-trip expenditures decrease over trips within the paycheck cycle until an upward jump on the first trip since the next payday. We document that paycheck receipt on paydays triggers two reactions: monthly mental-budget renewing and salience.

One possible reason why the existing studies found that, after the spike on a payday, the daily instantaneous consumption is flat afterward instead of decreasing over days is that most instantaneous-consumption products are essential products. In contrast, we examine a brand selling discretionary storable products. While the daily quantity usage after purchasing a product of this brand is quite stable, a customer's dollar-value consumption rate of the entire brand can vary substantially by purchasing more varieties and higher-quality varieties.

One reason why existing empirical research on the payday effects avoided examining storable products is that the results could be driven by stockpiling. Given that the daily usage of many storable products is fixed (e.g., consumers do not obtain more utility by spraying more

[7] Although some studies documented that the larger expenditures on paydays could be driven by monthly liquidity constraints (Kaplan et al., 2014; Kaplan and Violante, 2014a and 2014b; Carvalho et al., 2014), other studies found that consumers who do not face liquidity constraints also make larger expenditures on paydays (Stephens, 2003 & 2006; Olafsson and Pagel, 2018; Gelman, 2022). Additional studies have provided behavioral reasons for the larger expenditures on paydays, including present bias (Shapiro, 2005; Mastrobuoni and Weinberg, 2009; Kőszegi and Rabin, 2009; Gelman, 2022), projection bias (Dykstra, 2024), and changes in self-control (Dobkin and Puller, 2007; Riddell and Riddell, 2006).

fragrance during a day), after a larger expenditure on a payday, consumers may wait a longer period until the next store visit. Consequently, the payday effect may not necessarily generate any real impact that can make sellers earn more money.

However, for this cosmetic and personal-care brand, there are multiple channels through which the payday effect can generate such real impact. First, for many categories sold by this brand (such as fragrance and makeup), customers usually purchase and start to use a new item before the old one is used up. After purchasing the new item, either the frequency of the old item usage substantially drops, or the customers leave the old item untouched for a long time or even forever (similar to clothing). We find that on payday, consumers purchase more varieties, are more likely to purchase new varieties that they have never purchased before, and are more likely to make mistakes in terms of buying a new variety that they never purchase again. Second, we find that consumers are more likely to upgrade to a high-end variety within a product category on paydays than on non-paydays.

Compared to bank or credit card transaction data (widely used in the payday-effect literature), which only record the merchant name for each purchase, one advantage of our retail chain transaction data is that detailed information on each product purchased is recorded. Therefore, we can examine whether the payday effect leads to more variety seeking, new-product trying, mistake making, and product upgrading and hence rule out the possibility that the payday effect on storable-product purchases is merely driven by stockpiling.

The fourth strand of literature we contribute to is the broad economic literature involving intertemporal decision making. Traditional intertemporal utility maximization models usually assume that consumers are fully rational and capable of solving complicated dynamic programming problems, such as the intertemporal consumption-saving decision models in the macroeconomic literature and the dynamic discrete choice models of storable product purchases in the industrial organization literature.[8] However, on the one hand, consumers are neither sufficiently sophisticated to solve such complicated models nor completely naively myopic; on the

[8] For example, the buffer-stock saving models (Carroll, 1997; Deaton, 1991; Zeldes, 1989) and the stochastic dynamic general equilibrium (DSGE) models in the macroeconomics literature, the consumption-based asset pricing models (e.g., Campbell, 2003) in the finance literature, and the dynamic discrete choice model for storable product purchases in the industrial organization and marketing literature (Hendel and Nevo, 2006a, 2006b, 2013).

other hand, they may neither be insusceptible to temptation for higher present consumption nor be fully impatient.

Based on our empirical findings, we propose a simple model according to which consumers semi-intertemporally make intertemporal decisions. Instead of determining daily expenditures by solving a long-horizon intertemporal utility maximization problem at a daily granularity, consumers decompose the problem into three steps. First, they roughly determine monthly aggregate expenditures by solving a long-horizon problem at a monthly granularity. Second, at the beginning of a month, they divide the predetermined aggregate expenditures for the month into different bracket-specific mental accounts. Third, on a trip to a store that sells products belonging to a certain bracket-specific mental account, they make trip-level expenditure decisions and follow a rule of thumb by trying not to overspend beyond the predetermined monthly bracket-specific mental budget. The expenditures on storable products are completely allocated to the mental budget of the current month (paycheck cycle), even if the products will be partially consumed in the following months. This self-imposed restriction on the choice set of consumption paths provides two benefits: first, consumers can avoid solving complicated models while still achieving suboptimal outcomes; second, they can trade off between maintaining flexibility and counteracting temptation.

The remainder of this paper is organized as follows. Section 2 describes the background and the data. Section 3 provides prerequisite analyses: we document that consumers make more expenditures on paydays unconditionally, which is driven by making more expenditures on paydays conditional on shopping instead of a greater likelihood to shop on paydays; and we disconfirm the liquidity effect and stockpiling. Section 4 presents the main analyses: we first examine the difference in expenditures between the first trip since a payday and later trips within the paycheck cycle, providing evidence for monthly mental-budget renewals; then, we examine the difference between the first trips within a paycheck cycle that occurs on the payday and that occur on non-paydays, providing evidence for salience of paydays that generates overshoots on paydays. In Section 5, we build a stylized theoretical model to formally explain our empirical findings. Then, we conclude in Section 6.

2. Background and data

2.1. The stores

The chain stores that we examine in this study are a retail chain of a global cosmetic and personal-care brand targeting upper-middle-class customers. The brand operates in more than 70 countries, with its headquarters located in England. It sells products in eight categories: men and women fragrance, home fragrance, makeup, facial skin care, hair care, body care, bath and shower, and accessories. The brand positions itself as an internationally green company, aiming at improving the quality of people's lives by producing environmentally friendly and natural products. The brand targets upper-middle-class consumers, who are unlikely to face monthly liquidity constraints.

Our data cover all the individual-level transaction records from 2011 to 2015 of this retail chain within a Southeast-Asian country. The retail chain has approximately 300 stores and more than 600,000 member customers within this country. For each transaction record, the data have detailed information about the member ID, what products are purchased, the listed prices of the products and the discount rates, the store location, the time of purchase, the payment method (cash vs. credit card), etc. For each product sold, the data have detailed information on the product characteristics, including the category, subcategory, and stock-keeping unit (SKU) of the product and the version, volume, and ingredients.

The data in this study have a unique combination of five merits compared to other data used in the literature on the payday effect. The combination of these merits makes our analyses feasible. First, the retail chain does not have special promotion or sales targeting at paydays: we confirm this with the CEO of this retail chain in this Southeast-Asian country; in addition, given that we can observe the daily prices in the data, we run a regression of the daily discount rate averaged across products and do not find that the discount rates are higher on paydays than on non-paydays (see Table A.1 in Appendix A). Thus, we can rule out the possibility that the large expenditure on paydays is driven by lower prices. We also control for daily prices in our regressions. Many existing studies use bank account or credit card transaction data. One advantage of those data is

that purchases in a wide range of brackets can be observed. One disadvantage of them is that sellers' daily prices are difficult to be observed and hence cannot be controlled for.[9]

Second, the average purchasing cycle is approximately 90 days (the standard deviation is 114 days), which is appropriate for our analyses on the effect of the monthly reoccurring paydays on the purchases of storable products. The purchasing cycle is neither as long as that of cars nor as short as that of groceries.

Third, the data span 5 years, which sufficiently allows us to observe a longitudinal purchase history for a member customer given the 90-day average purchasing cycle.

Fourth, the retail chain belongs to a global cosmetic and personal-care brand. In general, products in the cosmetic and personal-care bracket are discretionary products instead of essential products. In addition, most products sold by this specific retail chain brand are high-quality varieties. Correspondingly, member customers of this brand are people who pursue a high-quality life. Thus, they should belong to at least the upper-middle class and should not face monthly liquidity constraints.[10]

Fifth, member customers of this brand have a large degree of brand loyalty; thus, they do not switch to other brands quite often, which allows us to observe a sufficient longitudinal purchase history for a customer and mitigate one disadvantage of our data that the data focus only on one brand. In the cosmetic and personal-care markets, brands even within the high-end class are substantially differentiated horizontally. Therefore, high brand loyalty is common among customers. Moreover, the brand examined in our study has several major worldwide competitors,

[9] Another type of data used in the literature on the payday effect is diary or survey data. One disadvantage of those data is that they usually record respondents' weekly level expenditures instead of their daily level expenditures. A second disadvantage is that they are less accurate and even biased compared to administrative data (see the discussions in Olafsson and Pagel (2018)).

[10] While the consumers we examine in this study are high-income consumers, the results of the payday effect on storable product purchases have general implications because every consumer needs to purchase storable products regardless of income. The reason for focusing on this small group of consumers is that by doing so, we can rule out confounding explanations for the payday effect such as the liquidity constraint story.

and many of them either do not operate or have a much smaller presence in this Southeast-Asian country.[11]

Table 1 reports the descriptive statistics of important variables, including variables based on unconditional customer-day-level observations and those based on customer-trip-level observations conditional on visiting the retail chain.

Table 2 reports the descriptive statistics separately for each combination of whether the customer is a cash or a credit card user and whether the trip occurs on a payday or on a non-payday. On average, on a trip, credit card users have a larger expenditure, a larger basket size, a higher likelihood of purchasing new products, and a higher probability of making mistakes than cash users, regardless of whether the trip occurs on a payday or on a non-payday. For credit card users, on average, a payday trip incurs a larger expenditure, a larger basket size, a higher likelihood of purchasing new products, and a higher probability of making mistakes than a non-payday trip. In contrast, for cash users, the difference between payday and non-payday trips is smaller.

2.2. The country

Our data cover the global brand's retail chain within a Southeast-Asian country. The country has a prevalent payday: the 26th day of each month. The country has a population of more than 200 million. It was classified as a lower-middle-income country by the World Bank in 2015, with the average monthly earnings being US$ 145.26. The country has a relatively high-level of income inequality, with a GINI coefficient equal to 40.4. Given that the brand we examine in this study is considered a global brand and that the average pe-trip expenditure is US$ 22.84, the member customers of this brand within this lower-middle-income Southeast-Asian country belong to at

[11] We need a certain degree of brand loyalty only for observing multiple trips to the retail chain within our five-year sample period. Switching to a substitute brand occasionally would not generate biases to our estimates on the payday effect if the switching decision is orthogonal to whether it is on a payday or a non-payday. Our estimate on the payday effect on the expenditure conditional on shopping at this brand would be smaller than the entire payday effect if consumers are more likely to upgrade from a low-class substitute brand to this high-class brand on paydays. However, we do not find that consumers are more likely to shop at this brand on paydays (see Section 3.4).

least the upper-middle class in this country and hence should not face monthly liquidity constraints (hand-to-mouth).

3. Prerequisite analyses

In this section, we document that consumers make more expenditures on paydays, which is driven by making more expenditures on paydays conditional on shopping instead of a greater likelihood to shop on paydays. In addition, we rule out the possibility that the results are driven by the liquidity effect. Moreover, we document a rich set of real effects of paydays in our context (including variety seeking, new-product trying, product upgrading, and purchase mistakes) to rule out the possibility that the observed expenditure pattern is simply a result of stockpiling. These analyses serve as prerequisites for our formal analyses on monthly mental-budget renewing and salience, which will be presented in Section 4.

3.1. A regression discontinuity design

We first conduct the following regressions at the customer-calendar-day level with a regression discontinuity (RD) design:

$$y_{it} = \gamma_0 + \gamma_1 I(\tau_t \geq 0) + f(\tau_t) + \beta X_{it} + \varepsilon_{it} \quad (3.1)$$

The dependent variable y_{it} is the expenditure made by customer i at the retail chain on day t. If the customer does not visit the retail chain on day t, then $y_{it} = 0$. The calendar-day-level observations for a customer include every day from one day after the customer's first trip in the sample period to the day of her last trip.

We define an RD window as $[-12, 12]$, i.e., from 12 days before a payday to 12 days after the payday, which spans two adjacent payday cycles. τ_t denotes the position of day t within the RD window relative to the payday. For example, $\tau_t = 0$ denotes the payday; $\tau_t = -1$ denotes one day prior to the payday; $\tau_t = 1$ denotes one day after the payday.[12] The 0-1 indicator $I(\tau_t \geq 0) =$

[12] We choose $[-12, 12]$ (a 25-day-length window) to be the RD window because, first, we want the window to be able to cover a full month as much as possible, and second, we need to guarantee that there is no overlap between any two adjacent windows. For example, given that a nonleap February has only 28 days, if we use $[-14, 14]$ to be the RD window, the 14th after the payday in February is also the 14th day prior to the payday in March; then, τ_t will face the dilemma of whether it should be set -14 or 14. In addition, if

1 if day t within the RD window is either the payday or after the payday; $I(\tau_t \geq 0) = 0$ if day t is before the payday. $f(\tau_t)$ is a flexible polynomial of τ_t, allowing the coefficients of each term in the polynomial to be different between the domain where $\tau_t < 0$ and the domain where $\tau_t \geq 0$; in addition, we require that $f(0)$=0. One example for $f(\tau_t)$ is as follows:

$$f(\tau_t) = \begin{cases} a_1\tau_t + b_1{\tau_t}^2 + c_1{\tau_t}^3 & if\ \tau_t < 0 \\ a_2\tau_t + b_2{\tau_t}^2 + c_2{\tau_t}^3 & if\ \tau_t \geq 0 \end{cases}$$

$f(\tau_t)$ is to capture the trend of the forcing variable τ_t (the relative distance to the payday) in affecting customers' expenditure patterns over time at the retail chain of this cosmetic and personal-care brand.

The parameter of main interest is γ_1 before the indicator $I(\tau_t \geq 0)$. γ_1 captures how much customers' expenditure patterns are shifted upward by paycheck receipt on a payday.

We include a rich set of control variables in X_{it}. First, we include customer fixed effects to control for the heterogeneity of individual demand. Second, we include store fixed effects to control for the heterogeneity across locations. There are approximately 300 stores of the retail chain in this Southeast-Asian country, and all of them are covered by our data. Third, we include year fixed effects to control for any possible time trends in the retail chain's business growth and market expansion, consumers' awareness and learning, and macroeconomic conditions in the country. Fourth, month-of-year fixed effects are included to control for seasonality. Day-of-week fixed effects are included to control for the difference between business days and weekends and the difference across business days. We also include the public-holiday indicator. Fifth, to rule out the possibility that the larger expenditures on paydays are due to lower prices, we include the daily average discount rate.[13]

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the 26th day of a month is Saturday or Sunday, the payday is on Friday. However, our empirical results are robust to changes in the definition of RD windows.

[13] The price of a product in a day is the same across stores in this country. We employ multiple measures of the daily average discount rate. One measure averages the discount rates of all products sold in a day weighted by the sales volume of each product. A second measure averages the discount rates of all products with equal weight. A third measure averages the discount rates of products within a customer's basket weighted by the customer's purchase volume of each product. The empirical results are robust to these measures. The empirical results are also robust to controlling for quadratic and cubic terms of the discount rate.

3.2. Higher unconditional expenditures on paydays

Table 3 reports the baseline regression results. The key parameter γ_1 is significantly positive across different specifications for $f(\tau_t)$. This result indicates that paychecks received on a payday can elevate customers' expenditures on the brand. The parameter γ_1 is small in magnitude because the regressions in Table 3 are at the customer-day level and most of y_{it} for a customer i are equal to zero. On average, a customer visits the retail chain approximately every 90 days. Given that the mean of the dependent variable y_{it} is 0.263, based on γ_1 in column 3 of Table 3 (0.0128), the payday effect can shift up customers' expenditure propensity by 4.7% (=0.0128/0.263).[14]

Alternative to Table 3, we run a customer-calendar-day-level regression of the expenditure conditional on store visit with γ_0, γ_1, and the polynomial $f(\tau_t)$ in equation (3.1) replaced with a set of fixed effects for each possible value of τ_t:

$$y_{it} = \sum_{j=-12}^{12} T_j \cdot I(\tau_t = j) + \beta X_{it} + \varepsilon_{it} \qquad (3.2)$$

where T_{-1} is normalized to zero. The estimates of these fixed effects ($T_j s$) are displayed in the first diagram of Figure 1. A sudden spike is observed at $\tau_t = 0$ (paydays).

3.3. Disconfirming the liquidity effect

One possible explanation for the larger expenditures on paydays is that paychecks received on a payday can provide a substantial amount of liquidity to financially constrained consumers. However, our results are unlikely to be driven by this effect.

First, the retail chain examined in this study belongs to a global cosmetic and personal-care brand. In general, products in the cosmetic and personal-care bracket either do not fall into the necessity product group (such as fragrance and makeup) or fall into that group but have many brands with a wide range of qualities. Most products in this group sold by the retail chain in our

[14] The coefficients of control variables are consistent with intuition. The level of discounts tends to increase expenditures.

study are high-quality varieties. The brand positions itself as an internationally green company, aiming at improving the quality of people's lives by producing environmentally friendly and natural products. The member customers of this brand are people who pursue a high-quality life. Thus, they should belong to at least the upper-middle class and should not face monthly liquidity constraints.

Second, to rule out the possibility that the results are driven by more occasional purchases by low-income consumers on paydays, we focus on transactions by member customers and exclude transactions by nonmember customers. To become a member, a customer needs to register at the stores and provide her demographic, contact, and address information. 67.5% of the transactions were made by members. Moreover, within members, we focus on those frequent purchasers (members with at least five transactions in the sample period).[15]

Third, we divide cities in this country into high-average-income and low-average-income cities based on the city-average income. The difference in the magnitude of the payday effect between the two groups of cities is neither statistically nor economically significant (See Table A.2 in Appendix A). This result further confirms that customers of this brand in this country are high-income residents in each city, regardless of the average income of the city.

Fourth, if the larger expenditure on paydays were driven by the liquidity effect, we should not have observed the immediate drop on the day after payday in the first diagram of Figure 1. The reason is that consumers with liquidity constraints should not immediately expend all of the paycheck and exhaust the new liquidity on a payday; they should still have much liquidity on the day after a payday.

Fifth, we divide the customers in the sample into two groups: cash users and credit card users. We rerun the regression of equation (3.2), allowing T_js to be different across the two groups. If the larger expenditures on paydays are driven by the liquidity effect, the jump in expenditures on paydays should be larger for cash users than for credit card users. The reason is that credit card users should be even less likely to face liquidity constraints than cash users: first, consumers do not need to repay immediately after purchasing with credit cards; second, banks only approve credit card applications by customers with sufficient financial net worth (credit worthiness).

[15] The results are robust to changes in the threshold.

However, as shown in the last two diagrams in Figure 1, the jump is larger for credit card users than for cash users both in dollar values (0.011 vs. 0.003) and in percentages ($\frac{0.011}{0.286} = 3.9\%$ vs. $\frac{0.003}{0.217} = 1.4\%$).[16] [17] [18]

3.4. More likely to shop or spend more conditional on shopping?

Another possible reason for the significantly positive γ_1 in Table 3 is that consumers may simply be more likely to shop on paydays than on other days. They make expenditures on this retail chain together with other expenditures during their payday shopping trips.

We rerun the customer-calendar-day-level regressions of equation (3.1) but the dependent variable y_{it} is an 0-1 indicator of whether customer i makes expenditure on this brand on day t. As shown in Table A.3 in Appendix A, γ_1 is insignificant, at least suggesting that consumers are not more likely to shop on paydays at this retail chain. The insignificant γ_1 could be caused by either of the following two reasons. First, consumers are not more likely to shop on paydays at all because shopping costs not only money but also time and the available time does not necessarily increase on paydays. In these regressions, the indicators of weekends and public holidays in which consumers have more free time are significantly positive but the indicator of paydays is not

[16] One possible explanation for why cash users do not make larger expenditures on paydays is that consumers may feel more attached to their money when paying with cash and hence be less subjective to behavioral biases associated with the payday effect. Agarwal et al. (2024) employed the sudden 2016 Indian Demonetization for identification and found that consumers felt less attached to their money with digital transactions than with cash transactions (subdued endowment effects).

[17] A second possible explanation is that given that credit card transactions can earn cashback or mileages (Egan et al., 2024), the effective price of an item faced by credit card users is lower than that faced by cash users. Thus, credit card users are more sensitive to the payday effect.

[18] A third possible explanation is that many cash users may not work as employees who receive paychecks on the nationally prevailing paydays. One example is the small vendors or merchants who receive payments from cash transactions every day. They may prefer cash to credit cards for their own purchases because, first, they have plenty of cash on hand, and second, they get used to cash transactions. During the sample period, the new mobile payment technology (Quick Response (QR) code) had not been introduced into this lower-middle-income Southeast Asian country. Compared with credit cards, QR-code payment is more straightforward, efficient, secure, and less costly, and hence is a better substitution for cash. Agarwal et al. (2022) provided evidence that the introduction of the QR-code payment technology into Singapore in 2017 substantially benefited small vendors. Another example is the farmers who receive payments in harvest seasons instead of on the nationally prevailing payday in each month, and farmers are likely to prefer cash to credit cards for their own purchases.

significant. Second, consumers may be more likely to shop on paydays, but it does not make them more likely to visit a store of this retail chain and purchase its products.[19]

Next, we drop all the customer-calendar-day-level observations with zero purchases on the day and run the customer-trip-level regressions of equation (3.2) conditional on the customer making expenditures on this brand on the day. The dependent variable is the customer's expenditure on the trip conditional on that she visits the retail chain and makes purchases.[20]

The estimates of fixed effects for each τ_t are displayed in Figure 2. The fixed effect for $\tau_t = -1$ is normalized to zero. A sudden spike is observed at $\tau_t = 0$ (paydays). Therefore, the positive payday effect on the unconditional expenditures (as shown in Figure 1 or Table 3) is driven by more expenditures on paydays conditional on visiting the retail chain instead of a greater likelihood of visiting on paydays.

In Figure 2, the average jump at $\tau_t = 0$ from the level at $\tau_t = -1$ (normalized to a zero level) is \$0.758, \$0.954, and \$0.400 for all members, credit card users, and cash users, respectively. Given that the average per-trip expenditure is \$22.838, \$25.969, and \$17.447 for all members, credit card users, and cash users, respectively, the payday effect can shift up customers' expenditures conditional on store visit by 3.3% (=0.758/22.838), 3.7% (=0.954/25.969), and 2.3% (=0.400 /17.447).[21]

Moreover, we even tend to underestimate the magnitude of the payday effect because some customers may not work as employees who receive paychecks on the nationally prevailing payday of each month. For example, small business owners may receive payments every day or in certain seasons instead of on the payday of each month.

3.5. Real effects of paydays

[19] The second reason is more likely. Olafsson and Pagel (2018) found that consumers are 11% more likely to go on any shopping trip on paydays.
[20] If a customer makes multiple trips to the retail chain in a day, we will aggregate them as one trip. These cases are very occasional in the data.
[21] We also run the regressions in Tables 3 and Figures 1 and 2 with the sample only including credit card users. The results are similar and are available upon request.

Many products sold by this brand are storable goods with a stable consumption rate. For example, it is unlikely that a customer will increase her daily consumption rate of fragrance following a large purchase on a payday, because spraying too much fragrance at one time even deceases the utility. Correspondingly, a possible concern is that, after a larger expenditure on a payday, consumers may wait a longer period for the next store visit. Consequently, the payday effect may not generate any real effects.[22]

However, for categories such as fragrance and makeup, consumers do not purchase a new item only after finishing the old item. Because an item in these categories usually takes years to finish, customers usually purchase new varieties before the old varieties are used up. After the purchase of new varieties, either the frequency of old varieties substantially drops, or the customers leave the old varieties untouched for a long time or even forever. This consumption pattern is very similar to that of clothing. Therefore, the payday effect does cause customers to spend more money on this brand.

To conduct formal tests for the real effect of paydays on the expenditures at the retail chain, we run the trip-level regressions of equation (3.2) with the dependent variable being the number of varieties purchased on the trip (basket size) and the indicator of whether the customer purchases a variety for the first time, respectively. As shown in panels A and B in Figure 3, conditional on visiting, on average, the payday effect makes a credit card user expand her basket by approximately 0.1 more varieties on paydays; moreover, the payday effect elevates her probability of purchasing a new variety by approximately 0.63% on paydays.

Further, we run a customer-trip-product-level regression of equation (3.2) with the dependent variable y_{it} as whether the product purchased by customer i on day t is a high-end variety within a product category. High-end varieties in a product category are defined as varieties with prices above the average price of the category. As shown in panel C of Figure 3, customers are more likely to upgrade to a high-end variety on paydays.

[22] Nevertheless, previous studies have provided empirical evidence that, on many storable products, a larger expenditure caused by sales promotions can increase the following-up consumption rates, including Ailawadi and Neslin (1998) on ketchup, Hendel and Nevo (2006b) on detergent and soft drinks, and Bell and Boztug (2007) on bacon, butter, crackers ice cream, margarine, soft drinks, sugar, detergent, and paper towels.

After confirming the multiple channels of the real impacts of the payday effect that can cause customers to spend more money on this brand, we further check whether the payday effect increases a customer's dollar-value daily consumption rate of products in this brand at home. We construct a proxy for this daily at-home consumption rate as the spending incurred on a trip divided by the number of days from the current trip to the next trip. Then, we run a customer-trip-level regression of equation (3.2) with this proxy as the dependent variable. As shown in panel D of Figure 3, the payday effect can shift up a credit card user's customer's dollar-value daily consumption of products in this brand by US$ 0.0212, a nontrivial magnitude relative to the average daily consumption rate (US$ 0.263).

In addition, we examine whether customers are more likely to make mistakes on paydays. We run a customer-trip-level regression of equation (3.2) with the dependent variable defined as whether the customer on the trip purchased a new variety that she never purchased again. As shown in Figure 4, conditional on visiting, on average, the payday effect increases the probability of purchasing a new variety that will never be purchased again by approximately 1.08%.[23]

4. Main analyses: monthly mental accounting and salience

4.1. Monthly mental accounting

Consumers may not be capable of solving a long-horizon intertemporal utility maximization problem under an intertemporal budget constraint due to limited rationality. When making

[23] In the regression of whether the customer purchased a new variety that she never purchased again within the sample period, we only include customers with at least n visits in the sample period and delete their last m visits ($m < n$). Without doing so, for example, on a customer's last visit in the sample period, we will count all the first-time varieties in her basket as her mistakes but she may in fact purchase the same variety on trips beyond the sample period. Even though we exclude a customer's last m trips in the sample period, there is still a possibility that she purchases the same variety after more than m trips. However, at least, having not purchased the variety again during the following m visits could indicate that the customer is not quite satisfied with the variety. Admittedly, this method cannot completely eliminate the measurement errors in the dependent variable. However, the estimated payday effect on this dependent variable is substantially larger than that on new-variety purchases (1.08%>0.63%), suggesting that the estimate should not be completely driven by the measurement errors. Moreover, in Section 4, we find that while monthly mental-budget renewals and salience of paydays both can elevate the measure for new-product trying, only the latter can elevate the measure for mistakes. The empirical results are robust to changes in m and n. For Figure 4, m =3 and n =7.

purchase decisions, even without facing a temporal liquidity constraint, consumers may still self-impose a monthly mental budget constraint to avoid overspending. The mental budget is renewed every month by paycheck receipt.

To test the existence of the mental budget that is renewed monthly by paycheck receipt, we run the following regressions based on customer-trip-level observations:

$$y_{it} = \psi I(\text{trip on payday}) + \sum_{k=1}^{5} \varphi_k I(k\text{th trip in the cycle given no trip on payday}) + \tilde{f}(\tau_t) + \beta X_{it} + \varepsilon_{it} \quad (7.1)$$

In equation (7.1), $I(trip\ on\ payday)$ is an indicator of whether the trip on day t is on a payday. Defining a paycheck cycle as from a payday to the day before the next payday, $I(kth\ trip\ in\ the\ cycle\ given\ no\ trip\ on\ payday) = 1$ if the trip is the kth trip within the paycheck cycle and there was no trip on the payday; it equals zero otherwise.[24] If the first trip of the paycheck cycle occurs on the payday, trips after the first trip are omitted. $\tilde{f}(\tau_t)$ is a set of fixed effects for each possible value of τ_t. The dependent variable is the expenditure made on the trip.

As shown in column 1 of Table 4, for credit card users, from φ_1 to φ_5, the estimates gradually decrease. The pattern indicates that as long as it is the first trip of the paycheck cycle, it will involve a larger purchase even if the trip is not on the payday. The reason is that the purchase decision is made under a new mental budget constraint renewed by the paycheck. [25] We observe a similar pattern for cash users.

The gradual decrease from φ_1 to φ_5 also suggests that the per-trip expenditure decreases over trips within a paycheck cycle. This empirical pattern indicates that even though they do not face a monthly liquidity constraint, consumers may still budget their spending every month targeting a rule-of-thumb saving rate for their incomes in the month instead of solving the complicated lifetime utility maximization problem under an intertemporal budget constraint. For each month (or paycheck cycle), they can have a mental cushion that consists of the remaining money from the paycheck of the cycle that can be spent before breaking the target saving rate. On

[24] The case $k = 5$ includes the fifth trip and thereafter trips within a paycheck cycle.
[25] The result of main interest is the decreasing trend from φ_1 to φ_5. The signs of φ_1 through φ_5 do not have much interpretation. The reason is that the omitted trips include trips after the first trip of a paycheck cycle if the first trip of the paycheck cycle occurs on the payday.

later trips within a paycheck cycle, the cushion becomes thinner, and hence consumers cognitively turn up the intrinsic device of self-control and make smaller expenditures accordingly.

One concern is that the decreasing trend in φ_1 through φ_5 may be driven by the possibility that the average per-trip expenditure in a month with four trips may be smaller than that in a month with only one or two trips. Therefore, in column 2 of Table 4, we include only the trips in a customer-paycheck-cycle cell with two trips in the regression sample; the results indicate that the expenditure on the first trip within a paycheck cycle is substantially larger than that on the second trip. Similarly, in column 3 of Table 4, we include only the trips in a customer-paycheck-cycle cell with three trips; the results indicate that the expenditure on the first trip is larger than that on the second trip, which is larger than that on the third trip.[26]

4.2. Salience and projection bias

We also find that the larger expenditures on paydays cannot be fully explained by the monthly renewing of mental budget constraints. We run the following regressions based on the customer-trip-level observations:

$$y_{it} = \omega I(\text{1st trip in the cycle}) + \sum_{l=0}^{26} \lambda_l I(\text{1st trip in the cycle } \& \ days_after_payday = l) + \gamma_0 + \beta X_{it} + \varepsilon_{it} \qquad (7.2)$$

In equation (7.2), $I(\text{1st trip in the cycle})$ is an indicator of whether the trip on day t is customer i's first trip of the paycheck cycle. $I(\text{1st trip in the cycle } \& \ \tau_t = l) = 1$ if the trip is customer i's first trip of the paycheck cycle that occurs on the l th day after the payday; $I(\text{1st trip in the cycle } \& \ \tau_t = l) = 0$ otherwise. We drop the trips that occur beyond 27 days after the payday within a paycheck cycle because some paycheck cycles are shorter than 28 days.[27] Trips that are not the first trip in a paycheck cycle are omitted. ω captures the difference between the first trip of a paycheck cycle and the trips that are not the first trip in a paycheck cycle. λ_l ($0 \leq$

[26] The frequencies of customer-paycheck-cycle cells with different numbers of trips are reported in Table A.4 in Appendix A.
[27] The empirical results are similar if we keep these trips.

$l \leq 26$) captures the difference between the first trip of a paycheck cycle that occurs on the lth day (within five days) after the payday and the first trip of a paycheck cycle that occurs on the 27th day after the payday. The dependent variable is the expenditure made on the trip.

As shown in Figure 5, for credit card users, λ_l drops sharply from the payday ($l = 0$) to one day after the payday ($l = 1$) and is roughly flat thereafter. Conditional on the first trip of a paycheck cycle, the expenditure is dramatically larger if the trip is on the payday than if the trip occurs one day after the payday. With ω controlling for the mental-budget-renewing effect, one possible explanation for the sharp decrease from λ_0 to λ_1 is that the paycheck receipt event on paydays not only causes customers to renew their monthly mental budgets but also generates a salience effect leading to overshoots in expenditures on paydays.[28]

The salience of paydays can be associated with people's psychological status on paydays that is different from the status on ordinary days.[29] Consumers may treat a payday as a milestone or a landmark for self-reward after hard working for one month, and thereby they obtain higher transaction utility on top of acquisition utility if they make a purchase on a payday (Steed, 2018).[30]

[28] The idea of salience appeared in the psychology literature earlier than in the economics literature. As described by psychologists Taylor and Thompson (1982), "salience refers to the phenomenon that when one's attention is differentially directed to one portion on the environment rather than to others, the information contained in that portion will receive disproportionate weighing in subsequent judgments." Later, salience was formalized into economic models by Bordalo et al. (2012 and 2013) and Koszegi and Szeidl (2013). Empirical studies on salience include Chetty et al. (2009), Finkelstein (2009), Hastings and Shapiro (2013), Busse et al. (2015), Chang et al. (2018), and Ma (2021)

[29] The unique psychological status on paydays and its consequences have been well documented in the psychology, medical science, behavioral economics, and marketing literature. To name a few, Goodyear et al. (2020) found that the anxiety levels are different before and after paydays even for people with substantial liquid assets. Multiple studies found that paycheck arrival can reduce people's levels of self-control and hence increase liquor consumption (Osborn, 1898; Stephens, 2006) and drug abuse (Dobkin and Puller, 2007; Riddell and Riddell, 2006). Evans and Moore (2011) documented an increase in short-run mortality on paydays for many different causes of death (e.g., external causes, heart disease, heart attack, stroke), which is evident for both genders and for all age groups, races, marital status groups, and education groups. Mani et al. (2013) found that payday receipts can improve people's cognitive performance. Dykstra (2024) found that people have different levels of projection biases or projective misperceptions before and after paydays. Mishra et al. (2010) found that people are more likely to engage in promotion-focused activities (e.g., fitness programs emphasizing physical activity to improve healthfulness) immediately on paydays and are more likely to engage in prevention-focused activities (e.g., fitness programs focusing on reducing the intake of unhealthful foods) shortly before paydays.

[30] According to Thaler (1985), acquisition utility depends on the value of the product, whereas transaction utility depends solely on the perceived merits of the transaction. Consumers consider both acquisition utility and transaction utility when they make purchasing decisions.

[31] In addition, consumers may treat a paycheck as "a license to spend" (Addoum et al., 2019) and hence suffer less prominently from paying money out of pocket.

Dai et al. (2014) have provided evidence that temporal landmarks such as a birthday and the outset of a new year or semester induce people to relegate past imperfections to a previous period, promote bigger-picture thinking, and thus motivate aspirational behaviors (e.g., dieting, exercising, dating, goal pursuit). In our context, the evidence that customers purchase more varieties and are more likely to attempt new products on paydays (panels A and B of Figure 3) is consistent with the story of bigger-picture thinking on paydays.[32]

Salience of paydays may also trigger projection bias, which can also contribute to the overshoots in expenditures on paydays.[33] Direct evidence for projection bias is that, as shown in Figure 4, customers are more likely to purchase a new variety that they never purchase again. Never purchasing again could indicate that consumers decided ex post that the previous decision was a mistake.[34]

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[31] Consumers' self-reward or self-gift behavior has been examined very early in the behavioral marketing literature (e.g., Mick and Demoss, 1990). Recently, neuroscience studies provided evidence that self-reward can increase the release of dopamine (a key substrate of intrinsic motivation) and hence help people accomplish long-term goals by encouraging small achievements (see Di Domenico and Ryan, 2017). Recent neuroeconomic research has established the effect of dopamine on people's economic decision making (e.g., Set et al., 2014). In the traditional behavioral economic literature, Asheim (1997) incorporated self-reward into a theoretical model with time-inconsistent preferences.

[32] Another possible explanation for the novelty-seeking behavior on payday is that the payday effect makes consumers less risk-averse, given that purchasing a new variety may incur a risk that the new variety does not match the purchaser's tastes. However, the change in risk attitude is unlikely to be the reason for novelty seeking in our setting. First, many products sold at this retail chain (e.g., fragrance and makeup) can be sampled before purchase; thus, consumers can decide whether a new variety fits their preferences. Second, Carvalho et al. (2014) have documented that there is no before-after difference in risk-taking around paydays.

[33] Projection bias refers to the phenomenon that people tend to mistakenly predict their future tastes by exaggerating the degree to which their future tastes will resemble their current tastes. The idea of projection bias appeared in the psychology literature earlier than in the economics literature (see Loewenstein and Schkade (1999) for a psychology literature review). Later, projection bias was formalized into economic models by Loewenstein et al. (2003). Empirical studies on projection bias include Colin et al. (2007), Busse et al. (2015), Chang et al. (2018), and Pan et al. (2022).

[34] Busse et al. (2015) stated that tests on making mistakes in purchasing decisions can provide direct evidence for projection bias. Colin et al. (2007) tested projection bias based on returning of weather-related clothing. We do not use returning as a proxy for mistakes because, unlike clothing, cosmetic and personal-care products cannot be returned after being opened. In our data, only 0.07% of purchased items were returned.

4.3. Cash users have similar mental-budget-renewing effects but smaller salience effects compared to credit card users

In terms of absolute magnitudes, cash users are less susceptible to salience of paydays ($\lambda_0 - \lambda_1 = 0.333$) than credit card users ($\lambda_0 - \lambda_1 = 0.979$), which is consistent with Agarwal et al.'s (2024) finding that consumers feel more attached to their money with cash transactions than with digital transactions when spending money. In contrast, the effect of mental budget renewing is similar on cash users ($\omega = 0.995$) and on credit card users ($\omega = 1.187$). The reason is that the monthly budget itself has nothing to do with the transaction mode over the counter.

For cash users, the monthly mental-budget-renewing effect and the salience effect, respectively, contribute to 75% ($\frac{0.995}{0.995+0.333}$) and 25% ($\frac{0.333}{0.995+0.333}$) of the elevation of expenditures on paydays. For credit card users, the monthly mental-budget-renewing effect and the salience effect, respectively, contribute to 55% ($\frac{1.187}{1.187+0.979}$) and 45% ($\frac{0.979}{1.187+0.979}$) of the elevation of expenditures on paydays.

4.4. Bracket-specific mental accounts within monthly mental budgets

We observe that λ_1 through λ_{26} are roughly flat instead of monotonically decreasing, suggesting that customers allocate expenditures on this brand into a mental account separate from other expenditures. Although daily overall expenditures on other products (especially instantaneous-consumption products) will gradually exhaust a consumer's overall monthly mental budget over time, the unspent money in the monthly mental account for this specific brand will not change until she makes an expenditure on this brand. Therefore, we only observe that expenditures on this brand decrease over trips within a paycheck cycle (as shown in Table 4) but do not observe that, after the initial drop from the payday to one day after the payday, the expenditure on the first trip of a paycheck cycle continues to decrease over days within the paycheck cycle.

4.5. Projection bias can be triggered by salience but not by mental-budget renewing

We estimate equations (7.1) and (7.2) using other dependent variables. While we observe purchase mistakes on the first trip of a paycheck cycle drop substantially from a payday to one day after a pay day (panel A of Figure 6), we did not find that mistakes monotonically decrease over trips within a paycheck cycle (columns 1 and 2 of Table 5). This result pattern suggests that only the salience of paycheck receipt can trigger projection bias and monthly mental-budget renewing itself cannot trigger projection bias. In contrast, both the monthly mental-budget renewals and the salience of paydays can increase variety seeking, new-product trying, and product upgrading (see columns 3 through 8 of Table 5 and panels B through D of Figure 6).

5. A stylized model

To explain the empirical findings in this study, in this section, we develop a stylized theoretical model to formalize the mechanisms of monthly mental budgeting, salience, and projection bias.

5.1. Monthly mental budgets

we propose a framework according to which consumers semi-intertemporally make intertemporal decisions. In the model, instead of determining daily expenditures by solving a long-horizon intertemporal utility maximization problem at a daily granularity, consumers decompose the problem into three stages. First, they roughly determine monthly aggregate expenditures by solving a long-horizon problem at a monthly granularity. Second, at the beginning of a month, they divide the predetermined aggregate expenditures for the month into different bracket-specific mental accounts. Third, on a trip to a store that sells products belonging to a certain bracket-specific mental account, they make the trip-level expenditure decisions and follow a rule of thumb trying not to overspend beyond the predetermined monthly bracket-specific mental budget.

Suppose that a consumer's lifetime has $\mathbb{T}$ months. In the first stage, in a month (paycheck cycle) $\mathbb{t}$, the consumer roughly determines the target of the aggregate expenditure for the current month either based on a behavior model or a long-horizon intertemporal utility maximization model that appears to be rational at a monthly granularity. Without loss of generality, we assume

the latter: in a month (paycheck cycle) $\mathbb{t}$, the consumer calculates the monthly amount of consumption $\mathbb{C}_{\mathbb{t}}$ (as well as $\{\mathbb{C}_j\}_{\mathbb{t}<j\leq\mathbb{T}}$) to maximize the life-cycle utility

$$E_{\mathbb{t}}\sum_{j=\mathbb{t}}^{\mathbb{T}}\tilde{\delta}^{j-\mathbb{t}}\mathbb{u}(\mathbb{C}_j) \tag{8.1}$$

subject to

$$\mathbb{A}_{\mathbb{t}+1}=(1+\mathbb{r})(\mathbb{A}_{\mathbb{t}}+\mathbb{Y}_{\mathbb{t}}-\mathbb{C}_{\mathbb{t}}) \tag{8.2}$$

$$\mathbb{A}_{\mathbb{T}+1}\geq 0 \tag{8.3}$$

In equations (8.1) and (8.2), $\tilde{\delta}$ is the monthly discount factor; $\mathbb{r}$ is the monthly interest rate. $\mathbb{Y}_{\mathbb{t}}$ is the monthly income in month $\mathbb{t}$; it is received on the payday, which is the first day of month (paycheck cycle) $\mathbb{t}$. $\mathbb{Y}_{\mathbb{t}}$ can be either deterministic or stochastic. If stochastic, the uncertainty of $\mathbb{Y}_{\mathbb{t}}$ is realized at the beginning of month $\mathbb{t}$ before the decision of $\mathbb{C}_{\mathbb{t}}$ is made. $\mathbb{A}_{\mathbb{t}}$ is the outstanding asset at the beginning of month $\mathbb{t}$ before $\mathbb{Y}_{\mathbb{t}}$ is received. We assume that the consumer does not face temporal liquidity constraints because she has either considerable initial wealth or easy access to credits. Accordingly, $\mathbb{A}_{\mathbb{t}}$ is allowed to be negative. However, we assume that $\mathbb{A}_{\mathbb{T}+1}\geq 0$, i.e., the consumer cannot have unpaid debts at the end of her lifetime.

The solution to the lifetime utility maximization problem, $\mathbb{C}_{\mathbb{t}}$, can be represented by a function of $\mathbb{A}_{\mathbb{t}}+\mathbb{Y}_{\mathbb{t}}$:

$$\mathbb{C}_{\mathbb{t}}=\mathbb{f}(\mathbb{A}_{\mathbb{t}}+\mathbb{Y}_{\mathbb{t}}) \tag{8.4}$$

Given the monthly income $\mathbb{Y}_{\mathbb{t}}$ and the corresponding monthly consumption decision $\mathbb{C}_{\mathbb{t}}$, the target saving rate for the income in month $\mathbb{t}$ is:

$$s_{\mathbb{t}}=\frac{\mathbb{C}_{\mathbb{t}}}{\mathbb{Y}_{\mathbb{t}}} \tag{8.5}$$

After deciding the monthly consumption target $\mathbb{C}_{\mathbb{t}}$, in the second stage, the consumer considers how to allocate $\mathbb{C}_{\mathbb{t}}$ across product brackets. For simplicity, we assume that there are only two product brackets: an instantaneous-consumption bracket and a storable product bracket. The former one has to be consumed the same day as the purchase day, whereas the latter can be stored for many days. The consumer decides the monthly consumption targets of the two brackets, $\mathbb{c}_{\mathbb{t}}$ and $\mathbb{b}_{\mathbb{t}}$, respectively, by solving the following annual utility maximization problem:

$$\max_{\mathbb{c}_\mathbb{t},\mathbb{b}_\mathbb{t}} \mathbb{c}_\mathbb{t}^{\bar{\alpha}} \mathbb{b}_\mathbb{t}^{\bar{\beta}} \tag{8.6}$$

subject to

$$\mathbb{c}_\mathbb{t} + \mathbb{b}_\mathbb{t} \leq \mathbb{C}_\mathbb{t} \tag{8.7}$$

The solutions are as follows:

$$\mathbb{c}_\mathbb{t} = \frac{\bar{\alpha}}{\bar{\alpha} + \bar{\beta}} \mathbb{C}_\mathbb{t} \tag{8.8}$$

$$\mathbb{b}_\mathbb{t} = \frac{\bar{\beta}}{\bar{\alpha} + \bar{\beta}} \mathbb{C}_\mathbb{t} \tag{8.9}$$

In the third stage, the consumer makes purchase decisions for the instantaneous-consumption product on each day within the month and makes purchase decisions for the storable product on each store visit within the month. Because the expenditures on these two products belong to different mental accounts, the purchase decisions of the two products are independent of each other. To avoid overspending, she uses $s_\mathbb{t}$ (the saving rate regarding the monthly income) as the target saving rate of the entire income in month $\mathbb{t}$. In addition, she uses $\mathbb{c}_\mathbb{t}$ and $\mathbb{b}_\mathbb{t}$ as the reference points for the expenditures on the instantaneous-consumption product and the storable product, respectively.

We assume that the visit to stores selling storable products occurs randomly and does not occur every day; however, at the beginning of a month, the consumer knows how many times she is going to visit the stores within the month. During a visit, the consumer can purchase one unit of the storable product that contains $\bar{t}$ days' usage amount and can be stored for $\bar{t}$ days. The daily usage amount is fixed; consumers do not obtain more utility by consuming a larger amount in a day. Correspondingly, the purchase decision is regarding product quality instead of quantity. Varieties with higher qualities have higher prices. Denote the quality of the variety as b and the per-unit price as $\bar{t}b$. The dollar-value expenditure on the trip is $e = \bar{t}b$. Denote the daily utility flow of consuming this storable product as $u(b)$. We assume that $u'(.) > 0$ and $u''(.) < 0$.

The present value of the daily consumption utility flows associated with the purchased storable product as a function of the expenditure e is:

$$U(e) = u\left(\frac{e}{\bar{t}}\right) + \delta u\left(\frac{e}{\bar{t}}\right) + \cdots + \delta^{\bar{t}-1} u\left(\frac{e}{\bar{t}}\right) = \frac{1-\delta^{\bar{t}}}{1-\delta} u\left(\frac{e}{\bar{t}}\right) \tag{8.10}$$

where δ is the daily discount factor.[35]

On a certain trip to the store, denote the unspent money in the monthly mental budget for the storable product ($\mathbb{b}_{\mathbb{t}}$) as h. The consumer determines the expenditure on the storable product during the store visit by solving the following utility maximizing problem:

$$\max_{e} U(e) + g(h - e) \tag{8.11}$$

The first order condition is

$$\frac{1-\delta^{\bar{t}}}{1-\delta}\frac{1}{\bar{t}}u'\left(\frac{e}{\bar{t}}\right) - g'(h-e) = 0 \tag{8.12}$$

In equation (8.11), $g(h-e)$ represents the utility of leaving a cushion $h-e$ to the monthly mental budget $\mathbb{b}_{\mathbb{t}}$. Accordingly, $g'(h-e)$ in equation (8.12) captures the pain from spending a dollar, which triggers internal cognitive control. We assume that $g'(.) > 0$ and $g''(.) < 0$, i.e., the pain from spending a dollar becomes more prominent when the cushion is thinner (closer to exhausting the mental budget $\mathbb{b}_{\mathbb{t}}$).[36]

Differentiate the first order condition as shown in equation (8.12) w.r.t. h, we have

$$e^{*\prime}(h) = \frac{g''(h-e)}{\frac{1-\delta^{\bar{t}}}{1-\delta}\frac{1}{\bar{t}^2}u''\left(\frac{e}{\bar{t}}\right) + g''(h-e)} > 0 \tag{8.13}$$

$e^{*\prime}(h) > 0$ is in line with the empirical results in Table 4 that the per-trip expenditure decreases over trips within a paycheck cycle because the expenditure on each trip to the brand will reduce h for the next trip. After the next payday, because the consumer renews the monthly mental budget, h jumps to $\mathbb{b}_{\mathbb{t}+1}$. Correspondingly, the consumer makes a larger expenditure on the first trip since the next payday and the per-trip expenditure decreases over trips within the next paycheck cycle.

[35] We assume that when consumers make intertemporal decisions within a month horizon, they do not consider daily interest rates because banks count interest monthly instead of daily.

[36] Day $\bar{t}$ can be after the next payday. Correspondingly, although the storable product purchased today in the current paycheck cycle could be partially consumed in the next paycheck cycle, the expenditure made today is allocated to the consumer's mental budget for the current paycheck cycle.

Although the consumer uses $\mathbb{b}_{\mathbb{t}}$ as a reference, she may not necessarily spend all of $\mathbb{b}_{\mathbb{t}}$ in paycheck cycle $\mathbb{t}$. Whether the consumer underspends, overspends, or spends exactly $\mathbb{b}_{\mathbb{t}}$ on the storable product within the paycheck cycle depends on the shape of $g(.)$.

While we assume that, in the first stage, consumers appear to solve a long-horizon intertemporal utility maximization model that is rational at the monthly granularity, the actual consumption outcomes may not be rational at the monthly granularity. First, the model in the first stage only helps consumers roughly determine an expenditure target $\mathbb{C}_{\mathbb{t}}$ (or a savings target) for a month and adjust the intension of their intrinsic self-control device every day according to the distance to the target. They do not necessarily exactly spend $\mathbb{C}_{\mathbb{t}}$ at the end of the month. Second, they allocate expenditures instead of consumption in the month to the mental account of the current month ($\mathbb{C}_{\mathbb{t}}$), although storable products purchased in the current month will be partially consumed in later months

5.2. Reasons for $g''(.) < 0$

There are two reasons for $g''(.) < 0$, i.e., the pain from spending a dollar becomes more prominent when the consumer is closer to exhausting the mental budget $\mathbb{b}_{\mathbb{t}}$: a behavioral reason and a rational reason.

The behavioral reason is that as a consumer moves closer to exhausting the mental budget, she can become more worried about the potential overspending at the end of the paycheck, pay more attention to the self-control problem, and exert more intrinsic self-control effort by being more careful when spending money on this product bracket.[37]

The rational reason is that if there is uncertainty of preferences in the future, leaving a thick cushion is beneficial in that it can provide more flexibility to adjust to potential preference shocks in the remaining days of the paycheck cycle. To illustrate this, suppose that a consumer' first trip

[37] Note that Benhabib and Bisin (2005) developed a theoretical model in which consumers start to pay attention to the self-control problem after the potential loss caused by not doing so surpasses a certain threshold. In contrast, in our model, $g''(.) < 0$ implies that the attention paid to or the intrinsic effort exerted to the self-control problem is monotonically increasing when the cushion against overspending becomes thinner.

to the brand after a payday occurs on the t_1th day since the payday. She decides to purchase a variety in a product range with quality b_1. The daily utility flow of consuming this variety is $u_1(b_1)$. On the first trip, she knows that she will have a second trip within this paycheck cycle on the t_2th day since the payday. However, there is a probability p that, on the second trip, she becomes interested in a new product subcategory and hence brings it into her consideration set; correspondingly, her preference in terms of daily utility flow will become

$$u_1(b_1) + u_2(b_2) \tag{8.14}$$

where b_2 is the quality of the purchased variety in the new product subcategory; then, she will spend all the remaining money in this mental budget on this new product because there will not be a third trip to this brand within this paycheck cycle. If the preference shock does not occur, she will leave the remaining money in the mental budget unspent and the daily utility flow will be $u_1(b_1)$ in the following days until the next trip or the product on hand is used up.

For simplicity, we assume that one unit of this new product contains $\bar{t} - (t_2 - t_1)$ days' usage amount and can be stored for $\bar{t} - (t_2 - t_1)$. Then, on the first trip, the consumer chooses the expenditure e (or the daily consumption quality $\frac{e}{\bar{t}}$) by solving the following utility maximization problem:

$$\begin{aligned} \max_e \sum_{t=1}^{t_2-t_1} \delta^t u_1\left(\frac{e}{\bar{t}}\right) + (1-p) \sum_{t=t_2-t_1+1}^{\bar{t}} \delta^t u_1\left(\frac{e}{\bar{t}}\right) \\ + p \sum_{t=t_2-t_1+1}^{\bar{t}} \delta^t \left(u_1\left(\frac{e}{\bar{t}}\right) + u_2\left(\frac{\mathbb{b}_{\mathbb{t}} - e}{\bar{t} - (t_2 - t_1)}\right)\right) \end{aligned} \tag{8.15}$$

which can be rearranged to

$$\max_e \sum_{t=1}^{\bar{t}} \delta^t u_1\left(\frac{e}{\bar{t}}\right) + p \sum_{t=t_2-t_1+1}^{\bar{t}} \delta^t u_2\left(\frac{\mathbb{b}_{\mathbb{t}} - e}{\bar{t} - (t_2 - t_1)}\right) \tag{8.16}$$

If we denote $\sum_{t=1}^{\bar{t}} \delta^t u_1\left(\frac{e}{\bar{t}}\right)$ as $U(e)$ and $p \sum_{t=t_2-t_1+1}^{\bar{t}} \delta^t u_2\left(\frac{\mathbb{b}_{\mathbb{t}}-e}{\bar{t}-(t_2-t_1)}\right)$ as $g(\mathbb{b}_{\mathbb{t}} - e)$, the utility maximization problem becomes:

$$\max_e U(e) + g(\mathbb{b}_{\mathbb{t}} - e) \tag{8.17}$$

which is a special case of equation (8.11) where $h = \mathbb{b}_{\mathbb{t}}$. $g(.)$ in equation (8.17) also satisfies $g'(.) > 0$ and $g''(.) < 0$ as long as ${u_2}'(.) > 0$ and ${u_2}''(.) < 0$. The pain or disutility from spending a dollar represented by the derivative of $g(.)$ comes from the decrease in flexibility to adjust to potential preference shocks in the future.[38]

More broadly, the daily purchase decision of instantaneous-consumption products subject to a monthly budget constraint can also be represented by the unconstrained utility maximization problem with the pain from spending dollars showing up in the objective function. The pain comes from intertemporal substitution: spending more on instantaneous-consumption will reduce instantaneous-consumption tomorrow given the monthly budget constraint.

In contrast, intertemporal substitution is not the major component of the pain from spending money on storable products because the purchase decision (on product quality) today will determine the daily utility flow not only for today but also for many days thereafter, given that the daily consuming amount is fixed. The pain from spending mainly comes from the intrinsic device of self-control or the reduction in flexibility to adjust to preference shocks in the future.

5.3. Salience

The large gap between the first trip within a paycheck cycle that occurs on the payday and the first trip that occurs on the day after the payday (as shown in Figure 5) cannot be fully explained by the renewal of the monthly mental budget. Therefore, in this subsection, we add a component of salience into the model.

Suppose that $g(h - e)$ also depends on whether the day is a payday or a non-payday. We assume that

$$g'(h - e|payday) < g'(h - e|nonpayday) \tag{8.18}$$

In other words, the pain from spending a dollar is less prominent on paydays because it is diluted by the spike of cash inflow generated by paycheck receipt. Consumers may treat a payday as a

[38] Although the consumer is capable of spending beyond $\mathbb{b}_{\mathbb{t}}$ to adjust to the preference shock, breaking the rule of thumb will incur other costs such as having to use more complicated methods (such as solving an intertemporal utility maximization problem) to evaluate their current status and plan for future decisions.

milestone or landmark for self-reward after hard working for one month (Steed, 2018) and treat a paycheck as "a license to spend" (Addoum et al., 2019); hence, they turn down the internal device of self-control. Consequently, according to the first-order condition displayed by equation (8.12), we should observe the expenditure overshoots on paydays after renewing the monthly mental budget (recovering the cushion h to $\mathbb{b}_{\mathbb{t}}$).

5.4. Projection bias

As shown in Section 4.5, salience of paydays instead of monthly mental-budget renewing can trigger projection bias, which can also contribute to the overshoots in expenditures on paydays. Therefore, in this subsection, we add a component of projection bias into the model.

Suppose that the utility of consuming b for the storable product on a non-payday and that on a payday, respectively, are as follows:

$$u(b, nonpayday) = u(b) \tag{8.19}$$

$$u(b, payday) = \omega u(b) \tag{8.20}$$

where $\omega > 1$, i.e., the same consumption provides a higher utility flow on a payday than on a non-payday.

Following the framework of Loewenstein et al. (2003), due to projection bias, the utility of consumption on a non-payday perceived at a payday is

$$\begin{aligned} u(b, nonpayday \mid payday) &= (1-\alpha)u(b, nonpayday) + \alpha u(b, payday) \\ &= [1 + (\omega - 1)\alpha]u(b) = \varpi_1 u(b) \end{aligned} \tag{8.21}$$

where the parameter $\alpha \in [0,1]$ measures the degree of projection bias. Similarly, the utility of consumption on a payday perceived on a non-payday is

$$\begin{aligned} u(b, payday \mid nonpayday) &= (1-\alpha)u(b, payday) + \alpha u(b, nonpayday) \\ &= [\alpha + (1-\alpha)\omega]u(b) = \varpi_2 u(b) \end{aligned} \tag{8.22}$$

In equations (8.24) and (8.25), $\varpi_1 = 1 + (\omega - 1)\alpha$ and $\varpi_2 = \alpha + (1-\alpha)\omega$. We have $\varpi_1 > 1$ and $\varpi_2 > 1$.

For simplicity, we assume that one unit of such storable product contains 30 days' usage amount. If the customer purchases on a payday, the present value of perceived utility flows is

$$U(e|payday) = u\left(\frac{e}{30}, payday\right) + \sum_{\tau=1}^{29} \delta^{\tau} u\left(\frac{e}{30}, nonpayday \mid payday\right)$$
$$= \left[(1 + (\omega - 1)\alpha)\delta \frac{1 - \delta^{29}}{1 - \delta} + \omega\right] u\left(\frac{e}{30}\right) \tag{8.23}$$

If the customer purchases on a non-payday, say, one day after the payday, then the present value of perceived utility flows is

$$U(e|nonpayday, 1)$$
$$= \sum_{\tau=1}^{29} \delta^{\tau-1} u\left(\frac{e}{30}, nonpayday\right) + \delta^{29} u\left(\frac{e}{30}, payday \mid nonpayday\right) \tag{8.24}$$
$$= \left[\frac{1 - \delta^{29}}{1 - \delta} + \delta^{29}(\alpha + (1 - \alpha)\omega)\right] u\left(\frac{e}{30}\right)$$

Under a reasonable set of parameter values,[39] [40]

$$\left[(1 + (\omega - 1)\alpha)\delta \frac{1 - \delta^{29}}{1 - \delta} + \omega\right] > \left[\frac{1 - \delta^{29}}{1 - \delta} + \delta^{29}(\alpha + (1 - \alpha)\omega)\right] \tag{8.25}$$

Therefore, we have

$$U'(e|payday) > U'(e|nonpayday, 1) \tag{8.26}$$

[39] Both the empirical and experimental literature found that the degree of projection bias α is large in magnitude. For example, Colin et al. (2007) examined the purchasing behavior of weather-related clothing and estimated α to be between $1/3$ and 0.5. Chaloupka et al. (2019) examined cigarette smokers' prediction about their future abstinence and estimated α to be 0.77. Acland and Levy (2015) examined gym attendance behavior and estimated α to be even 0.94.

[40] For example, assuming that the daily discount factor $\delta = 0.9994$ (the corresponding annual discount rate is 0.8), $\omega = 1.2$ (the daily instantaneous utility on a payday is 20% higher than that on a non-payday), and $\alpha = 0.5$, we can calculate $\frac{U(c|payday) - U(c|nonpayday,1)}{U(c|payday)} = 9.07\%$. Therefore, under reasonable assumptions for the parameters, projection bias can cause a substantial difference between the perceived utility of purchasing on a payday and that of purchasing on a non-payday and hence cause a substantial difference in the willingness to pay.

According to the first order condition displayed in equation (8.12), the expenditure on the first trip within a paycheck cycle is larger if the first trip occurs on the payday than if the first trip occurs one day after the payday, even without assuming that $g(\mathbb{b}_t - e)$ depends on whether the trip occurs on a payday or a non-payday.

The overshoots in expenditures on storable products on paydays are unlikely to be driven by present bias because the purchase decision today will affect not only the utility flow today but also the utility flows in many days following. See Appendix B for detailed discussions on disconfirming present bias.

5.5. Potential extension

As shown in Figure 5, besides the substantially larger expenditure on paydays, the expenditure on the first trip of a paycheck cycle on non-paydays is roughly flat instead of monotonically decreasing over days, suggesting that customers allocate expenditures on this brand into a mental account separate from other expenditures. Although daily overall expenditures on other products (especially instantaneous-consumption products) will gradually exhaust a consumer's overall monthly mental budget over time, the unspent money in the monthly mental account for this specific brand will not change until she makes an expenditure on this brand.

However, there is a weak pattern in Figure 5 that the expenditures on the first trips on non-paydays slightly decrease first and then slightly increase later. This empirical pattern might be driven by two competing forces: weak interdependence among bracket-specific mental accounts and precautionary saving for expenditure shocks. While we are reluctant to make too much out of this empirical result because the pattern is week, we would like to point out a direction to extend the theoretical model by incorporating these two components.

5.5.1. Interdependence among bracket -specific mental accounts

The pain of spending a dollar on this product bracket may depend not only on the unspent money in the monthly mental budget for this product bracket (denoted as $h \leq \mathbb{b}_t$) but also on the unspent money in the entire monthly mental budget (denoted as $H \leq \mathbb{C}_t$). Then, $g'(h - e)$ in the first order

condition displayed in equation (8.12) should be $g'(h-e|H)$, which is decreasing in H. That is, the pain from spending a dollar on this product bracket is less prominent if the unspent amount of money in the entire monthly mental account is larger. Consequently, the expenditure on this product bracket on the first trip within a paycheck cycle will be smaller if the first trip occurs on a later day in the cycle. The reason is that the daily expenditure on the instantaneous-consumption bracket makes H gradually decrease every day.

5.5.2. Expense shocks

If mental accounts are completely independent of each other, the potential overall expenditure shocks in the future should not affect the consumer's current purchase decisions on the instantaneous-consumption product and the storable product. The reason is that the consumer would allocate expense shocks to a mental account built up by $\mathbb{Y}_{\mathbb{t}} - \mathbb{C}_{\mathbb{t}}$ (monthly savings) instead of the mental accounts of $\mathbb{c}_{\mathbb{t}}$ and $\mathbb{b}_{\mathbb{t}}$, given that precautionary saving to deal with future uncertainty is one important motive for saving.

If the consumer would not let her mental account of savings fully absorb the expense shocks, she may reduce the current expenditures on the instantaneous-consumption product and the storable product. On a later day within a paycheck cycle, given that the number of days (exposed to expense shocks) remaining within the cycle is smaller, the aggregate unrealized uncertainty within the cycle is smaller. Accordingly, the reduction in expenditures on the instantaneous-consumption product and the storable product to leave a cushion within the monthly mental account of $\mathbb{C}_{\mathbb{t}}$ for the uncertainty should be smaller.[41] Therefore, the expenditure on the first trip of a paycheck cycle should be larger if the first trip occurs on a later day within the cycle.

In Figure 5, there is a weak pattern that the expenditures on the first trips on non-paydays slightly decrease first and then slightly increase later. One possible explanation is that the first force dominates the second force in early days of a paycheck cycle, whereas the second force

[41] The cushion here is similar in spirit to the liquidity cushion discussed in Olafsson and Pagel (2018). One difference is that the former one is capped by the monthly flow $\mathbb{C}_{\mathbb{t}}$, whereas the latter one is a stock variable that consists of all the liquid assets (e.g., cash, checking account balance, and credit lines).

dominates the first force in later days of a paycheck cycle. Mathematically formalizing these two forces in the theoretical model is out of the scope of this paper.

6. Conclusion

Analyzing the individual-level transaction data of the retail chain of a global cosmetic and personal-care brand (storable products) targeting upper-middle-class customers, we find that, besides making larger expenditures on a payday, even on a non-payday, customers make larger expenditures as long as it is their first trip to the retail chain since a payday. Thereafter, the per-trip expenditures decrease over trips within the monthly paycheck cycle until an upward jump on the first trip since the next payday.

This empirical pattern suggests that consumers may have month-specific mental accounting. They budget their spending every month targeting a rule-of-thumb saving rate for their incomes in the month even if they do not face a monthly liquidity constraint. A paycheck receipt on a payday causes consumers to renew their monthly mental budgets and hence we observe an upward jump on the first trip since the payday even if the trip occurs on a non-payday. On later trips within the paycheck cycle, because they have already partially used the money in their monthly mental budget on the previous trips within the paycheck cycle, they cognitively turn up their intrinsic device of self-control and reduce expenditures to avoid overspending beyond the target saving rate of the paycheck.

This self-imposed restriction on the choice set of consumption paths provides two benefits. First, consumers can avoid solving complicated models while still achieving suboptimal outcomes. Second, they can trade off between maintaining flexibility and counteracting temptation for higher present consumption. As implied by the theoretical model in Amador et al. (2006), an optimal commitment device should impose a minimum level of savings in each period.

We also find that, given that it is the first trip after the payday of a paycheck cycle, the expenditure is dramatically larger if the trip is on the payday than if the trip occurs one day after the payday. This empirical pattern suggests that paycheck receipt on paydays not only causes customers to renew their monthly mental budgets but also generates a salience effect leading to an excess downturn of the internal device of self-control and an overshoot in expenditures on paydays.

One the one hand, salience of paydays may be necessary for enabling consumers to use paydays as milestones to decompose a long-horizon intertemporal problem into simpler periodical problems and renew their periodical mental budgets. On the other hand, salience of paydays causes overshoots in expenditures.

While mental-budget renewing has similar effects on cash and credit card users, cash users are less susceptible to salience of paydays than credit card users. Additionally, projection bias can be triggered by salience of paydays but not by mental-budget renewing.

Consumers further decompose a monthly mental budget into bracket-specific mental accounts. We only observe that expenditures on this brand decrease over trips within a paycheck cycle (as shown in Table 4) but do not observe that, after the initial drop from the payday to one day after the payday, the expenditure on the first trip of a paycheck cycle continues to decrease over days within the paycheck cycle. Although daily overall expenditures on other products (especially instantaneous-consumption products) will gradually exhaust a consumer's overall monthly mental budget over time, the unspent money in the monthly mental account for this specific brand will not change until she makes an expenditure on this brand.

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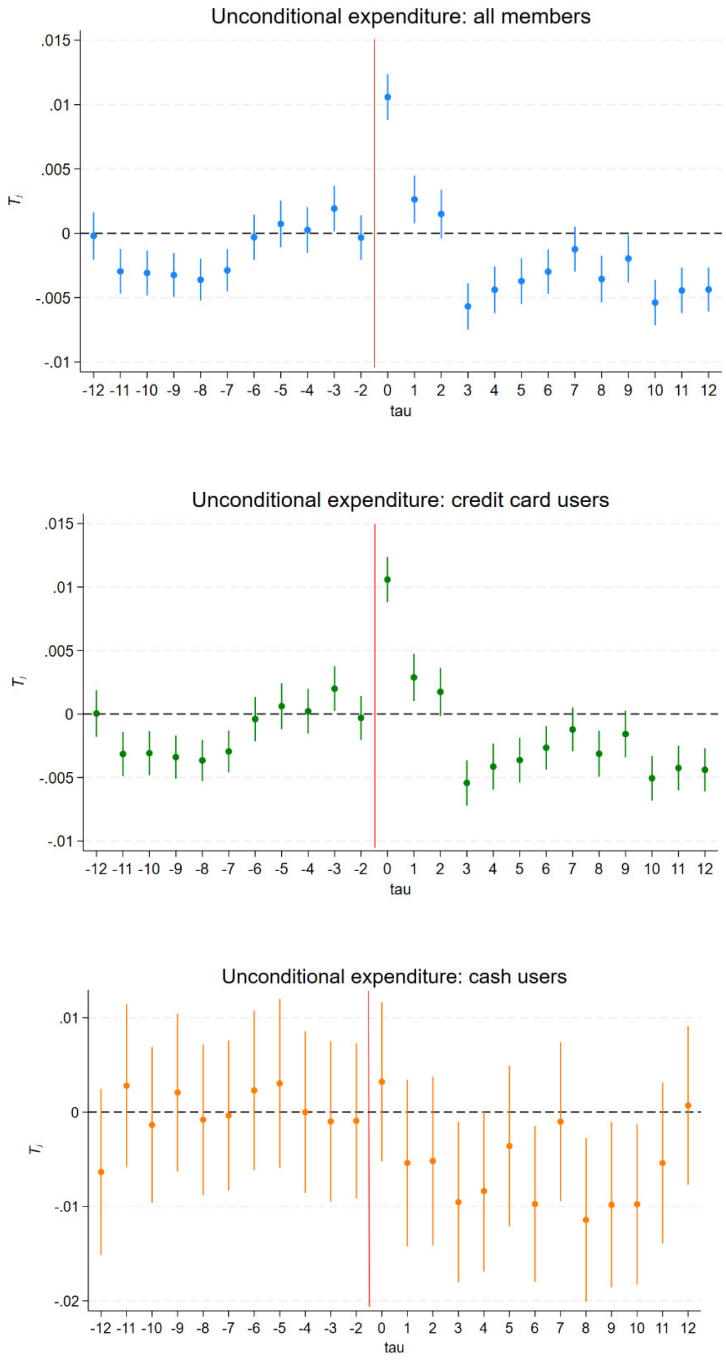


Figure 1. Unconditional Expenditure. Alternative to Table 3, we run a customer-calendar-day-level regression of unconditional daily expenditure based on equation (3.2), $y_{it} = \sum_{j=-12}^{12} T_j \cdot I(\tau_t = j) + \beta X_{it} + \varepsilon_{it}$, where T_js are a set of fixed effects for each possible value of τ_t and T_{-1} is normalized to zero. The estimates of these fixed effects are displayed in the figure. The vertical bars represent the 95% confidence intervals. The first diagram shows the estimates for all members. The second and third diagram show the estimates for credit card and cash users, respectively. A sudden spike is observed at $\tau_t = 0$ (paydays).



Figure 2. Expenditure conditional on visit. We run a customer-trip-level regression of expenditure conditional on store visit based on equation (3.2), $y_{it} = \sum_{j=-12}^{12} T_j \cdot I(\tau_t = j) + \beta X_{it} + \varepsilon_{it}$, where T_js are a set of fixed effects for each possible value of τ_t and T_{-1} is normalized to zero. The estimates of these fixed effects are displayed in the figure. The vertical bars represent the 95% confidence intervals. A sudden spike is observed at $\tau_t = 0$ (paydays).

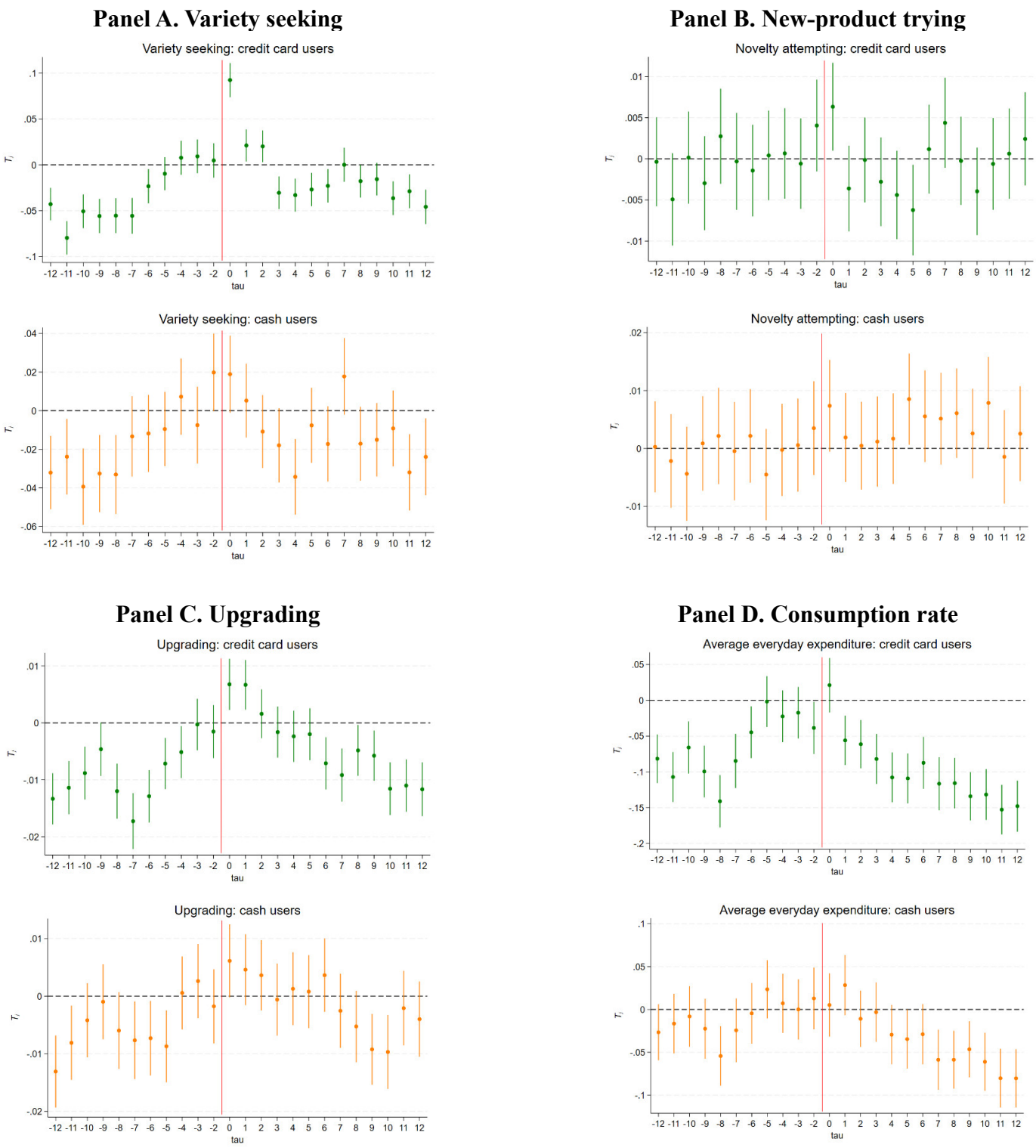


Figure 3. Real impacts of the payday effects. Based on equation (3.2), we run customer-trip-level regressions of variety seeking, new-product trying, product upgrading, and the consumption rate. The fixed effect for $\tau_t = -1$ is normalized to zero. The vertical bars represent the 95% confidence intervals. A sudden spike is observed at $\tau_t = 0$ (paydays) for credit card users.

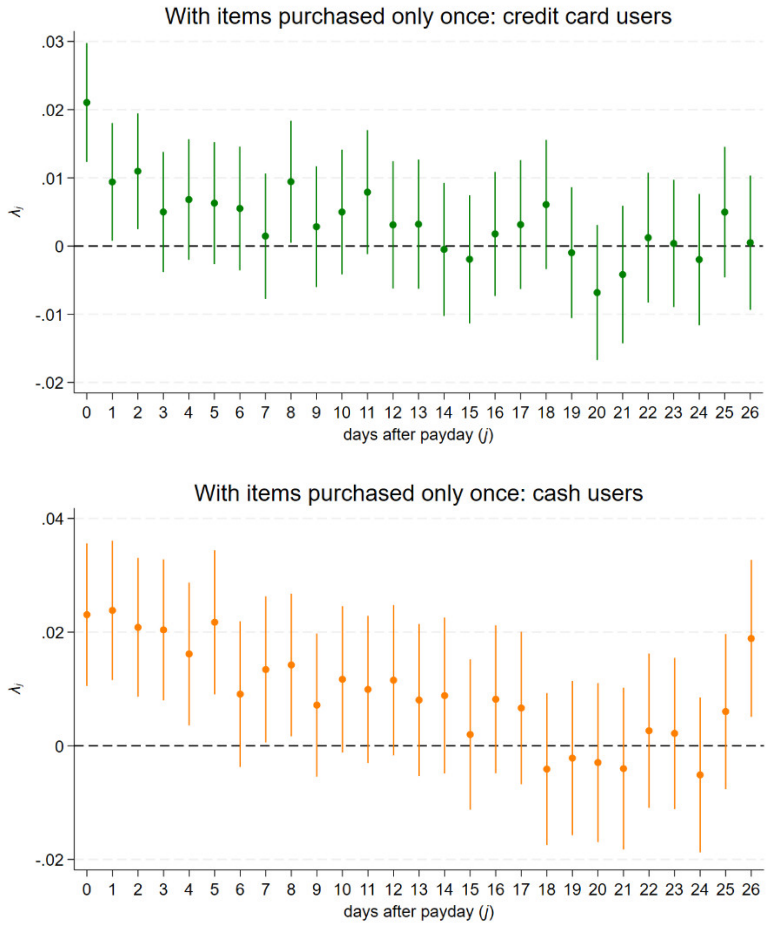


Figure 4. Mistakes. Based on equation (3.2), we run customer-trip-level regressions of purchasing mistakes. The fixed effect for $\tau_t = -1$ is normalized to zero. The vertical bars represent the 95% confidence intervals. A sudden spike is observed at $\tau_t = 0$ (paydays) for credit card users.

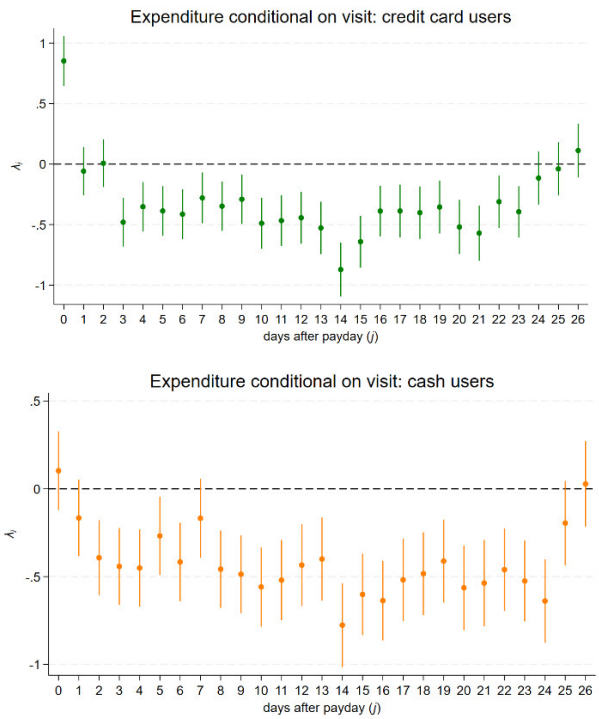


Figure 5. Salience of paydays. The diagrams display the estimates of λ_ls in the following equation:

$$y_{it} = \omega I(\text{1st trip in the cycle}) + \sum_{l=0}^{26} \lambda_l I(\text{1st trip in the cycle \& } days_after_payday = l) + \gamma_0 + \beta X_{it} + \varepsilon_{it} \quad (7.2)$$

A paycheck cycle is defined as from a payday to the day before the next payday. $I(\text{1st trip in the cycle})$ is an indicator of whether the trip on day t is customer i's first trip of the paycheck cycle. $I(\text{1st trip in the cycle \& } \tau_t = l) = 1$ if the trip is customer i's first trip of the paycheck cycle that occurs on the lth day since the payday; $I(\text{1st trip in the cycle \& } \tau_t = l) = 0$ otherwise. We drop the trips that occur beyond 27 days after the payday within a paycheck cycle because some paycheck cycles are shorter than 28 days. Trips that are not the first trip in a paycheck cycle are omitted.

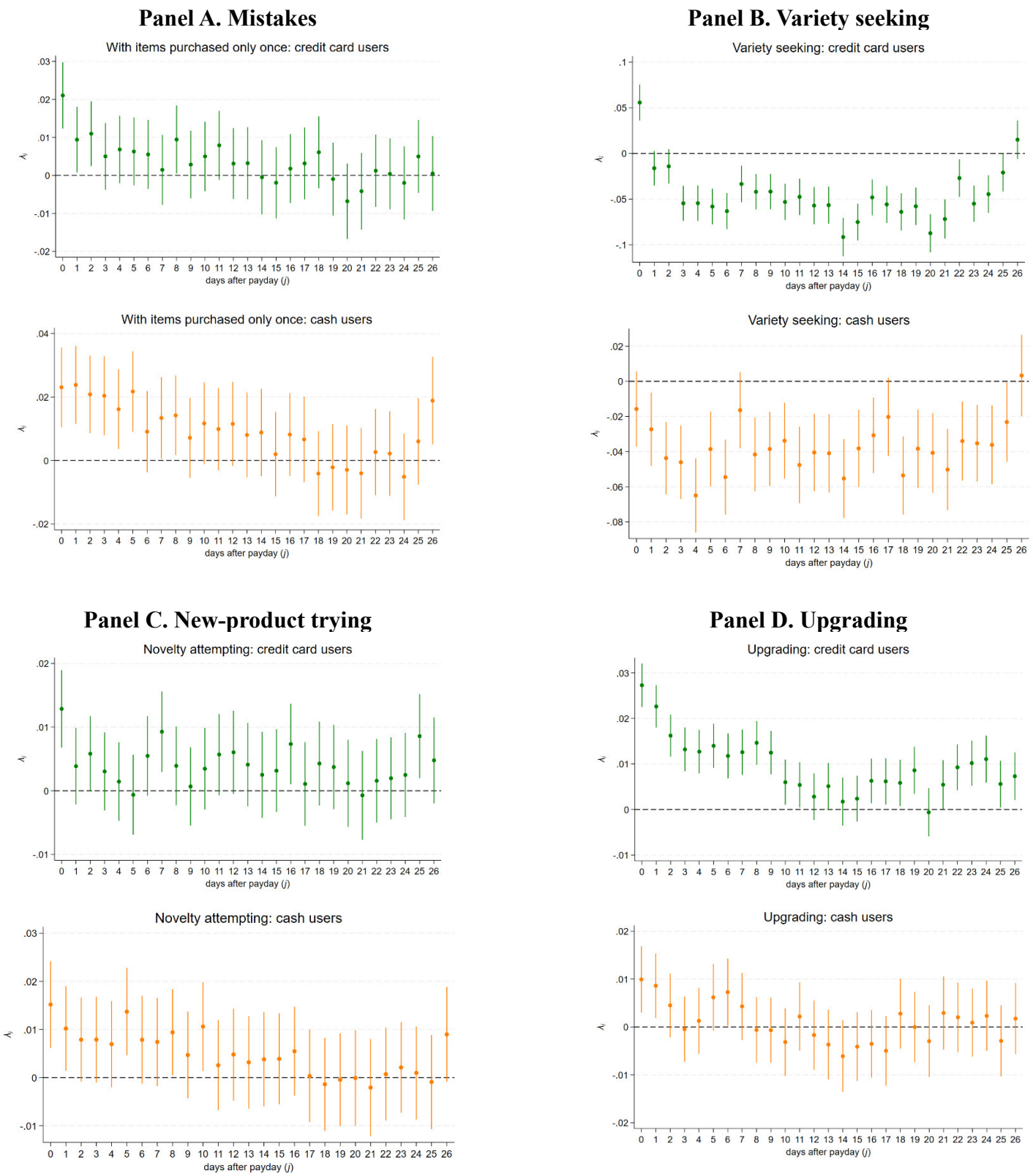


Figure 6. Salience and projection bias on paydays. This figure reports the results of regressions similar to those in Figure 5 but with different dependent variables, including the indicator of

whether the customer on the trip purchased a new variety that she never purchased again (mistakes), the number of varieties purchased on the trip (variety seeking), the indicator of whether the customer purchases a variety for the first time (upgrading), and the indicator of whether the product purchased by customer i on day t is a high-end variety within one of the eight categories (upgrading). High-end varieties in a category are defined as varieties with prices above the average price of the category.

Table 1. Descriptive statistics

Variable	Description	Mean	Std Dev
Panel A: unconditional customer-calendar-day-level observations			
Unconditional expenditure	Unconditional customer-day-level expenditure	0.263	3.005
Indicator of store visit		0.012	0.107
Panel B: customer-trip-level observations conditional on store visiting			
Customer-trip-level expenditure		22.838	16.379
Variety seeking	Basket size or number of varieties purchased on a trip	2.166	1.476
New-product trying	Indicator of whether purchased a variety that has never been purchased before	0.780	0.414
With items never purchased again	Indicator of whether purchased a once-only variety that was never purchased again	0.693	0.461
Upgrading	Indicator of whether purchased a high-end variety	0.369	0.482
Days since the previous visit		93.974	114.400
Indicator of cash user		0.633	0.482
Indicator of credit card user		0.367	0.482

Table 2. Group-specific descriptive statistics

Panel A: unconditional customer-calendar-day-level observations		
Variable	Cash users	Credit card users
Unconditional expenditure	0.217	0.286
Indicator of store visit	0.012	0.011

Panel B: customer-trip-level observations conditional on store visiting				
	Non-payday		Payday	
Variable	Cash users	Credit card users	Cash user	Credit card user
Customer-trip-level expenditure	17.433	25.927	17.788	26.943
Variety seeking	1.770	2.387	1.827	2.574
New-product trying	0.732	0.806	0.746	0.831
With items never purchased again	0.632	0.726	0.649	0.763
Upgrading	0.329	0.387	0.334	0.390
Days since the previous visit	90.560	96.061	89.524	94.109

Table 3. Unconditional daily expenditures on the brand

Dependent variable: Unconditional daily expenditure on the brand	Column 1	Column 2	Column 3
γ_1 (payday effect)	0.00162***	0.00399***	0.0128***
	(0.000530)	(0.000809)	(0.00120)
Average discount rate	0.0153***	0.0153***	0.0153***
	(0.000544)	(0.000544)	(0.000544)
$f(\tau_t)$	Linear	Quadratic	Cubic
Customer fixed effects	✓	✓	✓
Store fixed effects	✓	✓	✓
Year fixed effects	✓	✓	✓
Month-of-year fixed effects	✓	✓	✓
Day-of-week fixed effects	✓	✓	✓
Public-holiday indicator	✓	✓	✓
Number of customers	235,185	235,185	235,185
Number of observations	186,359,552	186,359,552	186,359,552
R^2	0.660	0.660	0.660

$$y_{it} = \gamma_0 + \gamma_1 I(\tau_t \leq 0) + f(\tau_t) + \beta X_{it} + \varepsilon_{it}$$

The regressions in this table are at the customer-calendar-day level. The dependent variable y_{it} is the expenditure made by customer i at the retail chain on day t. If the customer does not visit the retail chain on day t, then $y_{it} = 0$. The calendar-day-level observations for a customer include every day from one day after the customer's first trip in the sample period to the day of her last trip. Standard errors in parentheses are clustered at the individual level. * denotes significance at a 10% level. ** denotes significance at a 5% level. *** denotes significance at a 1% level.

Table 4. Monthly mental accounting

Dependent variable	Column 1 Expenditure	Column 2 Expenditure	Column 3 Expenditure
Credit card users			
ψ	1.370***	0.757***	1.027
	(0.161)	(0.276)	(0.670)
$\boldsymbol{\varphi_1}$	**0.726*** **	**1.226*** **	**2.694*** **
	(0.131)	**(0.189)**	**(0.544)**
$\boldsymbol{\varphi_2}$	**-0.167**	**-0.443** **	**1.595*** **
	(0.137)	**(0.188)**	**(0.528)**
$\boldsymbol{\varphi_3}$	**-0.162**		**0.358**
	(0.179)		**(0.536)**
$\boldsymbol{\varphi_4}$	**-0.324**		
	(0.365)		
$\boldsymbol{\varphi_5}$	**-0.320**		
	(0.755)		
Cash users			
ψ	0.726***	0.417	-0.263
	(0.165)	(0.299)	(0.680)
$\boldsymbol{\varphi_1}$	**0.552*** **	**0.717*** **	**2.157*** **
	(0.132)	**(0.199)**	**(0.547)**
$\boldsymbol{\varphi_2}$	**-0.0798**	**-0.412** **	**0.784**
	(0.138)	**(0.197)**	**(0.534)**
$\boldsymbol{\varphi_3}$	**-0.0946**		**-0.290**
	(0.174)		**(0.544)**
$\boldsymbol{\varphi_4}$	**0.0946**		
	(0.325)		
$\boldsymbol{\varphi_5}$	**0.132**		
	(0.627)		
$\tilde{f}_{cash}(\tau_t)$ and $\tilde{f}_{card}(\tau_t)$	✓	✓	✓
Controls	✓	✓	✓
Number of customers	235,185	160,903	31,537
Number of observations	2,264,955	486,055	88,506
R^2	0.093	0.098	0.103

$$y_{it} = \psi I(\text{trip on payday}) + \sum_{k=1}^{5} \varphi_k I(k\text{th trip in the cycle given no trip on payday}) + \tilde{f}(\tau_t) + \beta X_{it} + \varepsilon_{it}$$

Column 1 displays the estimates of ψ and φ_ks in the equation above. $I(trip\ on\ payday)$ is an indicator of whether the trip is on a payday. A paycheck cycle is defined as from a payday to the day before the next payday. $I(kth\ trip\ in\ the\ cycle\ given\ no\ trip\ on\ payday) = 1$ if the trip is the kth trip of the paycheck cycle and there was no trip on the payday; it equals zero otherwise. The case $k = 5$ includes the fifth trip and thereafter trips within a paycheck cycle. If the first trip of the paycheck cycle occurs on the payday, trips after the first trip are omitted. $\tilde{f}(\tau_t)$ is a set of fixed effects for each value of τ_t. The dependent variable is the expenditure made on the trip. In column 2, we include only the trips in a customer-paycheck-cycle cell with two trips in the regression sample. In column 3, we include only the trips in a customer-paycheck-cycle cell with three trips. Standard errors in parentheses are clustered at the individual level.

Table 5. Monthly mental-budget renewals do not trigger projection bias

	Column 1 Mistake	Column 2 Mistake	Column 3 Variety seeking	Column 4 Variety seeking	Column 5 New-product trying	Column 6 New-product trying	Column 7 Upgrading	Column 8 Upgrading
Credit card users								
ψ	0.00391	-0.0107	0.0555**	0.0947	0.0187**	0.0223	0.00205	0.0145
	(0.0100)	(0.0219)	(0.0258)	(0.0629)	(0.00755)	(0.0165)	(0.00682)	(0.0161)
$\boldsymbol{\varphi_1}$	**-0.00836**	**-0.0295***	**0.0890*****	**0.190*****	**0.00936***	**0.0156**	**-0.00820***	**-0.00659**
	(0.00718)	**(0.0178)**	**(0.0181)**	**(0.0495)**	**(0.00539)**	**(0.0139)**	**(0.00495)**	**(0.0146)**
$\boldsymbol{\varphi_2}$	**-1.51e-05**	**-0.00673**	**-0.0764*****	**0.0896***	**0.00277**	**0.0176**	**0.00128**	**0.00279**
	(0.00718)	**(0.0175)**	**(0.0179)**	**(0.0479)**	**(0.00542)**	**(0.0136)**	**(0.00493)**	**(0.0143)**
$\boldsymbol{\varphi_3}$		**-0.00344**		**-0.0358**		**-0.00231**		**0.0112**
		(0.0180)		**(0.0490)**		**(0.0139)**		**(0.0147)**
Cash users								
ψ	0.0154	0.0206	0.0186	0.0652	0.0259**	0.0475**	0.00737	-0.00759
	(0.0142)	(0.0292)	(0.0278)	(0.0626)	(0.0109)	(0.0231)	(0.00950)	(0.0198)
$\boldsymbol{\varphi_1}$	**-0.0220****	**-0.0380***	**0.0805*****	**0.194*****	**0.00459**	**0.0134**	**0.00134**	**-0.0183**
	(0.00966)	**(0.0209)**	**(0.0187)**	**(0.0515)**	**(0.00737)**	**(0.0171)**	**(0.00664)**	**(0.0169)**
$\boldsymbol{\varphi_2}$	**0.00197**	**-0.0272**	**-0.0458****	**0.0337**	**0.00587**	**0.0130**	**0.0120***	**0.0142**
	(0.00967)	**(0.0206)**	**(0.0185)**	**(0.0498)**	**(0.00735)**	**(0.0168)**	**(0.00658)**	**(0.0164)**
$\boldsymbol{\varphi_3}$		**-0.0177**		**-0.0439**		**0.00419**		**0.00986**
		(0.0214)		**(0.0503)**		**(0.0173)**		**(0.0168)**
$\tilde{f}_{cash}(\tau_t)$ and $\tilde{f}_{card}(\tau_t)$	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Number of customers	99,264	23,407	160,903	31,537	133,009	27,348	154,609	30,860
Number of observations	282,657	58,279	486,055	88,506	388,068	72,235	836,574	155,603
R^2	0.031	0.033	0.105	0.105	0.030	0.029	0.047	0.043

This table reports the results of regressions similar to those in Table 4 but with different dependent variables, including the indicator of whether the customer on the trip purchased a new variety that she never purchased again (mistake), the number of varieties purchased on the trip (variety seeking), the indicator of whether the customer purchases a variety for the first time (new-product trying), and the indicator of whether the product purchased is a high-end variety within one of the eight categories (upgrading). High-end varieties in a category are defined as varieties with prices above the average price of the category. In columns 1, 3, 5, and 7, we include only the trips in a customer-paycheck-cycle cell with two trips in the regression sample. In columns 2, 4, 6, and 8, we include only the trips in a customer-paycheck-cycle cell with three trips. Standard errors in parentheses are clustered at the individual level. * denotes significance at a 10% level. ** denotes significance at a 5% level. *** denotes significance at a 1% level

Online Appendix

Appendix A. Addition figures and tables

Table A.1. Daily-level regressions of discount rates

Dependent variable: The daily discount rates averaged across products	Column 1	Column 2	Column 3	Column 4
The payday indicator	0.00639	0.00640	0.00643	0.00640
	(0.00571)	(0.00434)	(0.00417)	(0.00425)
Intercept	0.296***			
	(0.00101)			
Year fixed effects		✓	✓	✓
Month of a year fixed effects			✓	✓
Day of a week fixed effects				✓
Public holiday indicator				
Number of observations	1826	1826	1826	1826
R^2	0.000718	0.359	0.389	0.393

Standard errors in parentheses are clustered at the individual level. * denotes significance at a 10% level. ** denotes significance at a 5% level. *** denotes significance at a 1% level.

Table A.2. Unconditional daily expenditure on the brand: heterogeneity across high-average-income and low-average-income cities

Dependent variable: Unconditional daily expenditure	Column 1	Column 2	Column 3
γ_1 for high-average-income cities	0.000326	0.00379***	0.0144***
	(0.000755)	(0.00116)	(0.00164)
γ_1 for low-average-income cities	0.000311	0.00368***	0.0117***
	(0.000855)	(0.00130)	(0.00185)
Hypothesis test: γ_1 is not different across high- and low-average-income cities			
F value	0.00	0.00	1.27
P value	0.99	0.95	0.26
$f(\tau_t)$	Linear	Quadratic	Cubic
Other controls: average discount rate, customer fixed effects, store fixed effects, year fixed effects, month of a year fixed effects, day of a week fixed effects, and public holiday indicator	✓	✓	✓
R^2	0.662	0.662	0.660

$$y_{it} = \gamma_0 + \gamma_1 I(\tau_t \geq 0) + f(\tau_t) + \beta X_{it} + \varepsilon_{it},$$

The regressions are similar to those in Table 3 except that γ_1 is allowed to be different across high-average-income and low-average-income cities. Standard errors in parentheses are clustered at the individual level. * denotes significance at a 10% level. ** denotes significance at a 5% level. *** denotes significance at a 1% level.

Table A.3. Linear probability model of store visiting

Dependent variable: Daily indicator of store visit	Column 1	Column 2	Column 3
γ_1 (payday effect)	**-1.70e-14**	**7.65e-15**	**6.22E-14**
	(4.73e-14)	**(1.95e-13)**	**(3.33e-13)**
Average discount rate	4.25e-15	4.45e-15	4.44e-15
	(1.20e-14)	(1.85e-14)	(1.19e-14)
$f(\tau_t)$	Linear	Quadratic	Cubic
Customer fixed effects	✓	✓	✓
Store fixed effects	✓	✓	✓
Year fixed effects	✓	✓	✓
Month of a year fixed effects	✓	✓	✓
Day of a week fixed effects	✓	✓	✓
Public holiday indicator	✓	✓	✓
Number of customers	235,185	235,185	235,185
Number of observations	186,359,552	186,359,552	186,359,552

$$y_{it} = \gamma_0 + \gamma_1 I(\tau_t \geq 0) + f(\tau_t) + \beta X_{it} + \varepsilon_{it}$$

The regressions in this table are at the customer-calendar-day level. The dependent variable y_{it} is a 0-1 indicator of whether customer i makes any purchase at the retail chain on day t. The calendar-day-level observations for a customer include every day from one day after the customer's first trip in the sample period to the day of her last trip. Standard errors in parentheses are clustered at the individual level. * denotes significance at a 10% level. ** denotes significance at a 5% level. *** denotes significance at a 1% level.

Table A.4. Frequency table: customer-paycheck-cycle cells with different numbers of trips

Number of trips in the customer-paycheck-cycle cell	Frequency of cells	Percent
1	3044272	88.02%
2	367887	10.64%
3	40233	1.16%
4	5142	0.15%
5	852	0.02%
6	148	0.00%
7	33	0.00%
8	17	0.00%
9	4	0.00%
10	2	0.00%
11	1	0.00%
12	1	0.00%

Appendix B. Disconfirming present bias

The overshoots in expenditures on paydays are unlikely to be driven by changes in the level of present bias. Present bias operates on the timing of utility of consumption rather than on the timing of purchases or on the timing of monetary payments (see O'Donoghue and Rabin, 2015).

First, the brand only sells storable products (e.g., shampoo, fragrance, makeup) instead of perishable products or instantaneous-consumption products. A product purchased today is to be consumed in the next multiple months. Suppose that a customer is making a decision of whether to purchase a shampoo in this brand today or tomorrow. Most likely, she still has an unfinished shampoo at home, and thus her decision does not affect her utility of consumption today. Although there is a possibility that she has used up her shampoo at home and hence strongly prefers to purchase another shampoo today instead of waiting until tomorrow, the probability of running out the shampoo at home should be identical across a payday and a no-payday.

Second, if a customer makes a decision of whether to purchase a new variety that she has not ever purchased before (either a fragrance (makeup) with a different flavor (color) from the current one in use or a product in another category that she has never purchased before), she may desire to start the consumption flows of this new variety from today instead of waiting until tomorrow. However, this effect can only play an ignorable role in influencing the customer's decision. Suppose that the customer uses fragrance every day and is considering purchasing a new variety of fragrance that takes one month to finish. Following the present bias literature, if she purchases and starts to use it today, the present value of the utility flows associated with the fragrance is as follows:

$$U_1 = u + \beta\delta u + \beta\delta^2 u + \cdots + \beta\delta^{T-1} u$$

where u is the daily utility of consuming the fragrance, δ is the daily discount factor, and T is assumed to be 30. The parameter β captures the level of present bias. If $\beta = 1$, then there is no present bias; if $\beta < 1$, then the customer has present bias. The degree of present bias is decreasing in β. If she purchases it tomorrow, the present value of the utility flows is as follows:

$$U_2 = \beta\delta u + \beta\delta^2 u + \cdots + \beta\delta^{T-1} u + \beta\delta^T u$$

Then, the relative difference between purchasing today or tomorrow is:

$$\frac{U_1 - U_2}{U_1} = \frac{u - \beta\delta^T u}{u + \beta\delta u + \beta\delta^2 u + \cdots + \beta\delta^{T-1} u}$$

Suppose that the annual discount rate is 20% (a very high discount rate), then the corresponding daily discount factor $\delta = 0.8^{\frac{1}{365}} = 0.9994$. Meanwhile, we assume a very high degree of present bias ($\beta = 0.8$). [42] Then, the relative difference $\frac{U_1 - U_2}{U_1} = 0.89\%$, suggesting that whether purchasing today or tomorrow makes almost no difference. The change in $\frac{U_1 - U_2}{U_1}$ due to changes in the degree of present bias β caused by the payday effect is even smaller. Alternatively, if $T = 1$, i.e., the item in consideration is an instantaneous-consumption product instead of a storable product, $\frac{U_1 - U_2}{U_1} = 36\%$, indicating that whether purchasing it today or tomorrow makes much difference.

Although present bias plays a trivial role in decisions of storable-product purchases, consumers still need self-control devices to counteract temptation for higher present consumption. The reason is that trips to this retail chain occur infrequently. Assuming $\beta = 1$ (no present bias, if the customer purchases and starts to use the fragrance today, the present value of the utility flows associated with the fragrance is as follows:

$$U_3 = u + \delta u + \delta^2 u + \cdots + \delta^{T-1} u$$

If she purchases it on the next trip, say, 90 days later, the present value of the utility flows is

$$U_4 = \delta^{90}(u + \delta u + \delta^2 u + \cdots + \delta^{T-1} u)$$

Then, $\frac{U_3 - U_4}{U_3} = 1 - \delta^{90} = 5.35\%$, a nontrivial magnitude of temptation to be counteracted by intrinsic self-control devices.

Carvalho et al. (2014) examined low-income U.S. households and found that the payday effect on them should be mainly attributed to changes in the liquidity constraints instead of changes in the level of present bias. The reason is that the behavior difference between before and after paydays is significant only when making intertemporal choices about monetary rewards and is insignificant when making intertemporal choices about non-monetary real-effort tasks. While low-

[42] Note that Augenblick et al. (2015) estimated weekly δ to be 0.9930 (daily δ to be 0.9990) and β to be 0.9. See O'Donoghue and Rabin (2015) for a thorough literature review on present bias.

income consumers face different monetary liquidity constraints between before and after paydays, they do not face different time constraints. Augenblick et al. (2015) also suggested that intertemporal choices about real effort are better suited than intertemporal choices about monetary rewards to study present-biased preferences, because the latter are subject to several confounds.