Sticking to Your Plan: Empirical Evidence on the Role of Present Bias for Credit Card Paydown*

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Abstract

I use data from an online financial service to show that many consumers fail to stick to their self-set debt paydown plans, and argue that this behavior is best explained by present bias. Each user's sensitivity of consumption spending to paycheck receipt proxies for his short-run impatience. I empirically distinguish between consumers who are aware (sophisticated) and unaware (naive) of their future impatience by exploiting that this sensitivity varies with available resources for sophisticates only. Consistent with present bias, I find that sophisticated agents' planned paydown is more predictive of actual paydown than that of naives, and that their paydown falls with higher measured impatience. This highlights the importance of distinguishing between sophisticated and naive present-biased individuals in understanding their financial decision making.

In 2010, nearly 70% of households in the United States had at least one credit card, and more than half carried credit card balances from month to month. With interest-bearing debt averaging around $12,900 per household, and with a median interest rate of 13%, the cost of interest to the average American household was more than $140 per month (Ackerman, Fries, and Windle, 2012). At such substantial cost, the extent of credit card debt might appear puzzling. Previous work has indeed documented a variety of behaviors in credit

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markets that are hard to reconcile with standard motives for borrowing (see, for instance, Agarwal, Chomsisengphet, Mahoney, and Stroebel (2015b), Keys and Wang (2014), Agarwal and Mazumder (2013), Agarwal, Amromin, Ben-David, Chomsisengphet, and Evanoff (2010), Agarwal, Driscoll, Gabaix, and Laibson (2008)).

One potential explanation for the observed extent of household borrowing proposed by behavioral economists is present bias (e.g. Ausubel (1991), Laibson (1997), Heidhues and Kőszegi (2010) and Meier and Sprenger (2010)). According to this explanation, households are overly impatient in the short run relative to their long-run preferences. They borrow excessively and often fail to repay later, despite a genuine intention to reduce their debt.

In this paper, I use a unique dataset on planned and actual debt paydown to document that many consumers fail to follow through with self-set debt paydown plans. I then present an empirical measure for both features of an individual's present bias, the level of short-run impatience and the individual's awareness of her impatience. Using this measure, I show that considering an individual's potential present bias and, importantly, the individual's awareness of their own present bias (sophistication), significantly improves our understanding of her debt repayment patterns.

I study a sample of consumers who signed up for an online financial management service. The data contain the daily balances and transactions on all of their bank accounts and credit cards. Upon joining the service, users make a plan on how much they would like to reduce their debt balances each month. This feature allows me to evaluate success in debt paydown relative to a user's original plan. I find that planned debt paydown is predictive of actual paydown. No other characteristic, such as monthly income or original debt levels, significantly affects actual paydown once the user's original plan is controlled for. However, most users fall substantially short of their original paydown plans. For each dollar of planned paydown, the average user only reduces debt by 25 to 30 cents.

To understand whether potential present bias can explain this shortfall in actual relative to originally planned paydown, I use information on high-frequency consumption spending to measure an individual's short-run impatience. I also present a novel way to measure the degree to which individuals are aware of their impatience, classifying them as "sophisticated"(aware) or "naive"(unaware), to use the terminology of O'Donoghue and Rabin (1999). Finally, I show that the relationship between an individual's measures of present bias and debt paydown behavior is consistent with present bias, and that the distinction between sophisticated and naive users is important for understanding their debt paydown behavior. While alternative explanations can account for some features in the data, I argue that only present bias rationalizes all observed patterns.

Present bias suggests that for an individual who lives "paycheck to paycheck", the time

pattern of spending within paycheck periods will be influenced by short-run impatience: more impatient individuals consume more immediately after receiving the paycheck, and then their consumption declines until the next paycheck (Shapiro (2005)).[1] To measure each individual's level of impatience, I estimate the degree of such behavior using expenditures for goods which are instantly consumed, such as restaurant meals. I filter out the impact of other possible explanations, such as short-term credit constraints. Models of present bias further suggest that, unlike naive consumers, sophisticated consumers act more patiently when they have more available resources, and their consumption between paychecks becomes more even. To estimate how consumption sensitivity to paycheck varies with the level of resources, I exploit within-individual variation in resources over time. I address the potential endogeneity of available resources to consumption patterns by instrumenting with hypothetical balances based on regular, non-discretionary payments such as monthly rent. Based on these estimates, I classify households as sophisticated or naive.

I then relate these measures of impatience and sophistication to individual debt repayment behavior. For present-biased consumers, it is attractive to delay paying down debt from the current to the next pay cycle. This behavior allows them to avoid reducing consumption in the current pay cycle, when it is particularly valued. At the same time, the long-run cost between debt paid off two weeks earlier or later is small. Naive consumers are unaware of their future impatience, so they plan to repay their debt in the next pay cycle when they (incorrectly) believe they will be more patient. They do not realize that, when faced with the same decision in the future, they will repeatedly want to delay debt paydown. Thus they will often not actually succeed in paying off their debt. Sophisticated agents are aware of their future impatience, plan accordingly, and are able to reduce their debt levels. Amongst sophisticates, more impatient agents consume more and save less for debt paydown.

Empirically, I find that planned paydown is indeed significantly more predictive of actual paydown for users classified as sophisticated relative to naive users. For sophisticated individuals, higher impatience leads to lower debt paydown. Naive agents often do not adhere to their paydown plans irrespective of their degree of impatience. This behavior is consistent with the notion that these households repeatedly delay debt paydown. These findings confirm the implications of present bias for both types of consumers, and suggest that both, an individual's level of short-run impatience, as well as their sophistication, are key factors in

[1] Other papers have documented the sensitivity of consumption to the receipt of a paycheck (e.g., Stephens (2006), Hastings and Washington (2010), Gelman, Kariv, Shapiro, Silverman, and Tadelis (2014)) or other expected payments (e.g., Souleles (1999), Browning and Collado (2001), Hsieh (2003), Parker (1999), Scholnick (2013), Baugh, Ben-David, and Park (2014)), but have often not explicitly attributed this phenomenon to hyperbolic discounting. In a field experiment, Kaur, Kremer, and Mullainathan (2010) randomize when workers are paid and find evidence for self control problems with respect to work effort. Jappelli and Pistaferri (2010) survey this literature on consumption responses to income changes.

explaining her debt repayment behavior.

In general, it is hard to detect time-inconsistent behavior because an agent's initial intent and preferences are usually unobserved. My ability to measure success in debt paydown relative to each individual's intent strengthens the interpretation of failure to reduce debt levels as an actual deviation from planned behavior, rather than an ex-ante optimal behavior given unobserved factors.[2] The interpretation of my results as evidence for present bias is further strengthened by the large differences between those users classified as naive and those classified as sophisticated. Alternative explanations for failure to follow through with plans, such as overoptimism or an interpretation of plans as aspirational would not predict this relationship with my measure of sophistication. The ability to make and follow realistic plans is also one of the key theoretical distinctions between sophisticated and naive agents. Empirically confirming this behavior difference validates not only my empirical measure of sophistication, but also reinforces the importance of distinguishing between the two types in theoretical models of individual behavior.

I consider a number of alternative explanations for both the individuals' consumption sensitivity to paycheck receipt, and their debt repayment behavior. While some possible explanations might be consistent with either one of the observed patterns, no competing explanation can explain the joint behavior of consumption and debt repayment observed in the data. For example, some people might have developed a habit of going out for "date night" every two weeks. This behavior might, by chance, overlap with the receipt of their paycheck in a way that is unrelated to short-run impatience. However, if such behavior was driving observed consumption responses to paycheck receipt, one would not expect these agents to also have differential debt repayment behavior. I discuss that. for similar reasons, the following factors also fail to explain the joint patterns of consumption spending behavior and debt paydown: Non-separabilities in consumption or social coordination of consumption spending, time consistent preferences with high discount factors, loss of income, differences in the interpretation of what a plan means (e.g., aspirational versus realistic planning), overoptimism, a lack of planning skills, and financial literacy. The empirical results are also robust to different approaches to filtering out confounding factors, such as credit constraints and variations in measuring short-run impatience and sophistication. Specifically, I show that the consumption patterns used to measure short-run impatience and sophistication do not affect debt paydown other than through present bias. When estimating the sensitivity of consumption spending to paycheck receipt, my measure of short-run impatience, the results

[2]It does not allow me to rule out that the failure to pay down debt is due to shocks users receive after they have made their paydown plan. However, such random shocks are not expected to be systematically related to the observed characteristics of the user, especially those used to distinguish between naive and sophisticated individuals.

are robust to varying the number of days of spending required for sample inclusion and to alternative specifications, such as using levels or weekly spending instead of daily log spending, and using debit card spending only. Finally, as predicted by present bias, differences in behavior between sophisticated and naive users are driven by those with substantial levels of impatience, and excluding users who are noisily classified strengthens the results. I also illustrate the difference between using IV estimates, my preferred specification, rather than OLS estimates to classify users as sophisticated or naive.

Starting with Laibson (1997), several papers have used representative agent models to explore the role of present-biased preferences in explaining a wide range of aggregate consumption and financial decisions. They show that models with present-biased agents, modeled by quasi-hyperbolic discounting, can often rationalize the data better than models with standard time-consistent agents. For instance, Laibson, Repetto, and Tobacman (2007) estimate a life-cycle model with liquid and illiquid wealth, and find that the simultaneous holding of both types of assets can be explained by a model with present bias. Shui and Ausubel (2005) show that present bias can explain consumer choices between different credit card offers.[3] The current paper complements this literature by showing that cross-sectional variation in repayment behavior corresponds to cross-sectional differences in measured short-run impatience and sophistication.

Other papers have explored the role of present bias at the individual level. Meier and Sprenger (2010) conduct experiments to measure consumer impatience and find that more present-biased individuals have higher levels of credit card debt. Ashraf, Karlan, and Yin (2006) elicit time preferences via a survey, and find that consumers with a lower discount rate were more likely to use a savings commitment product offered.[4] Rather than determining impatience experimentally or through a survey, I infer the extent of short-run impatience directly from individuals' observed, real-life consumption behavior. This empirical approach also allows me to infer whether a person is aware of their short-run impatience (sophisticated), something previous papers have not been able to measure. The unique information on planned behavior also allows to validate this measure by showing that it is associated with following

[3] Skiba and Tobacman (2008) find that the behavior of payday loan borrowers is better captured by the hyperbolic model than the standard model. Paserman (2008), Fang and Silverman (2009) and Fang and Wang (2014) use similar approaches to show the effect of present bias on job searches, welfare program participation and mammogram usage.

[4] Several other papers have documented the influence of present bias based on consumer's choices between different contracting options. For instance, Madrian and Shea (2001), Choi, Laibson, Madrian, and Metrick (2004) and Carroll, Choi, Laibson, Madrian, and Metrick (2009) document the importance of default options in 401(k) savings plans, which can be attributed to the tendency of present-biased consumers to procrastinate. Present-biased preferences have also been shown to explain consumers' decisions regarding workouts (DellaVigna and Malmendier (2006)) or homework assignments (Ariely and Wertenbroch (2002)). DellaVigna (2009) provides an overview of the empirical evidence.

through with originally-made plans - a key difference in the behavior of sophisticated and naive agents. Since data on spending patterns is becoming more commonly available, the inference of a user's level of impatience and sophistication from consumption patterns can also be applied in other empirical settings.

The paper continues as following: Section 1 describes the data and presents summary statistics. Section 2 shows planned and actual paydown of users in my sample. Section 3 illustrates how present bias is reflected in consumption patterns and derives empirical predictions about debt paydown. Section 4 presents these consumption patterns and shows how they are used to measure impatience and sophistication. Section 5 presents the main results. Section 6 discusses alternative explanations and provides robustness checks, Section 7 concludes.

1 Data

1.1 Empirical Setting

The data are obtained from the online financial management service ReadyForZero (www.readyforzero.com), which offers users free help in managing their debt.[5] When customers sign up, they are prompted to make a plan of how much they want to reduce their debt each month, and are encouraged to link their bank accounts and credit cards, which grants the company read access. For each account, the data include daily snapshots of the balance, credit limit and transactions. The transaction data show the amount, date charged and description the customer sees on his bank account statement, as well as a code from the data provider which classifies transactions into different categories.[6] Based on the information provided, customers receive various types of advice, ranging from how to distribute their monthly planned payments amongst multiple credit cards to warnings about the implications of large expenditures. Many of the offered services, such as help in calculating how to split payments, can presumably appeal to a variety of households, irrespective of impatience or sophistication. It is therefore likely that this websites attracts users who vary in terms of these characteristics. Some of the services offered could potentially serve as commitment devices by increasing the psychological cost of deviating from planned consumption. However, the website does not actually restrict user behavior in any binding way.

[5] After the sample period of my data, ReadyForZero introduced a premium version of their product that allows users to make payments through the website.

[6] Gelman, Kariv, Shapiro, Silverman, and Tadelis (2014), Baugh, Ben-David, and Park (2014) and Baker (2013) use similar datasets from different data providers.

1.2 Sample Selection

I focus on those individuals who (i) have linked their checking account, (ii) receive regular bi-weekly paychecks, and (iii) appear to have linked all their active credit card accounts. These exclude a substantial fraction of users, most of whom have only linked their credit card accounts. I further restrict the sample to those users whom I observe for at least 180 days after sign up.[7] This allows me to measure how successful users are in sticking to their plan to pay off their credit card debt. The final sample includes a total of 516 users who fulfilled these criteria in September 2012.[8] Appendix C describes the sample selection in detail. To identify those with regular paychecks, I first isolate transactions which are likely paychecks. A user receives regular bi-weekly paychecks if he receives paychecks of similar amounts about every two weeks (13 to 16 days apart) and at most one paycheck is missed. To be included in the sample, regular paychecks are also required to account for at least 70% of a user's income.[9] I further restrict the sample to users for whom spending over time appears to be primarily financed by the observed income and changes in assets. This approach excludes users who most likely have additional sources of income that I do not observe, such as users with accounts that are not linked. I also exclude users who have only recently linked all their accounts such that at early times in the sample, observed spending or debt balances are known to be incomplete. Finally, I require users to have at least eight qualifying pay cycles with at least 45 days of spending on consumption goods to allow me to estimate individual level impatience and sophistication.

1.3 Income, Assets and Debt Paydown

The first panel of Table 1 shows that the median user is observed in the sample for over one year (415 days). During this time, the average user receives 28 paychecks, of which 21 are regular pay cycles during which the paycheck arrives on time and no additional payment is received in the same pay cycle. During regular pay cycles, the average user receives $3,805 per month on average; the median user receives $3,460.[10] The average credit card debt at

[7] A few users do not have a linked credit card account. Others do not make an explicit plan to reduce their debt and are therefore excluded from the sample.

[8] One concern may be that users in the final sample are likely to differ from the average user along several dimensions, many of which are unobserved. However, the users of ReadyForZero are a highly selected group to begin with. They are also uniquely suited to study the effect of potential present bias on debt repayment behavior. Further selecting a subset of users which best allows me to study such an effect does not lead to any additional loss in generalizability of the results.

[9] In the 2010 Survey of Consumer Finance, Ackerman, Fries, and Windle (2012) report that, on average, 68% of household income is made up of wages.

[10] In the 2010 Survey of Consumer Finance (SCF), Ackerman, Fries, and Windle (2012) find a median annual household income of $45,800 and average income of $78,500, of which roughly 70% are wages. Annual

sign-up is $13,942, or more than four times the user's average monthly income. Therefore, average debt is slightly higher than the $12,900 carried by households with revolving balances in the 2010 Survey of Consumer Finances (see Ackerman, Fries, and Windle (2012)). Data on interest rates is only available for a subset of accounts. Consumers face an average APR of 16.7% on their credit card accounts. On their bank account, users have an average cash balance of $5,584 and a median cash balance of $2,099, corresponding to 64% of average monthly income. Users also have substantial borrowing capacity left on their cards, $11,010 on average. There is significant heterogeneity across users in debt levels, both in absolute and in relative terms. The 25th percentile's debt level is 140% of monthly income, while the 75th percentile has almost five times as much debt as monthly income.

1.4 Spending

I measure spending by examining all purchases made with credit or checking cards. Each transaction is already classified into one of about 50 different spending categories, such as restaurant meals, groceries or utilities. I also observe cash withdrawals. I distinguish between three different kinds of expenditures: regular payments, discretionary spending and spending that qualifies as neither. Regular payments primarily include rent, mortgage and loan interest payments, but also smaller expenses such as magazine subscriptions.[11] Non-regular payments are classified as discretionary or non-discretionary based on the category assigned by the data provider. Discretionary expenditures are those for which the consumer had a choice of whether to incur the expense close to when it had to be paid or had discretion over how much to spend. Non-discretionary expenses are those for which the amount due depends on the accumulated behavior of the consumers in the past, but the consumer has no discretion on how much to pay once the bill arrives. Non-discretionary expenses primarily include utility or cell phone bills and similar expenses. Since consumption is not observed in the data, I proxy for consumption with expenditures likely to be consumed immediately or shortly after purchase.[12] Specifically, I focus on short-run consumables, such as restaurant meals, groceries, gas and entertainment, as well as exclusively restaurant and entertainment expenditures.[13]

Table 2 shows summary statistics of user's monthly expenditures. Total monthly discre-

median wage income is about $42,000 (12*3,460) so users in my sample earn more in wages than the median ($42,000 versus $45,800*.7=32,000), but less than the average ($46,000 = 12*3,805 versus $78,500*.7 = $55,000) household in the SCF.

[11]The appendix describes the identification of regular payments in detail. A set of transactions is classified as regular if the payments are about equal to each other and the payments are mostly 7, 14 or 30 days apart and not more than one payment was missed.

[12]Gelman, Kariv, Shapiro, Silverman, and Tadelis (2014) find that regular spending often coincides with income receipt, stressing the need to filter out regular payments and non-discretionary spending.

[13]The Online Appendix lists the types of expenditures included in each of these categories.

tionary spending is about $1,804 for the average user, which corresponds to about 52% of the user's regular income. Just under 30% of discretionary spending, $505, is spent on short-run consumables, of which $291 go to restaurant meals and entertainment.[14] Regular monthly payments average $1,211 per month, equivalent to 34% of users' regular income. Median monthly spending is slightly lower in all categories, but shows similar patterns.

2 Planned and Actual Paydown

The unique feature of my data is the information on planned paydown. When users sign up for an account at ReadyForZero, they are prompted to state how much they want to reduce their debt each month.[15] Based on this information, users receive payment reminders and the website helps them calculate how to split this monthly payment between the user's different accounts users. [16]

Table 3 shows that the average user plans to reduce their debt by $891 per month, which corresponds to 12% of debt balances and to 25% of the user's monthly income. The median of planned paydown is lower at $598, corresponding to 6% of debt levels and 18% of monthly income. Given these plans, the average user aims to reduce their debt level by 30% over the next three months and by almost half over the next 6 months.

Table 4 shows that planned paydown is strongly related to income and original debt levels. For each dollar of additional income users plan to spend between 30 and 40 cents on debt reduction. Original debt levels also increase planned paydown but not by much: an increase of $100 in debt is associated with $2 of higher planned paydown each month. Cash balances, remaining available credit, discretionary spending, the interest rate paid, and the number of credit cards owned have no significant effect on planned paydown. However, users who use their credit cards more, plan to pay more on debt reduction each month.

Compared to planned paydown, actual changes in debt levels are much lower. After 3 months, the average user has reduced debt levels by only $734 according to Table 3 - an average shortfall of $1,784, or 85% relative to the originally planned amount. A substantial

[14]Spending ratios in Table 2 are expressed in terms of a user's regular income. Many users have additional sources of income supplementing a dominant regular paycheck. Also, returns of earlier purchases to the store are hard to differentiate from additional irregular income. Therefore, the ratios of spending relative to user's regular income may appear relatively high.

[15]To do this, the user sees a screen with two bars showing the amount of monthly payment and the corresponding time it will take to repay their current debt. User can move a cursor to adjust the payment amount and time till paid off simultaneously until they settle on a certain amount. The website does allow users to change their plans later on, but no users in my sample do so.

[16]When calculating how to split a payment, the website helps users make sure they pay the minimum payment on each account and any remainder on the account with the highest interest charges. I abstract from the effect of different possible minimum payments as studied by Keys and Wang (2014) in this paper.

fraction of users even increase their debt levels, as reflected in the increase in debt of $292 for the 75th percentile. While consumers do not reduce their debt levels much relative to their original plans, most make substantial payments on their credit cards. However, additional spending usually offsets the payments made. Table 4 shows the relationship between planned and actual paydown controlling for additional user characteristics. For each dollar in planned paydown, the average user pays down between 25 and 29 cents. While most users therefore fall substantially short of their plans, originally planned paydown is still the single most predictive factor for actual paydown. Controlling for planned paydown, the user's income, debt levels, cash balances, available credit or spending behavior do not significantly affect actual debt reduction. This indicates that planned paydown contains additional information about the user's ability to reduce debt not captured by income or spending, such as spending needs or the ease of reducing spending.

Overall, the results show that while plans are predictive of actual paydown, many users have substantial problems following their plans to reduce credit card debt.[17] Not following through with originally made plans is a key prediction of present bias when individuals are naive about their own present bias. The remainder of the paper analyzes the what extent present bias can indeed explain the observed failure of sticking with debt paydown plans.

3 Present Bias, Debt Paydown and Consumption Patterns

Key theoretical insights and the possible implications of present bias are well established in the literature (e.g., Laibson, Repetto, and Tobacman (2003)). This section builds on this work to provide intuition on how present bias can affect consumption patterns and debt paydown decisions in my empirical setting. When interpreting the empirical results, I will show that the observed patterns are consistent with this intuition of present bias. I will also argue that no alternative explanation produces similar *joint* patterns of consumption choices and paydown decision, even though each resulting pattern on its own might be consistent with alternative explanations.[18]

[17] The results are very similar using paydown after 180 days instead of after 90 days.

[18] Present bias alone does not necessarily lead to the described effects in all possible situations, for instance if there is full commitment or if individuals have very large wealth. I will point out such restrictions but argue that they are unlikely to be important in my empirical setting.

3.1 Short-run Impatience and Sophistication

I think about present bias in terms of quasi-hyperbolic preferences, a popular way of modeling present bias. Each period t an agent with quasi-hyperbolic preferences discounts payoffs in period τ by $\beta\delta^{\tau-t}$, where $\beta \in [0,1]$ and $\delta \in [0,1]$. The agent's discount factor between any two periods is therefore not constant over time. Between any two consecutive future periods, the agent discounts by δ. In the short run, the agent is more impatient and applies an additional discount factor of β between the current and future periods. The lower β is, the more impatient the agent is in the short-run relative to his long-run preferences. β^E is the agent's expectation of his future impatience factor β. I focus on two extreme cases. A *sophisticated* agent is perfectly aware of his short-run impatience, i.e. $\beta^E = \beta$. A *naive* agent believes that his future preferences will be identical to his current preferences, not realizing that his future self will become impatient. Hence, $\beta^E = 1$ for naive agents. These preferences nest a standard, time-consistent, exponentially discounting agent with $\beta^E = \beta = 1$. I assume that all agents have the same long-term discount factor δ.[19]

3.2 Setting

Throughout the paper I focus on individuals who receive regular paychecks every two weeks. Individuals expect to live and receive paychecks for many years. Each paycycle, individuals decide how much to consume in each of the two weeks of the cycle, and how much to save for debt paydown. Users in my sample have little liquid wealth - only a little more than a regular monthly income on average, as shown in Table 1 - so I focus on individuals living paycheck to paycheck without substantial wealth to draw down. All users already have accumulated substantial debt once they enter the sample, so I abstract from debt build up in this paper.

3.3 Debt Paydown

Each paycycle, the agent decides whether to save some of his paycheck for debt reduction. Since the agent's lifetime utility is not affected much by whether debt is paid off two weeks earlier or later, saving little or entirely delaying a payment is attractive to present-biased agents. By definition, saving yields payouts in the future but entails current costs in the form of forgone consumption, which a present-biased agent overvalues relative to future benefits. When delaying debt reduction to the next pay cycle, this is not the case. Both the costs and benefits of reduced consumption lie in the future, so costs are not overvalued relative to benefits. If the agent can follow through with a plan to pay down debt the next pay cycle,

[19] Section 6.3 discusses why differences in the long-term discount factor cannot explain my results.

the benefit of saving in the current pay cycle is very low.

A naive agent indeed believes that his future selves will share the long-term preferences of the current self and will follow through with such a savings plan. Hence, a naive agent is likely to plan to save in the next pay cycle. He does not realize that he will be equally impatient in the future and will still want to delay debt payment. This behavior happens despite the fact that the naive agent does actually consider saving worthwhile; if faced with the choice of saving in the current period or not at all, he would prefer to save. Also note that as long as the agent's impatience is high enough to make delaying debt payment by one pay cycle attractive, the extent of the agent's impatience has little influence on his actual paydown. Irrespective of the extent of their present-bias, naive agents are prone to persistently procrastinate. This insight of naive agents' tendency to procrastinate costly tasks has been studied in general by O'Donoghue and Rabin (1999) and applied to retirement savings by Rabin and O'Donoghue (1999).[20]

Unlike the naive agent, a sophisticated agent is aware of his future impatience and knows that he cannot rely on his future self to save. However, the trade-off between saving and current consumption directly depends on the agent's level of short-run impatience. More present-biased agents consume more and save less in the current pay cycle, all else being equal.[21] Intuition 1 and 2 summarize these insights.

Intuition 1. *Naive agents are prone to procrastinate paying down their debt. Irrespective of the level of short-run impatience, they often fail to follow through with debt paydown plans.*

Intuition 2. *Sophisticated agents understand their own present bias and plan accordingly.*

[20] The literature has found little procrastination by naive agents and, hence, little difference in the behavior of naive and sophisticated agents in models in which any delay is costly. One example is an "eat-the-pie" problem. If the agent consumes a lot in the current period, his consumption in all future periods will have to be lower, so naive agents still find it worthwhile to save since they cannot expect their future selves to make up for a lack of savings in the current period. Similarly, in models with long periods, deferring savings by one period, usually a year rather than a few days, is more costly. Accordingly, Angeletos, Laibson, Repetto, Tobacman, and Weinberg (2001), for instance, find only small differences in the behavior of naive and sophisticated agents in a model of life cycle savings decisions in which the agent lives for 90 year-long periods.

[21] In addition to the direct effect of short-run impatience just outlined, higher impatience also affects the agent's trade-off between consumption and saving through two opposing indirect effects. First, if the agent is less impatient, his future selves are less impatient and choose resource allocations that better correspond to the agent's long-run preferences. A less impatient agent receives higher utility from the same future cash benefits of savings since he knows his future selves will allocate them more efficiently. Second, if the agent's future selves are more patient, they may also save more, decreasing the utility from additional savings in the current period due to wealth effects. I assume that the direct effect of impatience dominates behavior, such that more impatient agents save more. Theoretically, this assumption need not hold in all cases, as shown by Harris and Laibson (2002). However, they also find that for empirically sensible calibrations, consumption functions (and hence savings) are well behaved. The more impatient agents are, the more they consume and the less they save (Figure 4 in their paper).

Sophisticated agents are therefore better in following debt paydown plans than naifs. Amongst sophisticates, more impatient agents pay down less than more patient ones.

3.4 Consumption over the Pay Cycle

When deciding how to split consumption over the paycycle, both naive and sophisticated present-biased agents prefer to consume more early in the paycycle. That preference is stronger the higher their short-run impatience (lower β). Relative to a time-consistent agent, the consumption of both types of present-biased agents is therefore excessively sensitive to paycheck receipt. Intuition 3 summarizes this idea.

Intuition 3. *Present-biased agents consume more early in the paycycle, making their consumption spending sensitive to paycheck receipt. More impatient agents consume more early on than less impatient agents.*

Several papers have indeed documented excess sensitivity of consumption to the receipt of a paycheck (e.g., Stephens (2006), Hastings and Washington (2010), Gelman, Kariv, Shapiro, Silverman, and Tadelis (2014)) or other expected payments (e.g., Souleles (1999), Browning and Collado (2001), Hsieh (2003), Parker (1999), Scholnick (2013), Baugh, Ben-David, and Park (2014)) and Shapiro (2005) has argued that such behavior is best explained by present bias. In the empirical analysis, I will therefore use the extent of this sensitivity as a proxy for each individual's short-run impatience (β).

Differences between sophisticated and naive agents arise when individuals' current choices depend on their beliefs about their future choices, for instance because they pass on resources intended for debt paydown to their future selves. A naive agent does not anticipate being overly impatient in the future. Instead, he believes his future selves will share his current self's (relatively patient) long-run preferences. After deciding how much to save for debt paydown, the naive agent plans to split the remainder between current and future consumption such that the ratio of first to second period marginal utility is equal to the discount factor between the two periods, $\beta\delta \leq 1$. He expects his future self to follow through with this plan.

Unlike naive agents, sophisticated agents know that their future selves do not share their more patient long-run preferences, and will again be overly impatient. They know that of the resources left to the second period self, a smaller fraction will be saved by the future self than the first period self would like. How many resources the second period self consumes rather than saves depends on the level of available resources. When resources are higher, the declining marginal utility of consumption leads future selves to consume a smaller share of any marginal resources passed on to them. Hence, future selves act more in the interest of the first period's self. Aware of this reduced conflict in future resource allocation, the current

self is more willing to pass on additional resources to his future selves.[22] The insight that sophisticated agents act more patiently when available resources are higher has previously been pointed out by Harris and Laibson (2002).[23] This is not the case for naive agents, however, who are unaware of potential conflict of interest with their future selves.[24] Intuition 4 summarizes this insight. In the empirical analysis, I will distinguish between sophisticated and naive agents based on whether they appear to act more patiently when resources are higher.

Intuition 4. *Sophisticates are aware of the reduced conflict of interest with their future self when available resources are higher. They therefore act more patiently when resources are higher, leading them to smooth consumption more. Naive agents do not exhibit this behavior.*

3.5 Joint Patterns of Consumption and Debt Paydown

Figure 1 summarizes the implications of present bias for consumption over the paycycle and debt paydown and relates them to each other. The two upper panels show the sensitivity of consumption spending to paycheck receipt for sophisticated and naive agents. For both types, higher levels of short-run impatience are reflected in higher sensitivity of consumption spending to paycheck receipt (Intuition 3). Sophisticated agents act more patiently when

[22] Consider the following stylized example to illustrate this effect. Anna is present-biased and likes to eat chocolate after each of her three teaching days per week, but has diminishing marginal utility from chocolate. She receives 4 chocolate bars at the beginning of the week. Ideally, she would like to eat two bars after her first class and save one each for the next two teaching days. However, she knows that she won't have the willpower to not eat both chocolate bars the next day. Since she won't have chocolate left for the third teaching day anyways, she decides to eat the third chocolate bar immediately rather than attempting to save it. Next week, Anna receives twice as many chocolate bars, 8. Again, she would prefer to eat half of them, 4, on the first day and save the other half for the two remaining teaching days. Again, she knows that the second day, she will be tempted to not just eat two, but three of the remaining chocolate bars. However, she also knows that she won't eat all 4 but save one for the last day. She decides to eat half the bars today, and save the other half for the next two days. In this case, she's more willing to save the additional chocolate bar, knowing that she won't eat all of them the next day, and that at least one will be left for the last day. Having more chocolate bars has made her act more patiently in the first period.

[23] Harris and Laibson (2002) do not model paycycles in their paper; agents receive i.i.d. income every period. I therefore have to assume that the intuition generalizes into my setting of regular paycycles. As far as I am aware, this has not been shown theoretically. However, should the result not generalize, my empirical measure of sophistication should not be able to distinguish sophisticates and naives well and lead to a bias against finding any differences.

[24] Note that hyperbolic discounting will not lead to this effect in all possible settings. For instance, if there is perfect commitment for sophisticated agents, the current self does not have to take any possible deviations of future selves into account. Similarly, for naive agents, planned consumption may not equal actual consumption. In the second period, the naive agent will end up consuming more than he had planned to, decreasing his actual consumption ratios. As argued above differences in the perceived value of savings will lead the naive agent to plan to save very little, leaving few additional resources to the second period self. This effect will therefore be small relative to that for the sophisticated agent.

resources are higher, so sensitivity is lower as resources are higher. This is not the case for naive agents (Intuition 4).

The two lower panels show planned and actual paydown for both types of agents. Sophisticated agents are aware of their future impatience. They plan accordingly and follow their plans, so their planned paydown is predictive of actual paydown. However, more impatient agents reduce their debt levels less, since they value current consumption more and perceive saving for debt paydown as particularly costly. Hence, the paydown of sophisticated agents decreases as their level of impatience rises (Intuition 2). Naive agents do not expect themselves to be overly impatient in the future and plan to reduce their debt levels substantially. However, when it is time to make payments, naive agents prefer to delay, making them prone to repeatedly procrastinate. Therefore, planned paydown is substantially less predictive of actual paydown for naive agents. Moreover, as long as the agent is impatient enough in the short-run to delay payments, the level of impatience is not predictive of the amount paid down (Intuition 1). Figure 1 shows that agents with no or very low levels of short-run impatience successfully plan to reduce their debt. If a person's present bias is small, neither the bias nor the agent's awareness of it much affects behavior.[25]

3.6 Evaluating the Role of Present Bias in the Data

The illustration of the effect of present bias so far has been stylized to convey the intuition established previously in other work. Before taking this intuition to the data - a naturally more complex setting - this section discusses how some of the simplifications can be adapted while preserving the same intuition.

For the consumption spending of present-biased agents to be sensitive to paycheck receipt, the agents' ability to consume out of future paychecks has to be limited. Users in my sample indeed have very limited cash resources, but many have substantial borrowing capacity which would allow them to smooth shocks. This may appear inconsistent with the idea that they live paycheck to paycheck. However, as long as financing consumption out of borrowing capacity rather than income is more costly, consumption spending will be sensitive to paycheck receipt. There are several reasons for why I expect this to be true in my setting: First, with substantial credit card debt, incurring further debt is costly. Consumers have to pay interest, 16.7% per year on average, on the additional debt. In addition, banks often increase minimum payments for higher debt levels and can raise interest rates as balances increase. Second, spare borrowing capacity often serves as a buffer stock against future shocks, so reducing it eliminates some of these benefits. It also restricts the use of a credit card for transaction

[25]The implications of empirically distinguishing between naive and sophisticated agents are addressed in detail in Section 6.

purposes. Finally, mental accounting may lead users to perceive high psychological costs of borrowing for consumption but not for consuming their regular paycheck.[26] Any of these reasons will make consumption out of borrowing rather than income more costly to the individual. It is therefore plausible that households live paycheck to paycheck in terms of their consumption, even with substantial extra borrowing capacity that could be used to smooth shocks.

The outlined patterns of consumption and debt paydown also do not arise from present bias alone under all theoretically possible parametrizations. For instance, if consumers could perfectly commit their future selves to follow the current self's plan, sophisticated users would not need to worry about their future behavior. They would therefore not act any differently when they have higher or lower resources and I would be unable to distinguish the two types. When interpreting my empirical results, I argue that present bias is the only explanation consistent with the behavior observed in the data. However, present bias alone does not necessarily lead to these observed patterns in all other scenarios.

Finally, similar predictions as outlined for present bias for either the consumption response to paycheck receipt or for differential paydown could be derived from alternative models of household behavior. For example, credit constraints, habits and inseparabilities between different consumption types could also explain why people spend more in the week following a paycheck receipt. Income shocks and overoptimism can also lead users to fail to stick to their debt reduction plan. Some of the explanations, such as the role of credit constraints, can be filtered out directly. Other explanations cannot be ruled out to explain either sensitivity to paycheck receipt or a failure to stick to debt paydown plans. In Section 6, I discuss these possible alternative explanations of the two phenomena and argue that present bias is the only explanation that is *jointly* consistent with both the expenditure sensitivity to paycheck receipt and the differential debt repayment behavior.

4 Consumption Patterns

This section estimates each user's sensitivity to paycheck receipt and how it is affected by varying resources over time (see Intuition 3 and 4). These consumption patterns capture a user's level of short-run impatience and sophistication, which I relate to debt paydown behavior in the next section.

[26] See Thaler (1990) for a description of the concept of mental accounting.

4.1 Sensitivity of Consumption to Paycheck Receipt

4.1.1 Regression Equation

The average sensitivity of consumption spending to paycheck receipt for user i is estimated in the following equation:

$$log(E_{it}) = \alpha_i + payweek_{it}\gamma_{1i} + X_{it}\psi_i + \varepsilon_{it} \tag{1}$$

E_{it} are user i's consumption expenditures on day t. $payweek_{it}$ is an indicator equal to 1 on the day of paycheck receipt and on the 6 subsequent days. X_{it} includes month fixed effects and day-of-week fixed effects. Estimating equation (1) separately for each user yields a user-specific estimate of sensitivity of consumption spending to paycheck receipt, captured by the coefficient on payweek, γ_{1i}.

I focus on two categories of consumption expenditures E_{it}: all short-run consumables and exclusively restaurant and entertainment.[27] In addition to restaurant and entertainment expenditures, short-run consumables include food and gas purchases.[28] Food and gas are more likely to be stored rather than immediately consumed. However, including such additional expenditures increases the amount of spending on which sensitivity to paycheck is estimated. Therefore I present results using both categories.

4.1.2 Filtering Out Credit Constraints

I am interested in capturing the extent of sensitivity to paycheck receipt that reflects a user's level of short-run impatience. However, expense shocks at times when consumers are credit constrained can also lead to increased spending in payweeks. To isolate the effect of short-run impatience, I restrict the sample to those paycycles in which short-run credit constraints are unlikely to play a role. Specifically, I restrict the sample to those times in which the user had enough resources (cash in his account and, especially, available credit on his cards) to afford the payweek's worth of spending in the previous week.[29] This restriction removes the instances in which the consumer may have wanted to spend more but could not afford to do

[27] Measuring consumption by expenditures can lead to misleading conclusions, as shown by Aguiar and Hurst (2005). I focus on expenditure categories that are likely to be a good proxy for actual consumption, such as restaurant meals and entertainment. I also estimate spending patterns over several pay cycles in which consumers do not experience income shocks. It is therefore unlikely that the estimates are driven by shifts in behavior from one regime to another in response to shocks.

[28] Over two thirds of the additional spending in short-run consumables goes to food.

[29] Specifically, if the spending of a payweek is not affordable in the previous week, I exclude that payweek and the week preceding it from the sample.

so until the next paycheck arrived.[30] In Section 6.3, I show that my results are also robust to more conservative measures of credit constraints.

4.1.3 Estimated Sensitivity to Paycheck Receipt

Table 5 shows summary statistics of the sensitivity estimates, γ_{1i}, across consumers, using expenditures on short-run consumables and restaurant and entertainment. The upper panel shows that the average user indeed consumes more during payweeks than non-payweeks even if credit constraints are unlikely to play a role. During payweeks, spending on short-run consumables is 6.1% higher, and spending on restaurants and entertainment is 4.6% higher. For the median user, both increase about 5% in payweeks relative to non-payweeks. There is substantial variation between users. The 75$^{\text{th}}$ percentile increases consumption in both categories by almost 20% in payweeks.[31] Sensitivity to paycheck receipt is statistically significant and positive for just under 10% of users when using short-run consumables. Only very few users have statistically significant negative estimates. To address that sensitivity is estimated with noise, I bootstrap standard errors for all estimates below in which sensitivity to paycheck is used as an explanatory variable.

4.2 Effect of Resources on Sensitivity to Paycheck Receipt

4.2.1 Regression Equation

The effect of variation in resources on the sensitivity to paycheck receipt is estimated separately for each user by the following equation:

$$log(E_{it}) = \alpha_i + payweek_{it}\gamma_{1i} + resources_{it}\gamma_{2i} + resources_{it} * payweek_{it}\gamma_{3i} + X_{it}\psi_i + \varepsilon_{it} \quad (2)$$

where, as in equation (1), E_{it} are each user's daily expenditures, $payweek_{it}$ is an indicator equal to 1 on the day of paycheck receipt and on the 6 subsequent days, and X_{it} includes month fixed effects and day-of-week fixed effects. $resources_{it}$ are a user's available resources, defined as the cash balances on his bank accounts plus the available credit on his credit cards.[32]

[30] Section 3.6 discusses why paycheck receipt can affect consumption spending in the presence of spare borrowing capacity.

[31] Appendix Figure A1 plots the distribution of the estimated sensitivity for both categories of consumption. The two distributions look very similar and confirm the key insights of Table 5: The mean of the distributions is shifted upwards from zero, and a t-test confirms that it is significantly different from zero.

[32] To distinguish sophisticates and naives, I argue in intuition 4 that sophisticates act more patiently when resources are higher. This is because they are aware of the reduced conflict of interest when the future self has higher resources and, hence, consumption levels. When taking this idea to the data, I cannot observe the level of resources currently expected for the future self. I therefore assume that higher resources in the

4.2.2 Wealth Fluctuations due to Regular Payments

To estimate the effect of varying resources, I exploit within-agent variation in resources over time.[33] However, the level of resources available to the agent at every point in time is not exogenous to the agent's consumption decision. There are two sources of endogeneity. First, expenditures in the beginning of the pay cycle reduce the resources available later in the pay cycle one-for-one. This can be addressed by measuring resources at the beginning of each pay cycle. Second, resources in the given pay cycle depend on past consumption. This is problematic if high prior spending not only reduces the agent's resources, but also his taste for consumption in the current period, leading to biased estimates. For instance, a user who went out regularly over the last weeks, going to the movies and eating out, has lower resources in the current pay cycle. Additionally, he may have a lower taste for new consumption, having seen the latest movies and been to his favorite restaurants. To address this endogeneity problem, I exploit variation in the agent's resources due to regular payments. Users in my sample are paid twice a month, but have regular *monthly* expenses, such as rent or mortgage payments. These monthly obligations lead to substantially lower resources during the two-week pay cycle when they are due relative to the other two weeks of the month. Another example are months with three paychecks for users who are paid bi-weekly (rather than twice a month). I exploit the systematic fluctuations in the level of resources caused by such regular payments to construct an instrumental variable for the level of resources. Based on the agent's regular payments, I calculate what his resources would have been if all non-regular spending was split evenly across the sample period. These hypothetical balances isolate the variation caused by regular payments from the variation caused by prior discretionary spending. Appendix Figure A2 illustrates the intuition for these calculated balances.

4.2.3 Measuring Sophistication by Effect of Resources on Sensitivity

Using the hypothetical balances based on regular payments as an instrumental variable allows to estimate how fluctuations in resources affect the sensitivity of consumption spending to paycheck receipt. The user-specific estimates captured by γ_{3i} in equation (2) are shown in the lower panel of Table 5. For the median user, the effect is close to zero in both short-

current period are associated with higher expected resources in the next period. As explained in the next section, I distinguish between paycycles with high resources and paycycles with low resources by whether the user had to pay large monthly bills during the paycycles. Without a large monthly bill due during the paycycle, I therefore assume that both current resources, as well as expected resources in the second week of the paycycle are higher.

[33] In the literature, the effect of higher resources on the sensitivity of consumption is often estimated across individuals, for instance by Stephens (2006). Using within-individual variation instead provides an alternative estimate of the effect of resources.

run consumable spending and exclusively restaurant and entertainment spending. For a substantial number of users, however, additional resources affect their sensitivity to paycheck receipt, increasing it for some and decreasing it for others.

As outlined in Section 3.4, additional resources lead sophisticated agents - but not naive ones - to act more patiently, and their consumption reacts less to payment receipt (Intuition 4). I split the sample into two groups. Those for whom additional resources reduce sensitivity to paycheck receipt, i.e., γ_{3i} is negative, and those for whom this is not the case, i.e., γ_{3i} is non-negative. Assuming that differences in the effect of resources are indeed caused by differences in sophistication, I call the first group "sophisticated" and the latter "naive". I show below that the joint patterns of consumption spending and debt paydown indeed support this notion. Table 6 shows the classification of users into sophisticated and naive. A substantial number of users are classified the same way, irrespective of whether the classification is based on spending on short-run consumables or on restaurant and entertainment only. However, for almost a third of users, the classification differs between the two categories. Therefore I present all results using both classifications and bootstrap standard errors whenever the estimates are used as explanatory variables in a regression.

4.2.4 Summary Statistics by Differences in Consumption Patterns

One concern is that agents classified as sophisticated or naive also differ substantially along dimensions other than sophistication. Specifically, differences in sophistication may not only lead to differences in debt paydown behavior, but may also reflect differences in the level of impatience, assets, earnings or total spending.

Table 7 shows average and median estimated sensitivity levels for naive and sophisticated users. In the first two columns the classification of sophistication is based on short-run consumables. In the last two, this classification is based on restaurant and entertainment spending only. On average, when sophistication is based on short-run consumables spending, estimated levels of sensitivity to paycheck receipt are larger for sophisticated agents. However, they are lower when based on restaurant and entertainment spending only and they are not statistically significantly different from each other.[34]

[34]There are several factors that could lead sensitivity estimates to differ between the two groups, though none seems to clearly dominate in my sample. First, average sensitivity estimates are biased slightly downwards for sophisticated agents. When resource levels are high, sensitivity is lower for a sophisticated agent than it is for a naive agent with the same level of impatience. Therefore average sensitivity, estimated for times of both low and high resource levels, will be lower for a sophisticated agent than for a naive one with the same level of impatience. Another factor is measurement error. If sensitivity of consumption to paycheck receipt is relatively low, sensitivity changes due to resource fluctuations are also small in absolute terms and, when measured with error, less likely to be detected. Sophisticated users with low levels of impatience have a higher likelihood of being incorrectly classified as naive than users with high levels of impatience. In

In addition to estimated levels of sensitivity, Table 7 shows some key summary statistics on income and debt levels across naive and sophisticated users. Income and credit card debt levels are very similar between the two groups. Average income is almost identical when sophistication is based on short-run consumable spending and slightly higher for sophisticated agents, \$3,905 relative to \$3,718, when based on restaurant and entertainment spending. Sophisticated users also have slightly lower debt levels, \$13,693 relative to \$14,144 when based on short-run consumable spending. However, this relationship is reversed when comparing median instead of average levels.[35] Table 7 also shows that sophisticated and naive agents have very similar spending across all categories, both in absolute terms and relative to their income.[36] Both types also use their credit card in similar ways: They charge between 31% and 35% of total purchases on their credit cards.[37] In general, the differences between sophisticated and naive agents in assets and spending are small and none is statistically significant. It is therefore unlikely that the classification into naive and sophisticated masks substantial differences between the two groups along other dimensions which could directly account for any differences in the debt repayment behavior.

4.2.5 Planned Paydown by Differences in Consumption Patterns

Section 3 argues that sophisticated agents are more likely to follow through with their debt paydown plans (Intuition 2). This could at least in part be because they make more realistic, less ambitious plans that take into account the extent of their short-run impatience. Table 8 analyzes the effect of short-run impatience and sophistication on planned paydown. Users'

the robustness checks in Section 6.2, I therefore exclude users with low sensitivity who are most likely to be misclassified. Finally, the level of impatience may be directly related to whether a user is aware of his short-run impatience. Users with high short-run impatience may be more likely to eventually become aware of their own time inconsistency relative to users with a relatively minor time inconsistency problem.

[35] Note that such small differences between sophisticated and naive agents are consistent with theoretical results on asset accumulation of present-biased agents. Whether sophisticated and naive agents behave differently depends on the situation modeled. I argued that the debt paydown decision agents face in my setting is prone to lead naive agents to repeatedly procrastinate, leading to the substantial differences in the behavior described. However, several papers (e.g., Angeletos, Laibson, Repetto, Tobacman, and Weinberg (2001)) argue that this is not the case in savings and asset accumulation decisions, since such decisions substantially influence the agent's future path. Accordingly, they find small differences in assets between sophisticated and naive agents.

[36] Vissing-Jorgensen (2011) finds that the type of goods borrowers buy are strongly associated with later repayment. I do not find large differences in spending in different categories. However, unlike Vissing-Jorgensen (2011), I can only distinguish the type of spending by the type of retailer, not what type of good users buy at a certain retailer.

[37] The use of credit cards for both groups does vary slightly with the estimated level of sensitivity to paycheck receipts. Among both sophisticated and naive consumers, those in the lower quintile of estimated sensitivity to paycheck receipt charge a higher percentage of spending on credit cards (36% and 44% of total discretionary spending when sophistication is based on short-run consumables), than consumers in the highest quintile of sensitivity to paycheck receipt (24% and 21%).

sensitivity to paycheck receipt or sophistication have no significant effect on planned paydown. As in Table 4 the main determinants of planned paydown are income and original debt levels. The results therefore suggest that present bias is not a first order determinant of planned paydown, at least relative to other factors such as income, existing debt levels and possible other considerations such as spending needs and ease of reductions in spending.

5 The Effect of Present Bias on Debt Repayment

Section 4 showed that consumption patterns over the paycycle are consistent with at least some users exhibiting present bias (Intuition 3 and 4). This section uses these patterns as proxies for the extent of each user's preset bias and relates them to their success in reducing debt levels to show that the joint patterns are as outlined in Section 3. Recall that for sophisticated consumers, planned paydown significantly increases actual paydown, but users with higher levels of impatience pay down less (Intuition 2). On the other hand, naive consumers are prone to repeatedly delay payments. For them, planned paydown and the extent of short-run impatience are less indicative of actual debt paydown (Intuition 1).

5.1 Debt Paydown by Type

Figure 2 shows the change in debt levels over the first 90 days. For each type, sophisticated and naive users are sorted into quintiles based on their estimated sensitivity to paycheck receipt. The graph shows the mean paydown for each group. In both groups, some users pay down substantial amounts of debt, so differences in the average paydown across groups are small, as also shown in Table 7. Among sophisticated users, those in the two lowest quintiles of sensitivity to paycheck receipt reduce their debt levels the most. As sensitivity to paycheck increases, paydown falls. For naive users, no such pattern exists: When sophistication is based on short-run consumables, naive users in the fourth quintile pay down the most. When sophistication is based on restaurant and entertainment spending, naive and sophisticated users look more similar: in both groups paydown is lower the higher measured sensitivity. However, the graph does not control for any characteristics of users, especially planned paydown, a key determinant of debt paydown. To do so, the next section shows regression analysis of the effect of sensitivity and planned paydown.

5.2 Regression Equation

To formally analyze the effect of potential present bias as captured by consumption patterns on debt paydown, I estimate the following regression:

$$\begin{aligned} Paydown_i = \mu_0 &+ Sensitivity_i \mu_{1n} + PlannedPaydown_i \mu_{2n} \\ &+ Sensitivity_i * Sophist_i \mu_{1s} + PlannedPaydown_i * Sophist_i \mu_{2s} \\ &+ X_i' \lambda + \nu_i \end{aligned} \tag{3}$$

where $Sensitivity_i$ is each user's sensitivity of spending to paycheck receipt, estimated by equation (1).[38] $PlannedPaydown_i$ is the amount the user originally had planned to pay down[39] and $Sophist_i$ is an indicator for whether the user is classified as sophisticated. X_i is a set of control variables, including debt levels at sign up and user's monthly income. I measure debt paydown over two horizons: 90 and 180 days. To make estimates comparable, debt paydown and planned paydown are therefore measured per day. Debt paydown is measured by the trend in debt balances over the given time horizon. Relative to the simple difference in debt levels, this measure filters out fluctuations in debt levels caused by the use of credit cards for transactions.[40] Since the regressors $Sensitivity_i$ and $Sophist_i$ (sophistication) are estimated from consumption patterns, standard errors in the second stage are bootstrapped.[41]

[38] Instead of using the average sensitivity to paycheck receipt estimated by equation (1), an alternative measure would be the base level of sensitivity captured by the coefficient on *payweek* in equation (2). Since sophisticated agents react less to paycheck receipt when they have higher resources, the average sensitivity is lower for a sophisticated agent than for a naive one, given the same level of impatience. This biases comparisons across the two groups. Using the baseline sensitivity estimated in equation (2) avoids this bias. However, because of the additional variables and the need to instrument for them, the estimates are much more noisy. Because of this higher precision, I use the average sensitivity in the regression analysis, since the focus is on intra- not inter-, group comparisons.

[39] As illustrated in Section 3.5, sophisticated are more likely to make realistic plans, but as Table 8 shows there is no significant effect of short-run impatience on planned paydown. Rather, planned paydown is strongly related to user's income and original debt levels.

[40] To measure the trend in debt levels, I fit a linear trend for the user's debt balances over the given horizon, such that average daily paydown equals the slope of the estimated trend line. In unreported robustness checks, I use the simple difference in debt levels and the results are very similar.

[41] For each user, I draw a bootstrap sample from the observations of consumption spending and re-estimate the first stage variables for each draw. Then I use these estimates in the second stage estimation and compute bootstrapped standard errors based on the second stage results of all draws. Using robust standard errors to interpret the results would not change the overall conclusions.

5.3 Regression Results

Table 9 shows the regression estimates for equation (3) over time horizons of 90 and 180 days.[42] For naive agents, the omitted category, an additional dollar in planned paydown increases actual paydown by 18 cents over the first 90 days when estimates are based on short-run consumables and 28 cents when based on restaurant and entertainment spending. Over 180 days, the effect is 13 cents and 17 cents respectively. Sensitivity to paycheck receipt has no consistent effect. This is in line with the idea that naive users are repeatedly tempted to delay debt paydown irrespective of whether they are only slightly or very impatient in the short-run (Intuition 1). For sophisticated users, planned paydown is significantly more predictive of actual paydown than for naive users. Specifically, the estimated effect in the first 90 days is 55 cents $(.18 + .37)$ and 37 cents $(.28 + .9)$ using estimates based on short-run consumables and on restaurant and entertainment spending. Over 180 days, the estimated effects are 52 cents $(.13 + .39)$ and 47 cents $(.17 + .30)$, respectively. Consistent with the notion of present bias (Intuition 2), the level of short-run impatience has a significant negative effect for sophisticated users, but no such relationship for naives exists. This difference between the two groups is statistically significant. Amongst sophisticated users, more impatient agents reduce their debt less. This effect is statistically significant (unreported test) and economically meaningful: moving from the 75^{th} to the 25^{th} percentile of estimated impatience levels increases debt paydown in the first 90 days after sign up by \$550 when using estimates based on short-run consumables, and by \$400 when based on restaurant and entertainment spending. This is a substantial fraction of the average paydown of \$734 over this time horizon.[43] There is no statistically significant difference in the effect of the control variables for sophisticated and naive users. In fact, most of the control variables have no substantial effect on actual paydown once planned paydown is included, consistent with the results presented in Table 4.[44]

The estimated relationship between the characteristics of a user's consumption patterns

[42] A possible concern about the specification in equation (3) is that planned paydown and the estimated level of sensitivity to paycheck receipt are highly correlated. In Appendix B.3, I estimate separate specifications in which either the sensitivity to paycheck or planned paydown is interacted with sophistication, and the respective other variable is only included as a control (not interacted with sophistication). The results are very similar.

[43] The estimated effects do not differ much depending on which spending category the estimates are based on. The difference between the 25^{th} and 75^{th} percentile for the estimated sensitivity based on short-run consumables is $.28 = .199 + 0.081$, as shown in Table 5. Multiplying the direct effect plus the difference for sophisticated agents by this differences yields an estimated effect of \$6.16 and \$4.48 per day, or \$554 and \$403 over 90 days.

[44] Appendix B.3 shows that the estimates are very similar when income and original debt levels are not interacted with sophistication, i.e. when the control variables are restricted to have the same influence for both types of users.

and his debt paydown reflects exactly what one would expect if both were caused by present-bias. It also reinforces the interpretation of sensitivity to paycheck receipt as a measure of impatience and validates the classification of users as naive or sophisticated. If the two categories did not actually capture a user's present bias, they would not relate to debt paydown behavior in the way predicted and confirmed in the regression results here.

6 Alternative Interpretations and Robustness

To interpret the results in Section 5 as evidence for the role of present bias requires that spending patterns and debt paydown are plausibly related only through a user's present bias. This section addresses alternative explanations for some of the patterns and shows that they fail to explain the *joint* behavior of debt paydown and consumption patterns.

6.1 Direct Relationship between Paydown and Consumption Patterns

A key concern is that user spending patterns are directly linked to debt paydown, not just through behavioral biases, since, by definition, debt paydown requires a reduction in consumption spending. The sensitivity to paycheck receipt, which is used to measure present bias, captures only how even consumption is over the pay cycle. It is unrelated to the *level* of consumption, which is what affects debt paydown. This leaves enough degrees of freedom to allow identification of potential differences in the amount paid down. In other words, sensitivity of consumption captures the ratio of first to second payweek consumption ($\frac{c_1}{c_2}$), but saving for debt paydown depends on the *level* of consumption spending ($saving = income - c_1 - c_2$). Therefore agents can exhibit the same level of sensitivity to paycheck receipt, while having different levels of debt paydown. Similarly, agents with the same amount of debt reduction may choose to split the remaining resources differently between the two periods of the pay cycle, leading to different sensitivity of consumption spending, but equal debt reduction.[45]

Nevertheless, it could be the case that alternative models of behavior, which have nothing to do with present bias, lead consumption patterns to be related to debt paydown. For instance, users who smooth consumption more when they have higher resources may also be those who consume a lower share of these additional resources, leading them to save more

[45]Consider the following example to illustrate this point: An agent with a paycheck of \$100 saves \$50 and consumes \$30 in the first period and \$20 in the second period, leading to 50% higher consumption in payweeks. Alternatively, the agent can consume \$60 in the first period and \$40 in the second, leading to the same sensitivity of consumption spending but different paydown. Similarly, saving \$50 but consuming \$25 each period leads to the same savings as in the first case, but completely smooths consumption.

for debt paydown. A high reduction in sensitivity as resources increase (i.e. a more negative coefficient on the interaction of $payweek * resources$) would lead to higher debt paydown. Figure 3 illustrates this alternative theory. It also shows that the theoretical predictions of present-bias differ and can be empirically distinguished from such an alternative theory. With potential present bias, the users expected to pay down the most are those with low levels of short-run impatience. For these users, additional resources reduce this already low sensitivity very little. Therefore expected paydown is highest when the effect of resources is close to zero. And expected paydown decreases for users with a high reduction in sensitivity after an increase in resources.

To estimate any direct relation between the reduction in sensitivity to paycheck receipt and debt paydown, I estimate the following regression equation:

$$Paydown_i = \mu_0 + (coefficient\_on\_payweek * resources)\mu_1 + X_i'\lambda + \nu_i \tag{4}$$

The regressor of interest is $(coefficient\_on\_payweek * resources)$ estimated in equation (2), which captures how additional resources affect an agent's sensitivity to paycheck receipt. Equation (4) is estimated with and without including the explanatory variables from the baseline specification (equation (3)) as additional controls. Table 10 shows that the direct relationship between paydown and the reduction in sensitivity with additional resources is weak in all specifications. None of the coefficients is statistically significant and several are positive. That is the opposite of what would be expected under the hypothesis that a reduction in sensitivity as resources increase leads to higher debt paydown.

6.2 Robustness of Identifying Sophistication

From a theoretical perspective, the distinction between sophisticated and naive agents becomes meaningless when users have very low or no short-run impatience. Relatedly, users with low levels of sensitivity to paycheck receipt are difficult to classify as either sophisticated or naive. With a low initial level of sensitivity, any potential reduction in the observed sensitivity which could identify a user as sophisticated is relatively low. Therefore such a reduction is less likely to be picked up in the estimation.

In Table 11, I exclude users with low levels of sensitivity. Starting with the baseline sample, I subsequently exclude users with the 10%, 15%, and 20% lowest estimated levels of sensitivity to paycheck receipt. Despite the reduction in sample size, the estimated differences between sophisticated and naive agents remain statistically significant and of similar magnitude. Consistent with theory, the differences between sophisticated and naive agents are indeed driven by those agents with higher levels of short-run impatience rather than those

with relatively low or no short-run impatience.

Appendix B.2 provides additional robustness checks on the classification of users as either sophisticated and naive. Ideally, users should be classified the same irrespective of whether estimates are based on short-run consumables or restaurant and entertainment spending only. Appendix Table A5 shows that results are very similar to the baseline when only consistently-classified users are included. If anything, the point estimates are more similar across categories, supporting the notion that previously misclassified users lead to additional noise in the estimation. Classification into sophisticated and naive is based on the effect of higher resources on sensitivity to paycheck receipt. When estimating this effect, resources are instrumented for by hypothetical balances as outlined in Section 4.2. This addresses the concern that past consumption levels may affect both the level of resources, as well as spending through unobservables such as a taste for consumption. This could lead to a negative coefficient absent any sophistication by the user. To understand the importance of this concern, I replicate the results classifying users as sophisticated or naive based on OLS instead of IV estimates of the effect of resources. If the endogeneity concern is important, a substantial number of users will be misclassified when using OLS estimates and the estimated differences between the two groups should be smaller. Indeed, Appendix Table A5 finds smaller differences between sophisticated and naive individuals which are mostly not statistically significant, reinforcing the need to instrument for the level of resources.

6.3 Alternative Explanations for Sensitivity to Paycheck

Consumption spending may be sensitive to paycheck receipt for reasons other than short-run impatience. This section argues that such alternative explanations cannot explain the joint patterns of consumption spending and debt paydown.

Credit Constraints One possible cause of consumption spending sensitivity to paycheck receipt are credit constraints. If users are credit constrained and suffer an expense shock, they have to wait until the next paycheck to incur the expense, making spending sensitive to paycheck receipt. Therefore, throughout this paper, the estimation of the sensitivity to paycheck receipt is based only on times when credit constraints are unlikely to have played a role. In this section, I replicate the main results using two alternative, more conservative measures of excluding periods of potential credit constraint. The first alternative takes into account that users may want to hold a buffer stock of resources at all times. It requires that spending in the given category would have been affordable in the pre-paycheck week without reducing a consumer's resources below a buffer stock, measured as the 5^{th} percentile of observed resources. The baseline specification requires spending only to be affordable,

even if this leaves the agents with no further buffer. The second alternative requires that the payweek's total discretionary spending, rather than just category-specific spending would have been affordable in the previous week. There is substantial heterogeneity across users. The majority have considerable borrowing capacity left on their cards, an average of about $11,000, as shown in Table 1. This group is never classified as likely constrained. Some users, however, regularly could not have afforded payweek spending in the previous week. Across all users, the baseline specification excludes about 20% of all days with positive spending as possibly credit constrained. Requiring total discretionary spending to be affordable or taking a buffer stock into account increases the number of excluded days to 22% and 28%, respectively. Appendix Table A1 shows that the estimated sensitivity decreases slightly when filtering out pay cycles in which the user may have been credit constrained. However, the estimated sensitivity would decrease even if credit constraints did not play any role, since the excluded pay cycles are those with the highest spending. On the individual level, the estimated sensitivities are highly correlated across the different measures.[46] Table 12 replicates the main results using sensitivity estimates based on the different restrictions. Throughout, the results are very similar to the baseline specification.

Habits, Non-Separabilities in Consumption, or Social Coordination Habits coinciding with payweeks are another possible explanation for higher spending during payweeks. For instance, some people may have a habit of going out for "date night" every two weeks. For some of them, this might by chance overlap with the receipt of their paycheck. Alternatively, some people may rationally coordinate some purchases with when they get paid. Or they may coordinate consumption spending with their potentially credit-constrained or present-biased friends or colleagues. However, if the estimated sensitivity of consumption were caused by habits, non-separabilities between consumption or social coordination, there is no reason to expect these users to have differential debt repayment behavior in the way observed in the data. Therefore, the estimated sensitivity to paycheck receipt is at least partially driven by short-run impatience. Otherwise, it would not relate to debt paydown in exactly the way predicted by present bias.

Time-Consistent Preferences with High Discount Factor For consumers who live paycheck to paycheck, time-consistent preferences with a very high discount factor can lead consumption spending to be higher early in the pay cycle. Similarly, consumers with a higher

[46] Appendix Table A1 also shows that, within each consumption category, the correlation between sensitivity estimates with different restrictions is more than 90%. Across the two spending categories - short-run consumables or restaurant and entertainment spending only - the estimates are also similar with correlations between 55% and 65%.

discount rate would also reduce their debt balances less. This is unlikely to be driving the results. First, the discount factor that would be necessary to lead to sensitivity of consumption spending over a two week horizon is so high that it is generally considered to be implausible, given consumers' relative patience in the long-run.[47] Second, time-consistent consumers should have no issue sticking to their original plans. In my setting, a time-consistent consumer with a high discount factor is likely to be classified as naive. For both time-consistent as well as naive present-biased consumers, the discount factor between any two periods does not vary with resource levels and their sensitivity to paycheck receipt should be unaffected. However, I find that these consumers follow their plans substantially less than consumers classified as sophisticated. Time-consistent preferences with a high discount factor can not explain why consumers whose consumption spending becomes less sensitive when resources are higher are more able to stick to their debt paydown plans.

Robustness of Estimating Sensitivity Finally, Appendix B.1 shows that the main results are robust to different specifications of estimating sensitivity to paycheck. In Appendix Table A2 the number of days of positive spending required for users to be included in the sample is 40 and 50 days instead of the 45 days required in the baseline. Instead of the log of daily spending, Appendix Table A3 uses sensitivity estimates based on spending measured in levels and normalized by average spending, as well as based on weekly spending. Throughout, the results are very similar to the baseline estimates. Finally, Appendix Table A4 shows results when sensitivity to paycheck receipt is estimated based only on spending on debit cards, excluding spending on credit cards. There are fewer users with enough spending on debit cards alone, but the results for this subsample are similar to the baseline estimates.

6.4 Alternative Explanations for Failing to Stick to Plan

Loss of Income A substantial loss of income from, for instance, job loss could render households unable to follow their original plan to reduce debt levels. However, all users in my sample have regular paychecks throughout the sample period. Therefore they do not experience a substantial reduction in their income which could force them to abandon their original plan.

Aspirational Plans and Alternative Interpretations of Plan Meaning When prompted by ReadyForZero to state how much they want to reduce their debt each month, users may differ in what they understand a plan to be. For instance, some users may view their planned

[47] Shapiro (2005) outlines this argument for the monthly horizon considered in his paper.

paydown as an aspirational goal rather than as a realistic plan which they are likely to stick to. However, differences in interpreting what a plan means should not affect how consumers allocate consumption over the pay cycle. Therefore, this cannot explain the systematic relationship between consumption patterns and the extent to which users follow their plan.

Lack of Planning Skills or Overoptimism A lack of planing skills or overoptimism could lead some users to make overly ambitious debt paydown plans and, hence, explain their failure to stick to their plans. Such bad planning either due to overoptimism or lack of planning skills in general could also lead to sensitivity of consumption spending to paycheck receipt. Users may be overoptimistic about the probability of receiving additional resources in the second week of a pay cycle or underestimate the cost of their first week's planned consumption. As a result, they might spend more of the paycheck when they receive it, and when additional resources fail to materialize, they reduce expenditures. However, there is no reason why the extent of overoptimism or lack of planning skills should vary systematically with an individual's level of resources. There is also no reason why variations in resources affecting sensitivity of consumption spending should closely relate to debt paydown. Hence, overoptimism alone does not predict the systematic differences between sophisticated and naive agents observed in the data.

Lack of Financial Literacy Several papers have shown that consumers' lack of basic financial literacy leads many to make suboptimal financial decisions.[48] A lack of financial literacy alone, however, cannot explain the results in this paper. Lack of financial literacy does not necessarily lead to sensitivity of consumption to paycheck receipt. However, consumers who better understand the implications of their financial decisions may also be better at planning and allocating resources over their two-week pay cycles, leading them to smooth consumption more. That being said, a lack of financial literacy would not predict that differences in the effect of resources on the sensitivity to paycheck receipt systematically predict which consumers are better able to follow their plan and reduce their debt levels. Nevertheless, the results are consistent with some - or even most - consumers lacking a thorough understanding of financial matters in addition to some having present-biased preferences.

[48] Lusardi and Tufano (2009) show that households with lower financial literacy more often report excessive debt balances. Bertrand and Morse (2011) find a lack of financial literacy among payday loan borrowers. Bernheim and Garrett (2003) and Bernheim, Garrett, and Maki (2001) show that financial education increases savings. Hastings and Mitchell (2011) show that while short-run impatience is a strong predictor for retirement savings in Chile, financial literacy is also correlated with savings levels. Stango and Zinman (2009) show that households who exhibit exponential growth bias borrow more. Agarwal and Mazumder (2013) find that households with higher cognitive ability measured by math scores make fewer financial mistakes, such as suboptimal use of credit cards. Hastings, Madrian, and Skimmyhorn (2013) provide an overview of this literature.

7 Conclusion

This paper shows that differences in consumers' short-run impatience and their sophistication about their own time-inconsistent preferences can help explain why some consumers struggle to pay off expensive credit card balances despite their intention to do so. The results have important policy implications for the regulation of credit markets. A set of theoretical papers has shown that common features in credit card contracts, such as teaser rates, disproportionally hurt consumers with behavioral biases (see Heidhues and Kőszegi (2010)).[49] By providing empirical evidence that such behavioral biases play a role in explaining credit card debt holdings, the paper provides additional justification for regulation like the Credit CARD Act of 2009. This regulation, for instance, prohibits issuers of sub-prime credit cards to backload fees, which would be very effective in preventing present-biased consumers from borrowing without fully internalizing the cost.[50] The results also have important implications for how to help consumers get out of debt. For instance, mechanisms that make commitment to long-term plans attractive to consumers could be a promising and cost effective way to do so.[51] One possibility would be to allow consumers to select a certain amount to be deducted from their regular paycheck to be put towards debt repayment, and to make it costly or complicated to change this selection. In the literature, similar ideas have been explored in helping present-biased consumers save, for instance by Thaler and Benartzi (2004) or Ashraf, Karlan, and Yin (2006).

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[49] Ponce-Rodriguez (2008) shows that banks in Mexico structure credit card contracts to exploit customers' potential behavioral biases. DellaVigna and Malmendier (2004) study how firms structure contracts with consumers who have self control issues. Several papers have explored the implications of behavioral biases for regulation and policy. Camerer, Issacharoff, Loewenstein, O'Donoghue, and Rabin (2003) argue for the benefits of some paternalistic regulation in the face of behavioral biases, including potential present bias. Mullainathan, Schwartzstein, and Congdon (2012) present a framework for the implications of potential behavioral biases for regulation and public finance. Gruber and Kőszegi (2004) study the implications of time-inconsistent preferences for the incidence of cigarette taxes.

[50] Agarwal, Chomsisengphet, Mahoney, and Stroebel (2015b) show that reductions in fees after the Credit CARD Act were not passed on to consumers. Agarwal, Chomsisengphet, Mahoney, and Stroebel (2015a) also show why reductions in the cost of funds may not be passed on to credit card borrowers.

[51] Amador, Werning, and Angeletos (2006) explore the trade-off between commitment to overcome temptation and the benefits of flexibility in the face of uncertainty.

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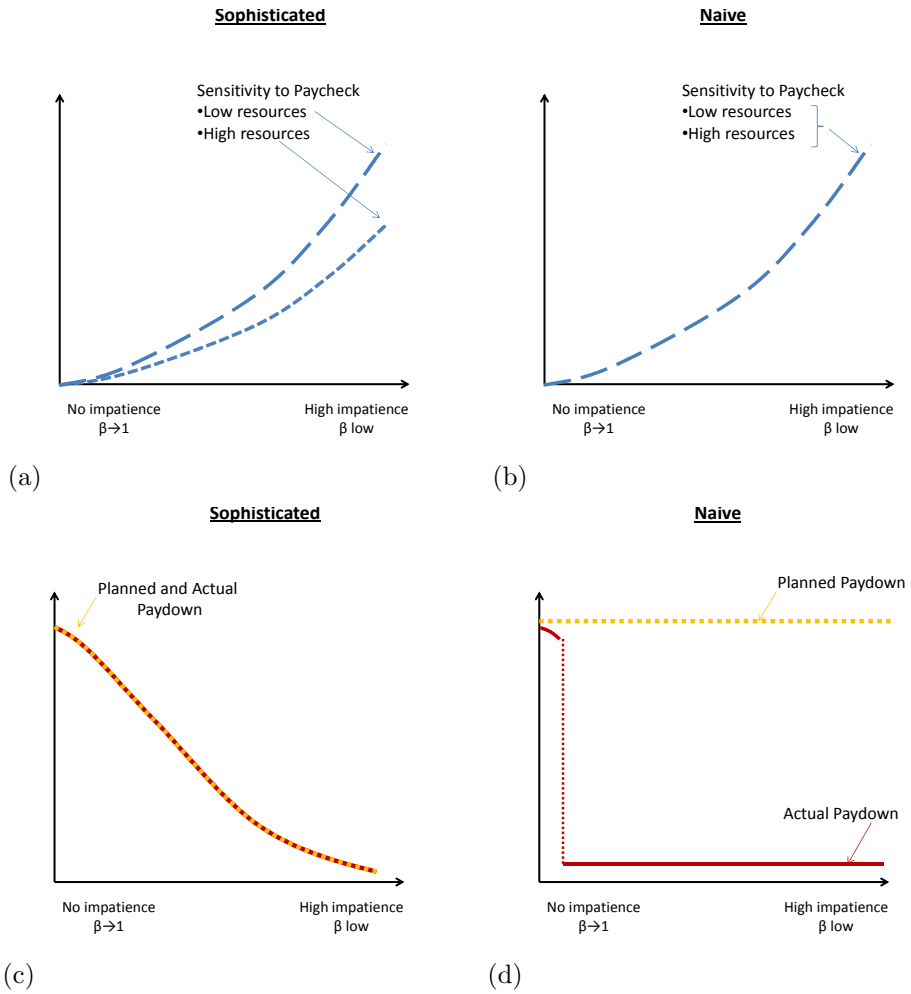
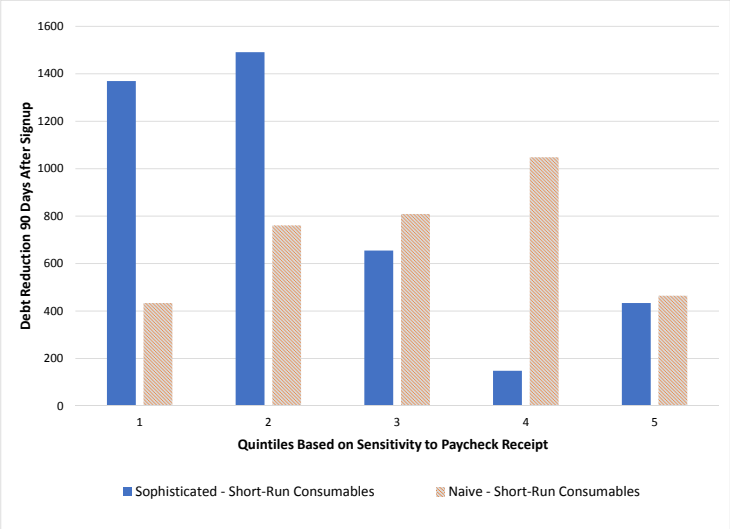
Figure 1: Relation of Consumption Patterns to Debt Paydown

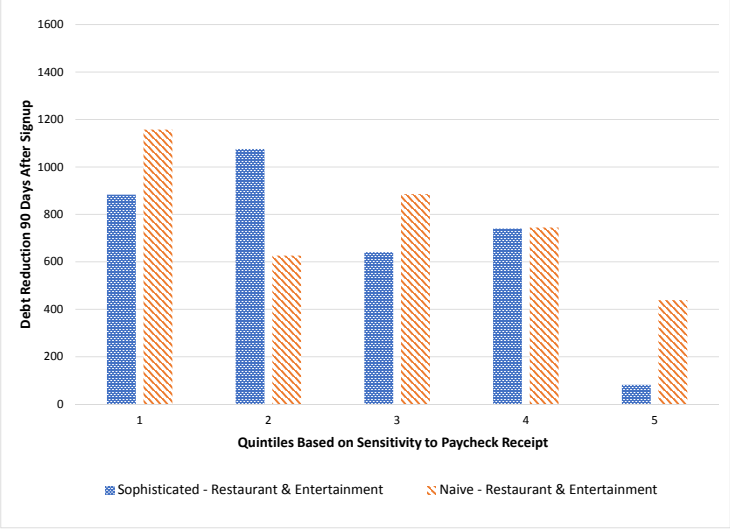


The figure illustrates the predictions for consumption patterns and debt paydown for present-biased agents. The two upper panels show the sensitivity of consumption spending to paycheck receipt for both types, with sophisticated agents at the left in panel (a), and naive agents at the right in panel (b). The two lower panels show planned and actual paydown for the two types, again with sophisticated agents at the left in panel (c), and naive agents at the right in panel (d). In each panel, the horizontal axis shows the level of short-run impatience, starting with very low impatience (or β close to 1) at the origin.

Figure 2: Mean Paydown after 90 Days by Sensitivity Quintiles



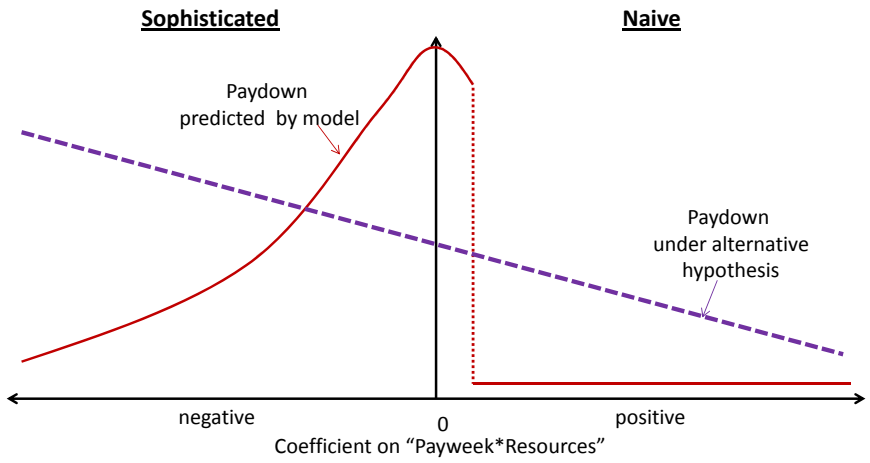
(a)



(b)

The figure shows the mean paydown over the first 90 days after sign-up for consumers classified as sophisticated and naive. For each type, consumers are sorted into five groups based on their estimated sensitivity to paycheck receipt.

Figure 3: Effect of Resources on Sensitivity and Debt Paydown



The figure shows the relationship between debt paydown and the effect of resources on sensitivity to paycheck receipt under the alternative theory that users who smooth consumption more when they have higher resources also save more for debt paydown. The horizontal axis shows the estimated effect of resource levels on sensitivity to paycheck receipt, captured by the coefficient γ_{3i} estimated in equation (2). Users are classified as sophisticated when the estimated effect is negative and as naive otherwise. The dotted line shows paydown under the alternative hypothesis. The figure also shows expected paydown as outlined in Section 3. To the right of the vertical axis, users are classified as naive. Expected paydown is therefore the same as in panel (d) of Figure 1. To the left, users are classified as sophisticated. Expected paydown is the same as in panel (c) of Figure 1, but mirror inverted to reflect the fact that short-run impatience is higher for sophisticated agents with a higher reduction in sensitivity as resources increase.

Table 1: Summary Statistics - Income and Assets

	Income and Assets					
	Obs.	Mean	Std. Dev.	25th pctile	50th pctile	75th pctile
Users						
Days in sample	516	415	150	262	430	584
Days in sample after sign-up		392	231	274	401	588
Nr of paychecks		28	12	19	26	38
Nr of paychecks - full paycycles		21	14	12	20	31
Income						
Avg. monthly income- regular paycycles	516	3,805	1,993	2,469	3,460	4,671
Median monthly income- regular paycycles		3,780	2,027	2,450	3,440	4,564
Avg. monthly non-paycheck income		300	442	0	135	406
Median monthly non-paycheck income		72	276	0	0	0
Fraction of regular income		0.89	0.12	0.83	0.92	0.99
Assets						
Credit Card Debt - $	516	13,942	14,029	4,582	9,777	18,331
Credit Card Debt - rel. to income		4.23	9.88	1.40	2.90	4.92
Cash Balances - $		5,584	15,063	911	2,099	5,178
Cash Balances - rel. to income		1.42	3.48	0.31	0.64	1.54
Total Credit - $		24,952	23,874	8,573	18,000	33,475
Total Credit - rel. to income		7.38	13.74	2.70	5.16	8.97
Available Credit - $		11,010	16,157	1,550	4,973	14,725
Available Credit - rel. to income		3.15	5.20	0.48	1.47	3.89
APR paid on debt - mean	401	16.70	5.69	13.24	16.33	20.35
APR paid on debt - median		16.78	6.59	13.24	16.24	20.45

The table shows mean, median and 25^{th} and 75^{th} percentile for how long users are observed in the sample, their income and assets.

Table 2: Summary Statistics - Spending

	Spending					
	Obs.	Mean	Std. Dev.	25th pctile	50th pctile	75th pctile
Discretionary Spending						
Total						
Avg. $	516	1,804	985	1,127	1,593	2,271
Avg. relative to avg. income		0.52	0.29	0.35	0.47	0.63
Median $		1,828	1,090	1,117	1,638	2,311
Median relative to avg. income		0.52	0.30	0.35	0.49	0.65
Non-Durable						
Avg. $	516	1,030	565	635	920	1,291
Avg. relative to avg. income		0.30	0.15	0.20	0.28	0.36
Median $		1,035	619	624	942	1,314
Median relative to avg. income		0.30	0.16	0.21	0.28	0.37
Short-run Consumables						
Avg. $	516	550	300	336	500	681
Avg. relative to avg. income		0.16	0.09	0.10	0.14	0.20
Median $		568	348	340	514	718
Median relative to avg. income		0.17	0.10	0.10	0.15	0.21
Restaurant&Entertainment						
Avg. $	516	291	173	172	256	370
Avg. relative to avg. income		0.09	0.06	0.05	0.08	0.11
Median $		279	189	152	246	364
Median relative to avg. income		0.08	0.06	0.04	0.07	0.10
Regular Payments						
Avg. $	516	1,211	806	619	1,050	1,673
Avg. relative to avg. income		0.34	0.20	0.20	0.31	0.44
Median $		1,276	1,009	475	1,096	1,902
Median relative to avg. income		0.35	0.25	0.15	0.33	0.50

The table shows mean, median and 25^{th} and 75^{th} percentile for spending of the users in the sample used throughout the paper.

Table 3: Summary Statistics - Plans and Paydown

	Plans and Debt Paydown					
	Obs.	Mean	Std. Dev.	25th pctile	50th pctile	75th pctile
Plans						
Planned Paydown - monthly - $	516	891	1,112	353	598	1,017
Planned Paydown - monthly - % of debt		0.12	0.18	0.04	0.06	0.11
Planned Paydown - monthly - % of income		0.25	0.37	0.11	0.18	0.30
Planned Paydown - 90 days - $	516	2,482	2,710	926	1,792	2,992
Planned Paydown - 90 days - %		0.28	0.26	0.11	0.18	0.33
Planned Paydown - 180 days - $	516	4,650	4,972	1,785	3,288	5,951
Planned Paydown - 180 days - %		0.47	0.30	0.22	0.36	0.66
Debt Paydown						
Change in Debt - 90 days -$	516	-734	3,041	-1,291	-222	292
Change in Debt - 90 days -%		0.02	0.92	-0.14	-0.02	0.04
Change in Debt - 180 days -$	516	-977	3,858	-2,087	-418	479
Change in Debt - 180 days -%		0.26	4.04	-0.20	-0.04	0.06
Shortfall relative to plan - 90 days - $	516	1,748	3,466	429	1,417	2,986
Shortfall relative to plan - 90 days - %		0.85	2.45	0.39	0.84	1.19
Shortfall relative to plan - 180 days - $	516	3,673	5,224	970	2,813	5,410
Shortfall relative to plan - 180 days - %		1.16	4.28	0.50	0.88	1.15
Payments made - 90 days	516	3,160	4,398	660	1,660	3,957
Payments made - 180 days		5,823	7,324	1,339	3,490	7,747

The table shows mean, median and 25^{th} and 75^{th} percentile for planned and actual debt paydown of the users in the sample used throughout the paper.

Table 4: Determinants of Planned Paydown and Actual Paydown after 90 Days

	Planned Paydown						Actual Paydown 90 Days					
Planned Paydown							0.288***	0.287***	0.288***	0.295***	0.283**	0.253**
							(0.008)	(0.009)	(0.008)	(0.007)	(0.011)	(0.031)
Median paycheck	0.349***	0.352***	0.352***	0.273***	0.384***	0.401***	0.137	0.146	0.130	0.200	0.154	0.230
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.419)	(0.410)	(0.458)	(0.403)	(0.404)	(0.314)
Original debt	0.025***	0.025***	0.025***	0.024***	0.025***	0.026***	0.004	0.005	0.003	0.005	0.006	0.009
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.739)	(0.685)	(0.915)	(0.710)	(0.656)	(0.534)
Cash balances		-0.001	-0.001	0.000	-0.004	-0.006		0.002	0.001	0.001	0.001	0.006
		(0.852)	(0.848)	(0.978)	(0.474)	(0.395)		(0.927)	(0.971)	(0.955)	(0.946)	(0.789)
Available credit		0.000		-0.001	-0.006	-0.006		-0.004		-0.004	-0.005	-0.006
		(0.987)		(0.782)	(0.131)	(0.216)		(0.850)		(0.871)	(0.835)	(0.842)
Total credit			0.000						0.001			
			(0.980)						(0.953)			
Total discretionary				0.145						-0.110		
spending				(0.237)						(0.705)		
Nr of credit cards					-7.080	-2.889					-9.097	-27.699
					(0.767)	(0.918)					(0.871)	(0.679)
Credit card usage					786.5**	776.6**					164.017	813.014
(% of expenditures)					(0.003)	(0.020)					(0.771)	(0.226)
APR						-1.518						1.173
						(0.826)						(0.965)
Constant	-430.3**	-426.9**	-427.3**	-515.6**	-556.1***	-205.5	-1,170.7	-1,157.0	-1,178.3	-1,081.8	-1,165.4	330.3
	(0.030)	(0.026)	(0.026)	(0.034)	(0.004)	(0.365)	(0.101)	(0.104)	(0.103)	(0.153)	(0.120)	(0.788)
N	516	516	516	516	516	401	516	516	516	516	516	401

Note: p-values in parenthesis, *** p<0.01, ** p<0.05, * p<0.1, winsorized 1%, sensitivity, robust standard error

The table shows estimates of the effect of various variables on planned paydown and actual paydown after 90 days with robust p-values in parentheses. All variables are winsorized at the 1% level. Median paycheck and level of original debt are measured in dollars.

Table 5: Sensitivity Estimates

	Sensitivity to Paycheck Receipt							
	Obs.	Mean	Std. Dev.	25th pctile	50th pctile	75th pctile	% statistically > 0	% statistically < 0
Sensitivity								
Short-Run Consumables	516	0.061	0.211	-0.081	0.049	0.199	9.3	1.4
Restaurants&Entertainment	516	0.046	0.201	-0.086	0.052	0.172	5.0	1.0
Effect of Resources on Sensitivity (γ_3)								
Instant Consumption	516	-0.473	8.932	-0.116	0.014	0.134		
Restaurants&Entertainment	516	0.122	4.082	-0.135	0.012	0.170		

The table shows summary statistics of the baseline estimates of each user's sensitivity to paycheck receipt and the effect of higher resources on this sensitivity. Sensitivity to paycheck receipt is captured by the coefficient on $payweek$ in equation (1). The effect of higher resources on sensitivity is captured by the coefficient on $payweek * resources$ in equation (2). Both equations are estimated separately for each user and include day of week and month fixed effects. Resources are instrumented for with calculated balances based on regular payments.

Table 6: Classification Into Sophisticated and Naive

	Restaurant&Entetainment		
	Naïve	Sophisticated	Total
Short-run Consumables			
Naïve	210	75	285
Sophisticated	66	165	231
Total	276	240	516

This table shows the number of users classified as sophisticated or naive. Users are classified as sophisticated if additional resources decrease sensitivity to paycheck receipt, i.e. if the coefficient on $payweek * resources$ in equation (2) is negative.

Table 7: Summary Statistics by Sophistication

	Sophistication based on					
	Short-run consumables			Restaurant & Entertainment		
	Naïve	Sophisticated	t-test for equality (p-value)	Naïve	Sophisticated	t-test for equality (p-value)
Sensitivity to Paycheck						
Average sensitivity	0.051	0.072	0.263	0.063	0.059	0.829
Median sensitivity	0.043	0.059		0.049	0.049	
Income and Debt						
Income - Mean	3,808	3,802	0.975	3,718	3,905	0.292
Credit Card Debt - Mean	14,144	13,693	0.713	14,194	13,652	0.659
Credit Card Debt - Median	9,430	10,133		9,672	9,997	
Credit Card Debt - avg. rel to income	3.786	4.773	0.306	3.941	4.558	0.507
Total Discretionary Spending						
avg $	1,844.0	1,755.8	0.307	1,772.3	1,841.5	0.426
avg % of income	52.9	51.6	0.598	51.5	53.3	0.493
avg % spend on credit cards	34.3	33.9	0.854	33.6	34.7	0.690
Short-run Consumables						
avg $ - mean	560.9	537.0	0.503	550.8	549.6	0.981
avg % spend on credit cards	31.1	31.1	0.981	30.5	31.8	0.633
Restaurant & Entertainment						
avg $ - mean	298.6	282.6	0.289	292.2	290.6	0.917
avg % spend on credit cards	32.4	32.4	0.978	31.3	33.6	0.423
Planned Paydown - 90 Days						
Mean	2,540.1	2,409.7	0.574	2,588.4	2,359.0	0.324
Median	1,795.1	1,723.3		1,688.8	1,795.1	
Payments Made - 90 Days						
Mean	3,375.0	2,895.0	0.201	3,343.4	2,949.4	0.303
Median	1,686.1	1,629.9		1,785.9	1,506.3	
Change in debt						
Avg. change - 90 days	-693.0	-784.2	0.735	-763.0	-700.3	0.816
Avg. change - 180 days	-787.1	-1,210.8	0.216	-832.8	-1,142.3	0.369
N	285	231		276	231	

The table shows summary statistics on estimated sensitivity to paycheck receipt, monthly income, debt, spending, as well as spending for users classified as naive or sophisticated. In the first two columns users are classified as sophisticated or naive based on estimates using short-run consumables. In the last two columns, this classification is based only on restaurant and entertainment spending.

Table 8: Sensitivity, Sophistication and Planned Paydown

	Planned Paydown	
	Short-run Consumables	**Restaurant& Entertainment**
Sensitivity	145.538	186.976
	(0.267)	(0.274)
Sophisticated	32.648	140.571
	(0.774)	(0.178)
Sensitivity * Sophisticated	-70.542	-126.329
	(0.775)	(0.613)
Median paycheck ($)	194.5***	257.5***
	(0.000)	(0.000)
Original debt ($)	17.8***	15.8***
	(0.000)	(0.000)
Cash balances	3.247	2.283
	(0.467)	(0.611)
Available credit	2.435	3.641
	(0.250)	(0.190)
Median paycheck * Sophisticated	-2.058	-112.168
	(0.979)	(0.133)
Original debt * Sophisticated	1.296	4.279
	(0.775)	(0.347)
Cash balances * Sophisticated	-4.209	-1.390
	(0.526)	(0.834)
Available credit * Sophisticated	0.327	-1.986
	(0.931)	(0.576)
Constant	-123.076	-198.269
	(0.277)	(0.124)
Number of individuals	516	516

The table shows estimates of the effect of short-run impatience and sophistication on planned paydown with p-values based on bootstrapped standard errors in parentheses. All variables are winsorized at the 1% level. Short-run impatience is measured as the coefficient β_1 in equation (1) using expenditures on short-run consumables or restaurant and entertainment as the dependent variable. Median paycheck and level of original debt are measured in dollars. Users are classified as naive if the effect of additional resources on the sensitivity of short-run consumables spending is positive and as sophisticated if the effect is negative.

Table 9: Effect of Impatience and Planned Paydown on Actual Debt Paydown by Naive and Sophisticated Agents

	Paydown 90 Days		Paydown 180 Days	
	Short-run Consumables	Restaurant& Entertainment	Short-run Consumables	Restaurant& Entertainment
Sensitivity	8.511	-3.293	6.461*	7.547*
	(0.241)	(0.613)	(0.099)	(0.083)
Planned paydown	0.179*	0.280***	0.129	0.177**
	(0.056)	(0.002)	(0.133)	(0.033)
Sensitivity * Sophisticated	-33.293***	-13.820	-10.179*	-17.774***
	(0.004)	(0.188)	(0.082)	(0.006)
Planned paydown * Sophisticated	0.371*	0.086	0.391*	0.295
	(0.098)	(0.666)	(0.065)	(0.119)
Median paycheck	1.938	-2.026	1.990*	-0.889
	(0.197)	(0.235)	(0.084)	(0.503)
Original debt	0.173	0.160	-0.028	0.005
	(0.161)	(0.201)	(0.786)	(0.962)
Median paycheck * Sophisticated	-2.116	5.597*	-2.412	2.735
	(0.502)	(0.074)	(0.290)	(0.282)
Original debt * Sophisticated	-0.346	-0.251	-0.148	-0.243
	(0.205)	(0.340)	(0.530)	(0.242)
Sophisticated	4.157	-8.474	-1.099	-7.299
	(0.469)	(0.127)	(0.797)	(0.077)
Constant	-12.035***	-7.636*	-8.585***	-6.217**
	(0.000)	(0.064)	(0.000)	(0.010)
Number of individuals	516	516	516	516

The table shows regression estimates of equation (3) with p-values based on bootstrapped standard errors in parentheses. All variables are winsorized at the 1% level. Paydown is measured as the average daily reduction in debt levels. Short-run impatience is measured as the coefficient β_1 in equation (1) using expenditures on short-run consumables or restaurant and entertainment as the dependent variable. Median paycheck and level of original debt are measured in thousands of dollars. Users are classified as naive if the effect of additional resources on the sensitivity of short-run consumables spending is positive and as sophisticated if the effect is negative.

Table 10: Direct Effect of Sophistication Measure on Debt Paydown

	Paydown 90 Days				Paydown 180 Days			
	I	II	III	IV	V	VI	VII	VIII
Short-run Consumables								
Coefficient on	-0.439	0.114	-0.224	0.683	-0.497	-0.539	-0.376	-0.075
Resources*Payweek	(0.432)	(0.935)	(0.675)	(0.602)	(0.145)	(0.551)	(0.238)	(0.927)
winsorized	1%	5%	1%	5%	1%	5%	1%	5%
Controls			Y	Y			Y	Y
N	516							
75th - 25th percentile	0.251							
Restaurant & Entertainment								
Coefficient on	-0.070	0.185	-0.075	0.492	0.320	0.843	0.267	0.925
Resources*Payweek	(0.864)	(0.867)	(0.847)	(0.643)	(0.218)	(0.182)	(0.271)	(0.118)
winsorized	1%	5%	1%	5%	1%	5%	1%	5%
Controls			Y	Y			Y	Y
N	516							
75th - 25th percentile	0.305							

The table shows regression estimates of equation (4) with p-values based on bootstrapped standard errors in parentheses. The coefficient on the interaction of *payweek* and *resources* is estimated in equation (2). Full controls include all regressors included in equation (3).

Table 11: Low Impatience Excluded

	Paydown 90 Days				Paydown 180 Days			
		Exclude if sensitivity in the lowest				Exclude if sensitivity in the lowest		
	Baseline	**10%**	**15%**	**20%**	**Baseline**	**10%**	**15%**	**20%**
Short-run Consumables								
Sensitivity	8.511	9.471	10.684	10.626	6.461*	5.963	6.379	6.087
	(0.241)	(0.212)	(0.161)	(0.169)	(0.099)	(0.141)	(0.117)	(0.139)
Planned paydown	0.179*	0.152	0.129	0.153*	0.129	0.118	0.102	0.117
	(0.056)	(0.126)	(0.196)	(0.086)	(0.133)	(0.172)	(0.252)	(0.180)
Sophisticated * Sensitivity	-33.293***	-33.412**	-32.203**	-30.319**	-10.179*	-10.352*	-9.786	-8.326
	(0.004)	(0.006)	(0.009)	(0.020)	(0.082)	(0.093)	(0.117)	(0.198)
Sophisticated * Planned paydown	0.371*	0.398*	0.414*	0.402*	0.391*	0.368*	0.388*	0.384*
	(0.098)	(0.094)	(0.082)	(0.082)	(0.065)	(0.080)	(0.071)	(0.079)
Sophisticated	4.157	7.080	6.068	6.494	-1.099	0.712	0.726	0.538
	(0.469)	(0.266)	(0.356)	(0.342)	(0.797)	(0.878)	(0.881)	(0.917)
Restaurant & Entertainment								
Sensitivity	-3.293	-3.014	-2.948	-2.154	7.547*	7.557*	7.897*	7.953*
	(0.613)	(0.652)	(0.669)	(0.760)	(0.083)	(0.084)	(0.084)	(0.092)
Planned paydown	0.280**	0.258**	0.277**	0.293**	0.177**	0.173**	0.178**	0.181*
	(0.002)	(0.004)	(0.003)	(0.002)	(0.033)	(0.047)	(0.048)	(0.053)
Sophisticated * Sensitivity	-13.820	-12.811	-11.693	-15.479	-17.774***	-17.270**	-17.443**	-19.011**
	(0.188)	(0.248)	(0.315)	(0.194)	(0.006)	(0.007)	(0.009)	(0.007)
Sophisticated * Planned paydown	0.086	0.115	0.103	0.090	0.295	0.313	0.312	0.331
	(0.666)	(0.573)	(0.624)	(0.682)	(0.119)	(0.120)	(0.131)	(0.121)
Sophisticated	-8.474	-7.792	-8.656	-6.562	-7.299*	-7.833*	-7.750	-7.155
	(0.127)	(0.213)	(0.192)	(0.337)	(0.077)	(0.080)	(0.102)	(0.156)
Median paycheck	Y	Y	Y	Y	Y	Y	Y	Y
Original debt	Y	Y	Y	Y	Y	Y	Y	Y
Constant	Y	Y	Y	Y	Y	Y	Y	Y
Number of individuals	516	465	439	413	516	465	439	413

The table shows regression estimates of equation (3) with p-values based on bootstrapped standard errors in parentheses. Variables are winsorized at the 1% level. Paydown is the average daily reduction in debt levels. Sensitivity is the coefficient β_1 in equation (1) with expenditures on short-run consumables or restaurant and entertainment as the dependent variable. Users are classified as sophisticated if additional resources reduce the sensitivity to paycheck receipt and as naive otherwise.

Table 12: Debt Paydown and Consumption Patterns - Different Restrictions on Sensitivity Estimates

	Short-Run Consumables			Restaurant & Entertainment		
	buffer	total discretionary	all	buffer	total discretionay	all
Dependent Variable: Paydown 90 Days						
Sensitivity	6.135	8.934	8.362	-8.555	-2.250	-2.222
	(0.369)	(0.158)	(0.221)	(0.146)	(0.737)	(0.723)
Planned paydown	0.180*	0.180*	0.179*	0.282***	0.280***	0.280***
	(0.058)	(0.058)	(0.079)	(0.002)	(0.001)	(0.001)
Sensitivity	-28.158***	-31.647***	-32.144***	-6.802	-15.936	-16.284
* Sophisticated	(0.013)	(0.002)	(0.006)	(0.471)	(0.115)	(0.136)
Planned paydown	0.380*	0.372*	0.368	0.094	0.094	0.083
* Sophisticated	(0.096)	(0.100)	(0.101)	(0.638)	(0.634)	(0.658)
Sophisticated	3.061	3.610	4.394	-9.066	-8.519	-8.246*
	(0.587)	(0.529)	(0.401)	(0.105)	(0.129)	(0.091)
Dependent Variable: Paydown 180 Days						
Sensitivity	4.428	3.920	5.593	2.950	7.126*	8.671**
	(0.276)	(0.326)	(0.126)	(0.464)	(0.077)	(0.049)
Planned paydown	0.139	0.139	0.139*	0.177**	0.177**	0.178**
	0.138	0.136	(0.135)	(0.036)	(0.034)	(0.024)
Sensitivity	-8.115	-6.921	-8.567	-12.701*	-17.812***	-19.583***
* Sophisticated	(0.238)	(0.271)	(0.130)	(0.058)	(0.002)	(0.005)
Planned paydown	0.420*	0.418*	0.416*	0.301	0.300	0.292
* Sophisticated	(0.071)	(0.071)	(0.065)	(0.113)	(0.114)	(0.114)
Sophisticated	-1.455	-1.550	-1.260	-7.672*	-7.395*	-6.991**
	(0.736)	(0.723)	(0.769)	(0.061)	(0.073)	(0.038)
Controls						
Median Paycheck	Y	Y	Y	Y	Y	Y
Original Debt	Y	Y	Y	Y	Y	Y
Constant	Y	Y	Y	Y	Y	Y
Nr of individuals	516	516	516	516	516	516

The table shows regression estimates of equation (3) with p-values based on bootstrapped standard errors in parentheses. Variables are winsorized at the 1% level. Paydown is the average daily reduction in debt levels. Sensitivity is the coefficient β_1 in equation (1) with expenditures on short-run consumables or restaurant and entertainment as the dependent variable. Users are classified as sophisticated if additional resources reduce their sensitivity to paycheck receipt and as naive otherwise.

Appendices

A Estimating Sensitivity to Paycheck Receipt

A.1 Distribution of Estimated Sensitivities

Figure A1 plots the distribution of the estimated sensitivity to paycheck receipt of expenditures on short-run consumables in the top panel, and of expenditures on restaurant and entertainment only in the bottom panel. The plot complements the summary statistics on the estimated sensitivity to paycheck receipt in Table 5. As indicated by the summary statistics, the mean of the distributions is shifted upwards from zero. A t-test confirms that it is significantly different from zero - that is the average user's expenditures react substantially to paycheck arrival. The two distributions also look very similar irrespective of whether expenditures on short-run consumables or restaurant and entertainment only were considered.

A.2 Hypothetical Balances Based on Regular Payments

Section 4.2.2 estimates the effect of changing resources on the sensitivity to paycheck receipt. To do so, I isolate the variation in resources uncorrelated with an individual's prior spending by calculating hypothetical balances for each consumer. Figure A2 illustrates the construction of these hypothetical balances. It shows actual (upper panel) and calculated balances (lower panel) for a hypothetical consumer who receives regular bi-weekly paychecks (illustrated by upward pointing arrows) and has to pay rent monthly every other pay date (downward pointing red arrows). The upper panel shows the agent's actual balances given his income, rent payments and spending patterns. The lower panel shows the agent's calculated balances. Instead of using the agent's actual spending, non-regular spending is assumed to be split equally across all days. Each day's balance is then calculated based on the agent's regular paycheck, regular rent payment, and average daily spending. The figure shows that the monthly regular rent payments lead to substantially lower resources during the pay cycle in which they have to be made compared to the pay cycle where no regular payment is due. The calculated balances isolate this exogenous variation in the agent's level of resources from the endogenous variation caused by prior discretionary spending.

A.3 Sensitivity to Paycheck Under Different Restrictions

Table A1 shows summary statistics of estimated sensitivity to paycheck under different restrictions in the top panel and the correlation between these estimates in the bottom panel.

The estimated sensitivity decreases as more pay cycles are filtered out in which the user may have been credit constrained. However, the estimated sensitivity would decrease even if credit constraints did not play any role, since the excluded pay cycles are those with the highest spending. On the individual level, the estimated sensitivities are highly correlated. Within a given consumption category (short-run consumables or restaurant and entertainment), the correlation between sensitivity estimates with different restrictions is more than 90%. Across the two spending categories, the estimates are also similar with correlations between 55% and 65%.

B Robustness of Paydown Results

B.1 Sensitivity Estimates Based on Level of Spending and Weekly Spending

To be included in the sample, users are required to have at least 45 days of positive spending. Table A2 replicates the baseline results requiring either 40 or 50 days of positive spending instead. Throughout, the results are very similar to the baseline estimates in Table 9.

In the baseline specification, spending is measured in logs and on a daily level. Instead, the first panel of Table A3 uses sensitivity estimates based on the actual amount spent and normalizes those estimates by average spending. The second panel uses weekly spending instead of daily spending. The results are very similar to the baseline estimates in Table 9.

Table A4 uses sensitivity estimates based only on debit card spending, excluding any spending on credit cards in the estimation. Some users do not have enough spending on debit cards, so the sample is smaller - 494 users when using short-run consumables and 488 when only restaurant and entertainment spending is used. Again the results are similar to the baseline.

B.2 Robustness to Sophistication Classification

The first four columns of Table A5 exclude users who get classified differently into naive and sophisticated based on short-run consumables or restaurant and entertainment spending. The results are similar to the baseline results in Table 9. If anything, the point estimates are more similar across categories, supporting the notion that previously misclassified users lead to additional noise in the estimation. The last four columns of Table A5 classifies users as sophisticated or naive based on OLS estimates of the effect of resources instead of using estimates when resources are instrumented for by hypothetical balances as outlined in Section

4.2. If the endogeneity concern motivating the use of IV estimates is important, we would expect a substantial number of users to be misclassified when using OLS estimates and, hence, to find fewer differences between the two groups. Indeed, Table A5 finds smaller difference between sophisticated and naive individuals which are mostly not statistically significant, reinforcing the need to instrument for the level of resources.

B.3 Specification

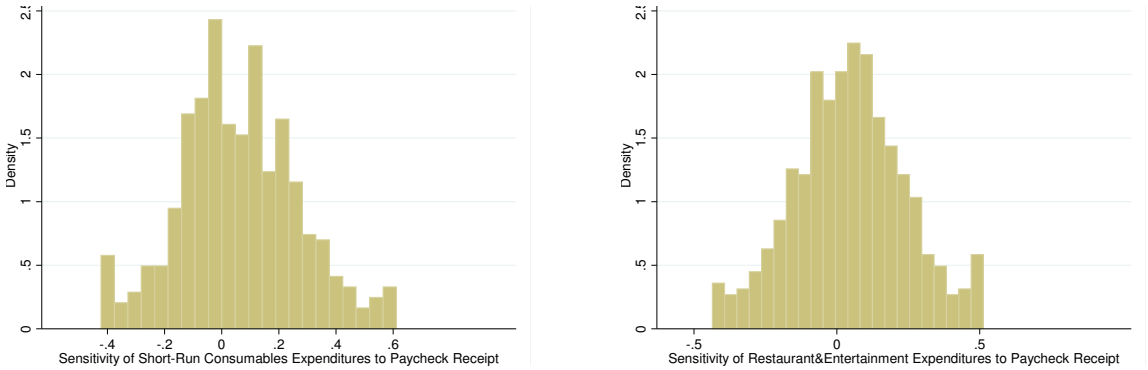
Table A6 shows estimates of equation (3) when the control variables, paycheck income and original debt levels, are assumed to have the same effect for both types of agents and are therefore not interacted with sophistication. In addition, the differences between sophisticated and naive agents in the effect of sensitivity and planned paydown are estimated separately. To do so, either sensitivity to paycheck or planned paydown is interacted with sophistication and the respective other variable is only included as a control (not interacted with sophistication). The results for each variable are very similar to the baseline results in Table 9.

C Data Preparation and Classifications

The following table illustrates how many users are lost at each step of the data selection process, starting with a random sample of users. I allow users to fulfill all sample criteria in 4 possible ways. First, they are included when all criteria are fulfilled considering all available data. Next, I restrict each user's data to one year, 270 days and 180 days after sign-up and include them if they fulfill all criteria during this shorter sample horizon. This includes users who acquire additional accounts later in the sample or switch jobs, such that they miss more than one paycheck or no longer have a regular paycheck later in the sample. The vast majority of users, 470 out of 516 fulfill the sample criteria when all their data are considered.

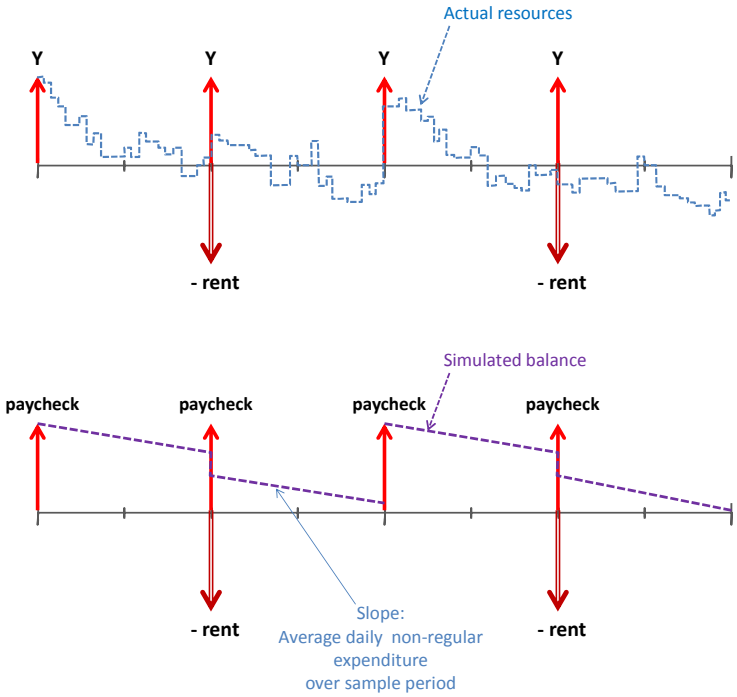
Users with a linked checking account in original sample	3653
and observed for at least 180 days after sign-up	2558
and all accounts linked at sign-up	2051
and a credit card and plan to reduce debt	1845
and at least one paycheck deposited into a checking account	1590
and regular bi-weekly paychecks	1118
and regular paychecks account for more than 70% of all income	923
and appear to have all relevant accounts linked	897
and at least 8 regular, non-constrained paycycles	698
and at least 45 days of positive spending	579
and fulfill all above criteria over the same horizon	519
fulfill criteria over full time observed	470
fulfill criteria during first year observed	21
fulfill criteria during first 270 days observed	12
fulfill criteria during first 180 days observed	13

Figure A1: Distribution of Individual-Level Sensitivity to Paycheck Receipt



The figure plots the distribution of the estimates of each user's sensitivity to paycheck receipt, captured by γ_{1i} in equation (1).

Figure A2: Hypothetical Balances Based on Regular Payments



The figure illustrates the construction of hypothetical balances based on regular payments. The upper panel shows actual balances for a hypothetical agent who receives regular bi-weekly paychecks (illustrated by upward pointing red arrows) and has to pay rent monthly every other pay date (downward pointing red arrows). The lower panel shows the agent's hypothetical balances based on regular payments and the assumption that spending is split equally across all days. Each day's balance is calculated based on the agent's regular paycheck, regular rent payment and average daily spending.

Table A1: Sensitivity Estimates under Different Restrictions

	Sensitivity to Paycheck Receipt					
	Obs.	Mean	Std. Dev.	25th pctile	50th pctile	75th pctile
Instant Consumption						
all	516	0.074	0.211	-0.064	0.066	0.201
category spending possible (baseline)		0.061	0.211	-0.081	0.049	0.199
buffer stock (5th percentile)		0.052	0.227	-0.093	0.040	0.190
total discretionary possible		0.057	0.216	-0.089	0.039	0.198
Restaurants&Entertainment						
all	516	0.056	0.201	-0.070	0.056	0.192
category spending possible (baseline)		0.046	0.201	-0.086	0.052	0.172
buffer stock (5th percentile)		0.041	0.223	-0.108	0.050	0.179
total discretionary possible		0.040	0.206	-0.089	0.042	0.163

Sensitivity Estimates

	Short-run Consumables				Restaurant&Entertainment			
		category spending		total		category spending		total
	all	baseline	with buffer	possible	all	baseline	with buffer	possible
Instant Consumption								
all	1							
category spending (baseline)	0.976	1						
category spending with buffer	0.903	0.927	1					
total discretionary possible	0.948	0.964	0.933	1				
Restaurant&Entertainment								
all	0.648	0.628	0.584	0.614	1			
category spending (baseline)	0.629	0.632	0.587	0.617	0.983	1		
category spending with buffer	0.553	0.564	0.624	0.574	0.885	0.900	1	
total discretionary possible	0.580	0.586	0.575	0.623	0.933	0.951	0.910	1

Correlation

The top panel shows summary statistics of each user's estimated sensitivity to paycheck receipt under restriction other than the baseline estimates. The bottom panel shows the correlation between these estimates of each user's sensitivity to paycheck receipt. Throughout the table, the first row shows sensitivity estimates based on all paycycles the user is observed. The second row shows the baseline estimates. The third row requires payweek spending in each category to have been affordable without reducing the user's resources below the 5^{th} percentile of observed resources. The fourth row requires total discretionary spending (rather than just spending in the respective category) to have been affordable. As in the baseline specification, sensitivity to paycheck receipt is captured by the coefficient on *payweek* in equation (1).

Table A2: Different Requirements for Days Observed for Sample Inclusion

	90 Days				180 Days			
	Short-run Consumables		Restaurant& Entertainment		Short-run Consumables		Restaurant& Entertainment	
	40 obs	50 obs	40 obs	50 obs	40 obs	50 obs	40 obs	50 obs
Sensitivity	8.260	2.825	-4.079	-9.562	5.813	4.290	5.197	5.713
	(0.227)	(0.720)	(0.491)	(0.178)	(0.142)	(0.318)	(0.234)	(0.230)
Planned paydown	0.180*	0.178*	0.280***	0.281***	0.103	0.127	0.160**	0.176**
	(0.052)	(0.060)	(0.001)	(0.002)	(0.223)	(0.141)	(0.047)	(0.035)
Sensitivity	-31.175***	-32.280***	-12.390	-8.248	-7.222	-10.515*	-17.108***	-16.111***
* Sophisticated	(0.004)	(0.010)	(0.197)	(0.463)	(0.192)	(0.098)	(0.008)	(0.022)
Planned paydown	0.360	0.380*	0.087	0.090	0.408**	0.401*	0.284	0.296
* Sophisticated	(0.104)	(0.094)	(0.658)	(0.656)	(0.049)	(0.060)	(0.128)	(0.119)
Median paycheck	1.817	1.752	-2.032	-2.682	1.015	1.804*	-1.654	-1.208
	(0.198)	(0.265)	(0.191)	(0.131)	(0.377)	(0.134)	(0.206)	(0.380)
Original debt	0.177	0.187	0.163	0.199	0.102	-0.029	0.106	0.019
	(0.127)	(0.139)	(0.170)	(0.116)	(0.356)	(0.786)	(0.336)	(0.845)
Median paycheck	-1.083	-2.564	5.909**	6.217*	-0.944	-2.571	3.497	2.944
* Sophisticated	(0.711)	(0.446)	(0.041)	(0.059)	(0.681)	(0.284)	(0.166)	(0.268)
Original debt	-0.337	-0.358	-0.253	-0.282	-0.244	-0.150	-0.294	-0.258
* Sophisticated	(0.186)	(0.198)	(0.300)	(0.289)	(0.329)	(0.530)	(0.203)	(0.213)
Sophisticated	2.728	4.664	-9.193	-10.069*	-3.063	-1.211	-7.854**	-7.793*
	(0.616)	(0.442)	(0.081)	(0.089)	(0.464)	(0.790)	(0.059)	(0.076)
Constant	-12.105***	12.622***	-7.564	12.341**	-8.012***	0.607	-5.758	1.192
	(0.000)	(0.000)	(0.384)	(0.026)	(0.000)	(0.748)	(0.165)	(0.649)
Number of individuals	537	493	537	493	537	493	537	493

This table shows regression estimates of equation (3) with p-values based on bootstrapped standard errors in parentheses. Variables are winsorized at the 1% level. Paydown is the average daily reduction in debt levels. Sensitivity is the coefficient β_1 in equation (1) with expenditures on short-run consumables or restaurant and entertainment as the dependent variable. Users are classified as sophisticated if additional resources reduce the sensitivity to paycheck receipt and as naive otherwise.

Table A3: Sensitivity Estimates Based on Levels and Weekly Spending

	Levels				Weekly			
	90 Days		180 Days		90 Days		180 Days	
	Short-run Consumables	Restaurant& Entertainment	Short-run Consumables	Restaurant& Entertainment	Short-run Consumables	Restaurant& Entertainment	Short-run Consumables	Restaurant& Entertainment
Sensitivity	4.844	4.783	1.426	1.048	11.585**	9.101**	8.032***	8.140***
	(0.350)	(0.186)	(0.582)	(0.674)	(0.013)	(0.045)	(0.008)	(0.006)
Planned paydown	0.179*	0.275***	0.140	0.176**	0.177*	0.278***	0.106	0.176**
	(0.054)	(0.002)	(0.134)	(0.037)	(0.054)	(0.002)	(0.199)	(0.035)
Sensitivity	-13.557*	-14.688**	-4.919	-8.621***	-14.306**	-22.644***	-9.213**	-14.014***
* Sophisticated	(0.089)	(0.035)	(0.228)	(0.039)	(0.044)	(0.005)	(0.045)	(0.002)
Planned paydown	0.354	0.089	0.415*	0.290	0.358	0.081	0.390**	0.292
* Sophisticated	(0.115)	(0.656)	(0.073)	(0.127)	(0.108)	(0.682)	(0.047)	(0.123)
Median paycheck	1.835	-1.905	2.092*	-0.841	1.739	-1.885	2.073*	-0.773
	(0.226)	(0.262)	(0.078)	(0.526)	(0.261)	(0.286)	(0.085)	(0.561)
Original debt	0.175	0.175	-0.071	0.004	0.198	0.162	-0.001	0.001
	(0.157)	(0.174)	(0.530)	(0.971)	(0.109)	(0.199)	(0.988)	(0.990)
Median paycheck	-1.441	5.640*	-2.445	2.797	-1.252	5.515*	-3.021	2.667
* Sophisticated	(0.642)	(0.073)	(0.297)	(0.273)	(0.690)	(0.084)	(0.202)	(0.291)
Original debt	-0.305	-0.255	-0.129	-0.231	-0.322	-0.248	-0.112	-0.235
* Sophisticated	(0.263)	(0.340)	(0.616)	(0.275)	(0.239)	(0.349)	(0.602)	(0.261)
Sophisticated	2.467	-7.437	-1.296	-7.349**	1.919	-6.975	-0.312	-6.857*
	(0.671)	(0.178)	(0.775)	(0.080)	(0.729)	(0.206)	(0.945)	(0.094)
Constant	-12.301***	-7.616**	-8.496***	-5.354**	-13.387**	-8.039	-9.366***	-6.713*
	(0.000)	(0.014)	(0.000)	(0.013)	(0.010)	(0.334)	(0.001)	(0.085)
Number of individuals	516	516	516	516	516	516	516	516

This table shows regression estimates of equation (3) with p-values based on bootstrapped standard errors in parentheses. Variables are winsorized at the 1% level. Paydown is the average daily reduction in debt levels. Sensitivity is the coefficient β_1 in equation (1) with expenditures on short-run consumables or restaurant and entertainment as the dependent variable. Users are classified as sophisticated if additional resources reduce the sensitivity to paycheck receipt and as naive otherwise.

Table A4: Sensitivity Based on Debit Card Spending Only

	Paydown 90 Days		Paydown 180 Days	
	Short-run Consumables	Restaurant& Entertainment	Short-run Consumables	Restaurant& Entertainment
Sensitivity	16.731**	8.256	6.907*	7.692**
	(0.010)	(0.145)	(0.072)	(0.010)
Planned paydown	0.149	0.184*	0.125	0.184*
	(0.209)	(0.074)	(0.275)	(0.080)
Sensitivity * Sophisticated	-31.065***	-13.943**	-6.599	1.395
	(0.002)	(0.090)	(0.261)	(0.774)
Planned paydown * Sophisticated	0.458**	0.219*	0.426*	0.144
	(0.048)	(0.037)	(0.062)	(0.380)
Median paycheck (in 1,000s)	1.556	1.246*	1.961	-1.507
	(0.366)	(0.094)	(0.140)	(0.302)
Original debt (in 1,000s)	0.219*	0.176***	-0.044	0.004
	(0.085)	(0.008)	(0.712)	(0.970)
Median paycheck * Sophisticated	-3.121	-1.722**	-2.612	3.587
	(0.359)	(0.030)	(0.313)	(0.187)
Original debt * Sophisticated	-0.374	-0.176**	-0.144	-0.091
	(0.182)	(0.023)	(0.570)	(0.650)
Sophisticated	5.933	2.975	-0.907	-8.253**
	(0.323)	(0.013)	(0.849)	(0.050)
Constant	-12.366	6.023	-8.845**	0.230
	(0.181)	(0.444)	(0.018)	(0.959)
Number of individuals	494	488	494	488

This table shows regression estimates of equation (3) with p-values based on bootstrapped standard errors in parentheses. All variables are winsorized at the 1% level. Paydown is measured as the average daily reduction in debt levels. Short-run impatience is measured as the coefficient β_1 in equation (1) using expenditures on short-run consumables or restaurant and entertainment as the dependent variable. Median paycheck and level of original debt are measured in thousands of dollars. Users are classified as naive if the effect of additional resources on the sensitivity of short-run consumables spending is positive and as sophisticated if the effect is negative.

Table A5: Sophistication Classification - Exclude Inconsistently Classified Users and Classification Based on OLS Estimates

	Consistently Classified Users Only				Classification based on OLS			
	Paydown 90 Days		Paydown 180 Days		Paydown 90 Days		Paydown 180 Days	
	Short-run Consumable	Restaurant& Entertainmen	Short-run Consumable	Restaurant& Entertainmen	Short-run Consumable	Restaurant& Entertainmen	Short-run Consumable	Restaurant& Entertainmen
Sensitivity	5.633	-4.140	1.973	6.480	6.741	-5.768	2.351	0.047
	(0.530)	(0.613)	(0.678)	(0.229)	(0.297)	(0.376)	(0.505)	(0.990)
Planned paydown	0.243**	0.240**	0.133	0.144*	0.261***	0.254**	0.194*	0.193*
	(0.048)	(0.026)	(0.208)	(0.090)	(0.004)	(0.015)	(0.067)	(0.077)
Sensitivity	-38.795***	-19.103	-9.739	-20.045**	-23.764**	-6.372	-0.887	-0.008
* Sophisticated	(0.007)	(0.139)	(0.184)	(0.016)	(0.021)	(0.539)	(0.865)	(0.999)
Planned paydown	0.331	0.316	0.456*	0.480**	0.141	0.073	0.261	0.186
* Sophisticated	(0.256)	(0.227)	(0.075)	(0.047)	(0.548)	(0.751)	(0.279)	(0.426)
Median paycheck	-0.016	0.308	0.354	0.423	1.307	2.504	0.380	2.568**
	(0.994)	(0.866)	(0.770)	(0.713)	(0.441)	(0.130)	(0.757)	(0.040)
Original debt	0.151	0.138	0.027	-0.008	0.198*	0.246**	0.037	-0.034
	(0.289)	(0.362)	(0.813)	(0.943)	(0.097)	(0.028)	(0.719)	(0.759)
Median paycheck	2.653	3.070*	0.365	0.568	0.329	-1.476	0.892	-2.771
* Sophisticated	(0.488)	(0.377)	(0.870)	(0.791)	(0.921)	(0.640)	(0.711)	(0.262)
Original debt	-0.404	-0.326	-0.265	-0.249	-0.427	-0.425**	-0.362	-0.152
* Sophisticated	(0.210)	(0.287)	(0.312)	(0.310)	(0.102)	(0.076)	(0.129)	(0.522)
Sophisticated	-3.634	-6.876	-6.417	-6.818*	6.269	7.826	-2.309	3.656
	(0.587)	(0.277)	(0.152)	(0.094)	(0.314)	(0.148)	(0.578)	(0.378)
Constant	17.229***	10.582	0.240	-0.456**	-17.621***	-15.978*	-10.305***	-12.218***
	(0.021)	(0.207)	(0.934)	(0.879)	(0.000)	(0.000)	(0.000)	(0.000)
Number of individuals	375	375	375	375	516	516	516	516

Note: p-values in parenthesis, *** p<0.01, ** p<0.05, * p<0.1, winsorized 1%, sensitivity, bootstrapped standard errors

This table shows regression estimates of equation (3) with p-values based on bootstrapped standard errors in parentheses. Variables are winsorized at the 1% level. Paydown is the average daily reduction in debt levels. Sensitivity is the coefficient β_1 in equation (1) with expenditures on short-run consumables or restaurant and entertainment as the dependent variable. Users are classified as sophisticated if additional resources reduce the sensitivity to paycheck receipt and as naive otherwise.

Table A6: Alternative Regression Specifications

	Paydown 90 Days						Paydown 180 Days					
	Short-run Consumables			Restaurant& Entertainment			Short-run Consumables			Restaurant& Entertainment		
Sensitivity	5.046	8.910		-2.876	-1.899		4.497	6.254		8.937**	7.786	
	(0.458)	(0.226)		(0.661)	(0.784)		(0.253)	(0.142)		(0.037)	(0.098)	
Planned paydown	0.223***		0.216***	0.268***		0.264***	0.176***		0.168***	0.194***		0.185***
	(0.000)		(0.001)	(0.000)		(0.000)	(0.002)		(0.005)	(0.000)		(0.001)
Sensitivity	-26.341**	-29.980***		-17.219*	-16.010**		-7.893	-10.137		-24.525***	-18.768**	
* Sophisticated	(0.012)	(0.009)		(0.097)	(0.132)		(0.189)	(0.115)		(0.000)	(0.005)	
Planned paydown	0.268		0.262	0.105		0.108	0.338**		0.337***	0.259*		0.264*
* Sophisticated	(0.126)		(0.128)	(0.527)		(0.496)	(0.044)		(0.037)	(0.065)		(0.052)
Median paycheck	1.199***	3.880***	1.547***	1.317***	4.002***	1.434***	0.853***	2.663***	1.054***	0.639***	2.624***	0.800***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Original debt	0.030	0.327***	0.035*	0.029	0.328***	0.033	-0.110***	0.188***	-0.115***	-0.115***	0.184***	-0.111***
	(0.184)	(0.000)	(0.094)	(0.265)	(0.000)	(0.161)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sophisticated	-3.695	5.029	-3.821	-1.621	0.021	-2.565	-5.806	2.474	-6.388	-4.134***	1.413	-5.516*
	(0.435)	(0.127)	(0.422)	(0.704)	(0.995)	(0.540)	(0.145)	(0.232)	(0.105)	(0.234)	(0.417)	(0.096)
Constant	-9.357***	-16.577***	-11.239***	-12.609***	-16.035***	-12.053***	-6.590***	-12.611***	-6.880***	-8.998***	-12.647***	-7.865***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Nr of individuals	516	516	516	516	516	516	516	516	516	516	516	516

This table shows regression estimates of equation (3) with p-values based on bootstrapped standard errors in parentheses. Variables are winsorized at the 1% level. Paydown is the average daily reduction in debt levels. Sensitivity is the coefficient β_1 in equation (1) with expenditures on short-run consumables or restaurant and entertainment as the dependent variable. Users are classified as sophisticated if additional resources reduce the sensitivity to paycheck receipt and as naive otherwise.