Sticking to Your Plan: Hyperbolic Discounting and Credit Card Debt Paydown*

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Abstract

Using detailed data from an online service, I analyze the influence of present bias on debt paydown behavior. Each user's sensitivity of consumption spending to paycheck receipt proxies for his short-run impatience. To distinguish between consumers who are aware (sophisticated) and unaware (naive) of their future impatience, I exploit that this sensitivity varies with available resources for sophisticated agents only. Consistent with present bias, planned paydown is significantly more predictive of actual paydown for sophisticated agents than naive agents and higher measured impatience reduces paydown for sophisticated agents only. The findings are inconsistent with several alternative explanations, including credit constraints.

In 2010, nearly 70% of households in the United States had at least one credit card. 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 found that standard motives for borrowing - such as acute liquidity shortages or a lack of resources - cannot fully account for the credit card debt observed in the data. Similarly, the discount rates necessary

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to produce such borrowing in many standard models are unreasonably high relative to empirical estimates (see Laibson, Repetto, and Tobacman (2003)). An alternative explanation for household borrowing behavior proposed by behavioral economists is present bias or short-run impatience (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. Despite genuine intention to reduce their debt, they borrow excessively and often fail to repay debt later.

In this paper, I 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 his or her impatience. Using this measure, I show that considering the possibility of household present bias can significantly improve our understanding of their debt repayment patterns. I study a sample of consumers who signed up for an online credit card debt 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. Based on insights from theoretical models of present bias, I suggest a novel way of using these data to measure an individual's short-run impatience. I also present a novel way to measure the extent to which they are aware of their impatience, classifying them as "sophisticated"(aware) or "naive"(unaware), to use the terminology of O'Donoghue and Rabin (1999). I also describe the implications of possible present bias on an individual's success in sticking to their repayment plan. Finally, I empirically show that the relation between each individual's measures of present bias and debt paydown behavior is consistent with these theoretical predictions.

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.[1] To measure each household'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

[1]This behavior has been documented empirically by Shapiro (2005). Other papers have documented the sensitivity of consumption to the receipt of a paycheck (e.g. Stephens (2006), Hastings and Washington (2010)) or other expected payments (e.g. Souleles (1999), Browning and Collado (2001), Hsieh (2003), Parker (1999), Scholnick (2010)), 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.

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 smoother. 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. Based on these estimates, I classify households as sophisticated or naive.

Then, I relate these measures of impatience and sophistication to individual household 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 not actually succeed in paying off their debt. Sophisticated agents are aware of their future impatience, plan accordingly and 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 households classified as sophisticated relative to naive households. For sophisticated individuals, higher impatience leads to lower debt paydown. Naive agents often do not adhere to their paydown plans irrespective of the level 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 a household's level of short-run impatience and sophistication are key factors in explaining their debt repayment behavior.

In general, it is hard to detect time-inconsistent behavior. 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 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

[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.

empirical measure of sophistication, but also reinforces the importance of distinguishing between the two types.

I consider a number of alternative explanations for both the individual's consumption sensitivity to paycheck receipt and 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. Similarly, many other factors - such as non-separabilities in consumption or overoptimism - also fail to explain the joint patterns of consumption spending behavior and debt paydown. My 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.

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 explain 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 hyperbolic discounting can explain consumer choices between different credit card offers. Skiba and Tobacman (2008) find that the behavior of payday loan borrowers is better captured by the hyperbolic model than the standard model.[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.

Several papers have also 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

[3]Paserman (2008), Fang and Silverman (2009) and Fang and Wang (2010) use similar approaches to show the effect of hyperbolic discounting on job searches, welfare program participation and mammogram usage.

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 households' observed, real-life consumption spending behavior. This empirical approach also allows me to infer whether a person is aware of the extent of their short-run impatience (sophisticated), something previous papers have not been able to measure. 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 illustrates how present bias is reflected in consumption patterns and derives empirical predictions about debt paydown. Section 3 presents these consumption patterns and shows how they are used to measure impatience and sophistication. Section 4 presents the main results. Section 5 discusses alternative explanations and provides robustness checks, Section 6 concludes.

1 Data

1.1 Empirical Setting

The data is obtained from the online financial management service ReadyForZero (www.readyforzero.com), which offers users free help in managing their debt. 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. Based on the information provided, customers receive various types of advice, ranging from how to distribute their monthly planned payments amongst multiple accounts 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 the measured characteristics.

[4] Several other papers have documented the influence of hyperbolic discounting 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.

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.

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.[5] This allows me to measure how successful users are in sticking to their plan to pay off their credit cards. The final sample includes a total of 556 users who fulfilled these criteria in September 2012.[6] Appendix D describes the sample selection in detail. To select those with regular paychecks, I first identify 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.[7] 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 more than eight qualifying pay cycles with at least 35 days of spending on consumption goods to allow me to estimate individual level of impatience and sophistication.

[5] 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.

[6] 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.

[7] 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.

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 (442 days). During this time, the average user receives 25 paychecks, of which 24 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 $3,913 per month and the median user $3,526.[8] The average credit card debt at sign-up is $15,204, about four and a half 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 16.6% on their credit card accounts. On their bank account, users have an average cash balance of $3,954 which corresponds to a little more than the user's regular monthly income. Users also have substantial borrowing capacity left on their cards, $11,907 on average. There is substantial heterogeneity across users in debt levels, both in absolute and in relative terms. The 25th percentile's debt level is 145% of monthly income, while the 75th percentile has five times as much debt as monthly income. When users sign up for the site, they plan to reduce their debt by an average of $2,747 in the first three months, almost 30% of debt. Most users, however, reduce their debt levels by a lot less - only $736 on average in the first 90 days and $1,125 over 180 days. A substantial share of users even increase their credit card debt, as reflected in the increase in debt levels by 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. Therefore, these summary statistics provide a first indication that many users have substantial problems following their plans to reduce credit card debt.

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

[8] 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 wage income is about $42,000 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 ($47,000 versus $78,500*.7 = $55,000) household in the SCF.

Table 1: Summary Statistics - Income and Assets

	N	Mean	p25	p50	p75
Users					
Days in sample	556	471	339	442	619
Nr of paychecks		25	16	23	34
Nr of paychecks - full pay cycles		24	15	22	32
Income					
Avg. monthly income	556	3,913	2,607	3,526	4,669
Median monthly income		3,896	2,571	3,485	4,623
Avg. monthly non-paycheck income		312	0	123	437
Median monthly non-paycheck income		91	0	0	0
Assets					
Credit Card Debt - $	556	15,204	4,962	10,669	19,303
Credit Card Debt - rel. to income		4.52	1.46	3.03	5.10
Average APR on credit cards - %	497	16.6	13.2	16.2	20.0
Cash Balances - $		3,954	637	1,812	4,452
Cash Balances - rel. to income		1.05	0.21	0.53	1.12
Available Credit - $		11,907	1,776	5,697	16,250
Available Credit - rel. to income		3.39	0.56	1.62	4.32
Debt Paydown					
Change in Debt - 90 days - $	556	-736	-1,332	-234	363
Change in Debt - 90 days - %		0.03	-0.14	-0.02	0.04
Change in Debt - 180 days - $		-1,125	-2,264	-470	553
Change in Debt - 180 days - %		0.25	-0.22	-0.04	0.06
Planned Paydown - 90 days - $		2,747	1,121	1,947	3,484
Planned Paydown - 90 days - %		0.29	0.11	0.19	0.37
Payments Made - 90 days - $		4,568	1,280	2,545	5,815
Spending					
Total Discretionary - Avg. $	556	1,710	996	1,475	2,122
Total Discretionary - rel. to income		0.48	0.29	0.41	0.60
Short-run Consumables - Avg. $		505	283	430	642
Short-run Consumables - rel. to income		0.15	0.08	0.12	0.18
Restaurant & Entertainment - Avg. $		263	138	214	338
Restaurant & Entertainment - rel. to income		0.08	0.04	0.06	0.09
Regular Payments - Avg. $		1,178	542	968	1,531
Regular Payments - rel. to income		0.32	0.17	0.28	0.41

The table shows mean, median and 25^{th} and 75^{th} percentile for key characteristics of the users in the sample used throughout the paper. If applicable, spending is normalized by the user's average monthly income from his regular paychecks. The summary statistics for the subsample of users with enough observations to estimate sensitivity based on restaurants and entertainment are similar.

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.[9] 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. Specifically, I focus on short-run consumables, such as restaurant meals, groceries, gas and entertainment, as well as exclusively restaurant and entertainment expenditures. Appendix D lists the types of expenditures included in each of these categories.

Table 1 shows summary statistics of user's monthly expenditures. Total monthly discretionary spending is about $1,700 for the average user, which corresponds to about 48% of the user's regular income. About 30% of discretionary spending, $505, is spent on short-run consumables, of which $263 go to restaurant meals and entertainment.[10] Regular monthly payments average $1,178 per month, equivalent to 32% of users' regular income. Median monthly spending is slightly lower in all categories but shows similar patterns.

2 The Effect of Present Bias on Consumption and Debt Paydown Behavior

This section outlines how present bias can affect consumption and debt paydown decisions. Since key theoretical insights are already well established in the literature (e.g. Laibson, Repetto, and Tobacman (2003)), this section provides intuition on the mech-

[9]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.

[10]Spending ratios in Table 1 are expressed in terms of a user's regular income. Many users have additional sources of income supplementing a dominant regular paycheck. Also, returns are hard to differentiate from additional irregular income. Therefore, the ratios of spending relative to user's regular income may therefore appear relatively high.

anism of how present bias can affect agents' consumption patterns and debt paydown decision. Appendix A provides a simple modeling framework on which the intuition outlined in this section is based. When interpreting the empirical results, I argue that no other explanation produces similar *joint* patterns of consumption choices and paydown decision as outlined in this section, even though each resulting pattern on its own is consistent with alternative explanations.

2.1 Short-run Impatience and Sophistication

In this paper, I think about present bias in terms of quasi-hyperbolic preferences, a popular way of modeling present bias. Each period an agent with quasi-hyperbolic preferences discounts payoffs in period τ by $\beta\delta^\tau$, 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.

2.2 Consumption over the Pay Cycle

Consider agents who live paycheck to paycheck. They receive a paycheck every two periods and decides how to split it between consumption and debt repayment. Agents choose consumption in the first period and pass all remaining resources on to their second period self, who will decide how much to consume and how much to save. Since agents choose consumption in the first period based on their beliefs about their future choices, whether an agent is aware (sophisticated) about his future self's short-run impatience matters.

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, $\beta \leq 1$. He expects his future self to follow through with this consumption plan.

Unlike naive agents, sophisticated agents know that their future selves do not share their more patient long-run preferences and will be overly impatient. They know that a smaller fraction of resources left to the second period self will actually be saved and a larger fraction consumed than the first period self would like. How many resources the second period self consumes rather than saves depends on the level of resources available. When resources are higher, the declining marginal utility of consumption leads future selves to consume a smaller share of 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. The insight that sophisticated agents act more patiently when available resources are higher has previously been pointed out by Harris and Laibson (2002).

When deciding how to split consumption over the paycycle, sophisticated agents, like naive 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. The extent of this sensitivity is higher for more impatient agents. However, only sophisticated agents act more patiently when resources are higher and reduce their consumption response to paycheck receipt. This is not the case for naive agents, who are unconcerned about potential conflict of interest with their future selves. [11]

2.3 Debt Paydown

Now consider the agent's decision about how much to save for 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-

[11] 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. Later, I will argue that differences in the perceived value of savings will lead the naive agent to plan to save very little, so this effect will be small relative to that for the sophisticated agent.

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 cost 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, 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.

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 the 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.[12]

2.4 Joint Patterns of Consumption and Debt Paydown

Figure 1 illustrates how consumption patterns and debt paydown relate to each other. The two upper panels show the sensitivity of consumption spending to paycheck receipt for sophisticated and naive agents. For both types, the level of impatience is reflected in the sensitivity of consumption spending to paycheck receipt. More impatient agents

[12]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).

spend more in payweeks relative to non-payweeks. The extent of this sensitivity is lower when resources are high for sophisticated agents. This is not the case for naive agents.

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. Therefore 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 resources for debt paydown as particularly costly. Hence, the paydown of sophisticated agents decreases as their level of impatience rises. 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 want to delay payments, the level of impatience is not predictive of the amount paid down. 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.[13]

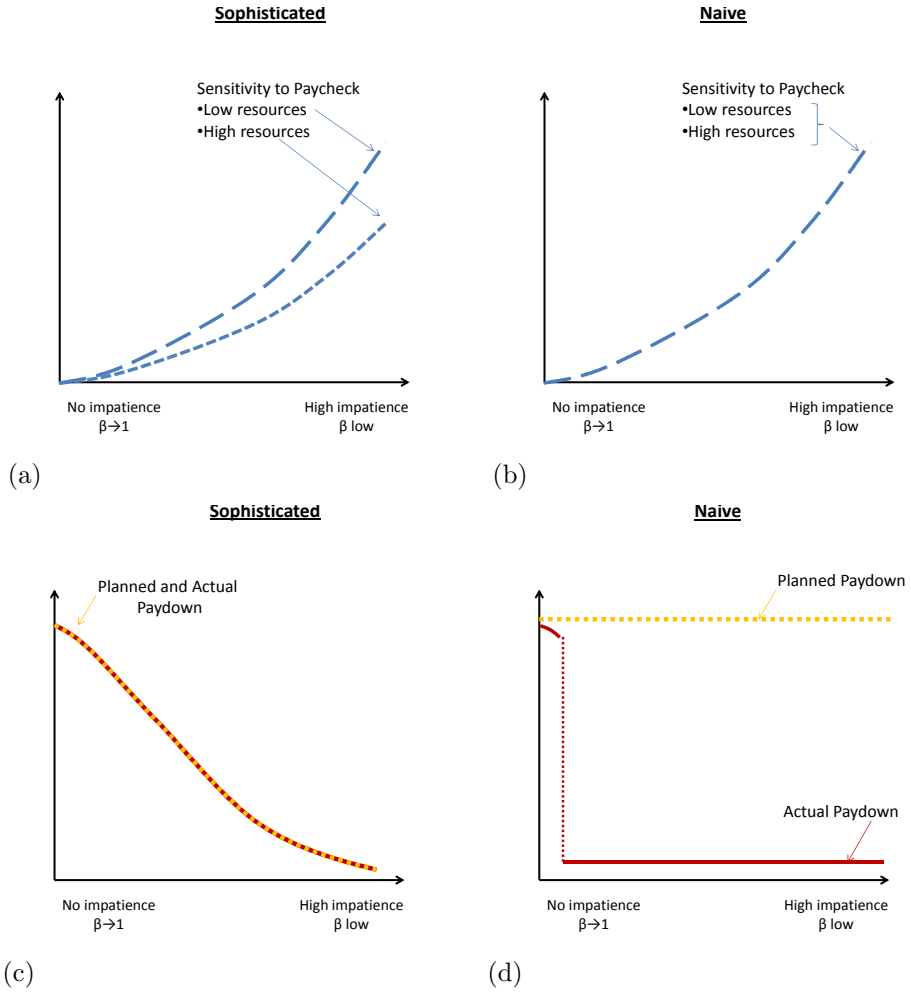
2.5 Evaluating the Role of Present Bias

Similar predictions 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 5, 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.

Similarly, present bias does not lead to the outlined patterns of consumption and debt paydown under all theoretically possible parametrizations. For instance, if consumers could perfectly commit their future selves to follow the current self's plan, sophisticated

[13]The implications of empirically distinguishing between naive and sophisticated agents are addressed in detail in Section 5.

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.

users would not need to worry about their future behavior. However, given the observed patterns, I argue that present bias is the only explanation consistent with the behavior observed in the data.

3 Consumption Patterns

This section estimates each user's sensitivity to paycheck receipt and how it is affected by varying resources over time. 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.

3.1 Sensitivity of Consumption to Paycheck Receipt

3.1.1 Regression Equation

The average sensitivity of consumption spending to paycheck receipt is estimated by the following equation:

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

where X_{it} includes month and day of week fixed effects. E_{it} are the user's daily expenditures on all short-run consumables or exclusively restaurant and entertainment.[14] 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}.

3.1.2 Filtering Out Credit Constraints

I am interested in capturing the extent of sensitivity to paycheck receipt reflecting 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 times in which short-run credit constraints are unlikely to play a role. Specifically, I restrict the sample to those

[14] 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.

times in which the user had enough resources (cash in his account and available credit on his cards) to afford the payweek's worth of spending in the previous week. This restriction removes the instances in which the consumer may have wanted to spend more but could not afford to do so until the next paycheck arrived. In section 5.3, I show that my results are also robust to using two alternative ways to exclude times with potentially binding credit constraints.

The fact that users have substantial resources which would allow them to smooth shocks may appear inconsistent with the idea that they live paycheck to paycheck. However, consumers in my sample primarily rely on spare borrowing capacity rather than substantial cash resources to smooth shocks. As long as financing consumption out of borrowing capacity rather than income is more costly, paycheck receipt affects consumption spending. There are several reasons for a consumer to consider decreasing borrowing capacity costly: First, with substantial credit card debt, incurring further debt is costly. Banks increase minimum payments or can raise the interest rates as balances increase. Second, lower spare capacity also restricts the use of a credit card for transaction purposes. Third, with uncertainty about future expense shocks, households like to keep a buffer stock of resources. Even a present-biased self may hesitate to touch such a buffer stock for the purpose of consumption, but would be willing to use it for an expense shock considered a legitimate spending need. Therefore, households may therefore live paycheck to paycheck in terms of their consumption even when they have substantial extra borrowing capacity that could be used to smooth shocks.

3.1.3 Estimated Sensitivity to Paycheck Receipt

Table 2 shows summary statistics of the sensitivity estimates, γ_{1i}. To estimate the sensitivity to paycheck receipt in a given category, I require users to have at least 35 days with positive spending in that category. Since restaurant and entertainment spending is defined more narrowly than short-run consumables, fewer users (510 instead of 556) satisfy these criteria. Restaurant and entertainment is less likely to be stored rather than consumed immediately relative to food and gas, the additional categories included in short-run consumables.[15] However, including such spending increases the amount of spending on which sensitivity to paycheck is estimated. Therefore I present results using both categories. The upper panel of table 2 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 6.7% higher and spending

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

Table 2: Sensitivity Estimates

	N	Mean	p25	p50	p75
Baseline Sensitivity Estimates					
Short-run Consumables	556	0.067	-0.115	0.048	0.227
Restaurants & Entertainment	510	0.044	-0.115	0.051	0.202
Baseline Effect of Resources on Sensitivity (γ_3)					
Short-run Consumables	556	-0.032	-0.231	-0.002	0.208
Restaurants & Entertainment	510	0.343	-0.263	0.001	0.222

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.

on restaurants and entertainment is 4.4% 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 more than 20% in payweeks.[16]

3.2 Effect of Resources on Sensitivity to Paycheck Receipt

3.2.1 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), X_{it} includes month and day of week fixed effects and E_{it} are each user's daily expenditures. $resources_{it}$ are a user's available resources, defined as

[16]Figure 4 in appendix B 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 2: The mean of the distributions is shifted upwards from zero and a t-test confirms that it is significantly different from zero.

the cash balances on his bank accounts plus the available credit on his credit cards.

3.2.2 Wealth Fluctuations due to Regular Payments

To estimate the effect of varying resources, I exploit within-agent variation in resources over time.[17] 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 has 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. Figure 5 in the appendix illustrates the intuition for these calculated balances.

3.2.3 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 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 2. For the median user, the effect is relatively small

[17] 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.

in both short-run consumption 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 2.2, additional resources lead sophisticated agents - but not naive ones - to act more patiently and their consumption reacts less to payment receipt. I split the sample into two groups. Those for whom additional resources reduce sensitivity to paycheck receipt, γ_{3i} is negative. Those for whom this is not the case, 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 3 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.

Table 3: Classification by Sophistication

	Restaurant & Entertainment		
	Naive	Sophisticated	Total
Short-Run Consumables			
Naive	173	79	252
Sophisticated	83	174	257
Total	256	253	509

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. There are 509 users with at least 35 days of positive spending in both categories when credit constraints were unlikely to play a role. One user has enough observations only for restaurant and entertainment spending, and 45 others have enough observations only for short-run consumables.

3.2.4 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 differ-

ences in the level of impatience, assets, earnings or total spending. Table 4 shows average and median estimated sensitivity levels for each group, tentatively labeled "naive" and "sophisticated". On average when sophistication is based on short-run consumables estimated levels of sensitivity to paycheck receipt are larger for sophisticated agents. However, those levels are lower when based on restaurants and entertainment only. 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 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.[18] 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.

In addition to estimated levels of sensitivity, table 4 shows some key summary statistics on income and debt levels. 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 only. Income and credit card debt levels are very similar between the two groups. On average, sophisticated agents have slightly higher income than naive agents, \$3,983 relative to \$3,841 when sophistication is based on short-run consumables. They also have slightly lower debt levels, \$14,257 relative to \$16,171. However, this relationship is reversed when comparing median instead of average levels.[19] Table 4 shows that naive agents spend slightly more than sophisticated agents, both in absolute terms

[18] In the robustness checks, I exclude users with low sensitivity who are most likely to be misclassified.

[19] Note that such small differences between sophisticated and naive agents are consistent with theoretical results on asset accumulation of present biased agents. As outlined in appendix A, 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.

Table 4: Summary Statistics by Sophistication

	Sophistication based on			
	Short-Term Consumables		**Restaurant & Entertainment**	
	Naive	Sophisticated	Naive	Sophisticated
Sensitivity to Paycheck				
Avg. Sensitivity	0.049	0.084	0.051	0.062
Median Sensitivity	0.042	0.062	0.038	0.039
Income and Debt				
Income - Mean $	3,841	3,983	3,926	4,029
Credit Card Debt - Mean $	16,171	14,257	15,657	15,128
Credit Card Debt - Median $	10,915	10,441	10,113	10,839
Credit Card Debt - avg. rel. to income	4.56	4.48	4.22	4.79
Total Discretationary Spending				
avg. $	1,729	1,692	1,845	1,690
avg. rel. to income	0.505	0.465	0.517	0.471
avg. % spent on credit cards	22.9	21.3	23.0	20.8
Short-Run Consumables				
avg. $ - mean	513	498	547	506
avg. % spent on credit cards	32.1	30.3	32.5	28.2
Restaurant & Entertainment				
avg. $ - mean	267	259	283	271
avg. % spent on credit cards	33.0	32.8	33.5	30.4
N	275	281	256	254

This table shows summary statistics on monthly income, credit card debt, spending, as well as credit card payments 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.

and relative to their income. Basing sophistication on only restaurant and entertainment spending, average total discretionary spending for naive agents is $1,845 or 52% of income. For sophisticated agents, it is $1,690 or 47% of income. Spending in the different sub-categories is, if anything, more similar between the two groups. Naive consumers also pay for a slightly higher fraction of their purchases by credit card. On average, they charge 23% of total purchases on their credit cards, compared to 21% for sophisticated consumers.[20] In general, the differences between sophisticated and naive agents

[20]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 (22% to 26%), than consumers in the highest quintile of sensitivity to paycheck receipt (16% to 18%).

in assets and spending are relatively small. It is therefore unlikely that the classification into naive and sophisticated masks substantial differences between the two groups along these dimensions which could directly account for any differences in the debt repayment behavior between the two groups.

4 The Effect of Present Bias on Debt Repayment

Section 3 showed that consumption patterns are consistent with at least some users exhibiting present bias. These patterns can be used as proxies for the extent of each user's present bias. This section relates these consumption patterns to the user's success in reducing debt levels to show that the joint patterns are as outlined in section 2. Recall that for sophisticated consumers planned paydown significantly increases actual paydown, but users with higher levels of impatience pay down less. 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.

4.1 Debt Paydown by Type

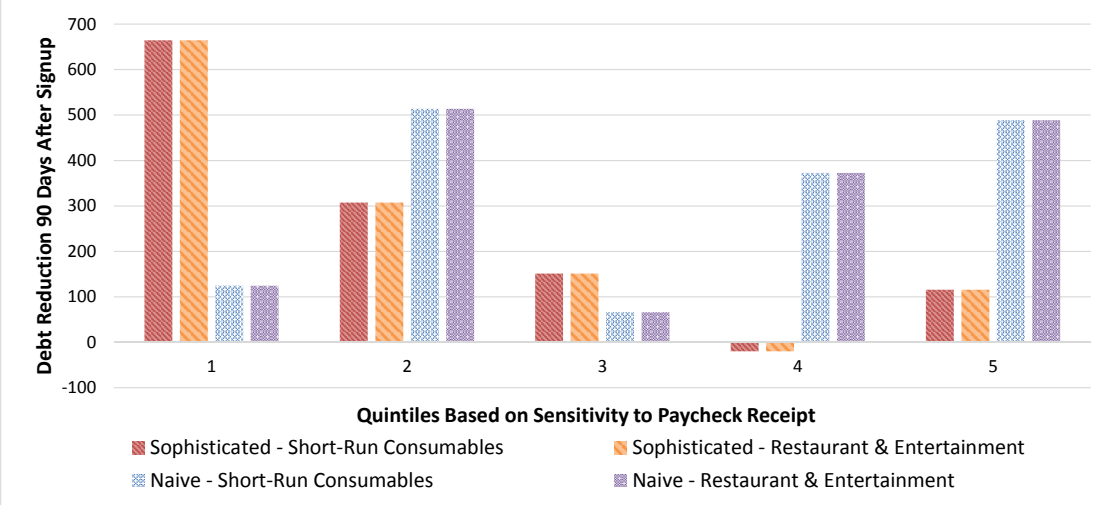
Figure 2 shows the change in debt levels over the first 90 days. For each type, sophisticated and naive users are sorted into quintiles based on their estimated sensitivity to paycheck receipt. The graph shows the median paydown for each group. In both groups, some users pay down substantial amounts pf debt, so there is little difference in the average paydown across groups.[21] Among sophisticated users, those with the lowest sensitivity to paycheck receipt reduce their debt levels the most. As sensitivity to paycheck increases, median paydown in each group falls. For naive users, no such pattern exists. While users in the second quintile pay down substantial amounts of debt, so do users with the highest estimated sensitivity to paycheck receipt. On the other hand, users in the lowest and the third quintile do not reduce their debt levels much.

4.2 Regression Equation

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

[21] Table 11 in the appendix confirms this.

Figure 2: Median Paydown (90 Days) by Sensitivity Quintiles



The figure shows the median 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.

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

where $Sensitivity_i$ is each agent's sensitivity of spending to paycheck receipt, estimated by equation (1).[22] $PlannedPaydown$ is the amount the user originally had planned to pay down[23] and X_i is a set of control variables, including debt levels at sign up and user's monthly income. Debt paydown is measured by the trend in debt balances over

[22]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 makes comparisons across the two groups biased. 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 not on intra - not inter - group comparisons.

[23]As illustrated in section 2.4, sophisticated agents should plan to pay down less the higher their short-run impatience. For naive agents, planned paydown should be high irrespective of short-run impatience. Empirically, I find no strong effect of short-run impatience on planned paydown. Rather, planned paydown is strongly related to user's income and original debt levels.

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.[24] To make estimates comparable over the different time horizons - 90 and 180 days - debt paydown and planned paydown are measured per day. Since the regressors $Sensitivity_i$ and $Sophist_i$ (sophistication) are estimated from consumption patterns, standard errors in the second stage are bootstrapped. [25]

4.3 Regression Results

Table 5 shows the regression estimates for equation (3) over time horizons of 90 and 180 days.[26] For naive agents, the omitted category, an additional dollar in planned paydown increases actual paydown by 14 cents over the first 90 days. Over 180 days, the effect is 6.7 cents when estimates are based on short-run consumables and 9 cents when based on restaurant and entertainment spending. Sensitivity to paycheck receipt has no consistent effect. For sophisticated users, planned paydown is significantly more predictive of actual paydown than for naive users. For sophisticated users, each dollar of planned paydown increases actual paydown between 30 and 36 cents. Specifically, the estimated effect in the first 90 days is 35 cents $(.14 + .21)$ and 31 cents $(.14 + .17)$ using estimates based on short-run consumables and on restaurant and entertainment spending. Over 180 days, the estimated effects are 30 Cents $(.07 + .23)$ and 36 Cents $(.09 + .27)$ respectively. Consistent with the notion of present bias, the level of short-run impatience significantly affects paydown for sophisticated agents. Specifically, more impatient agents reduce their

[24]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.

[25]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. Bootstrapped standard errors do not differ much from robust standard errors.

[26] 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 (theoretically for sophisticated consumers higher short-run impatience leads to both higher sensitivity to paycheck and lower planned paydown). This correlation makes it hard to identify their effects separately. I estimate separate specifications (unreported) 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 for each variable are slightly stronger when the other one is only included as a control, but differences are small. This indicates that planned paydown captures differences between users along multiple dimensions, not just impatience. Specifically, planned paydown controls for constraints and objectives which are known to the user (and hence incorporated in their plans), but unobserved to the econometrician. Empirically, planned paydown is primarily related to income and debt levels.

debt less. The total estimated effect for sophisticated agents (adding the coefficient on sensitivity to that of its interaction with sophistication) is similar in all specifications at around -13 over 90 days and slightly lower over 180 days. This effect is economically meaningful: moving from the 75th to the 25th percentile of estimated impatience levels increases debt paydown in the first 90 days after sign up by almost $400. That is more than half the average paydown of $760 by sophisticated agents over this time horizon.[27] The effect of the control variables, the user's median paycheck and the user's original debt levels, are all sensible and similar in magnitude across specifications. An additional $100 per paycheck increases debt paydown over 90 days by about 25 cents per day, or a total of $22.5. Over 180 days, the total effect is $18. Similarly, an additional $1,000 in original debt balances increases debt paydown by just under 10 cents per day over both, 90 and 180 days. While statistically significant, differences in income or original debt balances only explain a small fraction of the variation in debt paydown.

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

5 Alternative Interpretations and Robustness

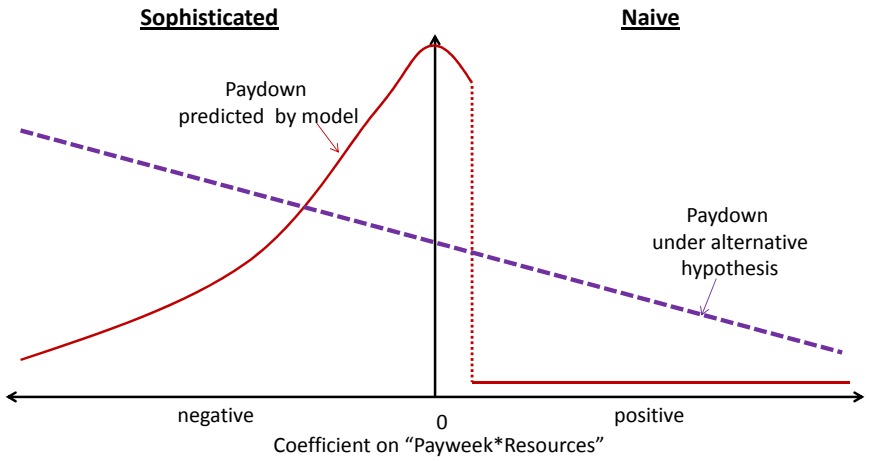
To interpret the results in Section 4 as evidence for the role of present bias requires that spending patterns and debt paydown are plausibly related only through a user's present bias. This section addresses alternative explanations for some of the patterns and shows that they fail to explain the *joint* behavior of debt paydown and consumption patterns.

Table 5: 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	7.346	-5.578	5.104	3.106
	(0.122)	(0.276)	(0.132)	(0.416)
Planned Paydown	0.136**	0.142**	0.067	0.090
	(0.022)	(0.037)	(0.187)	(0.100)
Sensitivity×	-20.411***	-7.314	-12.288***	-11.510**
Sophisticated	(0.004)	(0.377)	(0.009)	(0.023)
Planned Paydown×	0.208*	0.165	0.225**	0.268**
Sophisticated	(0.089)	(0.219)	(0.042)	(0.024)
Median Paycheck	2.474***	2.559***	0.922***	0.702***
	(0.000)	(0.000)	(0.000)	(0.007)
Original Debt	0.089***	0.099***	0.094***	0.037
	(0.000)	(0.001)	(0.000)	(0.167)
Sophisticated	-5.849	-4.783	-4.722	-5.814*
	(0.123)	(0.265)	(0.118)	(0.064)
Constant	-3.064	-3.698*	-0.352	0.119
	(0.103)	(0.097)	(0.814)	(0.938)
Nr of Individuals	556	510	556	510

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 & entertainment as the dependent variable. The regression is weighted by the standard error of the impatience estimate. 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.

Figure 3: Effect of Resources on Sensitivity and Debt Paydown



This 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 level on sensitivity to paycheck receipt, 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 2. 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.

5.1 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 smooth 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

[27]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 $.34 = 0.227 + 0.115$, as shown in Table 2. Multiplying the direct effect plus the difference for sophisticated agents by this differences yields an estimated effect of \$4.44 per day, or almost \$400 over 90 days.

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.[28]

Nevertheless, it could be the case that alternative models of behavior having 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 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 6 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 most are positive. That is the opposite of what would be expected under the

[28]Consider the following example to illustrate this point: An agent with a paycheck of \$100 saves \$50 and consumes \$30 in the first 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.

Table 6: Direct Effect of Sophistication Measure on Debt Paydown

	Paydown 90 Days				Paydown 180 Days			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Short-Run Consumables								
Coefficient on	0.13	2.32	-0.03	2.03	-0.20	0.88	-0.31	0.66
Resources*Payweek	(0.83)	(0.08)	(0.96)	(0.13)	(0.67)	(0.25)	(0.52)	(0.39)
winsorized	1%	5%	1%	5%	1%	5%	1%	5%
Controls	·	·	✓	✓	·	·	✓	✓
N				556				
Mean of Regressor				-0.032				
75^{th} - 25^{th} pctile				0.43				
Restaurant & Entertainment								
Coefficient on	0.41	1.59	0.52	1.15	0.25	0.87	0.31	0.56
Resources*Payweek	(0.42)	(0.31)	(0.30)	(0.45)	(0.32)	(0.28)	(0.17)	(0.49)
winsorized	1%	5%	1%	5%	1%	5%	1%	5%
Controls	·	·	✓	✓	·	·	✓	✓
N				510				
Mean of Regressor				0.343				
75^{th} - 25^{th} pctile				0.485				

This table shows regression estimates of equation (4) with p-values 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). Regression weights are the same as in equation (3), the standard error of the sensitivity estimate.

hypothesis that a reduction in sensitivity when resources increase leads to higher debt paydown.

5.2 Identifying Sophistication for Low Impatience Users

From a theoretical perspective, the distinction between sophisticated and naive agents becomes meaningless when users have very low or no short-run impatience. Similarly, users with low levels of sensitivity to paycheck receipt are difficult to classify as either sophisticated or naive. With a low level of sensitivity to begin with, 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 7, I exclude users with low levels of sensitivity. Starting with the baseline sample, I subsequently exclude users with the 5%, 10% 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, if anything, the estimated magnitudes increase.[29] 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.

5.3 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 for 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 times 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 at all. 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 substantial borrowing capacity left on their cards, an average of \$11,907, 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. Several do not have enough unrestricted pay cycles to estimate the sensitivity to paycheck receipt under the stricter definition of constraints. Across all users, the baseline specification excludes

[29] Note that the average level of sensitivity in the sample also changes, so a higher point estimate does not necessarily imply an increased effect.

Table 7: Low Impatience Excluded

	Short-Run Consumables				Restaurant & Entertainment			
		Exclude if sensitivity is in the lowest				Exclude if sensitivity is in the lowest		
	Baseline	5%	10%	20%	Baseline	5%	10%	20%
Dependent Variable: Paydown 90 Days								
Sensitivity	7.346	7.733	7.176	9.925**	-5.578	-4.792	-5.367	-8.631
	(0.122)	(0.110)	(0.152)	(0.044)	(0.276)	(0.360)	(0.315)	(0.114)
Planned Paydown	0.136**	0.141**	0.138**	0.193***	0.142**	0.139*	0.151**	0.098
	(0.022)	(0.022)	(0.024)	(0.008)	(0.037)	(0.057)	(0.040)	(0.219)
Sensitivity×	-20.411***	-21.745***	-20.623***	-24.005***	-7.314	-7.866	-8.092	-5.165
Sophisticated	(0.004)	(0.002)	(0.005)	(0.002)	(0.377)	(0.345)	(0.336)	(0.543)
Planned Paydown×	0.208*	0.210*	0.215*	0.231	0.165	0.185	0.182	0.244*
Sophisticated	(0.089)	(0.089)	(0.091)	(0.141)	(0.219)	(0.191)	(0.203)	(0.097)
Sophisticated	-5.849	-4.816	-5.803	-3.972	-4.783	-4.979	-4.912	-7.962*
	(0.123)	(0.215)	(0.145)	(0.346)	(0.265)	(0.258)	(0.274)	(0.062)
Dependent Variable: Paydown 180 Days								
Sensitivity	5.104	5.700*	5.460	6.519**	3.106	3.088	3.899	2.494
	(0.132)	(0.086)	(0.108)	(0.046)	(0.416)	(0.435)	(0.294)	(0.529)
Planned Paydown	0.067	0.060	0.056	0.091	0.090	0.071	0.115*	0.081
	(0.187)	(0.230)	(0.264)	(0.186)	(0.100)	(0.190)	(0.052)	(0.252)
Sensitivity×	-12.288***	-13.006***	-12.379**	-13.732***	-11.510**	-11.286**	-12.603***	-11.246**
Sophisticated	(0.009)	(0.007)	(0.011)	(0.006)	(0.023)	(0.029)	(0.009)	(0.032)
Planned Paydown×	0.225**	0.218**	0.227**	0.187	0.268**	0.284**	0.269**	0.320**
Sophisticated	(0.042)	(0.043)	(0.041)	(0.174)	(0.024)	(0.018)	(0.034)	(0.031)
Sophisticated	-4.722	-3.896	-4.482	-3.026	-5.814*	-6.389**	-6.105*	-8.489**
	(0.118)	(0.186)	(0.137)	(0.382)	(0.064)	(0.046)	(0.071)	(0.026)
Controls								
Median Paycheck	✓	✓	✓	✓	✓	✓	✓	✓
Original Debt	✓	✓	✓	✓	✓	✓	✓	✓
Constant	✓	✓	✓	✓	✓	✓	✓	✓
Nr of Individuals	556	528	500	444	510	484	459	408

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 & entertainment as the dependent variable. Users are classified as sophisticated if additional resources reduce the sensitivity to paycheck receipt and as naive otherwise. The regression is weighted by the standard error of the sensitivity estimate.

about 3% of all days with positive spending. Requiring total discretionary spending to be affordable or taking a buffer stock into account increases the number of excluded days to 5% and 11%, respectively. In the appendix, table 2 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.[30] Table 8 replicates the main results using sensitivity and sophistication 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 constraint 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 I argue that 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 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-

[30] Table 10 in the appendix 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 67% and 70%.

Table 8: Debt Paydown and Consumption Patterns - Different Restrictions on Sensitivity Estimates

	Short-Run Consumables			Restaurant & Entertainment		
	buffer	total discretionary	all	buffer	total discretionary	all
Dependent Variable: Paydown 90 Days						
Sensitivity	-0.157	7.053	3.548	-13.095***	-4.861	-2.519
	(0.974)	(0.179)	(0.449)	(0.009)	(0.388)	(0.611)
Planned Paydown	0.144**	0.137*	0.130**	0.145**	0.138**	0.154**
	(0.031)	(0.055)	(0.037)	(0.047)	(0.047)	(0.029)
Sensitivity×	-3.684	-21.645***	-14.110*	11.056	-7.184	-13.593*
Sophisticated	(0.629)	(0.008)	(0.059)	(0.151)	(0.416)	(0.062)
Planned Paydown×	0.182	0.201	0.225*	0.300**	0.176	0.138
Sophisticated	(0.173)	(0.102)	(0.084)	(0.049)	(0.239)	(0.323)
Sophisticated	-3.972	-5.715	-8.371*	-6.586	-5.225	-2.389
	(0.362)	(0.229)	(0.060)	(0.150)	(0.230)	(0.592)
Dependent Variable: Paydown 180 Days						
Sensitivity	4.606	3.443	2.915	2.289	3.635	3.249
	(0.156)	(0.324)	(0.375)	(0.527)	(0.288)	(0.309)
Planned Paydown	0.060	0.068	0.076	0.100	0.089	0.094
	(0.309)	(0.328)	(0.246)	(0.127)	(0.114)	(0.170)
Sensitivity×	-9.248*	-10.373**	-8.768	-8.057	-12.067**	-11.878**
Sophisticated	(0.071)	(0.047)	(0.105)	(0.131)	(0.026)	(0.060)
Planned Paydown×	0.258**	0.216*	0.187	0.299**	0.271**	0.251*
Sophisticated	(0.027)	(0.071)	(0.148)	(0.028)	(0.032)	(0.060)
Sophisticated	-6.841**	-5.428	-4.898	-7.116*	-6.283*	-5.080
	(0.037)	(0.132)	(0.177)	(0.054)	(0.063)	(0.165)
Controls						
Median Paycheck	✓	✓	✓	✓	✓	✓
Original Debt	✓	✓	✓	✓	✓	✓
Constant	✓	✓	✓	✓	✓	✓
Nr of Individuals	542	551	556	490	501	510

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 & entertainment as the dependent variable. Users are classified as sophisticated if additional resources reduce their sensitivity to paycheck receipt and as naive otherwise. The regression is weighted by the standard error of the sensitivity estimate.

run.[31] 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 who's consumption spending becomes less sensitive when resources are higher are better able to stock to their debt paydown plans.

5.4 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. All users in my sample have regular paychecks throughout the sample period. Therefore they do not experience a substantial reduction in their income reduction which could force them to abandon their original plan.

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

Overoptimism Overoptimism could lead some users to make overly ambitious debt paydown plans and, hence, explain their failure to stick to their plans. Such overoptimism could also lead to sensitivity of consumption spending to paycheck receipt. If users are overoptimistic about the probability of receiving additional resources in the second week of a pay cycle or if they 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

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

reason why the extent of overoptimism 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.[32] 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.

6 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)).[33] By providing empirical evidence that such behavioral biases play

[32] 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 (2012) find that households with higher cognitive ability measured by math scores make fewer financial mistakes, such as suboptimal use of credit cards.

[33] 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

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.[34] 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.[35] 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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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.

[34] Agarwal, Chomsisengphet, Mahoney, and Stroebel (2013) show that reductions in fees after the Credit CARD Act were not passed on to consumers.

[35] 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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Appendices

FOR ONLINE PUBLICATION

A A Simple Model

This section presents a simple model to illustrate the effects of present bias on consumption choices and debt paydown behavior, outlined in section 2.

A.1 Model Setup and the Agent's Choice

The agent has quasi-hyperbolic preferences, as outlined in section 2.1. The model focuses on one pay cycle consisting of two periods. At the beginning of each pay cycle, the agent receives a paycheck Y, which he splits between consumption in the two periods (c_1 and c_2) and debt repayment. The agent receives flow utility $u(c)$ from consumption c, where $u(.)$ is increasing and strictly concave. The benefits of any savings or debt repayment are summarized by $V(s)$, where $s = Y - c_1 - c_2$.[36] I will discuss below how $V(s)$ might depend on β or β^E and hence differ by agent type. Denote the agents' remaining resources in each pay cycle period by X_t. Consider two special cases:

1. **Low paycheck and no debt reduction/saving:** When Y is low, it only covers the agent's basic consumption needs and no agent wants to save, i.e. $u'(c_2) \geq V'(X_2 - c_2)$ for all $c_2 \leq X_2$ given all possible $X_1 \geq 0$.

[36] In an infinite horizon model, $V(s)$ would represent the agent's continuation value given his current period savings.

2. **High paycheck and potential debt reduction/saving:** Y is high enough so that all agents (time-consistent, naive impatient, sophisticated impatient) consider saving to pay down debt worthwhile.

A.1.1 Consumption over the Pay Cycle

The agent's optimization problem in the first period is

$$\max_{c_1} u(c_1) + \beta u(c_2) + \beta V(Y - c_1 - c_2)$$

subject to $c_1, c_2 \geq 0$ and $Y - c_1 - c_2 \geq 0$. The agent's optimization problem depends on the consumption and savings decision of his future self in the second period. It is here where the agents' beliefs about their future choices - that is the differences between naive and sophisticated agents - matter. The agent believes that his second period self will choose consumption and savings according to $u'(c_2^E) = \beta^E V'(X_2 - c_2^E)$.

Case 1: Low Paycheck - No Debt Paydown When the agent's paycheck is so low that it only covers his basic consumption needs, saving to pay down debt is not considered worthwhile and $c_2 = X_2$. The optimization problem in the first period reduces to[37]

$$\max_{c_1} u(c_1) + \beta u(c_2)$$

subject to $c_2 = X_2 = w - c_1$ and the agent's first order condition is

$$\frac{u'(c_1)}{u'(c_2)} = \beta$$

The ratio of first to second period marginal utility is equal to β. The agent consumes more in the first pay cycle period and more so when he

[37] The agent's belief about his future impatience does not matter in this case, since he consumes all remaining resources in the second period (and period 1 self knows this).

is more impatient (lower β). Relative to a time-consistent agent, the consumption of present-biased agents is therefore excessively sensitive to paycheck receipt, and the extent of this sensitivity is higher for more impatient agents.

Case 2: High Paycheck - Possible Debt Paydown When the agent receives a high paycheck such that some saving for debt paydown is potentially worthwhile, the agent chooses consumption in the first period given his beliefs about future consumption choices. Using the perceived first order condition in the second period, $u'(c_2^E) = \beta^E \delta V'(X_2 - c_2^E)$, the agent's FOC for consumption in the first period is

$$\frac{u'(c_1)}{u'(c_2^E)} = [\beta \frac{\partial c_2}{\partial X_2} + \frac{\beta}{\beta^E}(1 - \frac{\partial c_2}{\partial X_2})]$$

For the naive agent ($\beta^E = 1$) this simplifies to

$$\frac{u'(c_1)}{u'(c_2^E)} = \beta$$

For the naive agent, the ratio between first and second period expected marginal utility is therefore the same as in the case when the agent had low resources and did not even consider paying down debt.
For the sophisticated agent ($\beta^E = \beta$), the first order condition reduces to

$$\frac{u'(c_1)}{u'(c_2^E)} = [\beta \frac{\partial c_2}{\partial X_2} + (1 - \frac{\partial c_2}{\partial X_2})]$$

Note that $[\beta \frac{\partial c_2}{\partial X_2} + (1 - \frac{\partial c_2}{\partial X_2})] \in (\beta, 1)$. When the agent receives a low paycheck and does not plan to save in the second period, $\frac{\partial c_2}{\partial X_2} = 1$. That expression equals β, so that the Euler equation reduces to the one derived for the low paycheck case. As the agent receives additional resources and decides to save some of them at the end of the second period ($\frac{\partial c_2}{\partial X_2} <$

1), the effective discount factor for the sophisticated agent increases and approaches 1. Consumption across the two periods becomes more equal and the excess sensitivity of consumption to paycheck receipt declines. The increase in the effective discount factor with higher resource levels for sophisticated but not naive agents has been previously noted by Harris and Laibson (2002) in a life cycle model of consumption.

Intuitively, this increase happens because the agent is more patient in the long run (trade-off between period 2 consumption and savings) than in the short run (trade-off between period 1 and period 2 consumption). Therefore, the first period's self would like future selves to act more patiently and save a larger share of resources than future selves actually do. When resources are high, the declining marginal utility of consumption leads future selves to consume a smaller share of any additional resources passed to them. Hence, future selves act more in the interest of the first period's self. The current self is aware of this reduced conflict in how to allocate future resources. Thus he is more willing to pass on additional resources to his future selves. This reduces the current self's consumption reaction to paycheck receipt.

For an alternative intuition for the sophisticated agent's Euler equation, recall that the discount factor applied by a time-inconsistent agent between two periods changes. The first period's self discounts payoff from the next period by β. This is the relevant discount factor applied to the (marginal) share of resources consumed in the second period ($\frac{\partial c_2}{\partial X_2}$). Between any two future periods (between period 2 consumption and savings for debt reduction in the model context), the current self discounts payoffs only by $\delta = 1$. Therefore, $\delta = 1$ is the relevant discount factor applied to the (marginal) share of resources saved in the next period ($1 - \frac{\partial c_2}{\partial X_2}$). The period 1 self applies an effective discount factor between current and next

period's marginal utility that is a weighted average between the short- and long-run discount factor. The weights depend on how resources are used by the next period's self. With additional resources, the agent's second period self consumes a lower fraction of available resources, such that he prefers a higher ratio between first and second period marginal utility. This behavior smooths consumption more between the first and second period and decreases consumption sensitivity to paycheck receipt.[38]

A.2 Debt Paydown

To illustrate the agent's trade-off between consumption in the current pay cycle and saving to pay off debt, the first order condition for the naive agent in the first period can be written as

$$\begin{aligned} u'(c_1) &= \beta u'(c_2^E) \\ &= \beta V'(s^E) \end{aligned}$$

and for the sophisticated agent as

$$\begin{aligned} u'(c_1) &= [\beta \frac{\partial c_2}{\partial X_2} + (1 - \frac{\partial c_2}{\partial X_2})] u'(c_2) \\ &= [\beta \frac{\partial c_2}{\partial X_2} + (1 - \frac{\partial c_2}{\partial X_2})] V'(s) \end{aligned}$$

There are two effects that can cause sophisticated and naive agents to save different amounts. First, the sophisticated agent is aware of his

[38]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 into account any possible deviations of future selves. In this case, higher resources will not reduce the (non-existent) conflict of interest and affect consumption decisions. Similarly, there may be additional effects for naive agents. Specifically, planned consumption may not equal actual consumption since the naive agent will end up consuming more in the second period than he had planned to. Such behavior decreases actual consumption ratios for the naive agent as well. I will argue later that differences in the perceived value of savings will lead the naive agent to plan to save very little, so this effect will be small relative to that for the sophisticated agent.

future impatience. He knows his next period's self is likely to consume some of the resources the current self would prefer him to save for debt reduction. Being aware of this future behavior reduces the benefit of saving.[39] Second, the naive agent expects his future self to not be present-biased and therefore to save more. This expectation makes saving less attractive for the naive than the sophisticated agent, who knows he cannot rely on his future self for savings. In the model, the extent of this effect is reflected by the relative size of $V'(s^E)$ and $V'(s)$. If the agent expects to save more next period ($s^E > s$), the marginal value of savings is lower, encouraging first period consumption.

Which of these effects dominates depends on the specification of $V(s)$, the benefit of saving, and the agent's instantaneous utility function $u(c)$. Instead of making specific assumptions on $V(s)$, I outline when the literature has found differences in $V(s)$ between sophisticated and naive agents. The setting considered in this paper resembles settings in the literature finding substantial differences between the two types of agents.

The literature has found little difference in the behavior of naive and sophisticated agents in settings in which the agents' future paths depend significantly on how much they save today. An example is the "eat-the-pie" problem illustrated by Tobacman (2007). If the agent consumes a lot in the current period, his consumption in all future periods will have to be lower, even if future selves are not present-biased and save more. In such cases, 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. This implies substantial benefits of savings, $V(s)$, which are similar for both types of agents.[40]

[39] In the model, this effect is only indirectly reflected in c_2 and s being chosen according to the second period self's short-run impatient preferences, rather than the agent's long-term, more patient preferences, which a naive agent believes will determine his future choices.

[40] The same holds in models with long periods. If saving little in the current period means that any

Substantial differences between sophisticated and naive agents are found in settings in which the agent has to complete a certain task, but can choose in which period to do so. Once the task is completed, the agent's path of future payouts is independent of *when* the task was completed. In this case, it is attractive for naive agents to rely on their future selves to complete the task, since such a shift only delays payouts a little further into the future. This temptation can lead naive agents to repeatedly procrastinate such that they never complete the task.[41]

In my model, an agent's decision of whether to pay down debt today is similar to the second setting. Once the debt is paid off, whether the final payment was made two weeks earlier or later does not significantly affect the agent's lifetime payout path. Therefore, saving little or entirely delaying a payment from the current pay cycle to the next is attractive to present-biased agents. By definition, saving yields payouts in the future but entails current costs in terms of forgone consumption, which a present-biased agent overvalues relative to the future benefits of saving. However, when delaying debt payment to the next pay cycle, both cost and benefits lie in the future, so agents do not overvalue costs relative to benefits.

If the agent can follow through with a plan to pay down debt in the next pay cycle, the benefit of saving in the current pay cycle rather than delaying ($V'(s^E)$) is very low ($V'(s^E) \to 0$). Indeed, a naive agent 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, he plans to save in the next pay cycle. He does not realize, however, that he

savings are deferred by at least a year, the potential downside of doing so is much larger than if saving little means deferring by a couple of days. For instance, Angeletos, Laibson, Repetto, Tobacman, and Weinberg (2001) find little differences in a model of life cycle savings decisions in which the agent lives for 90 year-long periods.

[41] For instance, O'Donoghue and Rabin (1999) study situations like this and find that whether agents are naive or sophisticated substantially affects their choices, since naive agents repeatedly delay costly tasks. Rabin and O'Donoghue (1999) also apply these insights to retirement savings and argue that naive agents are likely to procrastinate and not accumulate enough assets for retirement.

will be equally impatient in the future and when faced with the same decision, will repeatedly delay and never actually pay off his debt. This perpetual delay will occur despite the fact that the naive agent considers saving worthwhile and, if faced with the choice of saving in the current period or not at all, would prefer to save. Also note that as long as the agent's impatience is high enough to make delaying payoff by one pay cycle attractive, the extent of the agent's impatience has little influence on his actual paydown behavior; irrespective of the extent of their present-bias, naive agents persistently procrastinate.

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. Therefore, saving in the current period yields substantial benefits for the sophisticated agent ($V'(s) \gg 0$). However, the trade-off between these (substantial) benefits of savings 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.

Higher impatience also indirectly effects the agent's trade-off between current 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 which deviate less from 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 that cash 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. For the empirical analysis, I assume that the direct effect of impatience dominates such that more impatient agents save more. Theoretically, this assumption need not hold in all cases. For instance, Harris and Laibson (2002)

show that consumption functions (and, hence, savings) of hyperbolic discounting consumers need not always be well behaved and this assumption is violated. However, they also find that for empirically sensible calibrations, consumption functions (and, hence, savings) are well behaved and agents consume more and save less the more impatient they are (Figure 4 in their paper).

B Estimating Sensitivity to Paycheck Receipt

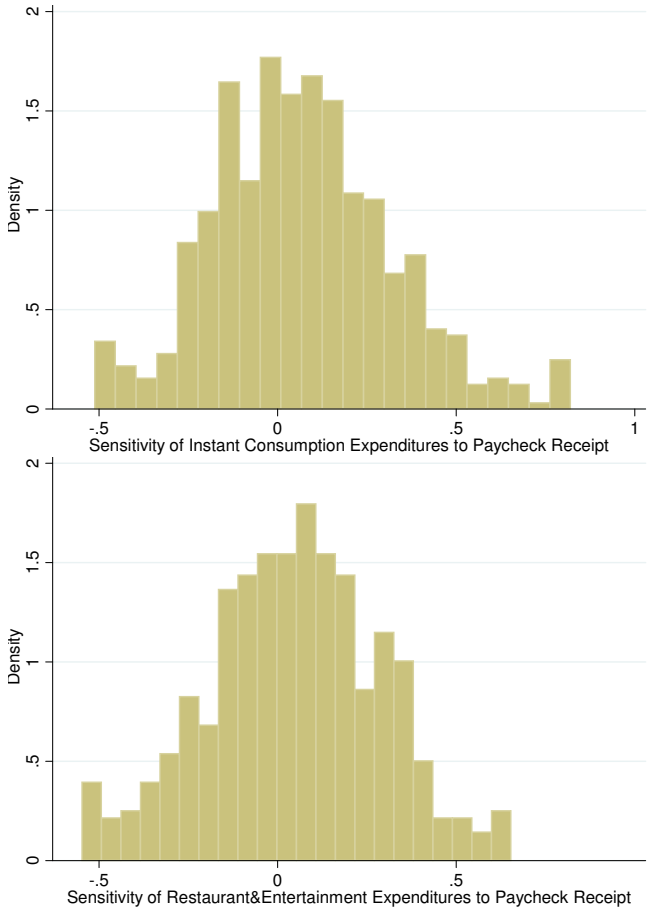
B.1 Distribution of Estimated Sensitivities

Figure 4 plots the distribution of the estimated sensitivity of expenditures on short-run consumables in the top panel and on restaurant and entertainment only in the bottom panel. The plot complements the summary statistics on the estimated sensitivity to paycheck receipt in table 2. 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.

B.2 Hypothetical Balances Based on Regular Payments

Section 3.2.2 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 5 illustrates the construction of these hypothetical balances. It shows actual (upper panel) and calculated balances (lower panel) for an agent who receives regular bi-weekly paychecks

Figure 4: Distribution of Individual-Level Sensitivity to Paycheck Receipt



This figure plots the distribution of the estimates of each user's sensitivity to paycheck receipt. Estimates are based on short-run consumables in the top panel and restaurant and entertainment spending in the bottom panel. Sensitivity to paycheck receipt is estimated separately for each user based on equation (1), $log(E_{it}) = \alpha_i + payweek_{it}\gamma_{1i} + X_{it}\psi_i + \varepsilon_{it}$. Sensitivity to paycheck receipt for each user is captured by γ_{1i}.

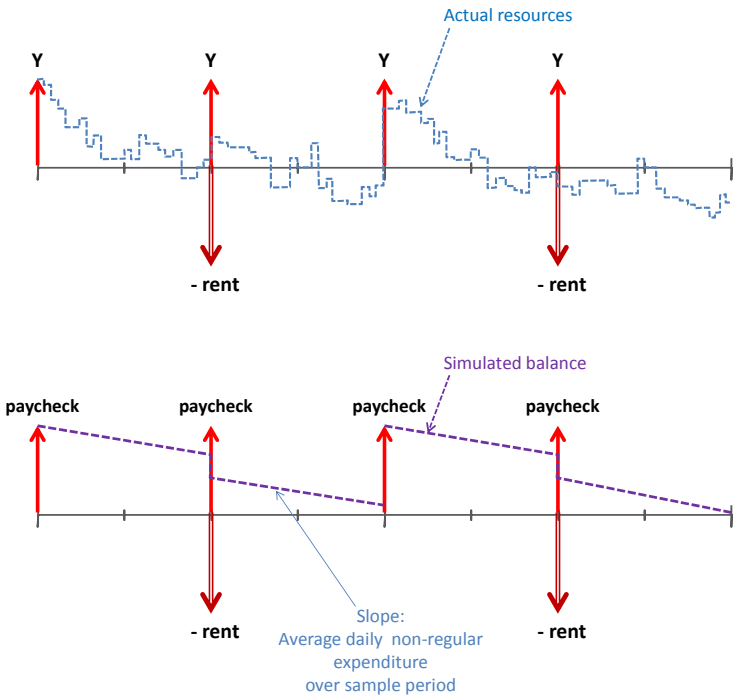
(illustrated by upward pointing arrows) and has to pay rent monthly every other pay date (downward pointing red arrows). The upper panel shows the agent's actual balances given his income, rent payments and spending patterns. The lower panel shows the agent's calculated balances. Instead of using the 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.

B.3 Sensitivity to Paycheck Under Different Restrictions

Table 9 shows summary statistics of estimated sensitivity to paycheck under different restrictions. 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.

Table 10 shows the correlation between estimates of sensitivity to paycheck receipt under different restrictions. 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 67% and 70%.

Figure 5: Hypothetical Balances Based on Regular Payments



The figure illustrates the construction of the hypothetical balances used to isolate the variation in resources uncorrelated with an individual's prior spending. Balances are shown 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 upper panel shows actual balances given actual spending of the hypothetical agent. The lower panel shows the agent's calculated 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.

C Debt Paydown by Sophistication

Table 11 shows summary statistics on planned paydown and actual changes in debt levels 90 and 180 days after sign-up. Both sophisticated and naive agents plan to pay down very similar amounts, on average $2,800 in the first 90 days. Actual paydown is substantially lower than planned paydown for both groups. The average reduction in debt levels is higher for sophisticated than naive consumers, $760 compared to $712 based on short-run consumables and $723 compared to $666 based on restaurant and entertainment spending. However, this is not the case for median pay-

Table 9: Sensitivity Estimates under Different Restrictions

Short-Run Consumables					
All	557	0.080	-0.090	0.062	0.233
Category Spending with Buffer	542	0.055	-0.117	0.047	0.221
Total Discretionary Possible	551	0.064	-0.113	0.044	0.223
Restaurant & Entertainment					
All	511	0.055	-0.105	0.060	0.221
Category Spending with Buffer	490	0.036	-0.120	0.046	0.201
Total Discretionary Possible	501	0.041	-0.122	0.045	0.204

This table shows summary statistics of each user's estimated sensitivity to paycheck receipt under restriction other than the baseline estimates, using spending on both, short-run consumables and restaurant and entertainment only. For each type of spending, the first row shows sensitivity estimates based on all paycycles the user is observed. The second 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 third 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).

down ($202 or $122, depending on the sophistication measure, relative to $300.).

Table 10: Correlation Between Sensitivity Estimates

	All	Category Spending Possible	Category Spending with Buffer	Total Discretionary Possible
		Short-Run Consumables		
Short-Run Consumables				
All	1.000			
Category spending possible	0.9851	1.000		
Category spending with buffer	0.9655	0.9505	1	
Total discretionary possible	0.9866	0.9753	0.9609	1
		Short-Run Consumables		
Restaurant & Entertainment				
All	0.6955	0.6904	0.6716	0.6924
Category spending possible	0.6863	0.7011	0.6613	0.6881
Category spending with buffer	0.6588	0.6509	0.6797	0.6608
Total discretionary possible	0.6707	0.6669	0.6547	0.6860
		Restaurant & Entertainment		
Restaurant & Entertainment				
All	1			
Category spending possible	0.9832	1		
Category spending with buffer	0.9561	0.9378	1	
Total discretionary possible	0.9833	0.9707	0.9549	1

This table shows the correlation between the estimates of each user's sensitivity to paycheck receipt under different restrictions. The first panel shows the correlation when all estimates are based on short-run consumables. The last panel shows the correlation when all estimates are based on restaurant and entertainment spending. The middle panel shows the correlation between estimates based on short-run consumables (columns) and those based on restaurant and entertainment (rows). In each panel, the first row and column show sensitivity estimates based on all observed paycycles. The second row and second column show the baseline estimates which only include paycycles in which spending in the respective category would have been affordable in the previous non-payweek given the user's resources. The third row and third column require 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 and fourth column require total discretionary spending to have been affordable. Sensitivity to paycheck receipt is captured by the coefficient on *payweek* in equation (1), which is estimated separately for each user and includes day of week and month fixed effects.

Table 11: Summary Statistics by Sophistication

	Sophistication based on			
	Short-Run Consumables		**Restaurant & Entertainment**	
	Naive	Sophisticated	Naive	Sophisticated
Change in Debt - 90 Days				
mean	-712	-760	-666	-723
median	-312	-202	-300	-122
Change in Debt - 180 Days				
mean	-969	-1,278	-1,070	-1,227
median	-557	-406	-629	-336
Planned Paydown - 90 Days				
mean	2,842	2,654	2,800	2,725
median	1,945	1,959	2,094	1,795
Payments Made - 90 Days				
mean	4,389	4,743	4,699	4,533
median	2,609	2,501	2,998	2,333
N	275	281	256	254

This table shows summary statistics on changes in debt levels and planned paydown, separated by 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 on restaurant and entertainment spending only. In both cases, users are classified as sophisticated if additional resources decrease sensitivity to paycheck receipt.

D Data Preparation and Classifications

Sample Selection Table 12 illustrates how many users are lost at each step of the data selection process, starting with a random sample of users. In the last step, I require users to have at least 35 days with positive spending in the respective category (short-run consumables or restaurant and entertainment only) for estimation of sensitivity to paycheck receipt. The minimum number of full pay cycles, 8, amounts to a little over two days of positive spending per week.

Paychecks Transactions are identified as paychecks when they are classified as such by the data provider or when their description contains one or more of the following words or word groups:

- "Payroll", "payroll", "PAYROLL", "PAYRLL", "PAYROL", "PAYPPD"
- "SALARY", "salary", "Salary", "FED SAL"
- "PPD", plus one of the following: "DIR DEP", "DIRDEP", "DIRECTDEPOSIT", "DIRECT DEPOSIT", "DIRECT DEP", "DIR.DEPST", "CO ID", "PAYMENTPPD"
- "CO ID" and "INDN", plus one of following: "DIR DEP", "DIRDEP", "DIRECTDEPOSIT", "DIRECT DEPOSIT", "DIRECT DEP"

Even if they meet the above criteria, transactions are not classified as a paycheck if they contain any of the following words:

- "tax", "Tax", "TAX"
- "PAYPAL", "paypal", "HALF.COM", "Square Inc", "SQUARE INC"

Finally, I classify regular deposits (identified the same way as regular payments described below) of more than $500 as paychecks.

Table 12: Paydown Sample Selection

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	1897
and a credit card and plan to reduce debt	1691
and at least one paycheck deposited into a checking account	1456
and regular bi-weekly paychecks	977
and regular paychecks account for more than 70% of all income	751
and appear to have all relevant accounts linked	734
and at least 8 regular, non-constrained paycycles	699
and enough days with positive spending to estimate sensitivity	
on short-run consumables	556
on restaurant and entertainment	510

Spending I first distinguish between regular and non-regular payments. Non-regular payments are further distinguished into discretionary spending and non-regular, non-discretionary spending. Discretionary spending is defined as expenses where at the time of the payment the consumer had discretion about i) whether to incur the payment at all or ii) how much to spend. Payments are classified as discretionary based on the type of expenditure category. An example of discretionary spending is a restaurant meal. For non-discretionary spending, such as are cell phone bills or utility bills, the amount due depends on past consumption, but there is no discretion once the bill arrives. I further consider short-run consumables, a subcategory of discretionary spending described below.

Regular Payments To classify transactions as regular payments they are first grouped into sets which have the same

- exact amount

- amount when cents are truncated
- amount rounded to the next integer
- amount rounded to multiples of $10 when the transaction amount is more than $100

A set of transactions is classified as occurring regularly every two weeks if

- there are at least 7 transactions
- the median difference between payments is between 13 and 16 days
- at most one payment in the sequence was missed, i.e. the maximum amount of time between payments is 31 days

A set of transactions is classified as occurring regularly monthly if

- there are at least 5 transactions
- the median difference between payments is between 28 and 31 days
- at most one payment in the sequence was missed, i.e. the maximum amount of time between payments is 64 days

Non-regular payments are further classified into short-run consumables, non-durables or total discretionary spending. These three broad categories consist of the following sub-categories as assigned by the data provider:

- Short-run Consumables
  - gasoline/fuel
  - groceries
  - restaurant/dining

  - entertainment (movie tickets, Netflix, iTunes, video/DVD rental, computer games, party stores, etc.)

- Total discretionary expenditure
  - short-run consumables
  - travel
  - gifts
  - drugstore purchases/personal care
  - pet expenditures
  - general merchandise (Target, Walmart, Cosco, etc.)
  - automotive expenditures (excluding car purchases), primarily oil checks and the like
  - toys and other children's products
  - clothing and shoes
  - healthcare/medical products
  - home maintenance
  - non-regular cable and online services
  - hobby expenditures
  - electronics
  - credit reports or services
  - advertising or custom management services
  - non-regular bills
  - PayPal purchases
  - unclassified credit card purchases
  - non-regular uncategorized transactions