Arbitrage Or Narrow Bracketing? On Using Money to Measure Intertemporal Preferences*

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Abstract

If experimental subjects arbitrage against market interest rates when making intertemporal allocations of cash, the data will reveal nothing about subjects' discount rates, only uncovering subjects' market interest rates. If they frame choices narrowly, market rates will not be salient and the experiment will uncover subjects' utility discount rates. We test arbitrage directly by forcing all transactions with subjects to be instant electronic bank transfers, thus making arbitrage easy and salient. We also employ four decision frames to test alternative hypotheses. Our evidence contradicts arbitrage, supports money as a valid reward, and suggests framing as a correlate with present bias.

Keywords: Discounting, arbitrage, primary rewards, present-bias, experiment

JEL-codes: C91, D81, D90

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1 Introduction

It has long been recognized that if experimental subjects can and do engage in intertemporal arbitrage, then utility maximization will be represented as maximizing present value of income. Individual discount parameters play no part in this, thus arbitrage will frustrate attempts to use cash rewards to measure subjects' discount parameters (Fisher 1930, Loewenstein 1987, Cubitt & Read 2007).

While prior literature had been characterized by both significant present bias (β of about 0.7 in models of quasi-hyperbolic discounting, as in Laibson, 1997) and extreme annual discount rates (80% to 100% annually, Frederick et al. (2002)), new experimental measures by Andersen, Harrison, Lau & Rutstrom (2008) and Andreoni & Sprenger (2012) find little present bias in many samples, and discounting near market interest rates.[1] Moreover, when present bias is detected, it is often in samples for which subjects face binding credit constraints, as in developing countries or among children.[2]

Although arbitrage was addressed early in this literature, (Coller & Williams 1999, Harrison et al. 2002, 2004), important recent findings have sparked renewed interest in arbitrage (Cohen et al. 2016, DellaVigna 2018).[3] In particular, Augenblick, Niederle & Sprenger (2015) showed that when Andreoni & Sprenger's Convex Time Budget (CTB) protocol is used to allocate cash there is little present bias, yet when the same subjects allocate effort, present bias is significant. Since allocating effort is thought to be more difficult to arbitrage, fears arose that arbitrage over money rewards was stripping present bias from the data and invalidating cash for measuring discounting.

There are several counterpoints to this argument. First, Augenblick et al. (2015) measured both the β and δ of quasi-hyperbolic discounting (Strotz 1955, Laibson 1997). For present bias, β is 0.89 for effort and 0.98 for cash, indirectly supporting arbitrage for cash but not work. On the other hand, the estimated discount factor δ produces an annual discount

[1]Intertemporal utility $U(c_0, ..., c_T) = u(c_0) + \beta \sum_{t=1}^{T} \delta^t u(c_t)$, is quasi-hyperbolic if $0 \leq \beta \leq 1$, and exponential if $\beta = 1$.

[2]See, for example, Kuroishi & Sawada (2018), Sawada & Kuroishi (2015), Janssens et al. (2017), Clot et al. (2017) and Lührmann et al. (2018). Sawada & Kuroishi (2015) finds that variables correlated with liquidity have no significant effect on present bias.

[3]Arbitrage refers to borrowing at the lower rate, and saving the higher rate when lab and market rates differ.

rate of about 5% for effort, a reasonable market rate, but 87% for money, an unreasonably high market rate.

Second, if subjects arbitrage in these studies, should we be surprised that they fail to arbitrage in other similar circumstances (Harrison et al. 2004)? Yet, a large literature on choice bracketing shows that in many situations individuals *narrowly* bracket their decisions, making choices in isolation rather than broadly considering the consequences of their choices for later decisions (Read et al. 1999, Rabin & Weizsacker 2009). Early experiments uncovering biases in discounting (Thaler 1981, Loewenstein & Thaler 1989), certain types of mental accounting (Thaler 1985), and the endowment effect over goods easily repurchased outside the lab (Kahneman et al. 1990), are failures of arbitrage attributed to narrow bracketing.

Third, Balakrishnan et al. (2017) applied CTBs to a sample in Kenya, conducting all payments electronically so that the "today" payment could be applied immediately. They found a β parameter similar to that in the effort allocation in Augenblick et al. (2015), while when the payment was made after a four hour delay β returned to 1, as in Andreoni & Sprenger (2012), suggesting that four hours could be enough delay to avoid present bias.[4]

Fourth, economic lab experiments testing equilibria in financial markets where arbitrage is given its best chance have instead found significant deviations of assets prices from fundamentals (Lei et al. 2001), contradicting (within-lab) arbitrage. Researchers in the field also find little evidence that individuals smooth consumption over small gains (for a summary, see Halevy, 2014).

Fifth, both psychologists and economists have found that individual discounting can vary across commodities (Chapman 1996, Tsukayama & Duckworth 2010, Reuben et al. 2010, Ubfal 2016). This is unsurprising if we think of present-bias as self-control; not all items are equally tempting. Ashraf, Karlan, and Yin (2006), for instance, find that although discounting parameters estimated using rice, ice cream, and money were correlated, only the estimates from money predict take-up of financial commitment. Others also find discounting estimated from money correlates with other intertemporal tradeoffs (Chabris et al. 2008, Meier & Sprenger 2010, 2015) including those using CTB elicitations (Sawada & Kuroishi

[4] This contrasts with the fMRI study of McClure et al. (2007) that found "immediacy" affects for gift cards delivered one hour after the decision, and which produced primary rewards no sooner than a day later, but may speak to their conjectures on the importance on framing with monetary rewards (p.5803).

2015, Andreoni et al. 2016, Aycinena et al. 2018, to name a few).

Sixth, a variety of physiological evidence corroborates the idea that the receipt of a cash reward presents the same as a primary reward. CTB results using cash correlate with pupil dilation (Lempert et al. 2015, 2016) and with 2D-4D digit ratios, an indicator of pre-natal testosterone exposure (Aycinena & Rentschler 2017). Löckenhoff, O'Donoghue & Dunning (2011) found that discounting and present bias are significantly correlated with psychological measures of anticipated emotional arousal at receiving monetary payments over time.

Finally, fMRI studies of temporal discounting (McClure et al. 2004, 2007, Kable & Glimcher 2007) using monetary incentives have not been hamstrung by arbitrage, and instead identify significant present bias. Also, in a pivotal study, Levy and Glimcher (2011, p. 14693) note an obvious truth from both the economics and psychology of exchange: "The ability of human subjects to choose between disparate kinds of rewards suggests that the neural circuits for valuing different reward types must converge." Their research looked at choices involving money, food, and water, and found support for the hypothesis that, "Partially distinct valuation networks for different reward types converge on a unified valuation network, which enables a direct comparison between different reward types and hence guides valuation and choice." That is, the brain has a mechanism by which money achieves value by its potential to be exchanged for a primary reward, in something of a neural re-imagining of the Kiyotaki-Wright (1993) model.[5] In a meta-study of 87 publications, Sescousse et al. (2013) find substantial overlap in brain areas involved in primary and monetary rewards. In a large meta-analysis, Bartra, McGuire & Kable (2013) (see also Levy & Glimcher, 2012) conclude that the evidence "aligns with an emerging consensus of a unitary system" (p. 424) of neural value of primary and monetary rewards.

We report on a CTB laboratory study using the protocol of Andreoni et al. (2015), but adjusted to make arbitrage as easy as possible. We experimentally manipulate subject's initial liquidity and whether subjects allocate receipts or payments between sooner or later dates, while equalizing the potential future value of earnings. We find only a modest fraction of subjects are arbitrageurs, and that money receipts and payments have distinct signatures

[5] See also Knutson et al. (2001), Ballard & Knutson (2009), Chib et al. (2009), and McNamee et al. (2013). See Yoo & Hayden (2018) for a different interpretation.

of value as commodities. Moreover, we find no significant present bias in the receipt frame most closely resembling Andreoni & Sprenger (2012) but find significant present bias in the payment frame that is reflective of the effort allocation in Augenblick et al. (2015). This framing effect is, like many framing effects, difficult for typical economic models to address. This makes the finding both worth replication and further investigation. The explanation may lie in understanding more precisely how brains assign values to options, and the role positive and negative frames may play in this.[6]

These results, in combination with those from neuroscience, should soothe worries that money is not a reliable reward when studying intertemporal choice. Moreover, they raise many constructive new hypotheses for how both money and commodities generate value in experimental environments, and how evidence on discounting could be used to improve models of intertemporal choice.

2 Arbitrage versus Narrow Bracketing

To prefer arbitrage, subjects must be forward looking; they broadly bracket their allocations of money to maximize the present value of their incomes. To perform arbitrage, subjects must have access to capital markets and sufficient liquidity to offset any experimental payments.

To expect subjects to reveal discount parameters using money rewards would require decision makers to narrowly bracket choices as they would with a desirable primary reward (Read et al. 1999, Rabin & Weizsacker 2009). It is important to note that making decisions that are not fully forward looking is not the same as consuming the allocations immediately, only that they consume a flow of utility immediately. Narrow bracketing is applied frequently in behavioral economics as a foundation for loss aversion, endowment effects, mental accounting, present-bias, and more.

Alternatively, one could take the observation of different discount parameters for effort and money at face value; perhaps the parameters are measured accurately for both money and effort, but individuals simply have different discount factors for each. Importantly, such

[6]In this vein, the work of Fisher & Rangel (2014) comes to mind. If a negative frame causes attention to be fixated on certain choices longer, this could result in the frame affecting values and, in turn, revealed discounting rates.

good-specific discounting can easily lead to time-inconsistent preferences.

To see this, imagine utility

$$U(x, y) = u(x_0) + v(y_0) + \delta_x u(x_1) + \delta_y v(y_1)$$

with good-specific discounting $0 < \delta_y < \delta_x < 1$. Let $\beta = \delta_y/\delta_x < 1$, and rewrite utility as

$$U(x, y) = u(x_0) + v(y_0) + \delta_x u(x_1) + \beta\delta_x v(y_1),$$

which naturally shows "present bias" for the good one is relatively more impatient for. We need only appeal to Jackson & Yariv (2014) to demonstrate that good-specific discount rates *must* result in time-inconsistent preferences.

Additionally, we show in Appendix Section A.1 that for commodity choices to present accurate measures of discounting requires the additional assumption that the commodity in use has no complements or substitutes with other items in the budget.

As has been the way of economics, hewing as closely as possible to Samuelson's (1937) statement of time-separable discounted utility, allowing commodity specific discount rates would appear to create an implausible degree of separability across commodities, and a tangled web of shifting time inconsistent preferences. So, while the suggestion of commodity-specific discounting has some appeal, it is perhaps a quick fix to a larger and more challenging issue.

3 Experimental Design

Sprenger (2015), Cohen et al. (2016) and DellaVigna (2018) provide recent overviews of the difficulties and advances in measuring discount rates. In light of the focus on arbitrage precipitated by the study of Augenblick et al. (2015) comparing time and effort allocations in the Andreoni & Sprenger (2012) Convex Time Budget framework, we used the CTB design as modified by Andreoni et al. (2015).

Subjects were shown a series of intertemporal budgets. For each budget, they chose from a set of eight options to allocate money over time at a fixed interest rate. Subjects first encountered eight budgets, each budget offering eight allocations between the day of the study and four weeks in the future. Next were eight budgets offering allocations between four weeks and eight weeks in the future.

Within each eight-budget decision sheet, subjects started by allocating \$21 at a 0% rate. The rate increased as subjects worked through the budgets. The rates differed slightly between the first (0-4 week) and second (4-8 week) allocations so that subjects weren't strongly primed by their first decisions. Interest rates ranged from 0% to 28.5%. Participants did not encounter the interest rates directly, but instead saw eight evenly-spaced options of allocations at the earlier date and the later date. The maximum sooner allocation was always the left-most option and the maximum later allocation was always the right-most option. The maximum later receipt/payment was always \$21. We present details on each budget in Appendix Table A1. The subjects' instructions and decision sheets are in Appendix Section B.

3.1 Experimental Conditions

Our 2×2 treatment randomization occurred between-subjects. In addition to allocating either receipts or payments across sooner and later dates, all subjects also got an initial payment on the date of the study and final payments on the day following their last chosen transaction. Initial payments, which could be negative, manipulated whether subjects initial liquidity is eased during the course of the study, or tightened. Final payments equalized maximum potential future value of earnings at \$23. All subjects got early and later payments to keep the total number of payments constant across subjects.

Credit-Receive (CR) subjects participated in a standard implementation of the CTB choosing an allocations of electronic transfers into their bank accounts that could be as high as \$21, along with \$1 initial and final transfers (to equalize the number of transactions across conditions). Credit-Pay (CP) subjects received an initial transfer of \$22 that could cover any of the subsequent repayment plans they could chose to implement. They received a final transfer of \$22. Debit-Receive (DR) subjects had to make an initial payment of \$22 to the EconLab before choosing a schedule for the EconLab to pay them back, thus had to remove \$22 from their personal funds. They received a final transfer of \$24. Lastly, Debit-Pay (DP) subjects received an initial payment of $1 from the EconLab (again, to equalize the number of transactions) before choosing from a schedule of payments to the EconLab, which could be as high as $21. They received a final transfer of $43. Appendix Table A2 shows the design of each cell in our study and the associated transfers.

3.2 Procedures

Our sample consists of 128 UC San Diego undergraduate volunteers, spread among 10 experimental sessions. We recruited only students with accounts at Chase Bank who would be willing to use Chase QuickPay for experimental transactions. Chase maintains a branch UC San Diego student center, and Quickpay is a free service for Chase clients who also have savings and checking accounts and a debit card. Prior to indicating their informed consent, and regardless of subsequent treatment randomization, participants were told that there was a possibility they would have use their own funds in the short run, although they were guaranteed earnings commensurate with their time and effort in the long run. After consent, everyone in the session was randomized into the same treatment. Following the session, one budget was randomly selected as the budget-that-counts for payments. This was common to the session.

Chase QuickPay offered a variety of advantages for this study. First, participants were informed that while there would be a stream of payments between them and the EconLab over the following eight weeks, they would not have to come back to the lab at any point. Second, QuickPay allowed scheduling of future payments. Following the participants' choices, but during the same session, we scheduled and verified all payments electronically, and any payments due on the date of the study were completed before subjects left the lab. Third, all subjects were required to schedule the same number of transfers, regardless of their decisions. We enforce this by making $0.01 transfers on the dates where subjects allocate zero dollars. No payments were made in cash. Fourth, choosing subjects with accounts at a financial institution with a physical presence on campus was the most natural way gain subjects' confidence in the transfers, and thus facilitate arbitrage. In a post-experiment questionnaire, 127 of 128 participants confirmed this confidence.

Three participants did not complete their transactions as scheduled and were removed from the sample. Seven did not respond to all 16 questions in their primary choice set and were also omitted, leaving 118 subjects in our estimation sample.[7]

4 Results

To compare choices across Pay and Receive conditions, and across budgets within each condition, we create a variable equal to the fraction of potential or residual income that is allocated to the sooner period. We call this variable *Adjusted Sooner Income*, or ASI. For example, if a subject in a Receive condition chooses \$7 today and \$14 in four weeks, from a budget that offered a maximum of \$21 today, her ASI is $7/21 = 0.33$. If a subject in a Pay condition chooses \$14 today and \$7 in four weeks, from a budget that allowed a maximum payment of \$21 today, her ASI is also 0.33, because the unpaid balance today is \$7. If the four-week interest rate increases to 5%, the maximum sooner receipt or payment decreases to \$20. Choosing to receive \$7 or pay \$13 today would thus correspond to an ASI of $7/20 = 0.35$.

A comparison of average choices across budgets is presented in Figure 1. For each choice we plot the budget line that subjects faced and the average choice from it, by condition. Several observations are apparent in this figure: 1) Choices vary by Receive/Pay framing. 2) Average choices are not near corner solutions except for at high interest rates. While the average interior choice masks many individual corner choices, it is notably inconsistent with a unique market interest rate that our relatively homogeneous sample can access. 3) When the interest rate is 0%, or close to 0%, subjects do not fully front-load income. This is especially true in the Pay condition, and is inconsistent with both the arbitrage hypothesis and a model in which the marginal utility of income is non-decreasing.

4.1 Treatment Effects on ASI

Arbitraging subjects should not be affected by Receive-Pay variation in framing. We test for differences across conditions in two ways. First, we ask whether the distribution of ASI

[7] In addition to the results reported here, our data collection also consisted of a second set of choices for each subject that switched the subjects' pay/receive condition to the opposite. Since we found strong order effects (which are also inconsistent with arbitrage, and in interesting and complex ways) we opted, due to constraints on words, to set this data aside for later analysis.

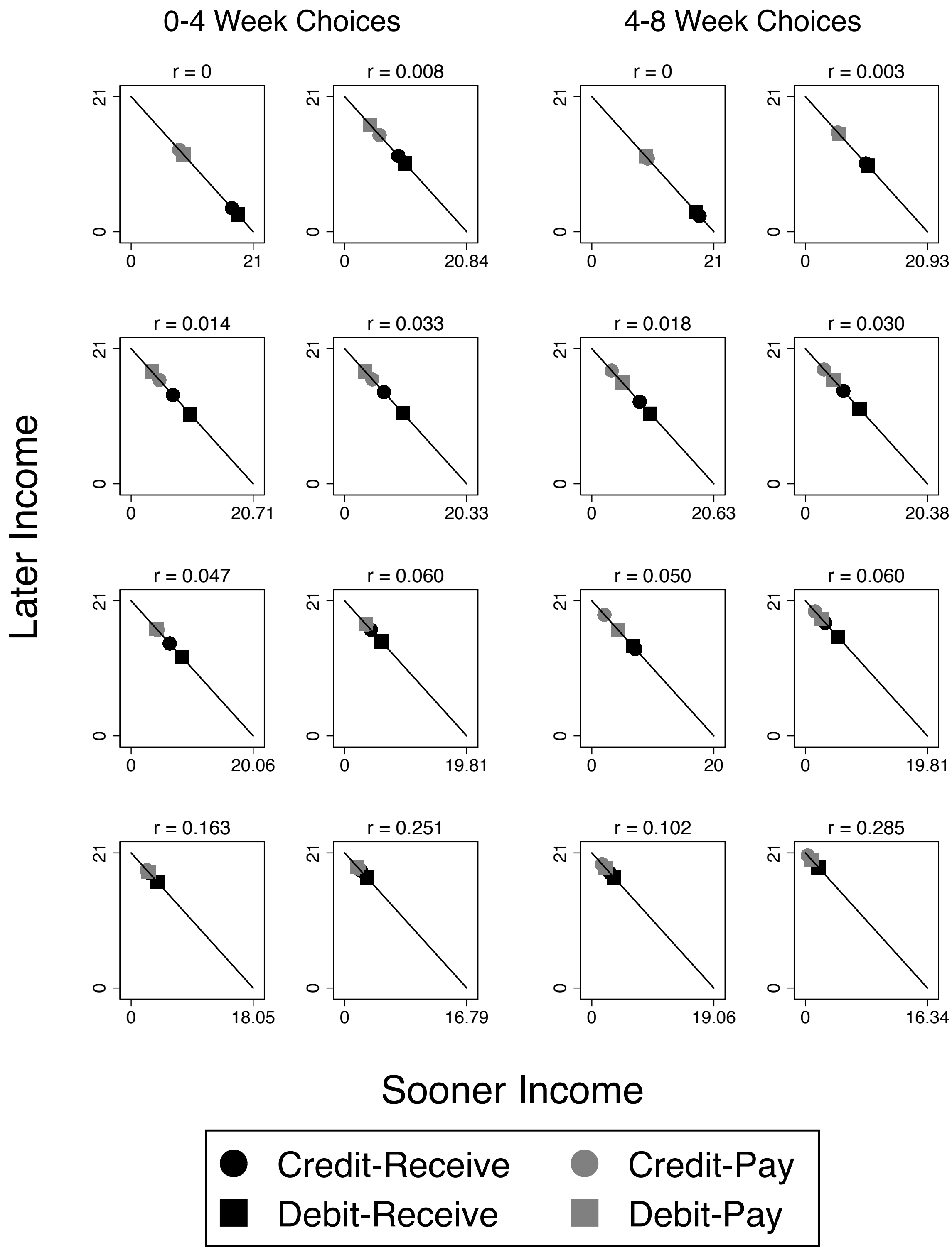

Figure 1: Average Choices by Budget and Condition

Table 1: Effect of Condition on Adjusted Sooner Income

Model:	Tobit	OLS		
DV:	ASI (1)	ASI (2)	$1(ASI = 1)$ (3)	$1(ASI = 0)$ (4)
Pay	-0.429*	-0.156**	-0.140**	0.087
	[0.095]	[0.012]	[0.029]	[0.399]
Debit	0.245	0.064	0.040	-0.127
	[0.275]	[0.431]	[0.492]	[0.262]
Pay × Debit	-0.197	-0.051	-0.108	0.072
	[0.421]	[0.571]	[0.423]	[0.598]
Constant	0.033	0.350	0.245	0.545
	[0.857]	[< 0.001]	[0.052]	[< 0.001]
DP vs. DR	-0.626*	-0.207***	-0.248**	0.158*
	[0.055]	[< 0.001]	[0.032]	[0.064]
DP vs. CP	0.048	0.013	-0.068***	-0.056
	[0.664]	[0.465]	[< 0.001]	[0.484]
Clusters	10	10	10	10
Bootstrap	Score	Wild	Wild	Wild
Observations	1888	1888	1888	1888

*** : $p < 0.01$, ** : $p < 0.05$, * : $p < 0.10$. [p-values clustered by session, wild-bootstrapped for OLS models, and score-bootstrapped for Tobit model]. Bootstrapped p-values are reproducible using the 'bootest' command in Stata, with a seed of 1. We present p-values rather than standard errors because they can be obtained precisely from the empirical parameter sampling distributions. Tobit estimates are interpreted as the impact of the variables on latent demand.

is identical under Receive and Pay.[8] We find ASI is clearly lower in the Pay conditions.[9] A Kolmogorov-Smirnov test rejects the equality of Pay and Receive: $D = 1.00$, $p < 0.01$ (pooled across Credit and Debit).[10] The Pay-Receive difference is also significant within each of the Credit and Debit conditions ($D = 0.51$, $p < 0.01$ and $D = 0.54$, $p < 0.01$, respectively). We cannot detect a difference between the Credit and Debit conditions: $D = 0.09$, $p = 0.95$ pooled, $D = 0.14$, p = 0.94 within Receive and $D = 0.13$, $p = 0.95$ within Pay.

Second, we regress ASI on Pay and Debit indicator variables, and their interactions.

[8] Appendix Figure A1 shows the empirical CDFs of ASI for each condition.

[9] Related results on gain-loss framing, see Loewenstein (1988).

[10] We use subject-mean ASI in our distributional tests, so $N = 118$.

Because ASI is constructed to lie between zero and one, we use a Tobit model to estimate the demand for ASI.[11] Additionally, we consider whether the likelihood of censoring at either $ASI = 1$ or 0 depends on experimental condition. Because treatment is randomized at the session level, clustering standard errors at the session level is appropriate here. With only ten sessions, however, this clustering can be unreliable (Donald & Lang 2007). We therefore adopt the wild-bootstrap cluster suggested by Cameron et al. (2008) for the OLS models. For the Tobit model, we use the score-bootstrap generalization of the wild bootstrap from Kline & Santos (2012).

Results are in Table 1. In column (1), we present estimates from a Tobit model with ASI as the dependent variable. Latent demand for ASI lower by 43 percentage points in Credit-Pay than in Credit-Receive, and lower by 63 percentage points in Debit-Pay than in Debit-Receive, although the estimates are imprecise according to the score-bootstrapped standard errors ($p = 0.10$, and $p = 0.06$, respectively). The OLS model in column (2) shows a smaller effect of the Pay condition on demand—a reduction of 16 percentage points within Credit, and a reduction of 21 percentage points within Debit—but it is more precisely estimated with the wild bootstrap technique ($p = 0.01$, and $p < 0.01$, respectively). In column (3), we find that the likelihood that $ASI = 1$ is 14 percentage points lower in Credit-Pay relative to Credit-Receive and 25 percentage points lower in Debit-Pay relative to Debit-Receive ($p = 0.03$ in both cases.). In column (4), we find a 16 percentage point increase in the likelihood of $ASI = 0$ in Debit-Pay relative to Debit Receive ($p = 0.06$), without a corresponding large or significant effect of the Pay condition with Credit. The only significant effect of the Debit treatment we can detect is that the likelihood of $ASI = 1$ is seven percentage points lower in Debit-Pay than Credit-Pay ($p < 0.01$).

Result 1: *Average choices were affected by choice framing. Subjects generally demand significantly more sooner income, ASI, in the Receive frame than the Pay frame. This is inconsistent with arbitrage.*

[11] Latent ASI could be below zero or greater than one if a subject wants to borrow in one period.

4.2 Corner Solutions

The strictest test for arbitrage is that subjects should behave as if they have linear indifference curves with a slope determined by the market interest rate. That is, we should observe exclusively corner solutions. While 70% of observed choices are at corners, this is significantly different from 100%.[12] At the subject level, 28% of participants make zero interior choices, which again deviates significantly from full arbitrage.[13]

What if we limit ourselves to the lowest and highest interest rates offered, where corners are most clearly optimal for arbitrageurs? All of our subjects are known to have interest-bearing savings accounts, so at $r = 0$, $ASI = 1$ is an arbitrageur's optimum. Nonetheless, only 43% of $r = 0$ choices are at $ASI = 1$, a significant difference from 100%.[14] Interior choices are taken by 48% of subjects at $r = 0$, a significant violation of arbitrage.[15]

On the other side of the same coin, arbitrage predicts that once the experimental rate exceeds the market rate, subjects should switch to $ASI = 0$. The highest 4-week rates offered were 29% and 25%, which translate to 2510% and 1733% annualized. Do choices collapse on $ASI = 0$ at this price? A significant fraction do not. Interior choices are made on 18% of choices at these very high rates.[16] Under 80% of choices are at $ASI = 0$.[17]

Result 2: *While many choices are corner solutions, we reject that all choice are corner solutions. This is true even at extreme interests rates where arbitrage should be most compelling. Interior choices are a meaningful aspect of the data, which is inconsistent with arbitrage.*

Figure 2 presents the frequency of corner choices for all of the experimental interest rates.[18] Here we see a clear distinction between Receive and Pay conditions, particularly at $r = 0$. Comparing the pooled Pay conditions to the pooled Receive conditions, we see a curious inconsistency across the Pay and Receive subjects. At $r = 0$, 75% of Receive subjects

[12] $p < 0.01$, H_0 : all choices at corners, s.e.'s clustered by subject.
[13] $p < 0.01$, H_0 : all subjects make no interior choices. For details, see Appendix Table A3.
[14] $p < 0.01$, H_0 : $ASI = 1$ for all choices, s.e.'s clustered by subject.
[15] $p < 0.01$, H_0 : zero interior choices, s.e.'s clustered by subject.
[16] $p < 0.01$, H_0 : zero interior choices, s.e.'s clustered by subject.
[17] $p < 0.01$, H_0 : $ASI = 0$ for all choices, s.e.'s clustered by subject.
[18] Appendix Figure A2 shows the pooled fraction of corner or corner-adjacent choices (choices one option removed from the corner) along with the upper bound of the 99% confidence interval associated with this frequency. Even by this very conservative measure, none of the confidence intervals include one.

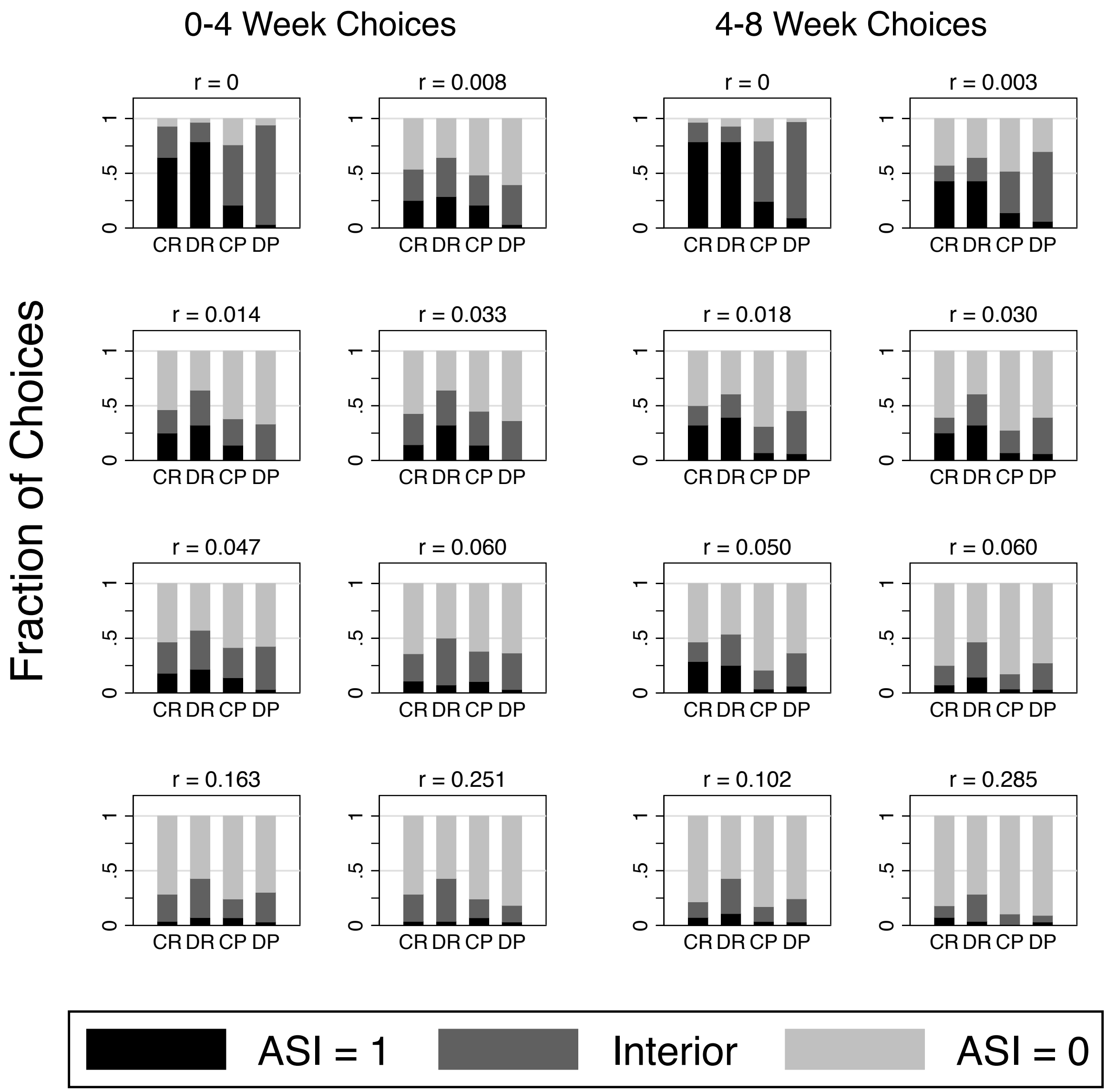

Figure 2: Corner Solution Frequency by Experimental Condition and Interest Rate

are willing to receive all of the money for free, while only 14% of pay subjects do the same.[19] We also anticipated that the Debit condition would encourage arbitrage by forcing subjects to confront their actual capital markets. We see no significant evidence of this effect.

Result 2.1 *The degree to which subjects select corner solutions depends on framing. At an interest rate of 0%, arbitrage requires $ASI = 1$ for all subjects. In the Pay frames, over*

[19]The difference is statistically significant ($p < 0.01$). The hypothesis test is from probit regressions of $ASI = 1$ on condition, s.e.'s clustered by subject. See Appendix Figure A3 for visualization of this substantial difference.

70% of choices involve allocating something to both periods. This portion is only 20% in the Receive frames. The Debit conditions, which were designed to be as favorable to arbitrage as possible, however, produces no additional corner solutions over the Credit conditions.

4.3 Present Bias

We use $t = 0$ to refer to a choice made for the 0-4 week period, and $t = 4$ for the 4-8 week period. Present bias would be seen if the demand for ASI is higher when $t = 0$. Arbitrage, by contrast, implies that demands for ASI should be independent of both t and condition.

Figure 3 presents demand for ASI by t within each condition. Panel A, the Credit-Recieve condition, corresponds to a standard CTB application. There is little difference between the two time periods, consistent with both arbitrage and the findings of several recent studies using CTB elicitations. Panels B, C and D graph demand in the other three conditions. All three show patterns suggesting present bias, especially Panel B, the Credit-Pay condition, and primarily at higher interest rates.

Table 2 lists coefficients of regressions testing for present bias. The dependent variable $1(t = 0)$ equals one if the sooner allocation is the hour of the study, and zero if the sooner allocation is in four weeks. Given the nonlinear relation between ASI and r in Figure 3, we use the log of $1 + r$ as our price variable. As is evident in three of the four conditions, the interaction between $1(t = 0)$ and $ln(1 + r)$ is predicted to be positive. We use both a Tobit regression to test for an overall impact of $1(t = 0)$, and Probit regressions to test for specific impacts on the likelihood of choosing all income sooner or later.[20] Below the estimates, we include the impact of $1(t = 0)$ when $r = 0.10$, to give an idea of the overall amount of present bias that manifests at a rate near the average of rates we offered.

In column (1) we find a statistically significant positive coefficient on the interaction term, consistent with overall present bias at prices away from $r = 0$. At $r = 0.10$, demand for ASI is 16 percentage points higher (\$3.11 out of \$19.09) when $t = 0$ ($p = 0.04$). This effect is largest in Credit-Pay at 41 percentage points higher (\$7.77 out of \$19.09, $p = 0.11$).

The Probit estimates in columns (2) and (3) take a different view of present bias by

[20] With the continuous explanatory variable of price, a Probit model can capture non-linearity that a linear model cannot.

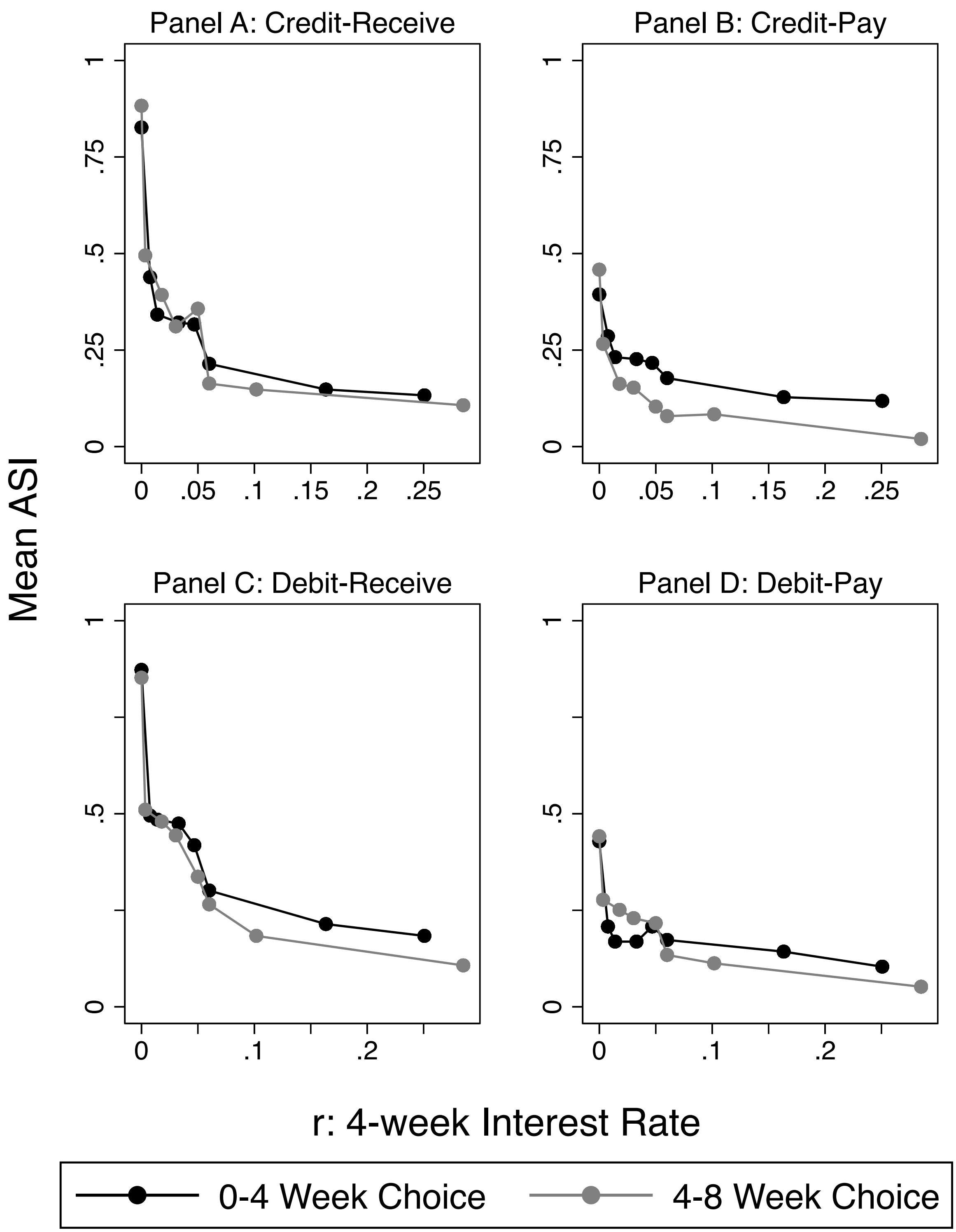

Figure 3: Demand Curves for Adjusted Sooner Income by Experimental Condition

Table 2: Estimates of Present Bias

Model:	Tobit	Probit	
DV:	ASI	$1(ASI = 1)$	$1(ASI = 0)$
	(1)	(2)	(3)
$ln(1 + \mathrm{r}) \times 100$	-0.068***	-0.017***	0.023***
	(0.011)	(0.004)	(0.002)
$1(t = 0)$	-0.033	-0.032**	-0.001
	(0.063)	(0.016)	(0.028)
$1(t = 0) \times ln(1 + \mathrm{r}) \times 100$	0.021***	0.004	-0.007***
	(0.007)	(0.004)	(0.002)
Constant	0.245	0.276	0.417
	(0.087)	(0.036)	(0.033)
Clusters	118	118	118
Observations	1888	1888	1888
Impact of $t = 0$ at $r = 0.10$:			
Pooled	0.163**	0.004	-0.071**
	(0.079)	(0.037)	(0.029)
Credit-Receive†	0.088	-0.085	-0.060
	(0.207)	(0.057)	(0.058)
Credit-Pay†	0.407	0.169	-0.145*
	(0.256)	(0.107)	(0.077)
Debit-Receive†	0.120	-0.014	-0.055
	(0.148)	(0.092)	(0.064)
Debit-Pay†	0.077	-0.022	-0.056
	(0.086)	(0.032)	(0.046)

*** : $p < 0.01$, ** : $p < 0.05$, * : $p < 0.10$ (s.e.'s clustered by individual).

† Estimated from treatment-specific regressions reported in the Appendix Tables A4, A5, A6, and A7. Tobit estimates are interpreted as the impact of the variables on latent demand. Probit estimates are the marginal effects averaged across the sample.

examining corner choices. These coefficients indicate a significantly lower likelihood $ASI = 1$ when $t = 0$ (column 2, $p = 0.05$), and of $ASI = 0$ when $t = 0$ and the price is high (column 3, $p < 0.01$). At $r = 0.10$, subjects are 7 percentage points less likely to select $ASI = 0$ ($p = 0.02$). In Credit-Pay, subjects are 15 percentage points less likely to choose $ASI = 0$ ($p = 0.06$), which is again far larger than for other treatments. This evidence points to significant present bias in the pooled data, driven mostly by large present bias effects in the Credit-Pay treatment, no present bias in Credit-Recieve, and modest present bias in the other two conditions.

Result 3 *Inconsistent with arbitrage, there is evidence of significant present bias in our data. While the effect is evident in our pooled data, the magnitude of present bias is the largest and most significant for the Credit-Pay condition, and the nearest to zero present bias in the Credit-Receive condition.*

5 Arbitrageurs?

While we reject arbitrage in general, it is important to ask whether individual subjects make choices consistent with arbitrage. These subjects have at most one switch point, moving from all-sooner to all-later income as the interest rate rises. They have at most one interior choice, and it will lie on the budget separating the two sets of corner choices.

Across all treatments, 33% of subjects meet this definition of an arbitrageur. However, there is considerable heterogeneity across treatments. Credit-Receive—the standard implementation of CTBs—garners the most arbitrageurs (46%). Next is Debit-Receive (32%), followed Credit-Pay (31%) and finally Debit-Pay (24%). Notice that Credit-Receive is framed like a standard CTB and has nearly twice as many arbitrageurs as the Debit-Pay treatment, which has a negative frame in common with effort supply.

The strong treatment effect on arbitrageurs is further evidence against arbitrage in general, and raises questions of whether arbitrage is even an objective of those we have just labeled arbitrageurs. It indicates that no more than a quarter of all people would be arbitrageurs regardless of the frame.[21]

6 Conclusion

There is a rich and evolving literature on estimating structural preference parameters for temporal discounting. Researchers have long relied on monetary rewards for these estimates.

[21] For example, Kuhn et al. (2017) find that behavior consistent with arbitrage responds to hunger and satiation.

From the beginning, however, researchers have noted the concern that arbitrage of cash rewards removes from the data of any signs of hyperbolic discounting that exists over primary rewards. Since arbitrage requires broad bracketing of decisions and present bias is rooted in narrow bracketing, this argument suggests an interesting model in which subjects integrate monetary rewards into long run financial plans, yet when faced with opportunities to spend that money submit to narrow bracketing and display present bias.

To explore the hypothesis that money may not be a reliable reward when studying intertemporal choice, we constructed a direct laboratory test of arbitrage. To give arbitrage its best chance, we recruited subjects with sufficient liquidity to arbitrage against the experimental payments. Next, all payments between the EconLab and our subjects were made with instant and direct bank transfers. This mechanically made arbitrage both obvious and easy. It also made "today" payments immediate. We used our 2×2 design to either add to liquidity by crediting their bank accounts (Credit Condition), or force subjects to pay us up-front and thus restrict their liquidity (Debit condition). Finally, we framed the actions of the subjects as choosing either when to receive cash payments from us (Receive condition) or when to pay cash to us (Pay condition). All four cells of the study offered subjects identical maximum potential future value, and identical transaction costs, and thus arbitrage would make the same predictions for each cell.

Our direct tests strongly contradict the arbitrage hypothesis. First, the choice frame matters. Subjects in the Receive conditions demanded significantly more sooner income than those in the Pay frames. Second, not all choices were made at corner solutions as arbitrage requires, especially at low interest rates. Finally, we find no evidence of present bias in the Credit-Receive condition, the condition corresponding to standard implementations of the CTB. By contrast, we find sizable present bias in the Credit-Pay condition, which has important framing elements in common with the effort-allocation task of Augenblick et al. (2015).

The Debit conditions—which were designed to favor arbitrage—showed no differential effects from the Credit conditions.

Neuroeconomists have argued that, much like how monetary theory accounts for money, for the brain to make choices across disparate baskets of goods, it must have a means–a currency–for comparing values. Levy & Glimcher (2012) measured subjects' rates of exchange between money and various food items outside of the fMRI scanner, then used this exchange rate to predict the neural exchange rate while in the scanner. They concluded that, "Both reward types did predict the exchange rate between money and food across our subject pool," supporting the notion of direct value for economic (and neural) currency.[22] A major meta-analysis by Bartra et al. (2013), finds a different route to the same conclusion. They state, "A principal insight from research on classical conditioning is that a conditioned stimulus can come to influence behavior in the same manner as the primary rewards with which it is associated. Money is presumably an especially well learned secondary incentive."

What does our study say about the within-subject differences found discounting toward effort versus money? In light of our findings rejecting arbitrage and the neurological evidence that money payments are likely part of a unitary reward system, it would seem that rejecting either one of the measurements on the basis of the reward media could not be supported. Instead we perhaps need to ask what it would imply for economic theory to accept both measurements as reflecting something true about preferences. To do so would be to integrate different levels of impatience for different commodities into a single utility framework, and perhaps even (as suggested by our findings) different levels of impatience for the same commodity depending on how the choice is framed. Until this is accomplished, however, an obvious implication of the work presented here is that using discount parameters from one good to predict choices on another could be misleading. Best practices would appear to indicate that if the researcher is interested in policies for effort, then discounting should be measured with effort. When the application is to money, the best media to use to design policies regarding personal finance is most likely money.

Given the ubiquity of Samuelson's (1937) model, the well learned reflex for assuming time separability and constant discounting may have led economists to force the interpretation of most data to fit this approach. Is it only the structure given by Samuelson (1937) that makes us surprised to see different commodities ruled by different discount rates? Interestingly, Samuelson (1937) himself warned of this. He says (page 139) that the model of discounted utility has "serious limitations...which almost certainly vitiate it even from a the-

[22]See also important contributions by Chib et al. (2009) and McNamee et al. (2013).

oretical point of view." The questionable assumption he points to first and most strongly is time-separable preferences. Abstracting away from time-separability and constant discounting, we can alternatively interpret the data as saying the marginal rates of intertemporal substitution within a good over time, or between goods over time, can be different. Moreover, they may depend on past, current, or perhaps future levels of consumption, accounting for endogenous tastes. The question for research will then be can we fashion a tractable and flexible theory that will allow us to analyze intertemporal choice from a productive and realistic perspective. Given our ever-sharper tools of experimental economics, we may be able to go beyond Samuelson's self-described "arbitrary" assumptions and, as he suggested, let observable facts shape a more full model of preferences.

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A Appendix for Online Publication

This appendix is to accompany "Arbitrage Or Narrow Bracketing?
On Using Money to Measure Intertemporal Preferences" by J.Andreoni, C. Gravert, M.Kuhn, S. Saccardo,& Y. Yang.

A.1 On Measuring Discounting with Consumption

As stated in the text, it is also necessary that there be no other items in a subject's current or future consumption that is a complement or substitute for the consumption being used as a reward in the lab. This point is most easily conveyed with a number of examples.

Example 1. *Substitutes.* A subject spends effort e each period and enjoys leisure, ℓ such that $\ell = 1 - e$. For simplicity assume no discounting and no interest. She lives for three periods with utility $U = u(1-e_1) + u(1-e_2) + u(1-e_3)$, where $u(\cdot)$ is strictly concave. She has 1 units of work to complete, thus faces the budget constraint $e_1 + e_2 + e_3 = 1$. Given this she will choose $e_k = 1/3$ for all k. Suppose she becomes a subject in an experiment and is required to exert effort $x_1 + x_2 = 1$. If the experiment is at the start of day 1 and she has yet to consume any work or leisure, she will again allocate her total effort (now increased by 1 unit) equally across the three periods: $e_1 + x_1 = e_2 + x_2 = e_3 = 2/3$. This has a continuum of solutions for x_1 and x_2, and since we do not observe e_k for any k, we learn nothing about preferences from this exercise.

Here the substitutablity between effort in the experiment or outside the experiment leads to a fully uninformative experiment.

Example 2. *Future Flexibility.* Continue with the prior example, but now suppose the experiment comes in the middle of the day and the subject has already spent $e_1 = 1/3$ units working. Now to smooth her work equally she must choose $x_1 = 1/3$, $x_2 = 2/3$, $e_2 = 0$ and $e_3 = 2/3$. Since any subject will be more constrained today when the task was unanticipated than in the future when the effort is anticipated, we naturally expect more cases of effort being higher later. If we neglect this, then observing only x_1 and x_2 would incorrectly lead us to conclude the subject is present-biased when in fact she is choosing leisure in the experiment to smooth her consumption. This example mirrors the conclusions of Carvalho et al. (2016).

This example shows problems with effort provision when it interacts with on some flow of consumption already experienced today, and the relatively greater flexibility one has later to absorb the anticipated demands for effort (or supply of food rewards) in the future than in the current period.

Example 3 *Complements.* Suppose a subject consumes goods a and b all of which are fully perishable. The subject's utility is $U = \min\{a_1, b_1\} + \delta \min\{a_2, b_2\}$, where $0 \leq \delta \leq 1$. Our subject has already planned the endowments in periods 1 and 2 of $w_1 = (3a_1, b_1)$ and $w_2 = (a_2, 3b_2)$. The experimenter gives the subject a choice between one unit of a_1 and two a_2. The subject will strictly prefer two a_2, leading the experimenter to conclude $\delta > 1/2$. Next, the experimenter offers one b_1 or two b_2. Now the subject prefers one b_1, leading the experimenter to infer $\delta < 1/2$. Thus, each good leads to mutually exclusive conclusions.

Now introduce a new commodity c which can be converted to either a or b 1-to-1, and, moreover c is storable (i.e. c is money). Suppose, however, that the subject treats c as perishable as well, that is, she narrow brackets her decision. The experimenter offers a choice between 1 unit of c_1 or k units of c_2. For any $k < 1/\delta$ the subject will prefer c_1 while for any $k > 1/\delta$ the subject strictly prefer the k units of c_2. This perfectly reveals the subject's δ.

Example 3 shows how money can be a superior way to elicit preferences if the subject narrow brackets consumption. The reason is that, other than discounting, money will have a relatively constant value across periods that will not be changed much by prior spending of money or recent consumption of other goods. You can notice that if we brought in a capital market through broadly bracketing the choice, Example 3 would end with the experimenter finding the switch point $k = 1 + r$, where r is the relevant market rate faced by the subject rather than $k = 1/\delta$.

A.2 Supplemental Figures and Tables

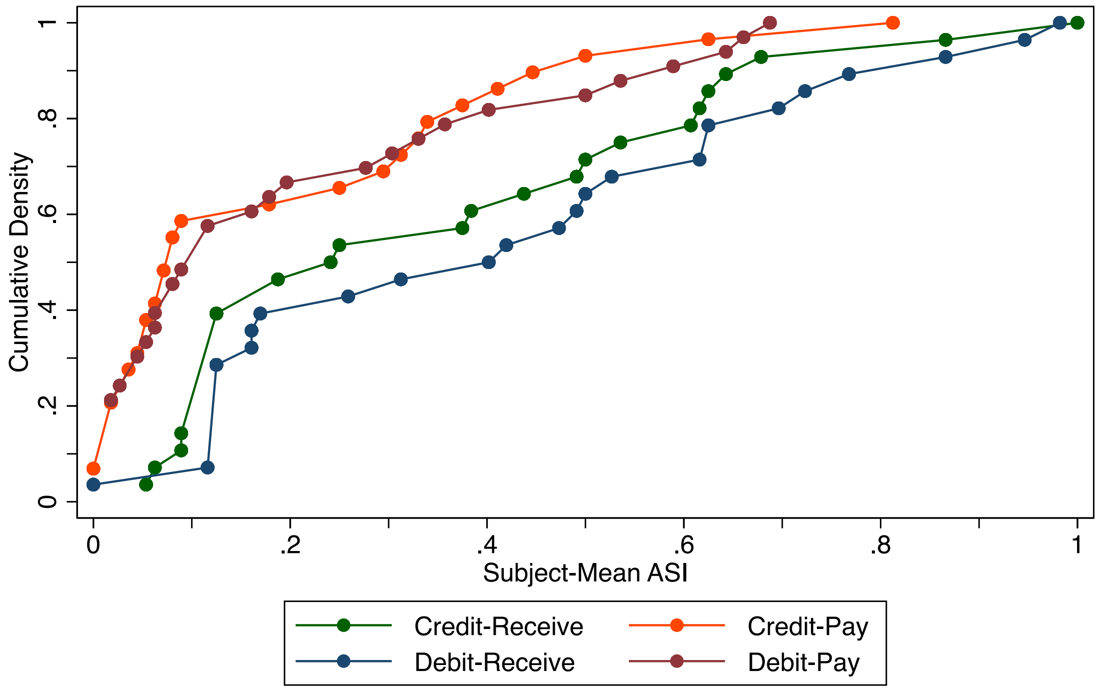

Figure A1: Distribution of ASI by Condition

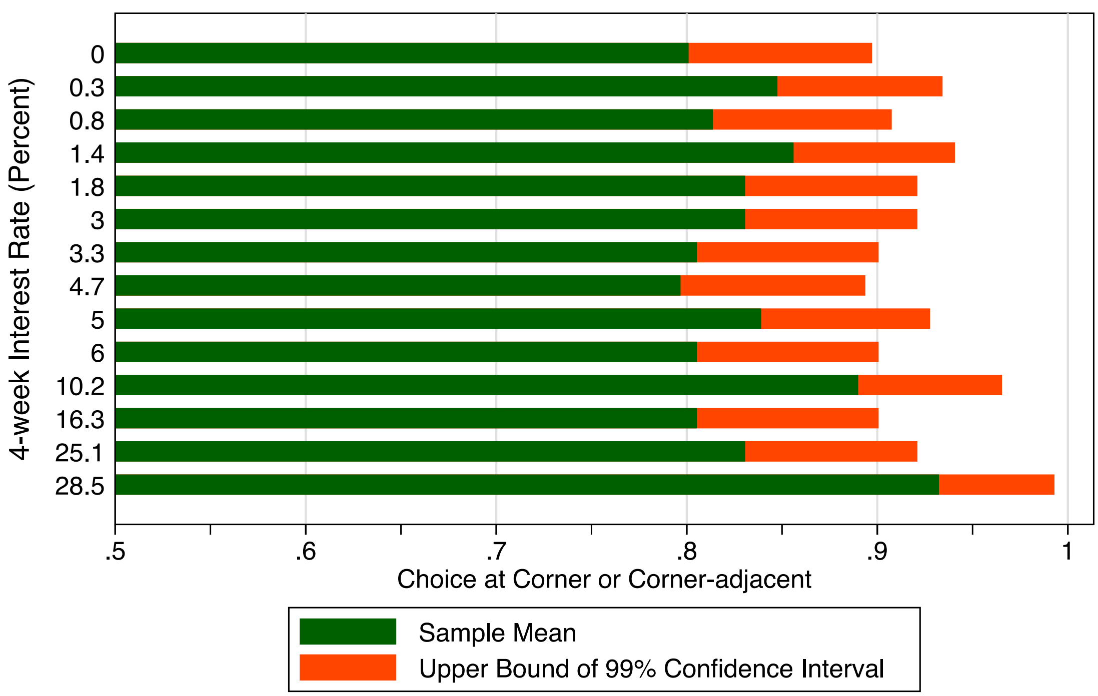

Figure A2: Corner Solution Frequency by Experimental Interest Rate

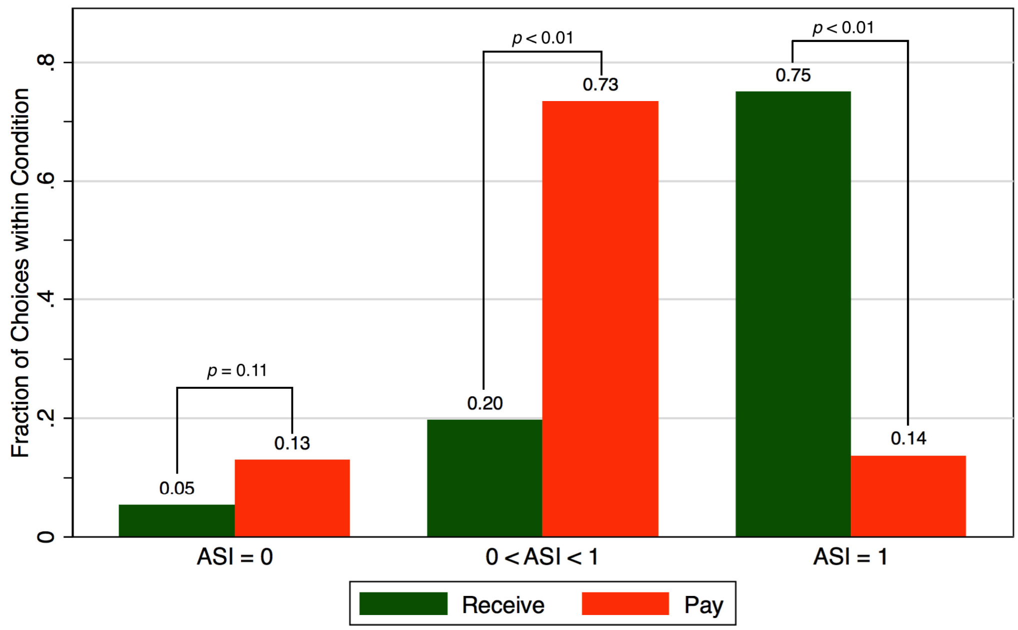

Figure A3: Corner and Interior Solutions on the Zero-interest Budgets

Table A1: Interest Rates in the Study

Horizon:	0-4 Weeks			4-8 Weeks		
Budget	4-wk Rate	Max. Early	Max. Late	4-wk Rate	Max. Early	Max. Late
1	0%	$21	$21	0%	$21	$21
2	0.768%	$20.84	$21	0.334%	$20.93	$21
3	1.400%	$20.71	$21	1.794%	$20.63	$21
4	3.296%	$20.33	$21	3.042%	$20.38	$21
5	4.686%	$20.06	$21	5%	$20.00	$21
6	6.001%	$19.81	$21	6.007%	$19.81	$21
7	16.343%	$18.05	$21	10.178%	$19.06	$21
8	25.074%	$16.79	$21	28.519%	$16.34	$21

4-wk Rate refers to the four-week interest rate implied by the offered budget. Max. Early refers to the maximum early receipt/payment that could be obtained from the budget. Max. Late refers to the maximum early receipt/payment that could be obtained from the budget.

Table A2: Design Differences by Condition and Frame

Condition:	Credit		Debit	
Frame:	Receive	Pay	Receive	Pay
Initial transfer, immediate	\$1	\$22	$-$22	\$1
Early date choice, 0 or 4 weeks	$\$x_t$	$-\$x_t$	$\$x_t$	$-\$x_t$
Later date choice, 4 or 8 weeks	$\$x_{t+k}$	$-\$x_{t+k}$	$\$x_{t+k}$	$-\$x_{t+k}$
Final transfer, 4 or 8 weeks + 1 day	\$1	\$22	\$24	\$43
Budget constraint	$(1+r)x_t + x_{t+k} = 21$			
Maximum \$ available	\$23	\$23	\$23	\$23
Number of subjects[†]	28	29	28	33

[†]: These numbers exclude three subjects who failed to execute their transfer schedule and seven who did not provide a choice for each budget set they faced. We use x_t to represent a subject's allocation to the early date, x_{t+k} to represent their allocation to the later date, and r to represent the four-week interest rate.

Table A3: Interior versus Corner Choices

A. Percent of Choices at Corner

	Credit	Debit	Pooled	
Receive	79.02	70.31	74.67	H_0: Full Sample % = 100
Pay	73.71	61.36	67.14	$z = 10.00$, $p < 0.01^{\dagger}$
Pooled	76.32	65.47	70.10	

B. Percent of Choices at or adjacent to Corner

	Credit	Debit	Pooled	
Receive	84.82	86.16	85.49	H_0: Full Sample % = 100
Pay	85.13	77.08	80.85	$z = 7.06$, $p < 0.01^{\dagger}$
Pooled	84.98	81.25	82.80	

C. Percent of Subjects with Zero Interior Choices

	Credit	Debit	Pooled	
Receive	53.57	39.29	46.43	H_0: Full Sample % = 100
Pay	4.14	0.00	11.29	$t_{117} = 17.36$, $p < 0.01$
Pooled	38.60	18.03	27.97	

D. Percent of Subjects with Two or Fewer Interior Choices

	Credit	Debit	Pooled	
Receive	71.43	50.00	60.71	H_0: Full Sample % = 100
Pay	51.72	24.24	37.10	$t_{117} = 11.19$, $p < 0.01$
Pooled	61.40	36.07	48.31	

†: test statistics adjust for s.e.'s clustered by subject.

Table A4: Estimates of Present Bias, Credit-Receive

Model:	Tobit		Probit	
DV:	ASI		$1(ASI=1)$	$1(ASI=0)$
	(1)	(2)	(3)	(4)
$ln(1+\text{r}) \times 100$	-0.096**	-0.110**	-0.024***	0.023***
	(0.038)	(0.048)	(0.008)	(0.005)
$1(t=0)$	-0.025	-0.171	-0.066*	$>$ -0.001
	(0.185)	(0.205)	(0.036)	(0.054)
$1(t=0) \times ln(1+\text{r}) \times 100$		0.027	-0.002	-0.006*
		(0.019)	(0.007)	(0.004)
Constant	0.441	0.516	0.438	0.414
	(0.260)	(0.261)	(0.078)	(0.066)
Clusters	28	28	28	28
Observations	448	448	448	448

*** : $p < 0.01$, ** : $p < 0.05$, * : $p < 0.10$ (s.e.'s clustered by individual).
Tobit estimates are interpreted as the impact of the variables on latent demand. Probit estimates are the marginal effects averaged across the sample.

Table A5: Estimates of Present Bias, Credit-Pay

Model:	Tobit		Probit	
DV:	ASI		$1(ASI=1)$	$1(ASI=0)$
	(1)	(2)	(3)	(4)
$ln(1+\text{r}) \times 100$	-0.047**	-0.064**	-0.022*	0.023***
	(0.019)	(0.025)	(0.011)	(0.007)
$1(t=0)$	0.279	0.142	0.009	-0.064
	(0.200)	(0.171)	(0.037)	(0.057)
$1(t=0) \times ln(1+\text{r}) \times 100$		0.028	0.017	-0.009
		(0.017)	(0.011)	(0.007)
Constant	-0.200	-0.124	0.163	0.548
	(0.204)	(0.191)	(0.060)	(0.070)
Clusters	29	29	29	29
Observations	464	464	464	464

*** : $p < 0.01$, ** : $p < 0.05$, * : $p < 0.10$ (s.e.'s clustered by individual).
Tobit estimates are interpreted as the impact of the variables on latent demand. Probit estimates are the marginal effects averaged across the sample.

Table A6: Estimates of Present Bias, Debit-Receive

Model:	Tobit		Probit	
DV:	ASI		$1(ASI = 1)$	$1(ASI = 0)$
	(1)	(2)	(3)	(4)
$ln(1 + \text{r}) \times 100$	-0.068***	-0.074***	-0.033***	0.018***
	(0.019)	(0.022)	(0.012)	(0.004)
$1(t = 0)$	0.080	0.013	-0.045	-0.029
	(0.132)	(0.125)	(0.044)	(0.062)
$1(t = 0) \times ln(1 + \text{r}) \times 100$		0.011	0.003	-0.003
		(0.010)	(0.013)	(0.003)
Constant	0.654	0.687	0.500	0.320
	(0.216)	(0.218)	(0.080)	(0.074)
Clusters	28	28	28	28
Observations	448	448	448	448

*** : $p < 0.01$, ** : $p < 0.05$, * : $p < 0.10$ (s.e.'s clustered by individual).
Tobit estimates are interpreted as the impact of the variables on latent demand. Probit estimates are the marginal effects averaged across the sample.

Table A7: Estimates of Present Bias, Debit Pay

Model:	Tobit		Probit	
DV:	ASI		$1(ASI = 1)$	$1(ASI = 0)$
	(1)	(2)	(3)	(4)
$ln(1 + \text{r}) \times 100$	-0.034***	-0.046***	-0.002	0.032***
	(0.008)	(0.013)	(0.002)	(0.007)
$1(t = 0)$	-0.023	-0.129*	-0.046*	0.087*
	(0.054)	(0.073)	(0.024)	(0.053)
$1(t = 0) \times ln(1 + \text{r}) \times 100$		0.022*	0.002	-0.015**
		(0.012)	(0.003)	(0.007)
Constant	0.104	0.159	0.066	0.375
	(0.096)	(0.098)	(0.029)	(0.056)
Clusters	33	33	33	33
Observations	528	528	528	528

*** : $p < 0.01$, ** : $p < 0.05$, * : $p < 0.10$ (s.e.'s clustered by individual).
Tobit estimates are interpreted as the impact of the variables on latent demand. Probit estimates are the marginal effects averaged across the sample.

B Subjects' Instructions and Decision Sheets

Welcome!

Thank you for participating in today's study.

Today's study will involve payments between you and the UCSD Econlab that will take place over the next 8 weeks. All the decisions about timing and amounts of these payments will be made today, in the EconLab, and you ***will not*** need to return to the Econlab, as all payments will be made electronically. The whole process will take about an hour. By the end of the 8 weeks, you can expect to have total earning of at least $15 and at most $25.

Eligibility for this study

To participate in this study you will need to understand and agree to several things. Please read this section very carefully. *If you feel that you do not meet all of the criteria below, please let us know and we will excuse you from the study.*

To take part in this study the following must be true for you:

- You must have an online Chase bank account with a minimum of $22 in your account.

- You must be enrolled in Chase QuickPay and willing to log in to your online banking during the study.

- While you will surely earn money in this study, achieving you final earnings will sometime involve you making *payments to* the EconLab as well as you *receiving money from* the EconLab.

- You must be willing to receive your payment *from* the EconLab and *to* the EconLab via Chase QuickPay.

- You must be willing to provide your name and e-mail address, as required by Chase QuickPay. This information will only be seen by Professor Andreoni and his assistants when using QuickPay. After the final payment has been sent, this information will be destroyed. Your identity will not be part of any subsequent data analysis. No personal bank data will be collected during the experiment.

- Once you decide to participate, you must faithfully carry out all payments.

If you do not agree or do not meet **all of these criteria** please inform us now.

Thank you!

Experimental Instructions

Earning money

In today's study, you will encounter 4 scenarios and make 8 choices in each scenario, for a total of 32 choices. Each of the 32 choices will be over how to allocate money between two points in time. One time is "earlier" and one time is "later". Both the earlier and later times may vary across different scenarios. While your final earnings from the experiment will be between $15 and $25, however the dates that you will receive these earnings will depend on the scenario. You could have your earnings as early as today before the end of the experiment, as late as 8 weeks and a day from today, or a date in between. All the payments will be done via Chase Quick Pay and will be scheduled by you today.

Once all 32 decisions have been made, we will **randomly select 1 of the 4 scenarios and then 1 of the 8 choices from that scenario as the *decision-that-counts*.** All 8 choices in a scenario will be on one sheet of paper: so one scenario corresponds to one ***decision sheet.*** The randomly selected scenario and choice will determine the exact amount of your actual earnings. Since all scenarios and choices are equally likely to be chosen, <u>**you should make each choice in each scenario as if it will be the *decision-that-counts***</u>**.**

Important: You will be given a total of 4 decision sheets, each with 8 decisions, making 32 decisions in total. At the top of each decision sheet you will be informed about the scenario for the choices.

At the end of the session today, you will schedule the payments of the decision-that-counts via Quick Pay, according to the days indicated by the *decision-that-counts*.

IMPORTANT NOTE: In order for you to receive your earnings from this study, you must schedule the payments truthfully based on your choice on the *decision-that-counts* and the selected scenario. We sincerely appreciate your cooperation.

On your table is a business card of Professor Andreoni with his contact information. Please keep this in a safe place. If one of your payments is not received you should immediately contact Professor Andreoni.

Please do not talk out loud during the rest of the study today. If you have any questions, please raise your hand, and someone will come to speak with you in private.

The decisions you will make are best described by examples, so before we begin the study, we are going to work through some examples of the choices and scenarios together.

When instructed to do so, please turn the page to begin the examples.

Credit-Receive decision sheets

NOW *and* 4 WEEKS from now — ID:

SCENARIO: If any choice on this sheet is randomly picked, you will **receive $1 from us today** before any payments to you will be made.
In 4 weeks and a day from now, you will **receive $1 from us** in addition to the payments you decided to receive on this sheet.
For each decision (1 to 8) below, decide on the **AMOUNTS** you would like **now** **AND** **in 4 weeks** by checking the corresponding box.
Only check one box per decision!

1	receive NOW... *and* receive in 4 WEEKS	$21.00 $0.01 □	$18.00 $3.00 □	$15.00 $6.00 □	$12.00 $9.00 □	$9.00 $12.00 □	$6.00 $15.00 □	$3.00 $18.00 □	$0.01 $21.00 □
2	receive NOW... *and* receive in 4 WEEKS	$20.84 $0.01 □	$17.86 $3.00 □	$14.89 $6.00 □	$11.91 $9.00 □	$8.93 $12.00 □	$5.95 $15.00 □	$2.98 $18.00 □	$0.01 $21.00 □
3	receive NOW... *and* receive in 4 WEEKS	$20.71 $0.01 □	$17.75 $3.00 □	$14.79 $6.00 □	$11.83 $9.00 □	$8.88 $12.00 □	$5.92 $15.00 □	$2.96 $18.00 □	$0.01 $21.00 □
4	receive NOW... *and* receive in 4 WEEKS	$20.33 $0.01 □	$17.43 $3.00 □	$14.52 $6.00 □	$11.62 $9.00 □	$8.71 $12.00 □	$5.81 $15.00 □	$2.90 $18.00 □	$0.01 $21.00 □
5	receive NOW... *and* receive in 4 WEEKS	$20.06 $0.01 □	$17.19 $3.00 □	$14.33 $6.00 □	$11.46 $9.00 □	$8.60 $12.00 □	$5.73 $15.00 □	$2.87 $18.00 □	$0.01 $21.00 □
6	receive NOW... *and* receive in 4 WEEKS	$19.81 $0.01 □	$16.98 $3.00 □	$14.15 $6.00 □	$11.32 $9.00 □	$8.49 $12.00 □	$5.66 $15.00 □	$2.83 $18.00 □	$0.01 $21.00 □
7	receive NOW... *and* receive in 4 WEEKS	$18.05 $0.01 □	$15.47 $3.00 □	$12.89 $6.00 □	$10.31 $9.00 □	$7.74 $12.00 □	$5.16 $15.00 □	$2.58 $18.00 □	$0.01 $21.00 □
8	receive NOW... *and* receive in 4 WEEKS	$16.79 $0.01 □	$14.39 $3.00 □	$11.99 $6.00 □	$9.59 $9.00 □	$7.20 $12.00 □	$4.80 $15.00 □	$2.40 $18.00 □	$0.01 $21.00 □

4 WEEKS from now *and* 8 WEEKS from now — ID:

SCENARIO: If any choice on this sheet is randomly picked, you will **receive $1 from us today** before any payments to you will be made.
In 8 weeks and a day from now, you will **receive $1 from us** in addition to the payments you decided to receive on this sheet.
For each decision (1 to 8) below, decide on the **AMOUNTS** you would like **in 4 weeks** **AND** **in 8 weeks** by checking the corresponding box.
Only check one box per decision!

1	receive in 4 WEEKS... *and* receive in 8 WEEKS	$21.00 $0.01 □	$18.00 $3.00 □	$15.00 $6.00 □	$12.00 $9.00 □	$9.00 $12.00 □	$6.00 $15.00 □	$3.00 $18.00 □	$0.01 $21.00 □
2	receive in 4 WEEKS... *and* receive in 8 WEEKS	$20.93 $0.01 □	$17.94 $3.00 □	$14.95 $6.00 □	$11.96 $9.00 □	$8.97 $12.00 □	$5.98 $15.00 □	$2.99 $18.00 □	$0.01 $21.00 □
3	receive in 4 WEEKS... *and* receive in 8 WEEKS	$20.63 $0.01 □	$17.68 $3.00 □	$14.74 $6.00 □	$11.79 $9.00 □	$8.84 $12.00 □	$5.89 $15.00 □	$2.95 $18.00 □	$0.01 $21.00 □
4	receive in 4 WEEKS... *and* receive in 8 WEEKS	$20.38 $0.01 □	$17.47 $3.00 □	$14.56 $6.00 □	$11.65 $9.00 □	$8.73 $12.00 □	$5.82 $15.00 □	$2.91 $18.00 □	$0.01 $21.00 □
5	receive in 4 WEEKS... *and* receive in 8 WEEKS	$20.00 $0.01 □	$17.14 $3.00 □	$14.29 $6.00 □	$11.43 $9.00 □	$8.57 $12.00 □	$5.71 $15.00 □	$2.86 $18.00 □	$0.01 $21.00 □
6	receive in 4 WEEKS... *and* receive in 8 WEEKS	$19.81 $0.01 □	$16.98 $3.00 □	$14.15 $6.00 □	$11.32 $9.00 □	$8.49 $12.00 □	$5.66 $15.00 □	$2.83 $18.00 □	$0.01 $21.00 □
7	receive in 4 WEEKS... *and* receive in 8 WEEKS	$19.06 $0.01 □	$16.34 $3.00 □	$13.61 $6.00 □	$10.89 $9.00 □	$8.17 $12.00 □	$5.45 $15.00 □	$2.72 $18.00 □	$0.01 $21.00 □
8	receive in 4 WEEKS... *and* receive in 8 WEEKS	$16.34 $0.01 □	$14.01 $3.00 □	$11.67 $6.00 □	$9.34 $9.00 □	$7.00 $12.00 □	$4.67 $15.00 □	$2.33 $18.00 □	$0.01 $21.00 □

Credit-Pay decision sheets

NOW *and* 4 WEEKS from now　　　　ID:

SCENARIO: If any decision on this sheet is randomly picked, you will **receive $22 from us** today before you make any payments to us.
In 4 weeks and a day from now, you will also **receive $22 from us**.
For each decision (1 to 8) below, decide on the **AMOUNTS** you would like to pay us **now** **AND** **in 4 weeks** by checking the corresponding box.
Only check one box per decision!

1	pay us NOW...	$21.00	$18.00	$15.00	$12.00	$9.00	$6.00	$3.00	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
2	pay us NOW...	$20.84	$17.86	$14.89	$11.91	$8.93	$5.95	$2.98	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
3	pay us NOW...	$20.71	$17.75	$14.79	$11.83	$8.88	$5.92	$2.96	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
4	pay us NOW...	$20.33	$17.43	$14.52	$11.62	$8.71	$5.81	$2.90	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
5	pay us NOW...	$20.06	$17.19	$14.33	$11.46	$8.60	$5.73	$2.87	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
6	pay us NOW...	$19.81	$16.98	$14.15	$11.32	$8.49	$5.66	$2.83	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
7	pay us NOW...	$18.05	$15.47	$12.89	$10.31	$7.74	$5.16	$2.58	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
8	pay us NOW...	$16.79	$14.39	$11.99	$9.59	$7.20	$4.80	$2.40	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□

4 WEEKS from now *and* 8 WEEKS from now　　　　ID:

SCENARIO: If any decision on this sheet is randomly picked, you will **receive $22 from us** today before you make any payments to us.
In 8 weeks and a day from now, you will also **receive $22 from us**.
For each decision (1 to 8) below, decide on the **AMOUNTS** you would like to pay us **in 4 weeks** **AND** **in 8 weeks** by checking the corresponding box.
Only check one box per decision!

1	pay us in 4 WEEKS...	$21.00	$18.00	$15.00	$12.00	$9.00	$6.00	$3.00	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
2	pay us in 4 WEEKS...	$20.93	$17.94	$14.95	$11.96	$8.97	$5.98	$2.99	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
3	pay us in 4 WEEKS...	$20.63	$17.68	$14.74	$11.79	$8.84	$5.89	$2.95	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
4	pay us in 4 WEEKS...	$20.38	$17.47	$14.56	$11.65	$8.73	$5.82	$2.91	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
5	pay us in 4 WEEKS...	$20.00	$17.14	$14.29	$11.43	$8.57	$5.71	$2.86	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
6	pay us in 4 WEEKS...	$19.81	$16.98	$14.15	$11.32	$8.49	$5.66	$2.83	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
7	pay us in 4 WEEKS...	$19.06	$16.34	$13.61	$10.89	$8.17	$5.45	$2.72	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
8	pay us in 4 WEEKS...	$16.34	$14.01	$11.67	$9.34	$7.00	$4.67	$2.33	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□

Debit-Receive decision sheets

NOW *and* 4 WEEKS from now — ID:

SCENARIO: If any choice on this sheet is randomly picked, you will **pay us $22 today** before any payments to you will be made.
In 4 weeks and a day from now, you will **receive $24 from us** in addition to the payments you decided to receive on this sheet.
For each decision (1 to 8) below, decide on the **AMOUNTS** you would like **now** **AND** **in 4 weeks** by checking the corresponding box.
Only check one box per decision!

1	receive NOW... *and* receive in 4 WEEKS	$21.00 $0.01 □	$18.00 $3.00 □	$15.00 $6.00 □	$12.00 $9.00 □	$9.00 $12.00 □	$6.00 $15.00 □	$3.00 $18.00 □	$0.01 $21.00 □
2	receive NOW... *and* receive in 4 WEEKS	$20.84 $0.01 □	$17.86 $3.00 □	$14.89 $6.00 □	$11.91 $9.00 □	$8.93 $12.00 □	$5.95 $15.00 □	$2.98 $18.00 □	$0.01 $21.00 □
3	receive NOW... *and* receive in 4 WEEKS	$20.71 $0.01 □	$17.75 $3.00 □	$14.79 $6.00 □	$11.83 $9.00 □	$8.88 $12.00 □	$5.92 $15.00 □	$2.96 $18.00 □	$0.01 $21.00 □
4	receive NOW... *and* receive in 4 WEEKS	$20.33 $0.01 □	$17.43 $3.00 □	$14.52 $6.00 □	$11.62 $9.00 □	$8.71 $12.00 □	$5.81 $15.00 □	$2.90 $18.00 □	$0.01 $21.00 □
5	receive NOW... *and* receive in 4 WEEKS	$20.06 $0.01 □	$17.19 $3.00 □	$14.33 $6.00 □	$11.46 $9.00 □	$8.60 $12.00 □	$5.73 $15.00 □	$2.87 $18.00 □	$0.01 $21.00 □
6	receive NOW... *and* receive in 4 WEEKS	$19.81 $0.01 □	$16.98 $3.00 □	$14.15 $6.00 □	$11.32 $9.00 □	$8.49 $12.00 □	$5.66 $15.00 □	$2.83 $18.00 □	$0.01 $21.00 □
7	receive NOW... *and* receive in 4 WEEKS	$18.05 $0.01 □	$15.47 $3.00 □	$12.89 $6.00 □	$10.31 $9.00 □	$7.74 $12.00 □	$5.16 $15.00 □	$2.58 $18.00 □	$0.01 $21.00 □
8	receive NOW... *and* receive in 4 WEEKS	$16.79 $0.01 □	$14.39 $3.00 □	$11.99 $6.00 □	$9.59 $9.00 □	$7.20 $12.00 □	$4.80 $15.00 □	$2.40 $18.00 □	$0.01 $21.00 □

4 WEEKS from now *and* 8 WEEKS from now — ID:

SCENARIO: If any decision on this sheet is randomly picked, you will **pay us $22 today** before any payments to you will be made.
In 8 weeks and a day from now, you will **receive $24 from us** in addition to the payments you decided to receive on this sheet.
For each decision (1 to 8) below, decide on the **AMOUNTS** you would like **in 4 weeks AND in 8 weeks** by checking the corresponding box.
Only check one box per decision!

1	receive in 4 WEEKS... *and* receive in 8 WEEKS	$21.00 $0.01 □	$18.00 $3.00 □	$15.00 $6.00 □	$12.00 $9.00 □	$9.00 $12.00 □	$6.00 $15.00 □	$3.00 $18.00 □	$0.01 $21.00 □
2	receive in 4 WEEKS... *and* receive in 8 WEEKS	$20.93 $0.01 □	$17.94 $3.00 □	$14.95 $6.00 □	$11.96 $9.00 □	$8.97 $12.00 □	$5.98 $15.00 □	$2.99 $18.00 □	$0.01 $21.00 □
3	receive in 4 WEEKS... *and* receive in 8 WEEKS	$20.63 $0.01 □	$17.68 $3.00 □	$14.74 $6.00 □	$11.79 $9.00 □	$8.84 $12.00 □	$5.89 $15.00 □	$2.95 $18.00 □	$0.01 $21.00 □
4	receive in 4 WEEKS... *and* receive in 8 WEEKS	$20.38 $0.01 □	$17.47 $3.00 □	$14.56 $6.00 □	$11.65 $9.00 □	$8.73 $12.00 □	$5.82 $15.00 □	$2.91 $18.00 □	$0.01 $21.00 □
5	receive in 4 WEEKS... *and* receive in 8 WEEKS	$20.00 $0.01 □	$17.14 $3.00 □	$14.29 $6.00 □	$11.43 $9.00 □	$8.57 $12.00 □	$5.71 $15.00 □	$2.86 $18.00 □	$0.01 $21.00 □
6	receive in 4 WEEKS... *and* receive in 8 WEEKS	$19.81 $0.01 □	$16.98 $3.00 □	$14.15 $6.00 □	$11.32 $9.00 □	$8.49 $12.00 □	$5.66 $15.00 □	$2.83 $18.00 □	$0.01 $21.00 □
7	receive in 4 WEEKS... *and* receive in 8 WEEKS	$19.06 $0.01 □	$16.34 $3.00 □	$13.61 $6.00 □	$10.89 $9.00 □	$8.17 $12.00 □	$5.45 $15.00 □	$2.72 $18.00 □	$0.01 $21.00 □
8	receive in 4 WEEKS... *and* receive in 8 WEEKS	$16.34 $0.01 □	$14.01 $3.00 □	$11.67 $6.00 □	$9.34 $9.00 □	$7.00 $12.00 □	$4.67 $15.00 □	$2.33 $18.00 □	$0.01 $21.00 □

Debit-Pay decision sheets

NOW *and* 4 WEEKS from now ID:

SCENARIO: If any decision on this sheet is randomly picked, you will **receive $1 from us today** before you make any payments to us.
In 4 weeks and a day from now, you will **receive $43 from us**.
For each decision (1 to 8) below, decide on the **AMOUNTS** you would like to pay us **now AND in 4 weeks** by checking the corresponding box.
Only check one box per decision!

1	pay us NOW...	$21.00	$18.00	$15.00	$12.00	$9.00	$6.00	$3.00	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
2	pay us NOW...	$20.84	$17.86	$14.89	$11.91	$8.93	$5.95	$2.98	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
3	pay us NOW...	$20.71	$17.75	$14.79	$11.83	$8.88	$5.92	$2.96	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
4	pay us NOW...	$20.33	$17.43	$14.52	$11.62	$8.71	$5.81	$2.90	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
5	pay us NOW...	$20.06	$17.19	$14.33	$11.46	$8.60	$5.73	$2.87	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
6	pay us NOW...	$19.81	$16.98	$14.15	$11.32	$8.49	$5.66	$2.83	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
7	pay us NOW...	$18.05	$15.47	$12.89	$10.31	$7.74	$5.16	$2.58	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
8	pay us NOW...	$16.79	$14.39	$11.99	$9.59	$7.20	$4.80	$2.40	$0.01
	and pay us in 4 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□

4 WEEKS from now *and* 8 WEEKS from now ID:

SCENARIO: If any decision on this sheet is randomly picked, you will **receive $1 from us today** before you make any payments to us.
In 8 weeks and a day from now, you will **receive $43 from us**.
For each decision (1 to 8) below, decide on the **AMOUNTS** you would like to pay us **in 4 weeks AND in 8 weeks** by checking the corresponding box.
Only check one box per decision!

1	pay us in 4 WEEKS...	$21.00	$18.00	$15.00	$12.00	$9.00	$6.00	$3.00	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
2	pay us in 4 WEEKS...	$20.93	$17.94	$14.95	$11.96	$8.97	$5.98	$2.99	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
3	pay us in 4 WEEKS...	$20.63	$17.68	$14.74	$11.79	$8.84	$5.89	$2.95	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
4	pay us in 4 WEEKS...	$20.38	$17.47	$14.56	$11.65	$8.73	$5.82	$2.91	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
5	pay us in 4 WEEKS...	$20.00	$17.14	$14.29	$11.43	$8.57	$5.71	$2.86	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
6	pay us in 4 WEEKS...	$19.81	$16.98	$14.15	$11.32	$8.49	$5.66	$2.83	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
7	pay us in 4 WEEKS...	$19.06	$16.34	$13.61	$10.89	$8.17	$5.45	$2.72	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□
8	pay us in 4 WEEKS...	$16.34	$14.01	$11.67	$9.34	$7.00	$4.67	$2.33	$0.01
	and pay us in 8 WEEKS	$0.01	$3.00	$6.00	$9.00	$12.00	$15.00	$18.00	$21.00
		□	□	□	□	□	□	□	□