

## Risk Preferences Are Not Time Preferences: Reply<sup>†</sup>

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*Can the well-known experimental phenomenon of present-bias in intertemporal choice be confounded with the risks associated with receiving payment? Can measurements of risk preferences be used to represent desires for smoothness in intertemporal payments? In our two 2012 papers in this journal we explored these two questions and found the answer to the first to be yes and the second to be no. We feel the three papers inspired by our work and published here underscore these arguments and point to interesting new possibilities for modeling and measuring risk over time. (JEL C91, D81, D91)*

In 2012, we published two companion papers in this journal, Andreoni and Sprenger (2012a,b). This reply addresses three papers whose main inspiration is the second in that pair, “Risk Preferences are not Time Preferences.” To address these, however, it is important to keep it in the appropriate context with respect to the first, “Measuring Time Preferences with Convex Budgets.”

Measuring discounting and present bias using laboratory experiments, with choices over money, is an especially challenging undertaking. At the time of writing our papers, the work that we saw as the best and most impressive was that by Andersen et al. (2008). This work combined multiple price lists for time allocations, mainly to identify discounting, with separate multiple price lists for risk, which were intended to capture the concavity of a cardinal utility function that would then transfer to the time-preference task. The Andersen et al. (2008) methods did indeed produce discount rates that were precisely estimated and of reasonable magnitude, about 10 percent annually. Estimating a constant relative risk averse utility function, they found a CRRA parameter of around  $\rho = 0.75$ , indicating substantial concavity of utility.<sup>1</sup>

In designing our experiments, we were motivated by two main questions. First, the estimate of curvature by Andersen et al. (2008) would imply that if we offered subjects intertemporal choices along a linear budget constraint, rather than simply at the corners of the budget (that is, “all later” or “all sooner”), we would see primarily interior choices. With enough variation in interest rate, we could identify curvature

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<sup>1</sup>In our formulation below,  $\alpha = 1 - \rho$ . Thus, a  $\rho = 0.75$  is equivalent to an  $\alpha = 0.25$ .

without using a risk task, and thus rely on a single instrument. This would not only be simpler to administer and easier to understand for subjects, we conjectured, but prior research suggested that this approach might yield consistent behavior and tightly estimated parameters.<sup>2</sup>

Second, we noted that Andersen et al. (2008) did not allow for considerations of present bias. At the time, present-biased preferences had been widely documented in a body of lab experiments using time-dated monetary payments (for a review, see Frederick, Loewenstein, and O'Donoghue 2002). This work was heavily cited in other studies exploring the implications of present bias. The severe challenge in correctly identifying present bias is that one must make everything identical about each exchange of money *except the time at which it was received*. In this regard, “immediate” payments have a clear potential advantage in both convenience and security. In particular, it will never be as easy or as safe to receive money later as it is to get it immediately and in the lab. Our experiment used six innovations to try to equalize both the convenience and confidence of receiving both payments (see Andreoni and Sprenger 2012a, pp. 3337–39), and 97 percent of subjects reported confidence in our future payments. Hence, the design delivers a precisely measured value of present bias without confounding issues of payment reliability and differential transaction costs.

Our design was simple. We asked subjects to solve the problem

$$\begin{aligned} & \max_{c_t, c_{t+k}} U(c_t, c_{t+k}) \\ & \text{s.t. } \frac{1}{r} c_t + c_{t+k} = m, \end{aligned}$$

where we assume that

$$U(c_t, c_t + k) = \begin{cases} c_t^\alpha + \beta \delta^k c_{t+k}^\alpha, & \text{if } t = 0 \\ c_t^\alpha + \delta^k c_{t+k}^\alpha, & \text{if } t > 0, \end{cases}$$

and where  $c_t, c_{t+k}$  are experimental payments received at times  $t$  and  $t + k$ , respectively. The utility parameter  $\alpha$  represents utility function curvature,  $\beta$  represents the degree of present bias as in models of quasi-hyperbolic discounting (Laibson 1997; O'Donoghue and Rabin 1999), and  $\delta$  represents the long-run discount factor. With variation in the early date,  $t$ , the delay length,  $k$ , and the interest rate,  $r$ , all three utility parameters can be identified. Note that this design, termed a Convex Time Budget (CTB), nests the standard intertemporal multiple price list, which forces subjects to choose either the bundle  $(c_t, c_{t+k}) = (0, m)$  or the bundle  $(mr, 0)$ , corresponding to the two budget corners. For good measure we also collected risky choice data as Andersen et al. (2008) did. This meant that our design nested the Andersen et al. (2008) approach and thus could do no worse in terms of measuring preferences. This fact was later demonstrated in Andreoni, Kuhn, and Sprenger (forthcoming).<sup>3</sup>

<sup>2</sup>See, for example, Andreoni and Miller (2002); Andreoni and Harbaugh (2009); Choi et al. (2007).

<sup>3</sup>Andreoni, Kuhn, and Sprenger (forthcoming) reproduces the CTB methods, as well as those used by Andersen et al. (2008) on the same subjects. Using estimates on each method to fit a model, the authors then used each model

Our approach indeed produced precisely estimated parameters, and a sensible annual discount rate of 30 percent (standard error = 6.4 percent). Beyond that, our results filled us with surprise. Contrary to expectations, utility was estimated to have only a slight degree of concavity, with  $\alpha = 0.920$  (0.006). This was due to the disciplining effect of allowing interior choices. The present-bias parameter, the greatest surprise, was estimated to be  $\beta = 1.004$  (0.002). So, while we got the precise estimates we had hoped to see, the point estimate suggested no present bias.

In hindsight, it is obvious to us that, using money, these parameters made sense. Arbitrage alone should produce apparently linear utility, rates about equal to credit card interest charges, and no present bias. This left two related puzzles. First, why had other studies with money found present bias while we found none? Second why did we find so much less utility function curvature than Andersen et al. (2008), to the point of our measures being uncorrelated with independent risky choice data?

This led to our second paper, "Risk Preferences are not Time Preferences" (Andreoni and Sprenger 2012b), which is the subject of this reply. Here we asked, given our additional controls on payment risk, was the risk of getting paid responsible for our differences? Since the future is inherently risky while the present is, essentially, risk free, we saw the most natural test of this to move all our payments into the future, but add risk to the later payments and see if behavior appears present biased. To make sure we were seeing effects of risk and not time, we also moved the risk earlier rather than later. Moreover, since we also wanted to know if using risky choice was a good way of capturing concavity of utility in the absence of risk, we also compared cases with only risk but with common ratios of probabilities to our conditions which combined risk and no risk.

Our results were again compelling. First, relative to a common-ratio counterpart condition, subjects systematically allocated more money to either a riskless sooner payment or a riskless later payment. This indicates that non-expected utility risk preferences can lead to behavior observationally equivalent to present bias. Hence, it is perhaps likely that some findings of present bias with money could be due to the evolution of payment risk through time. Second, subjects even violated common-ratio predictions when payment risk was equalized through time compared to risk-free conditions. This implies that using risk preferences to identify curvature in riskless settings may be problematic. This later result has now been reinforced by Miao and Zhong (2012) and Abdellaoui et al. (2013).

We have been very gratified by the enthusiastic adoption of our CTB methodology by economists across the globe, many of whom have used the technique to accomplish our original expectations of demonstrating heterogeneous amounts of present-biased behavior that are well correlated with other choices. The CTB has been used to show present bias among those who are hungry (Ashton 2014), low in glucose (Kuhn, Kuhn, and Villeval 2014), poor and near payday (Carvalho, Meier, and Wang 2014), primed with Confucianism (Liu, Meng, and Wang 2014), who perceive time to pass faster than it truly does (Brocas, Carrillo, and Tarrasó 2015), or

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to predict data in the other experiment. The CTB methods predicted as well or better than the Andersen et al. (2008) model both within sample and out of sample. The main reason for the superiority of the CTB is that Andersen et al.'s (2008) reliance on the risky choice data to identify utility curvature predicts far too many interior solutions in the CTB, whereas the CTB approach is able to predict which corner solutions will obtain in the Andersen et al. (2008) intertemporal choices with accuracy equal to the within-sample predictions of Andersen et al. (2008).

who are choosing over goods other than money (Augenblick, Niederle, and Sprenger forthcoming). In developing countries, the CTB has been used to show differential impact of policy on present-biased and time-consistent agents by Giné et al. (2012); Carvalho, Prina, and Sydnor (2013); Janssens, Kramer, and Swart (2013); Clot and Stanton (2014); and Sawada and Kuroishi (2015). The CTB has shown that both individuals and households exhibit present bias in rural China (Yang and Carlsson 2012). Children and teenagers have also been studied with the CTB, with several researchers showing how educational interventions can reduce present bias. These include Alan and Ertac (2014); Angerer et al. (2014); and Lührmann, Serra-Garcia, and Winter (2013). Finally, Shaw et al. (2014) used the CTB to study discounting over long horizons.

## I. The Conversation

Another surprising result of our publications (Andreoni and Sprenger 2012a,b) is the volume of related papers and comments that it inspired. We are grateful to the editor for handling these many manuscripts and selecting the three in this issue to publish. We agree with the editor that these three do indeed add to the conversation about how to measure preferences for risk over time in constructive ways.

While these are published as comments on our paper, which often connotes some error, correction, or difference in interpretation between the original authors and the comment, this is not the case here. We see all of these papers as complementary to our own, each contributing a new and expanded view of what we presented. None of these papers identifies a flaw in our methods or analysis, and none of them would have caused us to change our experimental designs had we learned these ideas prior to running our experiments.

### A. Cheung

Stephen Cheung (2015) first duplicates our results from our paper (Andreoni and Sprenger 2012b) with great precision. Then he introduces a case involving correlation in risks. In our experiment, the subject's risk of receiving earlier and later payments are resolved independently. Professor Cheung's experiment shows that the results look different when the earlier and later risks are perfectly correlated.

This is an interesting finding, and we credit Professor Cheung for providing original data. However, it does not change the fact that the future is inherently more risky than the present and, in experiments, the risks are unlikely to have much correlation, if any. Hence, the relevance of such correlated risks for examining experimental findings of present bias may be limited. In life, however, risks farther in the future may be more correlated than our experimental variables are, and when evaluating data from the field, the challenges raised by Professor Cheung may require attention.

### B. Epper and Fehr-Duda

Thomas Epper and Helga Fehr-Duda (2015) make the interesting and provocative point that some of our conditions in our paper (Andreoni and Sprenger 2012b) can be characterized by rank-dependent expected utility. The key insight of Professors

Epper and Fehr-Duda's work is that an earlier prospect and a later prospect need not be evaluated separately as two binary gambles. Instead, if the subject evaluates such intertemporal prospects by first integrating over time and then over risk, one yields a prospect with four outcomes (as opposed two prospects with two outcomes each). Subject choices induce a ranking between these four outcomes. When choices change, the ranking can change and hence the corresponding rank-dependent probability distortions can lead to a variety of interesting behaviors.

By coincidence, the potential for RDEU to organize our data had been pointed out to us by Professor Yoram Halevy, who made this observation independently of Professors Epper and Fehr-Duda. We learned of Epper and Fehr-Duda's work as we, including Halevy, were in the midst of preparing our own paper on the topic. Our paper, however, would have drawn a slightly different conclusion than that of the authors of this comment. Rather than stating that RDEU can prove a "unified account of all of Andreoni and Sprenger's key findings," we would instead have said that if one entertains a decision-maker who first integrates over time and then over risk, RDEU can rationalize a key violation of discounted expected utility.

Notwithstanding this difference, our experiment was not designed as a proper test of RDEU as it pertains to risk over time. RDEU is an atemporal model and so cannot be convincingly rejected by intertemporal choice data (something we noted in the text, Andreoni and Sprenger 2012b, p. 3371). We are grateful for the point illuminated by Professors Epper and Fehr-Duda. Though an *ex post* rationalization assuming a specific order of integration is not proof of a theory, the hypothesis advanced with respect to ordering of time and risk is ripe for experimentation.

The main conclusions of our paper (Andreoni and Sprenger 2012b), and reasons for writing it, are intact despite the well-taken point with respect to the order of integration: whether preferences under risk are different than preferences without risk because of RDEU or something else is not in question, and using a risk aversion measure to capture the concavity of utility without risk is likely to lead to a misspecified model.

### *C. Miao and Zhong*

Bin Miao and Songfa Zhong (2015) proceed on a similar path to Professor Cheung, replicating the initial findings and then demonstrating that the results of Andreoni and Sprenger (2012b) can be influenced by the extent of correlation between risks. Though the work of Miao and Zhong and Cheung are not perfectly in accord, together they raise interesting questions about how risks are experienced when correlated over time. As with the work of Professor Cheung, the correlation in risks considered by Miao and Zhong may not be ecologically relevant for issues related to experimental risk and present bias, but a set of potential applications for these insights exist.

One point of note is the assertion that models featuring preferences for the resolution of uncertainty such as Epstein and Zin (1989) and Chew and Epstein (1989) can rationalize our observed data. We noted that the application of such models in our environment is limited given that all uncertainty was resolved immediately at the end of the experiment (Andreoni and Sprenger 2012b, p. 3361). That is, there is in principle no uncertainty left to resolve. This purposeful move to sidestep these

models appears to have succeeded, as 100 percent of subjects expressed confidence in receiving their payments. Naturally, one can apply these models' functional forms without their assumptions being satisfied, but this seemed to us a somewhat uncomfortable step to take. As in the work of Epper and Fehr-Duda, what appears to be the critical question is whether individuals first evaluate risk or time. This may prove a fruitful research question arising from the body of this discussion.

## II. Conclusion

The three comments chosen by the editor represent three new interpretations of our data on using choices under risk to infer concavity of preferences without risk. None of these challenge the primary conclusion of our study: that risk preferences and time preferences are not the same. Each of the three provides an interesting hypothesis for explaining our admittedly puzzling data. We are grateful to all authors for broadening the discussion and invite more researchers to provide further tests to help clarify how to model and measure preferences for risk and time.

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