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SOME EMPIRICAL EVIDENCE ON DYNAMIC INCONSISTENCY

Richard THALER *

Cornell University, Ithaca, NY 14853, USA

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Individual discount rates are estimated from survey evidence. For gains, they are found to vary inversely with the size of the reward and the length of time to be waited. Rates are found to be much smaller for losses that for gains.

1. Introduction

The economic theory of intertemporal choice, as formulated by Irving Fisher, is both simple and elegant. In the case of perfect capital markets, everyone behaves the same way at the margin since firms and individuals borrow or lend until their marginal rate of substitution between consumption today and consumption tomorrow is equal to the interest rate. This, like all economic theory of the consumer, is normatively based. It is easy to show that if a consumer failed to act as the theory predicts, there would be some way to rearrange his consumption plan to make him better off. Yet do individuals really act this way? Economists at least since the time of Bohm–Bawerk have been skeptical. Both Bohm–Bawerk (1981) and Strotz (1955–1956) have speculated that people act as if their discount rates (the rate at which they trade-off consumption increments at different points in time) vary with the length of time to be waited. Strotz (1955–1956, p. 177) for example, states:

> 'Special attention should be given, I feel, to a discount function... which differs from a logarithmically linear one in that it

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> "over values" the more proximate satisfaction relative to the more distant ones... My own supposition is that most of us are "born" with [such] discount functions...'

It is this discount function which leads to Strotz's famous dynamic inconsistency. It can be illustrated with the following simple example:

(A) Choose between: (A.1) One apple today.
(A.2) Two apples tomorrow.

(B) Choose between: (B.1) One apple in one year.
(B.2) Two apples in one year plus one day.

While some people may be tempted to select (A.1) no one would select (B.1). Yet if the rate of discount is constant (as it 'should be') then the choices are formally identical. [Dynamic inconsistency arises if (B.2) is selected now and when the choice is reconsidered in 364 days (B.1) is selected.]

This letter describes an initial step in an attempt to discover whether individuals do choose in the manner in which Strotz suggested. Specifically the hypothesis to be tested is that the discount rate implicit in choices will vary inversely with the length of time to be waited.

In addition, another hypothesis, suggested by the model in Thaler and Shefrin (1981) will be tested. This hypothesis is that the discount rate will vary inversely with the size of the reward for which the individual must wait. This hypothesis is derived from viewing intertemporal choice as problem in self-control. Waiting for a reward requires some mental effort. If this effort does not increase proportionally with the size of the rewards (if there are some fixed psychic costs to waiting) then the hypothesized result will be present. A third hypothesis can be put simply: losses are different than gains. According to economic theory a person should be willing to pay the same amount to receive $100 a month sooner or to postpone paying $100 for a month. Yet it was not expected that this would be empirically validated. While I did not know exactly how preferences would differ for losses rather than gains one result was expected: The implicit discount rate for losses will be lower than for gains. Even someone who appears very impatient to receive a gain may nevertheless take a 'let's get it over with' attitude toward losses.

2. Method

As a preliminary method of investigating these hypotheses a set of questionnaires were prepared. Four different forms were used: three for gains and one for losses.

Space does not permit reproducing the instructions here, but they can be summarized as follows. For gains the subjects were told that they had won some money in a lottery held by their bank. They could take the money now or wait until later. They were asked how much they would require to make waiting just as attractive as getting the money now. Each subject received a 3×3 table to fill in with amounts varied in one dimension and length of time to wait in the other. The cover story for the fines involved a traffic ticket that could be paid now or later. In all cases subjects were instructed to assume that there was no risk of not getting the reward (or of avoiding the fine) if they waited. All amounts would be received (or paid) by mail.

The sizes of the prizes (fines) and the length of time to be waited was varied among the forms. The figures used are given in table 1.

Table 1

Form	Amounts	Time to wait
(1)	\$15, \$250, \$3000	3 mo. 1 yr. 3 yrs.
(2)	75, 250, 1200	6 mo. 1 yr. 5 yrs.
(3)	15, 250, 3000	1 mo. 1 yr. 10 yrs.
(4)	−15, −100, −250	3 mo. 1 yr. 3 yrs.

3. Results

The subjects were students at the University of Oregon who answered an advertisement in the newspaper. This was one of several tests they were asked to complete. About twenty useable responses were obtained for each form. (A few subjects did not understand the task and their responses were omitted from the analysis.)

The results are summarized in table 2 which resemble those the subjects were asked to fill in. I have reported the median responses (there was wide variation among subjects). The numbers in parentheses are the

Table 2
Median responses and (continuously compounded discount rates in percent).

	Amount of early prize	Later prize paid in		
		3 mo.	1 yr.	3 yrs.
(A)	$15	$ 30 (277)	$ 60 (139)	$ 100 (63)
	$250	$ 300 (73)	$ 350 (34)	$ 500 (23)
	$3000	$3500 (62)	$4000 (29)	$ 6000 (23)
		6 mo.	1 yr.	5 yr.
(B)	$75	$ 100 (58)	$ 200 (98)	$ 500 (38)
	$250	$ 300 (36)	$ 500 (69)	$ 1000 (28)
	$1200	$1500 (45)	$2400 (69)	$ 5000 (29)
		1 mo.	1 yr.	10 yrs.
(C)	$15	$ 20 (345)	$ 50 (120)	$ 100 (19)
	$250	$ 300 (219)	$ 400 (120)	$ 1000 (19)
	$3000	$3100 (39)	$ 400 (29)	$10000 (12)
	Amount of early fine	Later fine due in		
		3 mo.	1 yr.	3 yrs.
(D)	$15	$ 16 (26)	$ 20 (29)	$ 28 (20)
	$100	$ 102 (6)	$ 118 (16)	$ 155 (15)
		$ 251 (1)	$ 270 (8)	$ 310 (7)

continuously compounded discount rates implicit in the answers.

The first thing one notices in these tables is that the implicit discount rates are very large. While this may to some extent be a reflection of the hypothetical nature of the questions and the youth of the subjects, Hausman (1979) in his study of air conditioner purchases also found very high discount rates. Furthermore, the absolute magnitudes are less important than the relative variation within each table. As the tables show, these variations are quite dramatic and systematic. For the three forms using gains, both of the hypothesized effects are observed.

The implicit discount rates drop sharply as the size of the prize or the length of time increases. The only exception to this occurs for the middle column of form (B) where the rates for 12 months are higher than for 6 months. This result seems to have occurred because some subjects just doubled their 6 month responses in the 12 month column. In spite of this anomaly, however, the overall pattern is hard to ignore.

Form (D) produced qualitatively different results. The discount rates implicit in the answers here are much lower as was expected. The tendency for the rates to decline with increases in the size of the fine is also observed, but the effect of the length of time is not present. The essential result is that losses are very different from gains.

4. Discussion

Clearly if the results of this preliminary investigation are taken seriously, they cast considerable doubt on the descriptive validity of the standard theory of intertemporal choice. The standard theory would predict that the discount rates in each cell of each table would be equal for any given person, and differences among persons would only reflect differences in borrowing or lending rates. Instead we observe that the discount rates vary systematically across cells and the differences among individuals are much greater than variation in interest rates could possibly explain. Why? Consider each effect in turn.

Length of time. Responses imply that the subjects have a discount *function* which is non-exponential. Put simply, the relative marginal price of waiting for rewards appears to decline as the time necessary to wait increases. Two related explanations are intuitively appealing. First, the psychophysics of time suggests that the difference between today and tomorrow will seem greater than the difference between a year from now and a year plus one day. Yet an exponential discount rate requires that these differences be perceived to be equal. Second, for the longer time periods (3 years or more) arithmetic errors may help create the effect. A person who wanted to give the 'correct' answer would first figure his opportunity cost (depending on whether he was a borrower or lender) and then calculate the future value of the stated prize. To do this he would have to estimate an exponential growth function. Other researchers [Wagenaar and Sagaria (1975)] have found that individuals tend to underestimate such functions.

However, I do not believe this explanation should be overly stressed. It surely cannot explain the results for less than three years, and I believe only has a pronounced impact on the 10 year column in form (C).

Size effects. As the size of the reward increases the implicit discount rate falls. This result has an attractive self-control explanation. Waiting

for a reward requires effort. For small rewards ($15) a substantial (proportional) return may be required to make the wait worthwhile. Subjects may be thinking along the following lines: $15 is a dinner, $250 is a new stereo component or a trip to San Francisco, $3000 is a good used car. When they are asked how much they would have to receive to wait 3 months [form (A)] their responses are roughly 'an extra dinner', 'A new cartridge', or 'an extra night in San Francisco', and 'a fancy model of the same car'. Put in this way the answers seem at least somewhat more reasonable. The psychophysical concept of the just noticeable difference also seems to come into play here. For small amounts, the rate of return must be substantial before the gain seems worth the wait. A similar result for search theory is discussed in Thaler (1980).

An interesting side effect of this result is that subjects' actions are closer to the normative model, the larger are the stakes. This is consistent with the usual economists view that people get the big decisions right.

It should be noted that both the time and size effects can be 'explained' by introducing a 'fixed cost to waiting'. Yet the scenario used made the actual costs minimal. Thus if it is a fixed cost which yields these results, it is clearly a fixed *psychic* cost rather than some transactions cost.

Sign effects. That behavior is qualitatively different for gains and losses comes as no surprise. As I have argued elsewhere [Thaler (1980)] opportunity costs are generally *not* equated to out-of-pocket costs. Specifically, opportunity costs tend to be underweighted relative to out-of-product costs. [The same result appears in Kahneman and Tversky's 'Prospect Theory' (1979).] Since failure to wait for a reward creates an opportunity cost while postponing a loss incurs an out-of-pocket cost it should be expected that implicit discount rates will be higher for gains as we observe.

5. Conclusion

Economists are generally suspect of hypothetical questions, perhaps for good reasons. Nonetheless, recent studies by Grether and Plott (1979) and Grether (1980) have found no difference between the behavior of subjects who were playing for real money and those playing for hypothetical stakes. This seems to argue that the results reported here should not be dismissed out-of-hand. My colleague Baruch Fischhoff and I have

done extensive further testing with hypothetical questions and have obtained similar results. Real money experiments would be interesting but seem to present enormous tactical problems. (Would subjects believe they would get paid in five years?) Also, to use the stakes described here would be prohibitively expensive. Perhaps the most feasible research strategy is Hausman's technique of studying the implicit discount rates in consumer's actual decisions. Until more such studies are conducted, however, it would seem prudent to allow for the possibility that individual discount rates are not necessarily equal to the interest rate, and tend to vary with the size and sign of the reward, and the length of the delay.

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