Time Preference Analysis in Behavioral Economics Experiments

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Abstract

The paper aims to study the effect of time inconsistency on economic behavior by providing inter-temporal choices over popular experimental instruments in social psychology and economics, like the ultimatum game and the dictator game. Endowments gets monotonically influenced(either increase or decrease) by the time penalty on rewards, indicating a direct function of time preference. Traditional models of economics assumed that the discounting function is exponential in time leading to a monotonic decrease in preference with increased time delay; however, more recent neuroeconomic models suggest a hyperbolic discount function that can address the phenomenon of preference reversal.
Keywords: Inter-temporal Choices, Time preference/discounting, DG/UG, Present bias-Time Inconsistency, Quasi-Hyperbolic Discounting

1. Introduction

1.1. Time in behavioral economics

Inter-temporal choice is an economic term describing how current decisions affect what options become available in the future.
Time preference is the current relative valuation placed on receiving a good or some cash at an earlier date compared with receiving it at a later date. Time preferences are captured mathematically in the discount function. The higher the time preference, the higher the discount placed on returns receivable or costs payable in the future.
Temporal discounting is the tendency of people to discount rewards as they approach a temporal horizon in the future or the past (i.e., become so distant in time that they cease to be valuable or to have additive effects). To put it another way, it is a tendency to give greater value to rewards as they move away from their temporal horizons and towards the "now".

1.2. Games for economic experiment

1.2.1 Dictator Game (DG)

In the dictator game, the first player, "the dictator/proposer", determines how to split an endowment between themselves and the second player(the receiver which is unknown to the participant). It is at the dictator's own will to determine the endowment which ranges from giving nothing to giving all the endowment. [4]

1.2.2 Ultimatum Game (UG)

One player, the proposer, is endowed with a sum of money. The proposer is tasked with splitting it with another player, the receiver. Once the proposer communicates his decision, the receiver may accept it or reject it. If the receiver accepts, the money is split per the proposal; if the receiver rejects, both players receive nothing. [8]

2. Literature review

Nineteenth and early Twentieth century economists viewed inter-temporal choice as the joint product of multiple psychological motives. John Rae describes that not only do we not live forever but the exact date of our demise is uncertain, and thus this **“desire of accumulation”** is contravened by our natural preference for present pleasure (time preference, discounting the future)—“to spend is easy, to spare, hard.” [1] That capital which does get formed is thus a function of a person’s net factor of “the effective desire of accumulation”. “But man’s pleasures are not altogether selfish”; Rae’s empirical wisdom is that a person is also moved by “love” of others, “the conjugal and parental relations, the claims of their kindred and friends, without which no saving whatsoever would occur. Thus for Rae the “uncertainty and worthlessness of future goods” is counterbalanced. [3] Paul Samuelson, in 1937 introduced the DU model in an attempt to capture these preferences in a single parameter, “discounting rate”, and to make the point that representing inter-temporal trade-offs required a cardinal measure of utility.[6]. This has been formulated as:

$$U^t(c_t, ..., c_T) = \sum_{k=0}^{T-t} D(k)\dot{u}(c_{t+k})$$

where

$$D(k) = (\frac{1}{1+\rho})^k$$

In this formulation, $u(c_{t+k})$ is often interpreted as the person’s cardinal instantaneous utility function— her well-being in period $t + k$ and $D(k)$ is often interpreted as the person’s discount function—the relative weight she attaches, in period t, to her well-being in period $t + k$. p represents the individual’s pure rate of time preference (her discount rate), which is meant to reflect the collective effects of the ”psychological” motives.

According to the discounted utility approach, inter-temporal choices are no different from other choices, except that some consequences are delayed and hence must be anticipated and discounted (i.e., re-weighted to take into account the delay). However, many psychological studies have since demonstrated deviations in instinctive preference from the constant discount rate assumed in exponential discounting, in which valuation falls by a constant factor per unit delay and the discount rate stays the same. Hyperbolic discounting is an alternative mathematical model that agrees more closely with these findings. The most important consequence of hyperbolic discounting is that it creates temporary preferences for small rewards that occur sooner over larger, later ones. Individuals using hyperbolic discounting reveal a strong tendency to make choices that are inconsistent over time – they make choices today that their future self would prefer not to have made, despite knowing the same information. This dynamic inconsistency happens because hyperbolas distort the relative value of options with a fixed difference in delays in proportion to how far the choice-maker is from those options.[7]

3. Scope of Study

Through this study, We shall draw patterns of the proposer’s time preference when they play the ultimatum and the dictator game with rewards conditionally delayed for them and/or the proposer. We hypothesize that **”delegated amount”**(amount the proposer assigns to the receiver) gets monotonically influenced(either increase or decreases) by the period of delay in reward, indicating a direct function of time preference.

Next, we shall use the $\beta - \delta$ model, i.e. a **”quasi-hyperbolic”** discount function, proposed by Laibson (1997)[5], approximates the hyperbolic discount function above in discrete time, to explain our results.

$$f_{QH}(0) = 1,$$
$$f_{QH}(D) = \beta \times \delta^D$$

where β and δ are constants between 0 and 1; and again D is the delay in the reward, and $f_{QH}(D)$ is the discount factor. The condition $f(0) = 1$ is stating that rewards taken at the present time are not discounted.
- δ is in fact the **"discount rate"**, $(\frac{1}{1+\rho})$ from classical DU.
- β is the **"haze over future"** accounting for inconsistent time preference by acting as the present bias parameter. This model retains much of the analytical tractability of exponential discounting while capturing the key qualitative feature of discounting, with true hyperbolas.

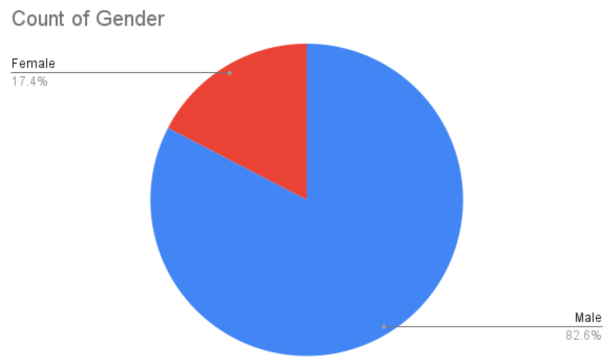

Figure 1. Gender Distribution

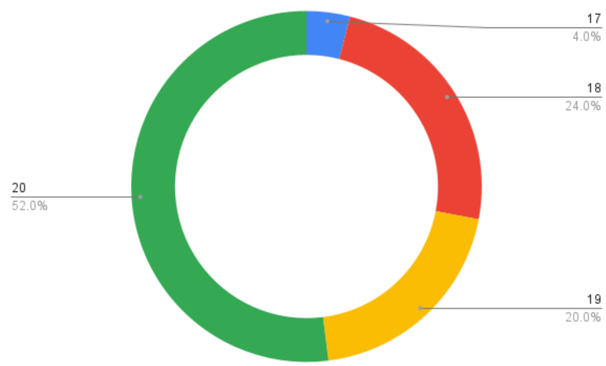

Figure 2. Age wise Distribution

4. Methodology

For the purpose of this experiment, we set up three google forms. They play two behavioral games with some changes in them.

4.1. Participants

The participants were mainly from IIIT Hyderabad between the ages 17 - 22. These were divided into three groups randomly. Out of the total 47 responses, the three groups had 17, 14 and 16 responses each. The following graph denotes the age and gender distribution of the sampled crowd. The plots can be seen in fig 1 and 2.

4.2. Design

There were 2 types of games in this experiment- Ultimatum game and Dictator game. Since we only wanted to evaluate an individual's willingness to give money to someone they don't know, we only recorded responses of the first participant, i.e the proposer.

The participants first play these games as they are played originally. This is ***Case 0*** for our experiment.

Then they play these modified games under the following three additional conditions:

- ***Case 1:*** The proposer receives the remaining sum (after delegation to the receiver) after a fixed time interval from the experimenter.
- ***Case 2:*** The receiver receives the delegated sum after a fixed time interval from the experimenter.
- ***Case 3:*** Both the proposer and the receiver receive the respectively delegated sums after a fixed time interval.

The fixed time interval is set to be **1 month**, **1 year** and **10 years** for the three groups.

Both the games had the proposed amount as 1000 rupees as it is a significant amount in the demographic. They could delegate the amount in multiples of 100. i.e. 0, 100, 200 etc. (To discretize the answer space, and reduce the complex-

Dictator Game		Delay Time		
		1 month	1 year	10 years
S.No.	Case	Amount delegated by proposer		
1	**Temporal Penalty on receiver**	235.29	250.00	287.50
2	**Temporal Penalty on proposer**	158.82	166.42	212.50
3	**Temporal Penalty on both**	211.76	185.71	262.50

Figure 3. Dictator Game - Mean Offers

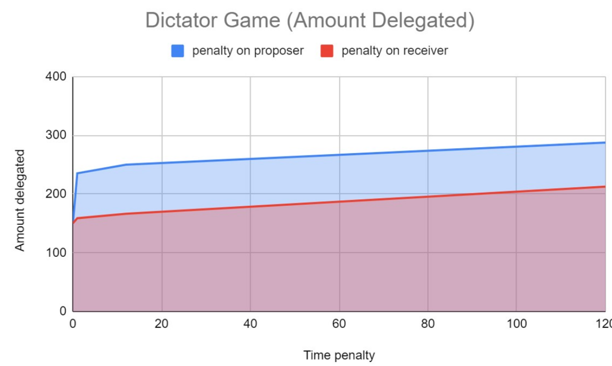

Figure 4. Dictator Game - Amount Offered

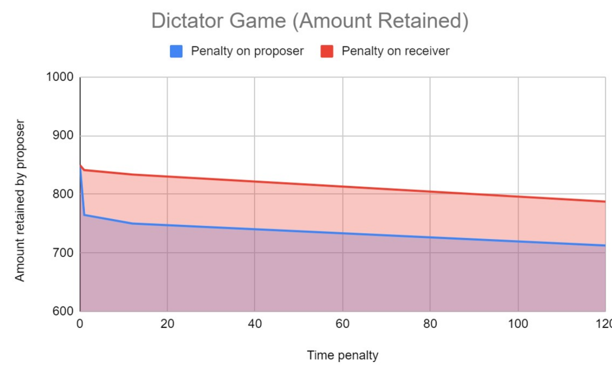

Figure 5. Dictator Game - Amount Retained

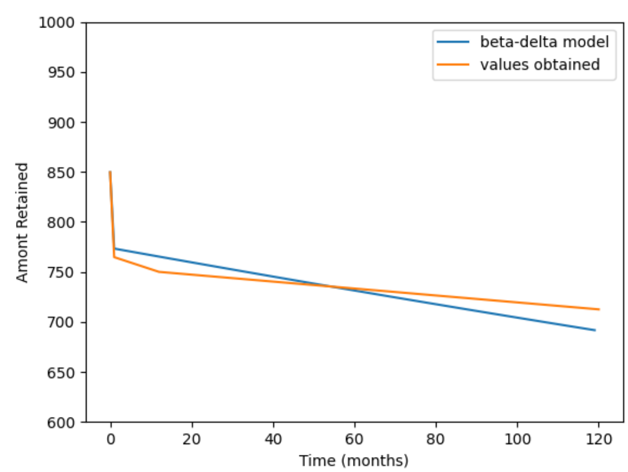

Figure 6. Dictator Game beta-delta model

ity for the participants). The ultimatum game had an additional condition that the receiver can reject the proposal and both of them would not receive any amount.

5. Results

5.1. Intra-game

5.1.1 Dictator Game

The base case value of delegation(i.e., instant endowment) for DG is **150.38 Rupees**, obtained by taking the average over all responses. The remaining mean delegations are as follows.

Result 1: In DG case 1, when a time penalty is levied on proposer's share, the amount they delegate successively increases with the time delay.

*F*igure 4 Since, utility of money gets discounted for the proposer, to maximize total utility in the game, they tend to delegate more to the receiver who enjoys complete utility of this sum. *F*igure 5 Since the delegated amount is increasing, we test the time-discounting model on the amount retained after delegation(which is decreasing).

After mathematically fitting a $\beta - \delta$ model to the observed mean data, we get:

$$\beta = 91.1005\%$$
$$\delta = 99.9055\%$$

The obtained curve in *F*igure 6 closely explains the observed data.

Result 2: In DG case 2, when a time penalty is levied on receiver's share, the proposer delegates lesser amount than than they would in Case 1.

*F*igure 4 Since, utility of money gets discounted for the receiver, to maximize total utility in the

Ultimatum game		Delay Time		
		1 month	1 year	10 years
S.No.	Case	Amount delegated by proposer		
1	**Temporal Penalty on receiver**	323.52	292.85	231.25
2	**Temporal Penalty on proposer**	364.70	300.00	243.75
3	**Temporal Penalty on both**	382.35	264.28	281.25

Figure 7. Ultimatum Game - Mean Offers

game, the proposer tends to delegate less to the receiver, and instead keep more share for themselves so that it doesn't get discounted temporally.

5.1.2 Ultimatum Game

The base case value of delegation(i.e., instant endowment) for UG is **355.60 Rupees**, obtained by taking the average over all responses. The remaining mean delegations are as follows.

Result 3: In UG case 1, when a time penalty is levied on proposer's share, the amount they delegate successively decreases with the time delay.

*F*igure 7 Since the utility of money for the proposer decreases with time, they want to save a higher amount. Interestingly, now that the receiver has choice too, the proposer expects altruism from the receiver in the form of acceptance of a lower sum, but at the same time is ready to risk a rejection as the time preference of the remaining sum is anyway unattractive, due to a discounted utility.
After mathematically fitting a $\beta - \delta$ model to the observed mean data, we get:

$$\beta = 97.5293\%$$
$$\delta = 99.5328$$

The obtained curve in *F*igure 8 closely explains the observed data.

Result 4: In UG case 2, when a time penalty is levied on receiver's share, the proposer delegates a higher amount than than they would in Case 1.

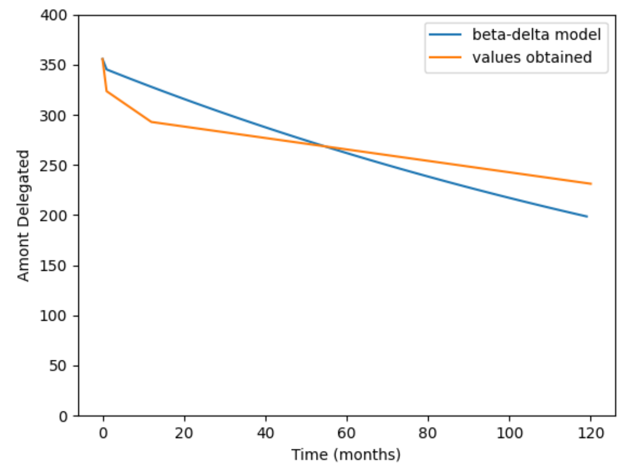

Figure 8. Ultimatum Game beta-delta model

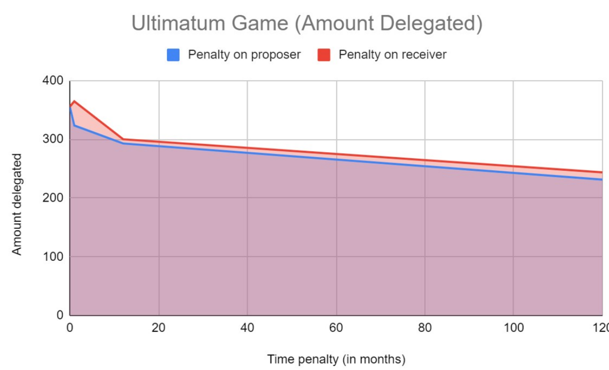

Figure 9. Ultimatum Game - Amount Offered

*F*igure 9 Since, utility of money decreases for the receiver, it creates a higher probability of rejection. Hence the proposer delegates a larger sum to protect the high present utility of the remaining amount.

5.2. Inter-game

Result 5: Overall, the amount delegated in ultimatum game, is higher than that delegated in the dictator game.

*F*igure 10 This obviously agrees with the notion that the proposer tries to assure acceptance of the offer by gratifying the receiver with a higher sum. This eliminates the risk of rejection.

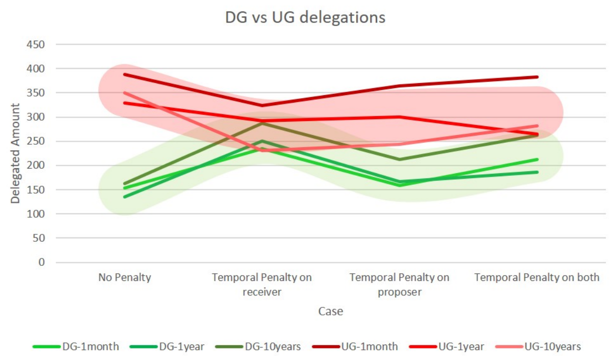

Figure 10. Mean Offers - DG vs UG

Result 6: Preference reversal of amount delegation occurs when the the time penalty is on the proposer. While they tend to delegate more amount in dictator game, they delegate lesser amount in Ultimatum Game.

The proposer's decision is both altruistic and rational when dictating a delegation, as they try to maximize total utility by reserving relatively lesser sum for themselves.
Since, utility of money decreases for the receiver, it creates a higher probability of rejection. Hence the proposer delegates a larger sum to protect the high present utility of the remaining amount.

Result 7: Preference reversal of amount delegation occurs when the the time penalty is on the receiver. While the proposer tends to delegate less amount in dictator game, they delegate more in Ultimatum Game.

Since, utility of money gets discounted for the receiver, to maximize total utility in the game, the proposer tends to delegate less to the receiver, and instead keep more share for themselves so that it doesn't get discounted temporally.
However, when the receiver decides over the acceptance of this proposal, it creates a higher probability of rejection because the utility of money decreases for the receiver. Hence the proposer delegates a larger sum to protect the high present utility of the remaining amount.

Result 8: In Case 3, when both proposer's and receiver's rewards are temporally penalized, the proposer shows reciprocal behavior in money delegation in the ultimatum and dictator game.

Note that Case 3, i.e., penalty on both, is essentially a **"framing"** of the no penalty case, yet varied behavior is observed. Ratio of mean offers for Case 3, when both proposer's and receiver's rewards are temporally penalized to base case are as follows.

- **Dictator Game - 1.46** (220.00/150.38)
- **Ultimatum Game - 0.87** (309.29/355.60)

In DG, the proposer gives out a larger sum as utility of money decreases for both of them, and hence being altruistic is not costly.
However, in UG, the proposer expects to retain a larger sum. Here, the proposer operates from the perspective that altruistically accepting a discounted sum is not costly for the receiver either. The proposer is anyway ready to risk loss of money as the utility decreases progressively.

6. Conclusions

- The trends of time preference in the two games of experimentation in behavioral economics are well explained by the Quasi-hyperbolic model of Time discounting.
- Time plays an important role in economic activity. As we see, the same inter-temporal choices can cause reciprocal results when applied in situations that are different in terms of the risk factor.
- In the ultimatum game, the actions of the proposer are no longer independent. They are influenced by an expectation of altruism

in the form of acceptance, when the temporal penalty is on the proposer. On the other hand, the actions are influenced by the risk of rejection, when the temporal penalty is on the receiver.

7. Limitations and Future Work

The trend of behavior in the case of temporal penalty over the receiver's reward could not be conveniently established as the sample space is limited. Time preference over this money experiment has only be studied for 4 temporal points(instantaneously, 1 month, 1 year, and 10 years) which limits the accuracy of modelling our observations using mathematical tools. Furthermore, different functional forms can be compared by way of the non-linear regression over the following models[2]:

- SModel of Samuelson (1937): $f(t) = 1/(1+r)^t$
- MModel of Mazur (1987): $f(t) = 1/(1+kr)$
- LPModel of Loewenstein and Prelec (1992): $f(t) = 1/(1+\alpha t)^{(\beta/\alpha)}$
- PPModel of Pelphs and Pollak (1968): $f(t) = 1/\delta\omega^t$

This will allow us to indicate the "best fit" explanation for practical economic behavior.

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