Chapter 6
Preference Reversal and Impulsivity in Discounting of Monetary Losses

Bartlomiej Wisnicki and Adam Karbowski

Abstract We investigate delay discounting of monetary losses using the experimental data ($N = 203$). Based on the titration algorithm, we estimate the individual delay discounting rates of monetary losses. We further compare the fit of exponential, hyperbolic, and q-exponential models to the experimental data. The obtained results suggest that the hyperbolic model fits better than the classical exponential one. Hence, the preference reversal effect in delay discounting of monetary losses is observed in our experiment. Moreover, the best fit for the data is obtained through the q-exponential model. Also, participants would strongly like to postpone the immediate loss, even for a month, while the difference between further postponement comes with a much lower discount.

Keywords Monetary losses · Preference reversal · Exponential and hyperbolic discounting

6.1 Introduction

The human economic behavior can be described with the use of three dimensions (Hendrikse, 2003; Karbowski, 2016)—degree of rationality (full or bounded), behavioral motivation (egoistic, altruistic, among others), and degree of self-control (unbounded or bounded willpower). This chapter focuses on the third dimension of human economic behavior—the degree of self-control.

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B. Wisnicki (✉) · A. Karbowski
Department of Business Economics, SGH Warsaw School of Economics, Warsaw, Poland
e-mail: bwisni@sgh.waw.pl

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In the economics literature, human self-control is measured using discounting procedures, i.e., individual delay discounting rates are computed based on experimental data (Holt et al., 2003; Myerson et al., 2017). In the domain of monetary gains, decision-makers usually choose a smaller and less delayed gain compared with a larger but more delayed one, but moving both gains by the same period promotes self-control, i.e., a choice of a larger and more delayed gain. This is a well-known preference reversal effect (cf., e.g., Ainslie & Herrnstein, 1981; Loewenstein & Prelec, 1992; Cubitt et al., 2004). The latter effect has been observed in the domain of monetary gains. The natural question arises whether a similar effect can be discovered in the area of monetary losses. In the COVID-19 times, the area of monetary losses seems particularly interesting due to a very serious threat of a prolonged economic downturn.

A decent number of behavioral economics articles find evidence that the delay discounting of monetary gains is hyperbolic rather than exogenous (cf. Ainslie, 1975; Azfar, 1999; Kirby & Maraković, 1995; Laibson, 1997; Estle et al., 2006). Following (Takahashi, 2013), we compare the fit of exponential, hyperbolic, and q-exponential models to the same experimental data on discounting monetary losses. We do that to first test the ongoing hypothesis that hyperbolic discounting serves as a better fit than exponential discounting when describing the delay discounting of monetary losses. This procedure allows us to test whether the preference reversal effect is present in the area of time discounting of monetary losses. Holt et al. (2003) show that the preference reversal effect occurs. However, their sample is limited to less than 50 participants. Similar procedures were performed in Ostaszewski & Karzel (2002); Estle et al. (2006), however, as well on much smaller samples. Therefore, we can treat our research as a replication of existing research with a sample that provides generalization on the general population.

Second, we also use the q-exponential discounting function and check how it fits the data (controlling for an increase in the number of estimated parameters) comparatively to the previous two functions. We do that also to obtain the value of an individual's impulsivity: it provides us with evidence over how persons change their relative preferences over losses with different time frames. To our knowledge, such research has not been performed for monetary losses but only gains (cf. Takahashi, 2013).

The article proceeds as follows. First, we present the materials and methods. Next, we present the obtained results. The discussion follows and closes the paper.

6.2 Method

6.2.1 Survey

We collected data through the online experiment on delay discounting of monetary losses. The experiment was conducted in the autumn semester 2020/2021 among

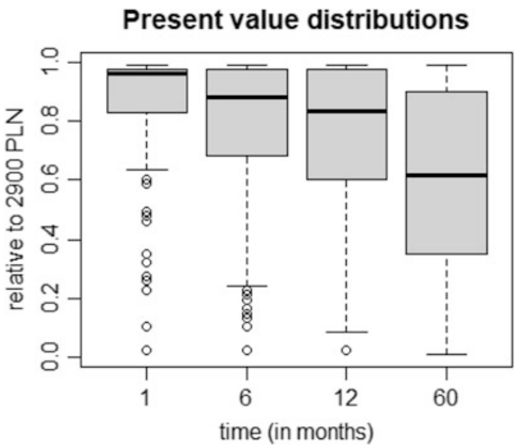

Fig. 6.1 Boxplots of the present value of the loss of 2900 in the time periods presented on the x-axis. The losses are normalized to a unit interval

the Polish University students—SGH Warsaw School of Economics. In total, 203 participants constituted a sample (86 males—average age: 24.5, 117 females—average age: 23.4). An in-depth description of the sample is in Karbowski & Wiśnicki (2021).

In the experimental task, we used the titration algorithm by Holt et al. (2003). In the first choice between two monetary losses (loss of 1450 PLN (about 320 EUR) now—option A—or 2900 PLN (640 EUR) in some fixed time period (1, 6, 12, and 60 months)—option B), option A was half the amount in option B. In the further choices, option A increased or decreased depending on the previous choices. The amount in option A after the sixth choice constituted the estimated equivalent amount in option B. This equivalent can be treated as the respondent's present value of a loss in a specific period.

We can plot the present value points, rescaled to a unit interval, for the corresponding time delay on the X-Y plot, which will show us the coordinates of one's discounting function. Figure 6.1 depicts the distributions of the present values for different time periods the loss is due. In line with the intuition, as the loss is due increases, the instant equivalent goes down. Moreover, the variance of the money equivalents increases with the analyzed time period. It is also in line with theory: we observe more variance in results since small differences in subjective discounting rates result in larger gaps between money equivalents as time comparison goes up.

6.2.2 Models of Discounting

Using the behavioral data, we estimate three models of intertemporal choice between losses. The first one is the classical exponential discounting following the rational paradigm of dynamic decision-making. In that sense, an individual should evaluate the losses in the following manner:

$$V(0) = V(t)e^{-k_e t}, \tag{6.1}$$

where $V(0)$ is an amount of instant loss, and $V(t)$ is the loss to be paid in time t (measured in months) for which the individual is indifferent.[1] The parameter k_e is the individual's discount rate. The formula represents time-consistent preferences as the discount rate depends only on the time difference between losses, not on the time of the loss itself.

An approach more consistent with behavioral decision-making is to adopt the hyperbolic discounting framework. Then, the indifference between losses would be

$$V(0) = \frac{V(t)}{1 + k_h t}, \tag{6.2}$$

with k_h being the parameter of the discount rate. This model shows that preferences are time inconsistent as individuals overvalue the loss if it is close to present. An alternative, more general measure is to apply the q-exponential discounting, cf. Cajueiro (2006) or Rambaud & Torrecillas (2013), of the following form:

$$V(0) = \frac{V(t)}{(1 + (1 - q)k_q t)^{\frac{1}{1-q}}}. \tag{6.3}$$

Here, apart from the discount rate k_q, we have a second parameter q that canonically puts weights between exponential and hyperbolic discounting (with $q \in [0, 1]$, the higher the q the discounting becomes more exponential). However, as (Takahashi, 2007) points out, q may take values outside of unit interval and has a broader interpretation. The value of q represents the rate of impulsivity that the decision-maker exhibits. Impulsivity here is defined by a strong will to delay the instant loss, manifested by hyperbolic and absent in exponential discounting. The rate of impulsivity decreases for $q < 1$, so the decision-maker chooses a higher discount rate (in exponential terms) for losses comparisons with a closer due date. A specific case of $q = 0$ represents the classic hyperbolic discounting. For $q > 1$ the individual exhibits increasing impulsivity, while for $q \rightarrow 1$ the formula (6.3) converges to exponential discounting presented in (6.1).

6.2.3 Data Analysis

We conduct statistical procedures to estimate the parameters for each of the presented discounting models. First, we find parameters by fitting curves through the indifference revealed in the survey. Hence, we find the estimated discount rates by

[1] We decided to switch the values of $V(0)$ and $V(t)$ from the canonical approach as we describe preferences over losses.

regressing the relative present values against the discounting functions of equations (1)–(3), presented in the previous subsection. As the functions are nonlinear, the estimated parameters are obtained via nonlinear regression using the Gauss–Newton algorithm.

The independent variable is the time the loss is due. We pool all the observations from different time comparisons, which benefits the number of degrees of freedom (811 or 800 for q-exponential discounting).

Thus, this study differs from the existing ones, as we use all the data from the sample, not only median data, to estimate parameters, cf. Takahashi (2007, 2013). As we obtained a fairly large and representative sample, we believe our results may, to some extent, be generalized.

Apart from the parameter estimates, we calculate the two information criterion for each model: the Akaike information criterion (AIC) and Bayesian information criterion (BIC), to help determine the model's quality. We employ the information criteria method rather than the standard R^2 criterion of fitness (with adjusted R^2 to penalize for loss in the degrees of freedom) for two reasons: first, it does not have the same interpretation in the nonlinear models as in the linear case and hence should not be universally applied (c.f. Spiess & Neumeyer, 2010); second, the values of the determination coefficient are usually very low and hence meaningless. Furthermore, to resolve the problem of heteroskedasticity of residuals, we employ the Eickert–White technique of estimating the covariance matrix (cf. Zeileis, 2006). All of the procedures were performed in R statistical language using the statistical packages.

6.3 Results

Figure 6.2 shows the fitted discounting curves for the three models along with the averages of indifference points obtained from the study. As we can see from the indifference points, the participants would strongly like to postpone the immediate loss, even for a month. At the same time, the difference between further

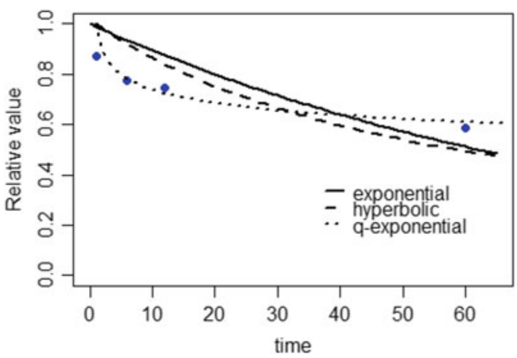

Fig. 6.2 Fitted discounting curves of exponential (solid line), hyperbolic (dashed line), and q-exponential (dotted line) to the indifference points (the averages are plotted as blue points)

Table 6.1 Estimated parameters of discounting models with information criteria regarding the model fitness

	Exponential	Hyperbolic	q-exponential
k	0.0112	0.017	0.2
q			−8.57
AIC	254.53	212.86	88.16
BIC	263.93	222.26	102.25

postponement comes with a much lower discount. This behavior is highly consistent with decreasing impulsivity connected to hyperbolic discounting.

As we can see from Table 6.1, the discount rates for exponential and hyperbolic discounting are close. Objectively, these values are rather substantial: over 1% monthly discount rate leads to about 14% annual rate. Such a high discounting rate shows a significant loss aversion of individuals: the postponement of a loss is desirable, even with a substantial interest.

In addition, we can see that the preference reversal effect occurs in the context of monetary losses. This phenomenon is indicated by the fact that the drop rate in the monetary equivalents decreases. It can also be seen due to the fact that hyperbolic discounting serves as a better fit to the data than the exponential one, as we can see from the information criteria values (note that lower values of AIC and BIC indicate a better model quality).

However, while showing an improvement over exponential discounting, the classic hyperbolic discounting model fails to fit completely into the data as it does not represent the scope of the impulsivity rate associated with losses. Instead, that scope is captured by the q-exponential discounting model, which generally fits well with the data.

Objectively, these values are rather substantial: over 1% monthly discount rate leads to over 14% annual rate. However, both of these values do not seem to capture the true magnitude of losses discount. The individuals seem to have a much higher discount rate at $t = 0$ than at subsequent periods. As the q-exponential model suggests, the initial discount rate is extremely high and is equal to about 20% monthly, but it shrinks with $q = -8.57$. This characterization shows a very rapid decrease in the impulsivity of delayed losses.

In comparison to Takahashi (2007), who studies gains, we can see that losses are attributed to a much higher discount rate and more severe decrease of that rate. These two factors indicate that individuals prefer not to be faced with a loss immediately and postpone it for a short period, even if the amount would increase sharply. On the other hand, when comparing two losses with distant due dates, the discount rate is low, and the time the loss is due does not make much difference to the decision-maker.

As we can see in Fig. 6.2, the q-exponential model fits very well compared to the other two models. Naturally, as a general framework, we expect it to fit data better than the specific ones. Therefore, to determine how well the data fit the specific model, we use the information criteria that balance the model's quality with the number of parameters used. Nevertheless, as both AIC and BIC are much lower for the q-exponential discounting model, we must declare it the best method to identify the intertemporal preferences over losses.

6.4 Discussion

The above results allow us to conclude that hyperbolic discounting serves as a better fit than the exponential one to describe the time discounting of monetary losses. The preference reversal effect occurs in the delay discounting of monetary losses. In the choice between two losses borne relatively soon, the participants prefer the more delayed loss, but postponing those two losses by the same period promotes the choice of a less delayed one. These results are a confirmation of already established results. Holt et al. (2008) confirm the preference reversal effect for a small sample of students. Our results indicate that a similar procedure performed on a larger sample also provides similar insight.

Further, the hyperbolic model constitutes a good fit to the experimental data, but an even better fit is achieved by the q-exponential model proposed by Takahashi (2007, 2013). Hence, while providing a better fit than the exponential one, the hyperbolic discounting framework does not fully represent an individual's preferences over losses incurred in different time periods. Hence, while a simpler framework of hyperbolic discounting might be sufficient to describe the decisions over gains (cf. Ostaszewski & Karzel, 2002; Estle et al., 2006), a richer one is necessary to represent the choices over losses.

Interestingly, the observed behavioral pattern of delay discounting of monetary losses reveals a very rapid decrease in impulsivity. It differs highly from the one observed in gains (cf. Takahashi, 2013). It means that decision-makers are very averse to immediate financial losses, and even a small postponing is highly preferred. However, when it comes to already significantly postponed losses, the subjective valuation of those losses is to a great extent similar. This finding might provide a potential insight into the optimal decision-making of financial institutions. Prolonging a loss repay (i.e., a bank loan) can be accepted with a significant postponement fee might be a desirable option when the loss is due. However, it might not be in the individual's consideration when the money is borrowed.

The observed results can be partly biased since our participants were students who might not be "liquid" enough. Thus they avoid immediate financial losses dramatically. Therefore, a natural extension of the above study would be to test more affluent experimental groups. Also, the use of real instead of hypothetical losses would greatly enhance the research's validity. However, it is very difficult to recruit people to participate in the experiment in which they lose real money. Therefore, some compensation would be needed.

Finally, we believe that a relationship of delay discounting with other forms of discounting of monetary losses is worth investigating. Thus, the correlations between delay discounting and social or probability discounting of financial losses need to be studied.

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