Laboratory of Economics and Management

Sant'Anna School of Advanced Studies
Piazza Martiri della Libertà, 33 - 56127 PISA (Italy)
Tel. +39-050-883-343 Fax +39-050-883-344
Email: lem@sssup.it Web Page: http://www.lem.sssup.it/

# LEM

## Working Paper Series

**Assessing elicitation task bias in time preference using experiments with artificial subjects**

Oksana Tokarchuk °
Roberto Gabriele °

° University of Trento, Italy

**2010/12** **July 2010**

ISSN (online) 2284-0400

# Assessing elicitation task bias in time preference using experiments with artificial subjects

Oksana Tokarchuk* Roberto Gabriele†

June, 30 2010

**Abstract**

Experimental results in research on time preference are often controversial. We propose a systematic investigation of choice task in multiple price list format (MPL) that is frequently implemented in experiments on time preference, through a computer simulation analysis. We conduct experiments with artificial subjects to demonstrate that elicited discount rates are highly dependent on the structure of elicitation task. We verify that implementation of choice task in MPL with nominal structure results in observation of hyperbolic discounting. Choice task in MPL with interest rates structure leads to elicitation of discount rates compatible with exponential discounting. Moreover, we show that the magnitude and intensity of corresponding pattern in data depends on the internal structure of elicitation task. Comparison between discount rates elicited with artificial and human subjects suggests that behavior of human subjects in experiments with MPL can be described by two simple rules: positive discounting and anchoring.

***Keywords***: *elicitation task bias, time preference, choice task, multiple price list, artificial agent simulations*

***JEL-Codes***: *D03, D91, C63 .*

*__Corresponding author:__ Oksana Tokarchuk, Department of Computer and Management Sciences, University of Trento, Italy. Tel.:+39.0461.282110. E-mail: oksana.tokarchuk@unitn.it

†Roberto Gabriele, Department of Computer and Management Sciences, University of Trento, via Inama, 5 (38100) Trento Italy. E-mail: roberto.gabriele@unitn.it.

# 1 Introduction

Choice task in multiple price list (MPL) format gained popularity in recent years and is considered to be the most appropriate elicitation method from the point of view of real incentives implementation (Andersen et al., 2006). However, discount rates elicited with MPL choice task differ both quantitatively and qualitatively among studies. On one hand, a large number of studies find support for hyperbolic discounting, meaning that elicited discount rates decrease with increase of the interval of elicitation (Green et al., 1997; Pender, 1996; Manzini et al., 2008; Tanaka et al., 2007). Discount rates elicited in these studies result considerably higher than interest rates observed in corresponding financial markets (Ostaszewski et al., 1998). At the same time several other studies present evidence of rather stable discount rates over time (Harrison et al., 2002; Read et al., 2005; Coller et al., 2006). Moreover, discount rates observed in these studies are typically much lower compared to studies that observe hyperbolic discounting and are closer in magnitude to corresponding market rates of interest.

Harrison and Lau (2005) express opinion by which hyperbolic discounting is observed due to incorrect experimental procedures implemented in corresponding studies. Normally, studies that observe stable discount rates implement real incentives and use front-end-delay (FED) presentation[1] to elicit time preference. They claim that correction of experimental procedures for these two factors should diminish observation of hyperbolic pattern in data. Contrary to this view Tanaka et al. (2007) as well as Manzini et al. (2008) implement real incentives but find support for hyperbolic discounting. Slonim et al. (2007) in addition to real incentives study the impact of FED and still observe evidence for hyperbolic discounting. Therefore, apparently similar experiments, at least from the point of view of experimental procedures, produce qualitatively different results.

A core feature that distinguishes studies mentioned above is the way in which choice questions that compose MPL are constructed. In studies that observe hyperbolic discounting subjects are choosing among the same nominal values for all intervals of elicitation (i.e., Green et al. (1997)). Discount rates corresponding to these constant nominal values decrease with increase of the elicitation interval. Therefore, in these experiments subjects are choosing from a set of discount rates that gets tighter as the interval of elicitation increases. We refer to this MPL structure as MPL with nominal structure ($-MPL) to emphasize that subjects are confronted with the same nominal values for all intervals of elicitation.

Alternative approach to constructing MPL choice questions is to fix the structure of interest rates from which corresponding nominal values are then calculated (Coller and Williams, 1999). In this case subjects are choosing from a stable set of discount rates while corresponding nominal values vary based

[1] Front-end-delay means that alternative available sooner is also delayed in time. For example, the choice with FED is between $ 100 in 1 month and $ 300 in 7 months. According to Harrison and Lau (2005) delayed presentation of both alternatives guarantees that subjects perceive both outcomes to be of the same nature. Alternative presentation, $ 100 immediately and $ 300 in 6 months, creates bias of immediacy which may lead to overestimation of discount rates.

on the length of elicitation interval. We refer to this way of constructing MPL table as MPL with interest rate structure (%-MPL) to underline that alternatives with which subjects are faced correspond to the same interest rates regardless of the length of elicitation period.

In the present paper with the help of experiments with artificial subjects (AS) we show that the structure of elicitation task determines behavioral patterns of elicited discount rates. We choose to run experiments with AS to concentrate our attention on the limits that a given elicitation structure imposes on individual choice and to avoid confounding with individual preferences of human subjects. Our simulations with random preference artificial subjects demonstrate that discount rates elicited with $-MPL present hyperbolic pattern while discount rates elicited with %-MPL are compatible with exponential pattern. We explore variables that determine corresponding patterns.

We replicate aggregate pattern of human behavior in experiments by imposing AS to follow simple rules: obeying positive discounting constraint and anchoring current choice to the previously made one. Our experiments suggest that the same behavioral rules drive the choice of subjects faced with different elicitation structures. Following the same choice rules in choice environments that differ in structure leads to elicitation of significantly different discount rates. We show how discount rates change with the change of the elicitation structure.

The rest of the paper is structured as follows. Next section introduces MPL elicitation method and investigates cognitive biases to which implementation of this method may lead. In Section 3 we introduce experiments with artificial subjects. We define and justify the choice of behavioral rules and present the results of experiments. Section 4 builds on results of Section 3 to explore variation of internal structure of $-MPL and %-MPL. Section 5 discusses the results and concludes.

## 2 Sources of bias in MPL

Choice task in MPL format presents subjects with a series of choices between option A and option B. The value corresponding to option A remains the same for all choices on the list while the value of option B varies from one choice question to the other. It is expected that subjects choose option A for certain values of corresponding option B and then switch their choice to option B. The value corresponding to the switch of the choice is considered to be the indifference value based on which discount rate is calculated.

Starting from Coller and Williams (1999) choice task in MPL format became the most widespread method for elicitation of time preference. Compared to the alternative method of elicitation, matching task, choice task in MPL format presents two main advantages. First of all, it is simple for subjects to understand, they just need to choose the preferred option. Second, implementation of real incentives in choice task is straightforward: the subject is paid according to the chosen option.

The biggest disadvantage of this method is that experimental researcher needs to decide the range of values among which subjects will be choosing (Andersen et al., 2006). By doing this the researcher imposes *a priori* limits on subjects' choice. We claim that the selection of these limits and the structure of choice options define magnitude and behavioral pattern of elicited discount rates.

Two approaches with regards to the structure of MPL choice can be distinguished in the literature. According to the first approach a fixed-amount reward of option A is delayed while variable amount of option B is paid sooner. The amount of option B for each choice question is the amount of option A - $x$, where $x$ is some proportion of option A. The amounts corresponding to option A and option B remain invariant for all horizons of elicitation. Table 1 provides an example of elicitation with choice task in \$-MPL format. Option A amounts to €400 and is delayed by 8 months, 1 year and 2 months, 3 years and 2 months, 5 years and 2 months and 10 years and 2 months. Option B is delayed by 2 months and ranges from €380 to €10.

In this elicitation numerical values corresponding to option A and option B remain the same for all elicitation intervals. Meanwhile, interest rates corresponding to each choice question diminish in a dramatic way with the increase of elicitation period. The range of interest rates among which subject's choice is comprised restricts with the increase of elicitation interval. Table 1 presents the range of interest rates corresponding to the options of choice discussed in the example above. Subjects are choosing on the hyperbolically restricted intervals of interest rates. We refer to this structure of MPL choice task as nominal MPL (\$-MPL).

According to the second approach introduced by Coller and Williams (1999) the amount of immediately available reward of option A is fixed. The amount of reward for a delayed option B is calculated as reward of option A + $x$, where $x$ is calculated as a return on the investment of the reward of option A in the experiment for the duration of elicitation period. Choice questions on the list vary according to the return associated with the investment of option A. In this case researcher decides the range and the structure of interest rates while nominal values are calculated based on this structure. For example, in Harrison et al. (2002) annual interest rates associated with options of choice range from 2.5 % to 50%.

In elicitation with this method nominal values corresponding to the same choice question differ among different elicitation periods but correspond to the same interest rate. For example, in table 2 subjects choose between €400 in 2 months and €410 in 1 year and 2 months, €400 in 2 months and 431 in 2 years and 2 months, each choice question corresponding to 2.5 % annual interest rate. We refer to this elicitation method as MPL choice task with interest rate structure (%-MPL). Faced with this structure of choice subjects are choosing from a stable interval of interest rates.

In theory the form and the structure of elicitation task does not influence elicited values. Suppose subject follows constant discounting with a discount rate of 20% annual. Her choice will be the same

| Alternative | Option B (pays in 2 months) | Option A (delayed) | Associated interest rate | | | | |
|---|---|---|---|---|---|---|---|
| | | | 6 months | 1 year | 3 years | 5 years | 10 years |
| 1 | €380 | €400 | 10 % | 5 % | 2 % | 1 % | 1 % |
| 2 | €360 | €400 | 21 % | 11 % | 4 % | 2 % | 1 % |
| 3 | €340 | €400 | 33 % | 16 % | 5 % | 3 % | 2 % |
| 4 | €320 | €400 | 45 % | 23 % | 7 % | 4 % | 2 % |
| 5 | €300 | €400 | 59 % | 29 % | 10 % | 6 % | 3 % |
| 6 | €280 | €400 | 73 % | 36 % | 12 % | 7 % | 4 % |
| 7 | €260 | €400 | 89 % | 44 % | 14 % | 9 % | 4 % |
| 8 | €240 | €400 | 107 % | 52 % | 17 % | 10 % | 5 % |
| 9 | €220 | €400 | 126 % | 61 % | 20 % | 12 % | 6 % |
| 10 | €200 | €400 | 147 % | 71 % | 23 % | 14 % | 7 % |
| 11 | €180 | €400 | 171 % | 83 % | 27 % | 16 % | 8 % |
| 12 | €160 | €400 | 198 % | 95 % | 31 % | 18 % | 9 % |
| 13 | €140 | €400 | 229 % | 110 % | 36 % | 21 % | 11 % |
| 14 | €120 | €400 | 267 % | 127 % | 41 % | 24 % | 12 % |
| 15 | €100 | €400 | 312 % | 147 % | 47 % | 28 % | 14 % |
| 16 | €80 | €400 | 369 % | 172 % | 55 % | 33 % | 16 % |
| 17 | €60 | €400 | 446 % | 206 % | 65 % | 39 % | 19 % |
| 18 | €40 | €400 | 561 % | 254 % | 79 % | 47 % | 23 % |
| 19 | €20 | €400 | 777 % | 340 % | 104 % | 61 % | 30 % |
| 20 | €10 | €400 | 1019 % | 432 % | 129 % | 76 % | 37 % |

Table 1: Experimental payoffs $-MPL framework (Tokarchuk, 2008).

| Alternative | Option A | Option B | | | | | Associated interest rate |
|---|---|---|---|---|---|---|---|
| | (pays in 2 months) | (Pays in 8 months) | (Pays in 1 year and 2 months) | (Pays in 3 years and 2 months) | (Pays in 5 years and 2 months) | (Pays in 10 years and 2 months) | |
| 1 | €400 | €405 | €410 | €431 | €453 | €513 | 2,5 % |
| 2 | €400 | €410 | €420 | €464 | €513 | €657 | 5 % |
| 3 | €400 | €415 | €431 | €500 | €580 | €841 | 7,5 % |
| 4 | €400 | €420 | €442 | €538 | €655 | €1.074 | 10 % |
| 5 | €400 | €425 | €452 | €579 | €740 | €1.370 | 12,5 % |
| 6 | €400 | €431 | €463 | €622 | €835 | €1.744 | 15 % |
| 7 | €400 | €436 | €475 | €669 | €942 | €2.218 | 17,5 % |
| 8 | €400 | €441 | €486 | €718 | €1.061 | €2.816 | 20 % |
| 9 | €400 | €446 | €498 | €771 | €1.195 | €3.570 | 22,5 % |
| 10 | €400 | €452 | €510 | €828 | €1.345 | €4.521 | 25 % |
| 11 | €400 | €457 | €522 | €888 | €1.512 | €5.716 | 27,5 % |
| 12 | €400 | €462 | €534 | €953 | €1.699 | €7.218 | 30 % |
| 13 | €400 | €468 | €547 | €1.021 | €1.908 | €9.101 | 32,5 % |
| 14 | €400 | €473 | €559 | €1.094 | €2.141 | €11.461 | 35 % |
| 15 | €400 | €479 | €572 | €1.172 | €2.401 | €14.414 | 37,5 % |
| 16 | €400 | €484 | €586 | €1.255 | €2.691 | €18.104 | 40 % |
| 17 | €400 | €490 | €599 | €1.344 | €3.014 | €22.709 | 42,5 % |
| 18 | €400 | €495 | €613 | €1.438 | €3.373 | €28.449 | 45 % |
| 19 | €400 | €501 | €627 | €1.538 | €3.773 | €35.594 | 47,5 % |
| 20 | €400 | €506 | €641 | €1.644 | €4.218 | €44.480 | 50 % |

Table 2: Experimental payoffs %-MPL framework (Tokarchuk, 2008).

whether she is faced with %-MPL or $-MPL.

Analysis of experimental evidence suggests that elicitation with $-MPL leads to elicitation of discount rates following hyperbolic pattern. Discount rates reported in Green et al. (1997), Ostaszewski et al. (1998) and Manzini et al. (2008) that implement choice task in $-MPL format decrease with increase of elicitation interval. Another study that implement $-MPL, Tanaka et al. (2007), find present-biased preferences.

Meanwhile discount rates elicited with %-MPL are compatible with constant discounting. Discount rates in Andersen et al. (2008), Botelho et al. (2005) and Harrison et al. (2002) that implement choice task with %-MPL format provide evidence for exponential discounting.

Tokarchuk (2008) conducts a study that directly compares elicitation with choice task in $-MPL and %-MPL formats. Elicitation is performed over the same amount of elicitation and the same time intervals. Discount rates elicited with %-MPL format are in line with other studies that implement this format and present exponential pattern. Discount rates elicited with $-MPL format decrease with increase of elicitation interval.

Experimental evidence suggests that discount rates are influenced by the structure of elicitation task. The effect of a structure of elicitation task is observed in other areas of social research. Poulton (1989) reviews studies in psychophysics that demonstrate that elicitation of value with categorical scales is sensible to the structure of the scale itself. Moreover, it is observed that in cases where more values are elicited in a sequential order, successive values are anchored to previously reported ones.

Gigerenzer (2002) observes that this effect is observed in situations in which subjects are uncertain about the correct answer. They may think that the limits imposed on the choice in MPL format represent the "correct"values from the point of view of the researcher. Therefore, they will adjust their choice according to this belief.

Zizzo (2010) refers to this behavior of subjects in experiments as purely cognitive experimenter demand effect. These kind of effects are difficult to overcome and the only solution is to change elicitation task.

In the next section we conduct experiments with artificial subjects that demonstrate that the structure of choice task in MPL format define the observed discount rates. Moreover, we suggest behavioral rules that human subjects may follow in their decision process.

# 3 Experiments with artificial agents

In the present section we present experiments with artificial subjects. This approach permits us to introduce the most neutral experimental conditions with respect to any effect that human subjects can be prone to in experiments and concentrate solely on the effects of the structure of elicitation task. This

approach was introduced by Gode and Sunder (1993) and was successfully implemented in several studies related to experimental economics (Duffy, 2006).

We base our experiments with AS on laboratory experiments conducted with human subjects reported in Tokarchuk (2008).

### 3.1 Behavioral rules and types of artificial agents

Artificial agents in the following experiments are faced with choice task in MPL format presented as a table. They make their choice between immediate and delayed payoffs for each choice question presented in the table. Experimental studies that implement MPL procedure to elicit time preference consider in their analysis only results of subjects that make consistent choices, i.e., make only one switch from choosing immediate payoff to choosing delayed payoff (Andersen et al., 2006). To reflect this feature we model the choice of artificial agents as a choice of the switching row in the table. Thus, given the number of choice questions, rows in the table, corresponding to the same elicitation interval, the choice of artificial agent will correspond to the choice question in which the switch from choosing immediate to delayed option happens for this agent.

We first consider artificial agents whose choice is generated by a random draw from the uniform distribution defined over all choice questions corresponding to a given elicitation interval. Choice generated in this way does not impose any requirements on rationality of the artificial agent and corresponds to random preferences. We call this type of artificial player *agent with random preferences* (RA).

Next, we proceed by imposing some simple decisional rules on behavior of artificial agents. One of the main assumptions of time preference research is positive discounting. Positive discounting means that the rate of substitution between present and future is positive. Although there exists some evidence of negative time discounting (Loewestein and Prelec, 1991), existing experimental results obtained in elicitation environment considered here are comparable with positive discounting.

In the framework of the present experiment positive discounting constraint translates into the following condition: reward of \$100 today is preferred to reward of \$ 100 paid in 2 months. Therefore, subject who chooses \$80 today over \$100 in 3 months cannot prefer \$100 in 6 months to \$80 today.

Positive discounting constraint applied to the experimental environment of artificial agents reduces the number of choice questions that subject views on the subsequent elicitation interval given the present choice. The switching point of the artificial agent with positive discounting constraint is defined over choice questions that satisfy positive discounting condition for the current elicitation interval given the choice on a previous elicitation interval.

In the framework of \$-MPL elicitation task positive discounting constraint necessarily reduces the number of choice questions analyzed on the current round given the previous choice. This happens due

to the fact that rewards do not change in value from one elicitation period to the other. Figure 1(a) provides an example of a choice that respects positive discounting constraint in the $-MPL format. If subject chooses €60 sooner to €400 to be paid in 8 months, then in 1 year and 2 months she will consider only options that are smaller than €60.

In %-MPL elicitation task elimination of choice questions from subjects' decision space by positive discounting constraint depends on numerical values of choice questions that compose %-MPL elicitation table on the current elicitation period. This, in turn, depends on the length of elicitation period and interest rate, annual revenue, corresponding to choice questions. Figure 1(b) provides an example of choice that obeys positive discounting constraint in %-MPL framework. If subject chooses €446 in 8 months to €400 in 2 months, in the next elicitation period she will consider choice alternatives with option B larger than €446.

To study the effect of positive discounting constraint on the choice behavior of artificial agents we perform simulations with *agents with random preferences and positive discounting constraint* (RAPD). The choice of RAPD is generated as a random draw from the uniform distribution defined over alternatives that satisfy positive discounting constraint for the current period of elicitation.

As it was mentioned in the previous section elicitation of preferences and values with choice task is affected by anchoring. Vast evidence of anchoring in choice task comes from experimental research on contingent valuation (Green et al., 1998). Literature in psychophysics demonstrates that subjects faced with sequential elicitation of value tend to anchor their current response to the previously reported value (Poulton, 1989).

We introduce anchoring by modeling the switching point as a random draw from a truncated the Poisson distribution[2]. This distribution is discrete and has only one parameter - the average number of successes, that permits to attribute the peak of probability to a certain position on the table.

We define *agent with random preferences anchored to the previous choice* (AN) as an artificial agent whose choice of a switching point is a random draw from the Poisson distribution. These players current choice has higher probability to lie closer to the choice made on a previous round while probability of choosing alternatives located further compared to the position chosen on previous round decreases with the distance from the previously chosen alternative.

Finally, we consider the combination of positive discounting constraint and anchoring. Analysis of decision rules in Tokarchuk (2008) provides evidence of joint effect of these two rules on subjects' choice. The choice of *agent with random preferences anchored to previous choice that respects positive discounting* (ANPD) is a random draw from Poisson distribution defined over choice questions that are allowed by positive discounting constraint for the current choice. Figure 1(a) schematizes the choice structure of

[2]Truncation of the support is justified by the fact that in each choice the number of options available is different.

ANPD in case of $-MPL. The figure shows the dependence of period $t$ choice on period $t-1$ choice in terms of available choice options and probability associated with them. The choice on elicitation period corresponding to 8 months limits choice questions considered on period 1 year and 2 months as in the case of RAPD. Poisson probability distribution on period 1 year and 2 months presents the peak on the choice question chosen for switch on period 8 months and diminishes when one moves towards the end of the table with choice questions.

For the case of %-MPL situation is similar (see Figure 1(b)). Positive discounting constraint decreases the number of choice questions considered for decision, although it does not necessarily removes all alternatives preceding the switching point, analogous to RAPD. Probability distribution is defined over the remaining choice questions with a peak corresponding to the choice question of the switch on a previous period.

To sum up, we study the behavior of four types of agents (Table 3). We start with a random preference agent and continue by adding more structure. We study the effect and interaction of two simple decision rules: positive discounting constraint and anchoring to the previous choice.

### 3.2 MPL structures

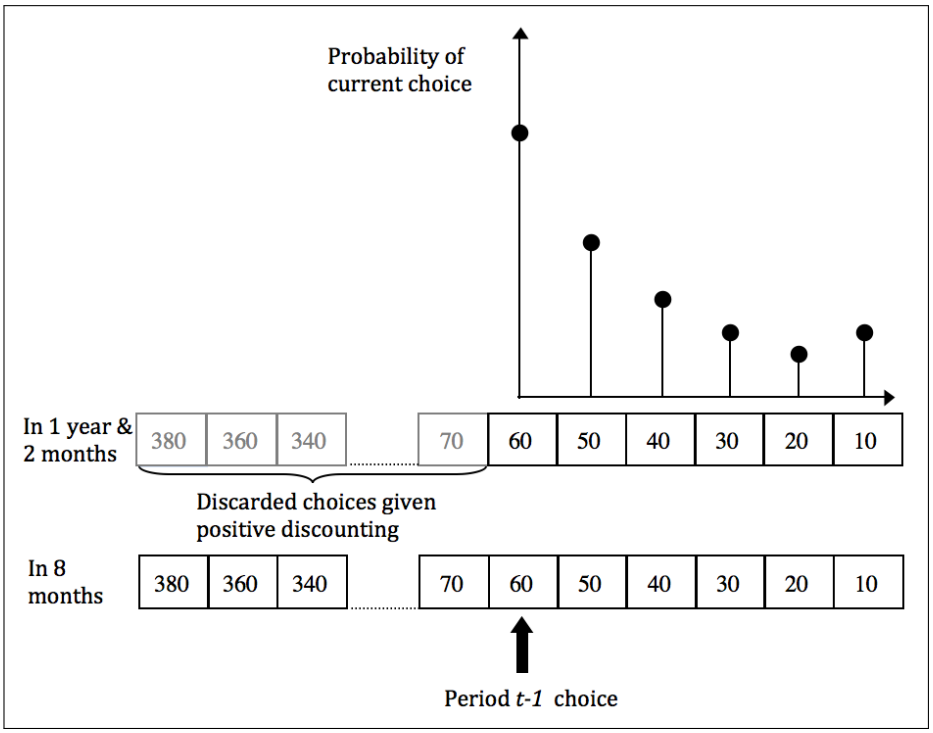
Present study compares patterns of discount rates elicited in experiments with artificial agents faced with choice task in $-MPL and %-MPL. The results of these experiments are compared with results of laboratory experiments performed with human subjects.

In our experiments with artificial agents we implement choice task in $-MPL and %-MPL formats adopted in Tokarchuk (2008) presented in Table 1 and 2. We choose this study as it is the only study that experimentally compares elicitation with choice task in $-MPL and %-MPL formats. In this study elicitation is performed over the same amount of money, the same elicitation periods are used for both choice structures, each structure contains the same amount of questions. In addition individual level data are available for analysis. By implementing these elicitation tasks we can compare results of artificial subjects to human subjects' results.

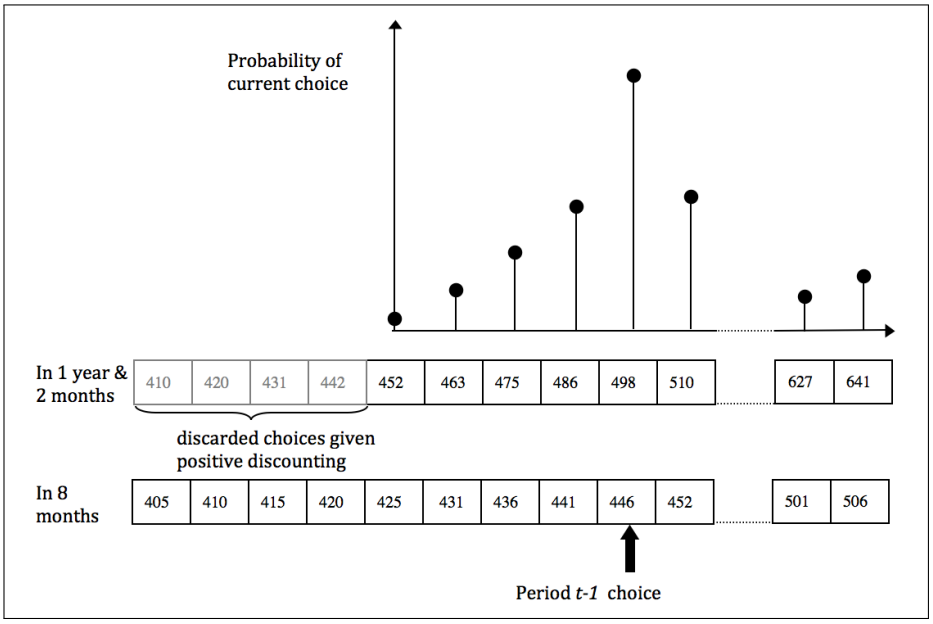
### 3.3 Design of experiments with artificial agents

We conduct two sets of experiments using artificial agents. In each experiment 200 artificial agents make their choice faced, respectively, with $-MPL and %-MPL formats of choice task. We use the MPL structures proposed in Tokarchuk (2008) to allow comparison between human and artificial agents results.

Within the same framework (i.e. $-MPL and %-MPL) we run four experiments. Each experiment is characterized by the type of population of artificial agents. In particular, we endowed agents with four behavioral patterns (see table 3) RA, RAPD, AN, ANPD.




(a) $ framework




(b) % framework

Figure 1: Representation of Anchoring choice structure with positive discounting constraint in the two frameworks under scrutiny.

Experiments that implement MPL elicitation method normally elicit discount rates within the same time horizon while different temporal horizons are presented to subjects in increasing order[3]. We follow this presentation of time horizons in our experiments with artificial agents.

In order to obtain comparable with human subjects results we set the choice of AS on first elicitation period as human subjects choice.

| Agent label | Agent description | Prob. distrib. used to represent behaviors | Positive discounting | Anchoring |
|---|---|---|---|---|
| RA | random preference agent | uniform distribution | no | no |
| RAPD | random preference agent with positive discounting | uniform distribution | yes | no |
| AN | anchored choices agent | poisson distrib. (trunc.) | no | yes |
| ANPD | anchored choices agent with positive discounting | poisson distrib. (trunc.) | yes | yes |

Table 3: The types of agents used in the simulation analysis.

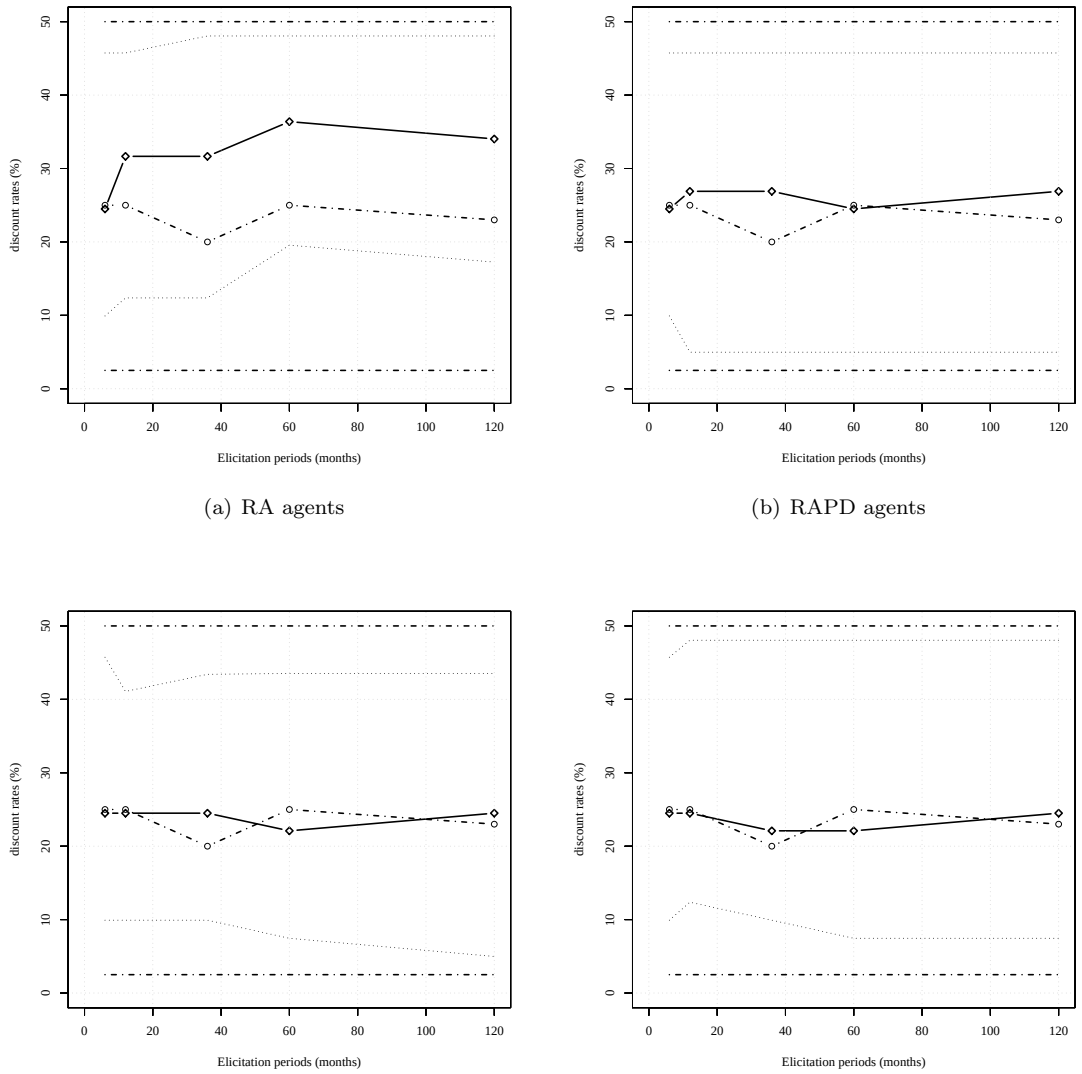
### 3.4 Results of experiments

In the present section we report the results of experiments with artificial agents. Figure 2 and 3 present median discount rates[4] elicited with artificial agents faced with choice task in $-MPL and in %-MPL format. Discount rates elicited with artificial agents are confronted with discount rates elicited with human subjects in the study described in Tokarchuk (2008). We choose to present our data in graphical form as this form of presentation has been used in early literature on time discounting and provides the most effective representation of our data.

Behavior of artificial agents of all types reflects qualitative patterns observed in the literature: the two structures lead to observation of significantly different discount rates. Discount rates elicited with choice task in $-MPL format present decreasing pattern, comparable with hyperbolic discounting. Discount rates elicited with choice task in %-MPL format are relatively stable across elicitation intervals, this pattern is compatible with exponential discounting.

[3]The order of elicitation intervals' presentation plays a great role for RAPD, AN and ANPD.

[4]Experimental studies on time preference report either regression coefficients corresponding to the fit of different discount functions to the data (Tanaka et al., 2007; Andersen et al., 2008; Harrison et al., 2002) or report some aggregate statistics, i.e., the mean of the sample (Green et al., 1997; Ostaszewski et al., 1998). We choose to report the median given high variability and non-normality of distribution of discount rates observed in the studies.




(a) RA agents

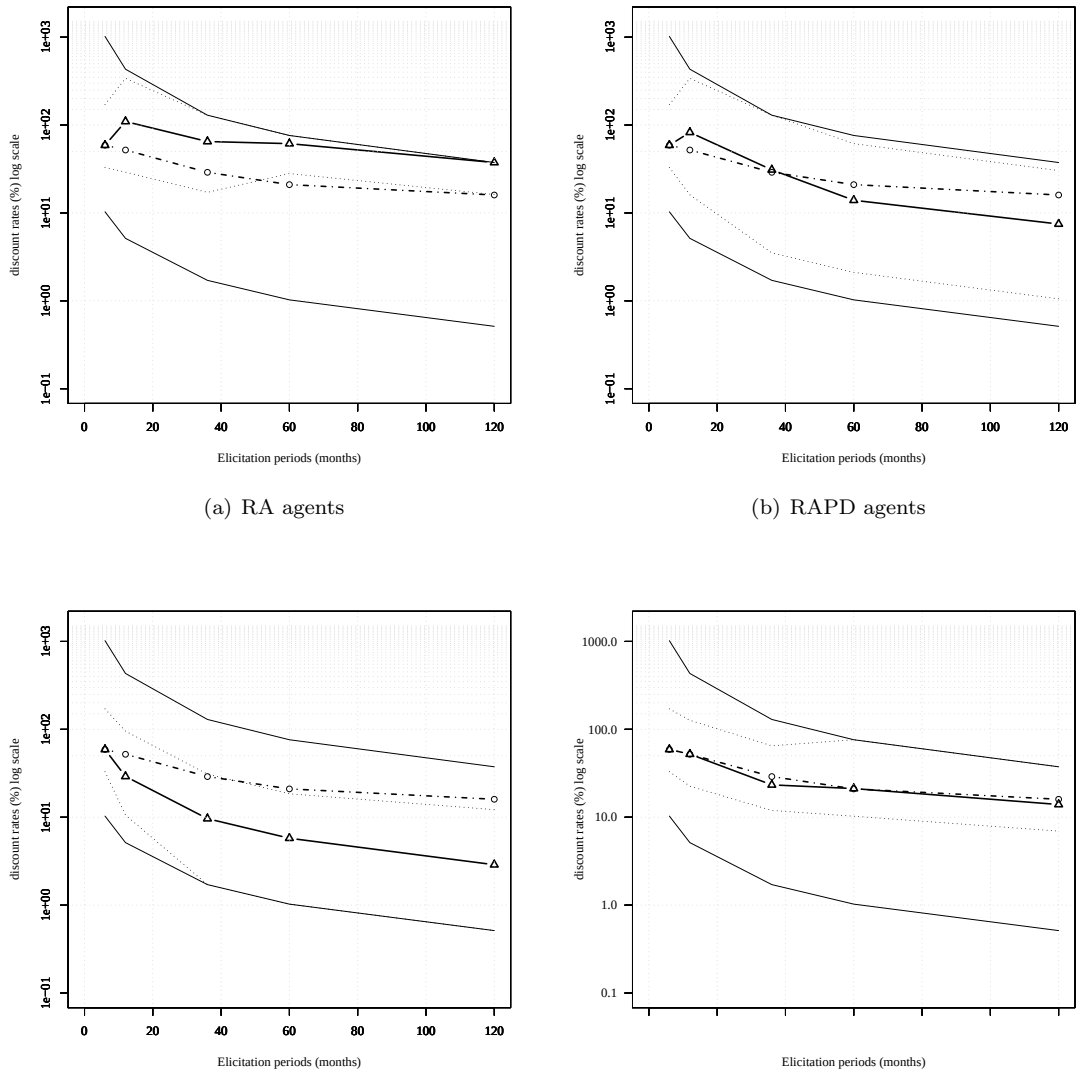
(b) RAPD agents

(c) AN agents

(d) ANPD agents

Figure 2: Simulated median discount rates (solid lines) and corresponding 95% confidence interval (dotted lines), human results (dashed lines with diamonds) and table limits (dashed lines) in %-MPL format).

Agents with random preferences, RA, do not posses any decision making structure, their choice is random. The choice of these agents fully reflects the structure of the elicitation task as the median of this choice corresponds to the central position of the table formed by the choice questions. Discount rates elicited with RA in our experiments lie extremely close to discount rates elicited in experiments with human subjects (Figures 2(a) and 3(a)). Although this similarity of discount rates does not prove that human subjects choice in experiments is random, it suggests that aggregate choice of human subjects, median in our case, can be interpreted as random.




(a) RA agents

(b) RAPD agents

(c) AN agents

(d) ANPD agents

Figure 3: Simulated median discount rates (solid lines) and corresponding 95% confidence interval (dotted lines), human results (dashed lines with diamonds) and table limits (dashed lines) in $-MPL format).

Introduction of positive discounting constraint into the choice of agents with random preference, RAPD, positions discount rates of artificial agents above the choice of human subjects in elicitation with choice task in %-MPL format (Figure 2(b)). This happens due to the fact that positive discounting constraint forces artificial agents to consider lower part of the table with choice questions that correspond to higher discount rates. When faced with choice task in $-MPL format artificial agents behave similar to human subjects (Figure 3(b)). Positive discounting constraint has stronger appeal in the elicitation with $-MPL structure as in this environment subjects are presented with the same nominal values for all elicitation intervals. In the environment of %-MPL positive discounting apparently does not drive the choice of subjects.

Agents with preferences anchored to the previous choice, AN, present pattern that is similar to agents with random preferences, RA, when faced with choice task in %-MPL format (Figure 2(c)). However, discount rates elicited with AN agents faced with $-MPL are lower compared to discount rates elicited with RA agents and human subjects (Figure 3(c)). The reason for this discrepancy is simple: the choice of AN agents is anchored to the position of the first choice question. While in the case of choice task in %-MPL format the first choice corresponds to the choice of RA agents and human subjects, in elicitation with choice task in $-MPL format the first choice corresponds to human subjects but is different from the choice of RA agents. Although in both cases the median choice of the AN agents is located in proximity of the position of first choice, for %-MPL structure this leads to observation of similar pattern with discount rates of agents with random preferences. In $-MPL environment their choice corresponds to lower discount rates as it is anchored to the position of the table associated with lower discount rates (see Table 1).

Adding positive discounting constraint to the decision rule of agents with preferences anchored to the previous choice, ANPD, brings their discount rates closer to discount rates of human subjects.

We perform statistical analysis to check whether discount rates elicited with AS differ from discount rates elicited in experiments with human subjects. Table 4 presents the results of Mann-Whitney test that investigates whether the two distributions in analysis have the same median[5]. We fail to reject the null hypothesis for RA, AN and ANPD artificial agents in %-MPL framework. In $-MPL framework the choice of ANPD is not different in median from discount rates of human subjects.

Table 5 reports the results of Student-t test with the null hypothesis testing whether discount rates elicited with AS and human subjects have the same mean. As in the case of Mann-Whitney test, in %-MPL framework only RAPD agents result to have significantly different mean compared to human subjects' discount rates. While in $-MPL framework only for discount rates elicited with ANPD agents we fail to reject the null hypothesis. We can conclude that in %-MPL environment RA, AN and ANPD agents have the same mean as human subjects.

The results of the tests demonstrate that discount rates elicited with ANPD agents have the same mean and median compared to discount rates elicited with human subjects both for %-MPL and $-MPL formats. In addition, discount rates elicited in %-MPL framework with RA and AN artificial subjects cannot be distinguished from discount rates of human subjects in mean and median[6].

Combination of two simple behavioral rules, positive discounting and anchoring to previous choice, reproduces behavior of human subjects in both elicitation frameworks. Moreover, elicitation in $-MPL

[5]We do not run the test on the first period of elicitation as it is arbitrary set equal to human subjects' choice.

[6]We also perform Kolmogorov-Smirnov test with null hypothesis of equality of distribution. We fail to refuse hypothesis that the distribution of discount rates of RA, AN and ANPD artificial agents are different from the distribution of discount rates observed with human subjects in %-MPL frame. While discount rates of ANPD artificial agents pass this test only for some elicitation periods in $-MPL frame. The results of this test are available upon request.

| Framework: | Player type: | Mann-Whitney tests: | choice order: | | | |
|---|---|---|---|---|---|---|
| | | | 2 | 3 | 4 | 5 |
| | ANPD | MW value | 2172 | 1539 | 1902 | 1707 |
| | | prob. MW | **(0.525)** | **(0.088)** | **(0.718)** | **(0.279)** |
| | AN | MW value | 1419 | 556 | 502 | 334 |
| | | prob. MW | (0.032) | (0.000) | (0.000) | (0.000) |
| $ | RAPD | MW value | 3118 | 3099 | 3154 | 3419 |
| | | prob. MW | (0.000) | (0.000) | (0.000) | (0.000) |
| | RA | MW value | 2612 | 1910 | 1297 | 950 |
| | | prob. MW | (0.024) | **(0.741)** | (0.010) | (0.000) |
| | ANPD | MW value | 1411 | 1634 | 1332 | 1376 |
| | | prob. MW | **(0.962)** | **(0.296)** | **(0.883)** | **(0.394)** |
| | AN | MW value | 1289 | 1676 | 1347 | 1388 |
| | | prob. MW | **(0.620)** | **(0.217)** | **(0.829)** | **(0.363)** |
| % | RAPD | MW value | 1930 | 2027 | 2001 | 1939 |
| | | prob. MW | (0.018) | (0.005) | (0.001) | (0.000) |
| | RA | MW value | 15139 | 17104 | 13751 | 14177 |
| | | prob. MW | **(0.599)** | **(0.152)** | **(0.719)** | **(0.277)** |

Table 4: Mann-Whitney tests results comparing human and artificial agents medians in different experiments. (In bold tests that do not allow to reject the null hypothesis: $H_0 : med_{human} = med_{art.agents}$).

| Framework: | Player type: | $t$ tests: | choice order: | | | |
|---|---|---|---|---|---|---|
| | | | 2 | 3 | 4 | 5 |
| | ANPD | diff between means: | -1.587 | -7.209 | -6.408 | -3.394 |
| | | t value: | -0.164 | -1.403 | -1.110 | -1.229 |
| | | prob(t>T) | **(0.871)** | **(0.174)** | **(0.280)** | **(0.232)** |
| | AN | diff between means: | -22.344 | -24.303 | -24.808 | -17.376 |
| | | t value: | -2.332 | -4.884 | -4.372 | -6.493 |
| | | prob(t>T) | (0.030) | (0.000) | (0.000) | (0.000) |
| $ | RAPD | diff between means: | 84.026 | 33.626 | 24.612 | 11.291 |
| | | t value: | 7.160 | 6.143 | 4.259 | 4.179 |
| | | prob(t>T) | (0.000) | (0.000) | (0.000) | (0.000) |
| | RA | diff between means: | 56.804 | 4.514 | -12.985 | -11.247 |
| | | t value: | 4.789 | 0.818 | -2.239 | -4.112 |
| | | prob(t>T) | (0.000) | **(0.420)** | (0.036) | (0.000) |
| | ANPD | diff between means: | 2.060 | 3.431 | 0.748 | 3.322 |
| | | t value: | 1.002 | 1.105 | 0.236 | 1.102 |
| | | prob(t>T) | **(0.331)** | **(0.287)** | **(0.817)** | **(0.290)** |
| | AN | diff between means: | 0.424 | 2.766 | 0.066 | 2.461 |
| | | t value: | 0.209 | 0.900 | 0.021 | 0.824 |
| | | prob(t>T) | **(0.837)** | **(0.383)** | **(0.983)** | **(0.425)** |
| % | RAPD | diff between means: | 7.489 | 9.589 | 10.552 | 12.178 |
| | | t value: | 3.584 | 3.087 | 3.368 | 4.105 |
| | | prob(t>T) | (0.002) | (0.008) | (0.005) | (0.001) |
| | RA | diff between means: | 2.108 | 5.089 | 1.377 | 3.840 |
| | | t value: | 1.076 | 1.689 | 0.448 | 1.329 |
| | | prob(t>T) | **(0.301)** | **(0.115)** | **(0.662)** | **(0.210)** |

Table 5: Student $t$ tests results comparing human and artificial agents means in different experiments. (In bold tests that do not allow to reject the null hypothesis: $H_0 : \mu_{human} = \mu_{art.agents}$).

and %-MPL setups lead to elicitation of significantly different discount rates. This suggests that the structure of the elicitation task plays an important role in elicitation procedure. When subjects are uncertain of the correct answer they let their choice to be guided by simple rules. Elicitation with choice task in $-MPL format leads to generation of evidence of hyperbolic discounting. Discount rates elicited with choice task in %-MPL format are more compatible with exponential discounting.

# 4 Investigation of table structure

There are no theoretical or empirical indications on how the choice task in MPL format should be constructed. Experimental literature accounts for a vast variety of elicitation structures that have been adopted in experiments with human subjects. The variability of discount rates reported in literature is even more vast. In the previous section we demonstrate that the structure of the elicitation task shapes elicited discount rates. In the present section we investigate the effect of the internal structure of choice task in $-MPL and %-MPL formats on elicited discount rates to explain variability of estimates of discount rates and their patterns.

## 4.1 Determinants of the MPL structure

The internal structure of the $-MPL depends on the choice of the initial amount of elicitation, number of choice questions, magnitude of the difference between choice alternatives and the number and the length of elicitation intervals. All these design features influence discount rates that can be elicited with a given structure as well as the qualitative pattern that can be observed by implementing this elicitation structure.

There is a big variety in the structure of $-MPL tables adopted in the literature. For example, Green et al. (1997) adopted a decision task that consisted of 24 alternatives and time frames that ranged from 3 months to 20 years. The limits on the discount rates that could be elicited with this elicitation structure are in the range of $4,370\%$ - $4\%$ for a 3-months period and decrease to $23\%$ - $0.05\%$ over an elicitation period of 20 years. The mean of discount rates elicited in this study ranges from $77\%$ to $6\%$.

Choice tasks in Tanaka et al. (2007) consists of 5 equally spaced alternatives with time frames ranging from 3 days to 3 months. The underlying structure of these types cannot elicit discount rates different from $29,825\%$ - $2,287\%$ over a 3-days period and $549\%$ - $55\%$ over a 3-months period. The study finds support for present-biased preferences.

In Manzini et al. (2008) design subjects are faced with tables of 10 equally spaced payoffs alternatives. The time frames correspond to 1, 2 and 4 months. This structure imposes limits on elicited discount rates of $10,800\%$ - $133\%$ over a 1- month elicitation interval and $934\%$ - $32\%$ over a 4-months interval.

The mean of discount rates elicited in this study ranges from 569% to 151%.

Elicitation with %-MPL elicitation format depends on the limits of the interest rate chosen by the researcher and the variation of the corresponding interest rate choice questions. Although the %-MPL offer an extensive freedom of choice of internal structure, the implementation of %-MPL format in experimental literature is limited to the structure developed in Harrison et al. (2002) (Read et al., 2005; Andersen et al., 2008). Interest rates corresponding to choice alternatives range from 2.5% to 50%. All these studies report rather similar discount rates, mean ranges in the interval 20%-30%, regardless of the amount and the length of the interval of elicitation.

Andersen et al. (2006) conduct the only study that investigates the influence of MPL structure on risk and time preferences. They find significant effect of the structure of MPL on elicited preferences for the case of risk preferences. While for time preference elicited with %-MPL choice task the differences between discount rates elicited with different structures of corresponding interest rates resulted not significant.

## 4.2 Design of experiments with artificial agents

The internal structure of the elicitation with choice task in $-MPL format is defined by the difference between successive choice alternatives which in turn determines the number of positions on the elicitation table. Other decisive features are the number of elicitation periods and their length. We explore the effect of the number of positions on the elicitation table and of the number of elicitation intervals on discount rates elicited with the $-MPL structure. We consider $-MPL tables that consist of 6, 15 and 25 equally spaced positions. We implement three types of temporal expansion. Each simulation is performed over 5 elicitation intervals that range from 1 to 12 months, from 6 to 36 months and from 6 to 120 months. Overall, we obtain a 3x3 experimental design[7].

The %-MPL elicitation structure relies on the limits and internal structure of the corresponding interest rate. In our exploration of the structure of the %-MPL table we study the effect of the limits imposed on interest rates and variation of these interest rates between neighboring positions on the table. We consider three limits imposed on corresponding interest rates: 1 to 20 %, 1 to 50 % and 1 to 150 %. We examine as well three possible variations of the interest rates in the table: symmetric, that corresponds to equal increases in interest rates; low skewed, that corresponds to smaller increases between positions associated with lower interest rates and larger increases between positions associated with higher interest rates, and high skewed, with large increases between low interest rate positions and small increases within high interest rate positions (choice questions are presented in the appendix).

All the choice questions in this section are constructed based on the initial amount of €400.

Experimental results in the previous section demonstrate that artificial agents with anchored preferences

[7]See appendix for the complete set of tables on which is based our investigation and for the lists of choice questions we use (Tables 6, 7, 8, 6, 9, 10 and 11).

that respect positive discounting constraint, ANPD, replicate dynamics of human subjects' choice. In this section we implement this type of agents to study the role of the internal structure on the choice[8].

### 4.3 Results of experiments

Figure 4 reports median discount rates observed in experiments with artificial agents faced with choice task in $-MPL format. In this figure the graphs reported in the columns correspond to experiments over the intervals of the same length, while the graphs reported in the rows of the figure correspond to the $-MPL structures with the same number of positions.

All the discount rates elicited in $-MPL format present hyperbolic pattern. The steepness of this pattern depends on the length of elicitation periods and the difference between elicitation intervals. The steepest hyperbolic pattern is observed in discount rates in Figure 4(a) that corresponds to elicitation intervals from 1 to 12 months and a 6-position table. These discount rates are also the highest in terms of magnitude. This figure is the best approximation of quasi-hyperbolic preferences: a large drop in the discount rates in the first interval and almost constant discount rates elicited over successive elicitation intervals.

Looking at the rows of Figure 4 discount rates in corresponding graphs decrease when moving from the left to the right. The steepness of the hyperbolic curve decreases significantly passing from Figure 4(a) to Figure 4(c). This movement corresponds to increase of the length of elicitation intervals keeping everything else constant. If researchers choose to conduct experiment with very short elicitation intervals they will obtain high discount rates with strong hyperbolic patterns comparable with quasi-hyperbolic discounting. This is usually the case when experiments are performed with real incentives.

Moving from the top to the down of the Figure 4 in columns as well leads to a substantial decline in discount rates. The steepness of the hyperbolic pattern of discount rates decreases in a considerable manner from the first to the last row of the figure. Here the movement is associated with more choice questions, i.e., subjects can express more precisely their switching point.

Although discount rates are elicited over the same amount of elicitation and artificial agents follow the same rules we obtain different discount rates depending on the chosen elicitation structure. The shorter are the intervals of elicitation the higher discount rates are elicited. Researchers tend to use fewer choice questions, i.e. divide the elicitation amount in fewer parts, to reduce the time necessary to perform the experiment and maintain concentration of subjects. However, fewer choice questions lead to elicitation of higher discount rates.

[8]Discount rates elicited with this type of agents depend heavily on the choice on the first round. In the previous section we model this first round choice as the choice of human subjects. We do not know what human subjects could choose in the elicitations considered in this section, thus we model the first choice of artificial agents as a random draw from uniform distribution. This model of choice does not change the results observed in previous section for %-MPL format and translates all the choices in $-MPL format in a parallel way above the results of human subjects.

Figure 5 presents results of experiments with implementation of different structures of choice task with %-MPL format. The rows of the figure correspond to elicitation over structures with different skewness of interest rates while the limits of interest rates are the same. In the columns elicitation is performed over different limits of interest rates while the skewness is kept constant.

Discount rates elicited in experiments with choice task in %-MPL format are rather constant and present patterns compatible with exponential discounting. Discount rates elicited with the highest limits result to be the highest discount rates, they are reported in the last row of the figure. Meanwhile discount rates reported in the first row of the figure elicited with lowest limits tend to be the lowest.

The difference in the skewness of corresponding interest rates is more pronounced for structures with higher limits on interest rates. In this case discount rates elicited with low-skewed structures are the lowest compared to other structures while discount rates elicited with high-skewed structures are the highest. Andersen et al. (2006) implements elicitation structure similar to the one reported in Figures 5(d), 5(e) and 5(f) with only 6 choice questions compared to 20 analyzed in experiments here. The lack of significant effect of structure in elicited time preferences reported in Andersen et al. (2006) can be explained by the narrow band of interest rates considered for elicitation and to the low number of choice questions.

Researchers that implement %-MPL format of choice task with real payoffs tend to adopt relatively low limits on the interest rates due to budget constraint. As our experiments show this leads to elicitation of relatively low discount rates comparable with market interest rates. However, in the light of our experiments, these discount rates cannot be interpreted as expression of the true time preference. The low magnitude of the discount rates and their relatively constant pattern are explained by the structure of elicitation task.

Elicitation with choice task in $-MPL and %-MPL formats leads to different results. Experiments presented in this section are conducted over the same amount of elicitation with artificial agents that follow the same behavioral rules. Nevertheless, discount rates elicited with $-MPL format present hyperbolic pattern while discount rates elicited with %-MPL format are compatible with exponential discounting hypothesis. Moreover, variation in the structure of each format leads to elicitation of significantly different discount rates keeping all the rest constant.

Results presented in this section provide explanation for the divergence of estimates of discount rates generally observed in research on time preference (Frederick et al., 2002). A vast variability of elicitation structures that is observed in experimental literature in this field leads to variability of elicited discount rates and patterns that these discount rates generate. However, none of the listed evidences can be explained by human individual preferences. They are rather the result of the structure of the elicitation task chosen by the researcher a-priori.

# 5 Discussion and Conclusions

This paper has investigated the influence of the structure of choice task in MPL format on elicited discount rates. We demonstrate that the structure of MPL choice task determines magnitude of discount rates and the pattern they exhibit in time. For our purposes we distinguish between two structures of MPL - nominal and the one based on interest rates. We show that implementation of choice task in $-MPL and %-MPL formats leads to elicitation of qualitatively different discount rates. Choice task in $-MPL format leads to elicitation of evidence compatible with hyperbolic discounting while implementation of %-MPL generates comparatively stable discount rates.

Harrison and Lau (2005) question whether hyperbolic discounting is an artifact of experimental procedures. They conclude that it is and blame on hypothetical nature of payoffs and lack of FED in elicitation of time preferences. This conclusion is based on discount rates elicited with %-MPL. Later results in Slonim et al. (2007) demonstrate that neither FED nor real incentives remove hyperbolic pattern from the data elicited with $-MPL. Our analysis suggests that evidence compatible with both types of discounting can be observed depending on the elicitation task.

Andersen et al. (2006) in their investigation of the effect of the structure on preferences elicited with choice task in MPL format conclude that this effect can be easily removed from data with the help of econometric tools. We claim that this correction is not possible. Results of our experiments with AS compared to performance of human subjects suggest that human subjects follow simple behavioral rules when faced with choice task in MPL format.

Choice task in MPL format regardless its simplicity is not familiar for subjects. Being uncertain about the correct answer they tend to base their choice on the underlying structure of elicitation task. They act to observe positive discounting constraint and anchor their current choice to previously reported one. Obeying to these rules lead to generation of discount rates that are defined by the structure of elicitation task. Thus, we can conclude that discount rates elicited with choice task in MPL format are artifacts of the structure of elicitation task.

Our investigation of the internal structure of choice task in $-MPL and %-MPL formats demonstrate that the the variety of estimates of discount rates observed in the literature can be explained by the variety of elicitation tasks that are adopted by each single study. In order to provide real incentives researchers tend to elicit time preferences over short intervals. Budget constraints often forces researchers to implement $-MPL format of choice task that imposes limits on the highest amount that can be paid to participants. Otherwise, choice task in %-MPL format with relatively low limits on interest rates are implemented. The problem of retaining subjects' attention during the experiment make researchers opt for facing subjects with less choice questions. All these design features exercise significant effect on elicited discount rates. Leading to blossoming of theoretical literature to explain these data.

The effect of the structure of elicitation task on elicited preferences can be defined as purely cognitive experimental demand effect (Zizzo, 2010). The only way to cope with it is to change the elicitation task. To help the field of intertemporal research to develop further there is an urgent need to develop elicitation tasks that are free from experimental demand effects. This task should be familiar to subjects, the kind of task that they are facing in everyday life. In present study we propose a novel tool that helps experimental researchers to test their elicitation tasks and procedures for possible cognitive biases imposed by the structure of the elicitation task. The use of this tool may help in the development of the new elicitation task.

# References


Andersen, S., Harrison, G., Lau, I. and Rutsrom, E. E. (2006), 'Elicitation using multiple price list formats', *Experimental Economics* **9**, 383–405.

Andersen, S., Harrison, G. W., Lau, M. I. and Rutsrom, E. E. (2008), 'Eliciting risk and time preferences', *Econometrica* **76**(3), 583–618.

Botelho, A., Harrison, G. W., Pinto, L., Rutsrom, E. E. and Veiga, P. (2005), 'Discounting in developing countries: a pilot experiment in Timor-Leste', Working paper 31, NINA.

Coller, M. and Williams, M. (1999), 'Eliciting individual discount rates', *Experimental Economics* **2**, 107–127.

Coller, M., Harrison, G. and Rutström, E. E. (2006), Does everyone have quasi-hyperbolic preferences?, Working paper 2006-1, University of Central Florida.

Frederick, S., Loewestein, G. and O'Donoghue, T. (2002), 'Time discounting and time preference: a critical overview', *Journal of Economic Literature* **40**(2), 351–401.

Gigerenzer, G. (2002), *Calculated Risks: How To Know When Numbers Deceive You*, Simon and Schuster.

Gode, D. and Sunder, S. (1993), 'Allocative efficiency of markets with zero-intelligence traders: market as partial substitute for individual rationality', *The Journal of Political Economy* **101**(1), 119–137.

Green, D., Jacowitz, K. E., Kahneman, D. and McFadden, D. (1998), 'Referendum contingent valuation, anchoring, and willingness to pay for public goods', *Resource Energy economics* **20**(2), 85–116.

Green, L., Myerson, J. and McFadden, E. (1997), 'Rate of temporal discounting decreases with amount of reward', *Memory and Cognition* **25**(5), 715–723.

Harrison, G. W. and Lau, I. (2005), 'Is the evidence for hyperbolic discounting in humans just an experimental artefact?', *Behavioral and Brain Sciences* **28**(5), 657.

Harrison, W., Lau, I. and Williams, M. (2002), 'Dynamic consistency in denmark: A longitudinal field experiment', *The American Economic Review* **92**(5), 1606–1617.

Loewestein, G. and Prelec, D. (1991), 'Negative time preference', *American Economic Review* **81**, 347–352.

Manzini, P., Mariotti, M. and Mittone, L. (2008), The elicitation of time preference, Working paper 08-05, CEEL, University of Trento.

Ostaszewski, P., Green, L. and Myerson, J. (1998), 'Effects of inflation on the subjective value of delayed and probabilistic rewards', *Psychonomic Bulletin & Review* **5**(2), 324–444.

Pender, J. L. (1996), 'Discount rates and credit markets: Theory and evidence from rural india', *Journal of Development Economics* **50**, 257–296.

Poulton, E. (1989), *Bias in quantifying judgment*, Hove, UK: Earlbaum.

Read, D., Airoldi, M. and Loewe, G. (2005), 'Intertemporal tradeoffs priced in interest rates and amounts: A study of method variance', LSEOR 05.77.

Slonim, R., Carlson, J. and Bettinger, E. (2007), 'Possession and discounting behavior', *Economics Letters* **97**(3), 215–221.

Tanaka, T., Camerer, C. and Nguyen, Q. (2007), 'Risk and time preferences: Experimental and household survey data from vietnam'.

Tokarchuk, O. (2008), Construction of time preference: an investigation of the role of elicitation method in exeprimental elicitation of time preference, Disa Working Paper 2008/8, Department of Management and Computer Science, University of Trento.

Zizzo, D. (2010), 'Experimenter demand effects in economic experiments', *Experimental Economics*.

# 6 Appendix

| Elicitation periods: | 1 | 3 | 6 | 9 | 12 |
|---|---|---|---|---|---|
| SS Amounts:* | | | | | |
| 340 | 211.76 | 66.80 | 32.95 | 21.87 | 16.36 |
| 280 | 514.29 | 151.50 | 73.50 | 48.51 | 36.20 |
| 220 | 981.82 | 264.63 | 125.73 | 82.42 | 61.30 |
| 160 | 1800.00 | 428.65 | 197.99 | 128.61 | 95.22 |
| 100 | 3600.00 | 704.88 | 311.91 | 199.83 | 146.95 |
| 40 | 10800.00 | 1385.32 | 561.36 | 349.86 | 253.83 |

| Elicitation periods: | 6 | 12 | 18 | 24 | 36 |
|---|---|---|---|---|---|
| SS Amounts:* | | | | | |
| 340 | 32.95 | 16.36 | 10.88 | 8.15 | 5.43 |
| 280 | 73.50 | 36.20 | 24.02 | 17.97 | 11.95 |
| 220 | 125.73 | 61.30 | 40.53 | 30.27 | 20.09 |
| 160 | 197.99 | 95.22 | 62.67 | 46.70 | 30.94 |
| 100 | 311.91 | 146.95 | 96.07 | 71.36 | 47.11 |
| 40 | 561.36 | 253.83 | 163.76 | 120.83 | 79.26 |

| Elicitation periods: | 6 | 12 | 36 | 60 | 120 |
|---|---|---|---|---|---|
| SS Amounts:* | | | | | |
| 340 | 32.95 | 16.36 | 5.43 | 3.25 | 1.63 |
| 280 | 73.50 | 36.20 | 11.95 | 7.15 | 3.57 |
| 220 | 125.73 | 61.30 | 20.09 | 12.02 | 5.99 |
| 160 | 197.99 | 95.22 | 30.94 | 18.47 | 9.20 |
| 100 | 311.91 | 146.95 | 47.11 | 28.05 | 13.94 |
| 40 | 561.36 | 253.83 | 79.26 | 46.95 | 23.25 |

Table 6: Discount rates associated with dollar MPL tables with 6 positions and different elicitation periods. Later Larger amount 400€. * SS: sooner smaller amount.

| Elicitation periods: | 1 | 3 | 6 | 9 | 12 |
|---|---|---|---|---|---|
| SS Amounts:* | | | | | |
| 350 | 171.43 | 54.62 | 27.01 | 17.94 | 13.43 |
| 325 | 276.92 | 86.00 | 42.25 | 28.01 | 20.94 |
| 300 | 400.00 | 120.77 | 58.94 | 38.98 | 29.12 |
| 275 | 545.45 | 159.64 | 77.33 | 51.01 | 38.06 |
| 250 | 720.00 | 203.53 | 97.78 | 64.33 | 47.93 |
| 225 | 933.33 | 253.70 | 120.77 | 79.22 | 58.94 |
| 200 | 1200.00 | 311.91 | 146.95 | 96.07 | 71.36 |
| 175 | 1542.86 | 380.72 | 177.27 | 115.44 | 85.58 |
| 150 | 2000.00 | 464.07 | 213.11 | 138.17 | 102.20 |
| 125 | 2640.00 | 568.34 | 256.71 | 165.55 | 122.14 |
| 100 | 3600.00 | 704.88 | 311.91 | 199.83 | 146.95 |
| 75 | 5200.00 | 896.59 | 386.16 | 245.30 | 179.64 |
| 50 | 8400.00 | 1200.00 | 497.06 | 311.91 | 227.05 |
| 25 | 18000.00 | 1823.81 | 704.88 | 432.95 | 311.91 |

| Elicitation periods: | 6 | 12 | 18 | 24 | 36 |
|---|---|---|---|---|---|
| SS Amounts:* | | | | | |
| 375 | 12.98 | 6.47 | 4.31 | 3.23 | 2.15 |
| 350 | 27.01 | 13.43 | 8.94 | 6.70 | 4.46 |
| 325 | 42.25 | 20.94 | 13.92 | 10.43 | 6.94 |
| 300 | 58.94 | 29.12 | 19.33 | 14.47 | 9.63 |
| 275 | 77.33 | 38.06 | 25.24 | 18.88 | 12.56 |
| 250 | 97.78 | 47.93 | 31.75 | 23.73 | 15.77 |
| 225 | 120.77 | 58.94 | 38.98 | 29.12 | 19.33 |
| 200 | 146.95 | 71.36 | 47.11 | 35.16 | 23.33 |
| 175 | 177.27 | 85.58 | 56.40 | 42.05 | 27.87 |
| 150 | 213.11 | 102.20 | 67.20 | 50.06 | 33.14 |
| 125 | 256.71 | 122.14 | 80.10 | 59.59 | 39.40 |
| 100 | 311.91 | 146.95 | 96.07 | 71.36 | 47.11 |
| 75 | 386.16 | 179.64 | 116.95 | 86.69 | 57.12 |
| 50 | 497.06 | 227.05 | 146.95 | 108.61 | 71.36 |
| 25 | 704.88 | 311.91 | 199.83 | 146.95 | 96.07 |

| Elicitation periods: | 6 | 12 | 36 | 60 | 120 |
|---|---|---|---|---|---|
| SS Amounts:* | | | | | |
| 350 | 27.01 | 13.43 | 4.46 | 2.67 | 1.34 |
| 325 | 42.25 | 20.94 | 6.94 | 4.16 | 2.08 |
| 300 | 58.94 | 29.12 | 9.63 | 5.77 | 2.88 |
| 275 | 77.33 | 38.06 | 12.56 | 7.52 | 3.75 |
| 250 | 97.78 | 47.93 | 15.77 | 9.44 | 4.71 |
| 225 | 120.77 | 58.94 | 19.33 | 11.56 | 5.77 |
| 200 | 146.95 | 71.36 | 23.33 | 13.94 | 6.95 |
| 175 | 177.27 | 85.58 | 27.87 | 16.65 | 8.30 |
| 150 | 213.11 | 102.20 | 33.14 | 19.78 | 9.85 |
| 125 | 256.71 | 122.14 | 39.40 | 23.49 | 11.69 |
| 100 | 311.91 | 146.95 | 47.11 | 28.05 | 13.94 |
| 75 | 386.16 | 179.64 | 57.12 | 33.95 | 16.86 |
| 50 | 497.06 | 227.05 | 71.36 | 42.32 | 20.98 |
| 25 | 704.88 | 311.91 | 96.07 | 56.75 | 28.05 |

Table 7: Discount rates associated with dollar MPL tables with 15 positions and different elicitation periods. Later Larger amount 400€. * SS: sooner smaller amount.

| Elicitation periods: | 1 | 3 | 6 | 9 | 12 | | 6 | 12 | 18 | 24 | 36 | | 6 | 12 | 36 | 60 | 120 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SS Am.:* | | | | | | SS Am.:* | | | | | | SS Am.:* | | | | | |
| 370 | 97.30 | 31.59 | 15.69 | 10.44 | 7.82 | 370 | 15.69 | 7.82 | 5.21 | 3.90 | 2.60 | 370 | 15.69 | 7.82 | 2.60 | 1.56 | 0.78 |
| 355 | 152.11 | 48.70 | 24.11 | 16.02 | 11.99 | 355 | 24.11 | 11.99 | 7.98 | 5.98 | 3.98 | 355 | 24.11 | 11.99 | 3.98 | 2.39 | 1.19 |
| 340 | 211.76 | 66.80 | 32.95 | 21.87 | 16.36 | 340 | 32.95 | 16.36 | 10.88 | 8.15 | 5.43 | 340 | 32.95 | 16.36 | 5.43 | 3.25 | 1.63 |
| 325 | 276.92 | 86.00 | 42.25 | 28.01 | 20.94 | 325 | 42.25 | 20.94 | 13.92 | 10.43 | 6.94 | 325 | 42.25 | 20.94 | 6.94 | 4.16 | 2.08 |
| 310 | 348.39 | 106.41 | 52.08 | 34.47 | 25.76 | 310 | 52.08 | 25.76 | 17.11 | 12.81 | 8.53 | 310 | 52.08 | 25.76 | 8.53 | 5.11 | 2.55 |
| 295 | 427.12 | 128.19 | 62.47 | 41.29 | 30.84 | 295 | 62.47 | 30.84 | 20.47 | 15.32 | 10.19 | 295 | 62.47 | 30.84 | 10.19 | 6.11 | 3.05 |
| 280 | 514.29 | 151.50 | 73.50 | 48.51 | 36.20 | 280 | 73.50 | 36.20 | 24.02 | 17.97 | 11.95 | 280 | 73.50 | 36.20 | 11.95 | 7.15 | 3.57 |
| 265 | 611.32 | 176.53 | 85.24 | 56.17 | 41.89 | 265 | 85.24 | 41.89 | 27.77 | 20.76 | 13.80 | 265 | 85.24 | 41.89 | 13.80 | 8.26 | 4.12 |
| 250 | 720.00 | 203.53 | 97.78 | 64.33 | 47.93 | 250 | 97.78 | 47.93 | 31.75 | 23.73 | 15.77 | 250 | 97.78 | 47.93 | 15.77 | 9.44 | 4.71 |
| 235 | 842.55 | 232.78 | 111.23 | 73.05 | 54.38 | 235 | 111.23 | 54.38 | 35.99 | 26.89 | 17.86 | 235 | 111.23 | 54.38 | 17.86 | 10.68 | 5.33 |
| 220 | 981.82 | 264.63 | 125.73 | 82.42 | 61.30 | 220 | 125.73 | 61.30 | 40.53 | 30.27 | 20.09 | 220 | 125.73 | 61.30 | 20.09 | 12.02 | 5.99 |
| 205 | 1141.46 | 299.51 | 141.42 | 92.52 | 68.74 | 205 | 141.42 | 68.74 | 45.40 | 33.89 | 22.49 | 205 | 141.42 | 68.74 | 22.49 | 13.44 | 6.70 |
| 190 | 1326.32 | 337.98 | 158.52 | 103.48 | 76.80 | 190 | 158.52 | 76.80 | 50.67 | 37.81 | 25.07 | 190 | 158.52 | 76.80 | 25.07 | 14.98 | 7.47 |
| 175 | 1542.86 | 380.72 | 177.27 | 115.44 | 85.58 | 175 | 177.27 | 85.58 | 56.40 | 42.05 | 27.87 | 175 | 177.27 | 85.58 | 27.87 | 16.65 | 8.30 |
| 160 | 1800.00 | 428.65 | 197.99 | 128.61 | 95.22 | 160 | 197.99 | 95.22 | 62.67 | 46.70 | 30.94 | 160 | 197.99 | 95.22 | 30.94 | 18.47 | 9.20 |
| 145 | 2110.34 | 482.98 | 221.12 | 143.22 | 105.89 | 145 | 221.12 | 105.89 | 69.59 | 51.82 | 34.31 | 145 | 221.12 | 105.89 | 34.31 | 20.47 | 10.19 |
| 130 | 2492.31 | 545.37 | 247.22 | 159.62 | 117.82 | 130 | 247.22 | 117.82 | 77.32 | 57.53 | 38.06 | 130 | 247.22 | 117.82 | 38.06 | 22.69 | 11.29 |
| 115 | 2973.91 | 618.17 | 277.09 | 178.26 | 131.36 | 115 | 277.09 | 131.36 | 86.05 | 63.97 | 42.28 | 115 | 277.09 | 131.36 | 42.28 | 25.19 | 12.53 |
| 100 | 3600.00 | 704.88 | 311.91 | 199.83 | 146.95 | 100 | 311.91 | 146.95 | 96.07 | 71.36 | 47.11 | 100 | 311.91 | 146.95 | 47.11 | 28.05 | 13.94 |
| 85 | 4447.06 | 810.92 | 353.42 | 225.34 | 165.32 | 85 | 353.42 | 165.32 | 107.83 | 79.99 | 52.75 | 85 | 353.42 | 165.32 | 52.75 | 31.38 | 15.59 |
| 70 | 5657.14 | 945.37 | 404.51 | 256.43 | 187.59 | 70 | 404.51 | 187.59 | 122.01 | 90.39 | 59.53 | 70 | 404.51 | 187.59 | 59.53 | 35.37 | 17.56 |
| 55 | 7527.27 | 1124.95 | 470.31 | 295.98 | 215.76 | 55 | 470.31 | 215.76 | 139.84 | 103.42 | 67.99 | 55 | 470.31 | 215.76 | 67.99 | 40.35 | 20.01 |
| 40 | 10800.00 | 1385.32 | 561.36 | 349.86 | 253.83 | 40 | 561.36 | 253.83 | 163.76 | 120.83 | 79.26 | 40 | 561.36 | 253.83 | 79.26 | 46.95 | 23.25 |
| 25 | 18000.00 | 1823.81 | 704.88 | 432.95 | 311.91 | 25 | 704.88 | 311.91 | 199.83 | 146.95 | 96.07 | 25 | 704.88 | 311.91 | 96.07 | 56.75 | 28.05 |

Table 8: Discount rates associated with dollar MPL tables with 25 positions and different elicitation periods. Later Larger amount 400€. * SS: sooner smaller amount.

| Low skewness | 1-20% | | | | |
|---|---|---|---|---|---|
| Elicitation periods: | 6 | 12 | 36 | 60 | 120 |
| 0.2 | 400.40 | 400.80 | 402.41 | 404.02 | 408.08 |
| 0.4 | 400.80 | 401.60 | 404.83 | 408.08 | 416.32 |
| 0.6 | 401.20 | 402.41 | 407.26 | 412.18 | 424.73 |
| 0.8 | 401.60 | 403.21 | 409.71 | 416.32 | 433.30 |
| 1 | 402.00 | 404.02 | 412.18 | 420.50 | 442.05 |
| 1.5 | 403.01 | 406.04 | 418.40 | 431.13 | 464.69 |
| 2 | 404.02 | 408.07 | 424.71 | 442.03 | 488.48 |
| 2.5 | 405.03 | 410.12 | 431.12 | 453.20 | 513.48 |
| 3 | 406.04 | 412.17 | 437.62 | 464.65 | 539.74 |
| 3.5 | 407.05 | 414.23 | 444.22 | 476.38 | 567.34 |
| 4 | 408.07 | 416.30 | 450.91 | 488.40 | 596.33 |
| 5.5 | 411.13 | 422.56 | 471.58 | 526.28 | 692.43 |
| 7 | 414.21 | 428.92 | 493.17 | 567.05 | 803.86 |
| 8.5 | 417.30 | 435.36 | 515.72 | 610.92 | 933.06 |
| 10 | 420.42 | 441.89 | 539.27 | 658.12 | 1,082.82 |
| 12 | 424.61 | 450.73 | 572.31 | 726.68 | 1,320.15 |
| 14 | 428.83 | 459.74 | 607.31 | 802.24 | 1,608.99 |
| 16 | 433.09 | 468.91 | 644.38 | 885.52 | 1,960.38 |
| 18 | 437.38 | 478.25 | 683.66 | 977.29 | 2,387.73 |
| 20 | 441.70 | 487.76 | 725.25 | 1,078.39 | 2,907.30 |

| Symmetric | 1-20% | | | | |
|---|---|---|---|---|---|
| Elicitation periods: | 6 | 12 | 36 | 60 | 120 |
| 1 | 402.00 | 404.02 | 412.18 | 420.50 | 442.05 |
| 2 | 404.02 | 408.07 | 424.71 | 442.03 | 488.48 |
| 3 | 406.04 | 412.17 | 437.62 | 464.65 | 539.74 |
| 4 | 408.07 | 416.30 | 450.91 | 488.40 | 596.33 |
| 5 | 410.10 | 420.46 | 464.59 | 513.34 | 658.80 |
| 6 | 412.15 | 424.67 | 478.67 | 539.54 | 727.76 |
| 7 | 414.21 | 428.92 | 493.17 | 567.05 | 803.86 |
| 8 | 416.27 | 433.20 | 508.09 | 595.94 | 887.86 |
| 9 | 418.34 | 437.52 | 523.46 | 626.27 | 980.54 |
| 10 | 420.42 | 441.89 | 539.27 | 658.12 | 1,082.82 |
| 11 | 422.51 | 446.29 | 555.55 | 691.57 | 1,195.66 |
| 12 | 424.61 | 450.73 | 572.31 | 726.68 | 1,320.15 |
| 13 | 426.71 | 455.21 | 589.55 | 763.54 | 1,457.49 |
| 14 | 428.83 | 459.74 | 607.31 | 802.24 | 1,608.99 |
| 15 | 430.95 | 464.30 | 625.58 | 842.87 | 1,776.09 |
| 16 | 433.09 | 468.91 | 644.38 | 885.52 | 1,960.38 |
| 17 | 435.23 | 473.56 | 663.74 | 930.29 | 2,163.61 |
| 18 | 437.38 | 478.25 | 683.66 | 977.29 | 2,387.73 |
| 19 | 439.54 | 482.98 | 704.16 | 1,026.61 | 2,634.85 |
| 20 | 441.70 | 487.76 | 725.25 | 1,078.39 | 2,907.30 |

| High skewness | 1-20% | | | | |
|---|---|---|---|---|---|
| Elicitation periods: | 6 | 12 | 36 | 60 | 120 |
| 1 | 402.00 | 404.02 | 412.18 | 420.50 | 442.05 |
| 3 | 406.04 | 412.17 | 437.62 | 464.65 | 539.74 |
| 5 | 410.10 | 420.46 | 464.59 | 513.34 | 658.80 |
| 7 | 414.21 | 428.92 | 493.17 | 567.05 | 803.86 |
| 8 | 416.27 | 433.20 | 508.09 | 595.94 | 887.86 |
| 10 | 420.42 | 441.89 | 539.27 | 658.12 | 1,082.82 |
| 11.5 | 423.56 | 448.50 | 563.87 | 708.91 | 1,256.38 |
| 13 | 426.71 | 455.21 | 589.55 | 763.54 | 1,457.49 |
| 14 | 428.83 | 459.74 | 607.31 | 802.24 | 1,608.99 |
| 15 | 430.95 | 464.30 | 625.58 | 842.87 | 1,776.09 |
| 16 | 433.09 | 468.91 | 644.38 | 885.52 | 1,960.38 |
| 16.5 | 434.16 | 471.23 | 653.99 | 907.64 | 2,059.51 |
| 17 | 435.23 | 473.56 | 663.74 | 930.29 | 2,163.61 |
| 18.5 | 438.46 | 480.61 | 693.83 | 1,001.65 | 2,508.27 |
| 19 | 439.54 | 482.98 | 704.16 | 1,026.61 | 2,634.85 |
| 19.2 | 439.97 | 483.93 | 708.33 | 1,036.77 | 2,687.23 |
| 19.4 | 440.40 | 484.89 | 712.52 | 1,047.02 | 2,740.65 |
| 19.6 | 440.84 | 485.84 | 716.74 | 1,057.38 | 2,795.12 |
| 19.8 | 441.27 | 486.80 | 720.98 | 1,067.83 | 2,850.66 |
| 20 | 441.70 | 487.76 | 725.25 | 1,078.39 | 2,907.30 |

Table 9: Amounts associated with interest rate MPL tables with 1-20% discount rates and different skewness structures. Later Larger amount 400€. * SS: sooner smaller amount.

| Low skewness | 1-50% | | | | |
|---|---|---|---|---|---|
| Elicitation periods: | 6 | 12 | 36 | 60 | 120 |
| 1 | 402.00 | 404.02 | 412.18 | 420.50 | 442.05 |
| 2 | 404.02 | 408.07 | 424.71 | 442.03 | 488.48 |
| 3 | 406.04 | 412.17 | 437.62 | 464.65 | 539.74 |
| 4 | 408.07 | 416.30 | 450.91 | 488.40 | 596.33 |
| 5 | 410.10 | 420.46 | 464.59 | 513.34 | 658.80 |
| 6 | 412.15 | 424.67 | 478.67 | 539.54 | 727.76 |
| 7.5 | 415.24 | 431.05 | 500.58 | 581.32 | 844.83 |
| 9 | 418.34 | 437.52 | 523.46 | 626.27 | 980.54 |
| 10.5 | 421.46 | 444.08 | 547.35 | 674.64 | 1,137.85 |
| 12 | 424.61 | 450.73 | 572.31 | 726.68 | 1,320.15 |
| 13.5 | 427.77 | 457.47 | 598.37 | 782.66 | 1,531.38 |
| 15 | 430.95 | 464.30 | 625.58 | 842.87 | 1,776.09 |
| 17.5 | 436.30 | 475.90 | 673.62 | 953.51 | 2,272.93 |
| 20 | 441.70 | 487.76 | 725.25 | 1,078.39 | 2,907.30 |
| 25 | 452.68 | 512.29 | 840.30 | 1,378.32 | 4,749.43 |
| 30 | 463.88 | 537.96 | 973.01 | 1,759.92 | 7,743.26 |
| 35 | 475.31 | 564.79 | 1,126.02 | 2,244.93 | 12,599.27 |
| 40 | 486.97 | 592.85 | 1,302.31 | 2,860.79 | 20,460.33 |
| 45 | 498.87 | 622.18 | 1,505.33 | 3,642.05 | 33,161.38 |
| 50 | 511.01 | 652.84 | 1,738.98 | 4,632.19 | 53,642.87 |

| Symmetric | 1-50% | | | | |
|---|---|---|---|---|---|
| Elicitation periods: | 6 | 12 | 36 | 60 | 120 |
| 2.5 | 405.03 | 410.12 | 431.12 | 453.20 | 513.48 |
| 5 | 410.10 | 420.46 | 464.59 | 513.34 | 658.80 |
| 7.5 | 415.24 | 431.05 | 500.58 | 581.32 | 844.83 |
| 10 | 420.42 | 441.89 | 539.27 | 658.12 | 1,082.82 |
| 12.5 | 425.66 | 452.97 | 580.87 | 744.89 | 1,387.14 |
| 15 | 430.95 | 464.30 | 625.58 | 842.87 | 1,776.09 |
| 17.5 | 436.30 | 475.90 | 673.62 | 953.51 | 2,272.93 |
| 20 | 441.70 | 487.76 | 725.25 | 1,078.39 | 2,907.30 |
| 22.5 | 447.16 | 499.89 | 780.72 | 1,219.32 | 3,716.85 |
| 25 | 452.68 | 512.29 | 840.30 | 1,378.32 | 4,749.43 |
| 27.5 | 458.25 | 524.98 | 904.29 | 1,557.67 | 6,065.83 |
| 30 | 463.88 | 537.96 | 973.01 | 1,759.92 | 7,743.26 |
| 32.5 | 469.56 | 551.22 | 1,046.80 | 1,987.93 | 9,879.66 |
| 35 | 475.31 | 564.79 | 1,126.02 | 2,244.93 | 12,599.27 |
| 37.5 | 481.11 | 578.67 | 1,211.05 | 2,534.53 | 16,059.62 |
| 40 | 486.97 | 592.85 | 1,302.31 | 2,860.79 | 20,460.33 |
| 42.5 | 492.89 | 607.35 | 1,400.25 | 3,228.26 | 26,054.22 |
| 45 | 498.87 | 622.18 | 1,505.33 | 3,642.05 | 33,161.38 |
| 47.5 | 504.91 | 637.34 | 1,618.06 | 4,107.89 | 42,186.84 |
| 50 | 511.01 | 652.84 | 1,738.98 | 4,632.19 | 53,642.87 |

| High skewness | 1-50% | | | | |
|---|---|---|---|---|---|
| Elicitation periods: | 6 | 12 | 36 | 60 | 120 |
| 5 | 410.10 | 420.46 | 464.59 | 513.34 | 658.80 |
| 10 | 420.42 | 441.89 | 539.27 | 658.12 | 1,082.82 |
| 15 | 430.95 | 464.30 | 625.58 | 842.87 | 1,776.09 |
| 20 | 441.70 | 487.76 | 725.25 | 1,078.39 | 2,907.30 |
| 25 | 452.68 | 512.29 | 840.30 | 1,378.32 | 4,749.43 |
| 30 | 463.88 | 537.96 | 973.01 | 1,759.92 | 7,743.26 |
| 31.5 | 467.28 | 545.88 | 1,016.66 | 1,893.43 | 8,962.73 |
| 33 | 470.71 | 553.91 | 1,062.20 | 2,036.90 | 10,372.41 |
| 34.5 | 474.15 | 562.05 | 1,109.72 | 2,191.04 | 12,001.67 |
| 36 | 477.62 | 570.30 | 1,159.31 | 2,356.64 | 13,884.39 |
| 37.5 | 481.11 | 578.67 | 1,211.05 | 2,534.53 | 16,059.62 |
| 39 | 484.62 | 587.14 | 1,265.03 | 2,725.61 | 18,572.37 |
| 40.5 | 488.15 | 595.73 | 1,321.35 | 2,930.83 | 21,474.48 |
| 42.5 | 492.89 | 607.35 | 1,400.25 | 3,228.26 | 26,054.22 |
| 45 | 498.87 | 622.18 | 1,505.33 | 3,642.05 | 33,161.38 |
| 46 | 501.28 | 628.21 | 1,549.48 | 3,821.80 | 36,515.36 |
| 47 | 503.70 | 634.28 | 1,594.88 | 4,010.26 | 40,205.45 |
| 48 | 506.13 | 640.41 | 1,641.57 | 4,207.85 | 44,265.02 |
| 40 | 486.97 | 592.85 | 1,302.31 | 2,860.79 | 20,460.33 |
| 50 | 511.01 | 652.84 | 1,738.98 | 4,632.19 | 53,642.87 |

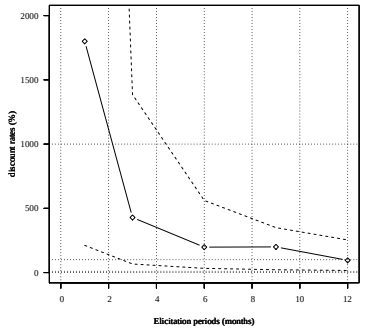
Table 10: Amounts associated with interest rate MPL tables with 1-50% discount rates and different skewness structures. Later Larger amount 400€. * SS: sooner smaller amount.

| Low skewness | 1-50% | | | | |
|---|---|---|---|---|---|
| Elicitation periods: | 6 | 12 | 36 | 60 | 120 |
| 2 | 404.02 | 408.07 | 424.71 | 442.03 | 488.48 |
| 3 | 406.04 | 412.17 | 437.62 | 464.65 | 539.74 |
| 4 | 408.07 | 416.30 | 450.91 | 488.40 | 596.33 |
| 5 | 410.10 | 420.46 | 464.59 | 513.34 | 658.80 |
| 7.5 | 415.24 | 431.05 | 500.58 | 581.32 | 844.83 |
| 10 | 420.42 | 441.89 | 539.27 | 658.12 | 1,082.82 |
| 12.5 | 425.66 | 452.97 | 580.87 | 744.89 | 1,387.14 |
| 15 | 430.95 | 464.30 | 625.58 | 842.87 | 1,776.09 |
| 22.5 | 447.16 | 499.89 | 780.72 | 1,219.32 | 3,716.85 |
| 30 | 463.88 | 537.96 | 973.01 | 1,759.92 | 7,743.26 |
| 37.5 | 481.11 | 578.67 | 1,211.05 | 2,534.53 | 16,059.62 |
| 45 | 498.87 | 622.18 | 1,505.33 | 3,642.05 | 33,161.38 |
| 55 | 523.40 | 684.87 | 2,007.75 | 5,885.84 | 86,607.91 |
| 65 | 548.93 | 753.31 | 2,671.74 | 9,475.82 | 224,477.87 |
| 80 | 589.16 | 867.77 | 4,084.08 | 19,221.33 | 923,648.70 |
| 95 | 631.82 | 997.98 | 6,212.22 | 38,669.75 | 3,738,373.38 |
| 110 | 677.02 | 1,145.88 | 9,403.77 | 77,172.57 | 14,889,014.21 |
| 125 | 724.88 | 1,313.64 | 14,167.94 | 152,805.13 | 58,373,516.74 |
| 140 | 775.53 | 1,503.64 | 21,247.50 | 300,243.17 | 225,364,896.19 |
| 150 | 810.91 | 1,643.96 | 27,768.40 | 469,041.57 | 549,999,994.33 |

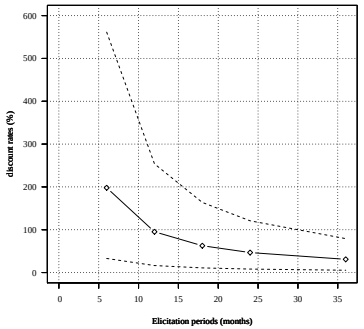
| Symmetric | 1-50% | | | | |
|---|---|---|---|---|---|
| Elicitation periods: | 1-150% | | | | |
| | 6 | 12 | 36 | 60 | 120 |
| 7.5 | 415.24 | 431.05 | 500.58 | 581.32 | 844.83 |
| 15 | 430.95 | 464.30 | 625.58 | 842.87 | 1,776.09 |
| 22.5 | 447.16 | 499.89 | 780.72 | 1,219.32 | 3,716.85 |
| 30 | 463.88 | 537.96 | 973.01 | 1,759.92 | 7,743.26 |
| 37.5 | 481.11 | 578.67 | 1,211.05 | 2,534.53 | 16,059.62 |
| 45 | 498.87 | 622.18 | 1,505.33 | 3,642.05 | 33,161.38 |
| 52.5 | 517.18 | 668.68 | 1,868.67 | 5,222.15 | 68,177.11 |
| 60 | 536.04 | 718.34 | 2,316.73 | 7,471.67 | 139,564.79 |
| 67.5 | 555.47 | 771.37 | 2,868.55 | 10,667.52 | 284,489.75 |
| 75 | 575.48 | 827.96 | 3,547.33 | 15,198.35 | 577,474.27 |
| 82.5 | 596.10 | 888.33 | 4,381.28 | 21,608.65 | 1,167,334.50 |
| 90 | 617.32 | 952.71 | 5,404.61 | 30,659.70 | 2,350,042.42 |
| 97.5 | 639.17 | 1,021.35 | 6,658.87 | 43,413.74 | 4,711,882.46 |
| 105 | 661.66 | 1,094.49 | 8,194.33 | 61,350.19 | 9,409,615.26 |
| 112.5 | 684.81 | 1,172.40 | 10,071.88 | 86,525.47 | 18,716,641.20 |
| 120 | 708.62 | 1,255.37 | 12,365.07 | 121,792.66 | 37,083,627.53 |
| 127.5 | 733.13 | 1,343.69 | 15,162.76 | 171,102.76 | 73,190,385.74 |
| 135 | 758.33 | 1,437.67 | 18,572.09 | 239,917.08 | 143,900,515.49 |
| 142.5 | 784.26 | 1,537.65 | 22,722.17 | 335,770.77 | 281,855,030.35 |
| 150 | 810.91 | 1,643.96 | 27,768.40 | 469,041.57 | 549,999,994.33 |

| High skewness | 1-150% | | | | |
|---|---|---|---|---|---|
| | 6 | 12 | 36 | 60 | 120 |
| 10 | 420.42 | 441.89 | 539.27 | 658.12 | 1,082.82 |
| 25 | 452.68 | 512.29 | 840.30 | 1,378.32 | 4,749.43 |
| 40 | 486.97 | 592.85 | 1,302.31 | 2,860.79 | 20,460.33 |
| 55 | 523.40 | 684.87 | 2,007.75 | 5,885.84 | 86,607.91 |
| 70 | 562.08 | 789.82 | 3,079.42 | 12,006.28 | 360,376.93 |
| 85 | 603.10 | 909.33 | 4,699.46 | 24,286.94 | 1,474,639.24 |
| 95 | 631.82 | 997.98 | 6,212.22 | 38,669.75 | 3,738,373.38 |
| 105 | 661.66 | 1,094.49 | 8,194.33 | 61,350.19 | 9,409,615.26 |
| 112.5 | 684.81 | 1,172.40 | 10,071.88 | 86,525.47 | 18,716,641.20 |
| 120 | 708.62 | 1,255.37 | 12,365.07 | 121,792.66 | 37,083,627.53 |
| 127.5 | 733.13 | 1,343.69 | 15,162.76 | 171,102.76 | 73,190,385.74 |
| 135 | 758.33 | 1,437.67 | 18,572.09 | 239,917.08 | 143,900,515.49 |
| 137.5 | 766.89 | 1,470.32 | 19,866.05 | 268,418.64 | 180,121,414.49 |
| 140 | 775.53 | 1,503.64 | 21,247.50 | 300,243.17 | 225,364,896.19 |
| 142.5 | 784.26 | 1,537.65 | 22,722.17 | 335,770.77 | 281,855,030.35 |
| 145 | 793.06 | 1,572.36 | 24,296.14 | 375,424.22 | 352,358,365.08 |
| 147 | 800.16 | 1,600.65 | 25,631.18 | 410,431.77 | 421,135,597.12 |
| 148 | 803.73 | 1,614.97 | 26,325.17 | 429,120.00 | 460,359,945.03 |
| 149 | 807.32 | 1,629.40 | 27,037.42 | 448,644.36 | 503,204,395.75 |
| 150 | 810.91 | 1,643.96 | 27,768.40 | 469,041.57 | 549,999,994.33 |

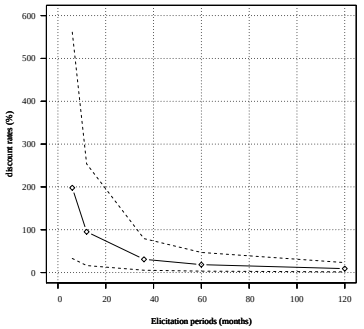
Table 11: Amounts associated with interest rate MPL tables with 1-150% discount rates and different skewness structures. Later Larger amount 400€. * SS: sooner smaller amount.



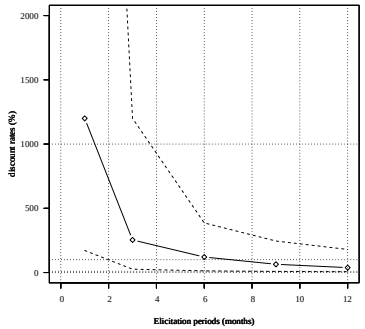

(a) Elicitation over 1, 3, 6, 9, 12 months, 6 positions



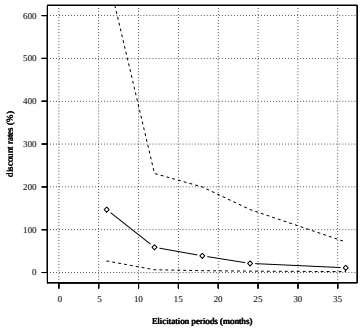

(b) Elicitation over 6, 12,18, 24, 36 months, 6 positions



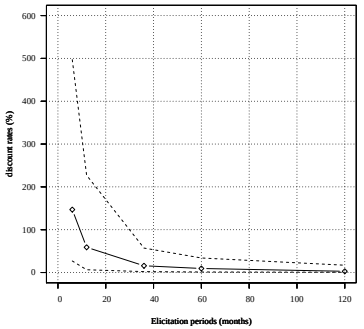

(c) Elicitation over 6, 12, 36, 60, 120 months, 6 positions



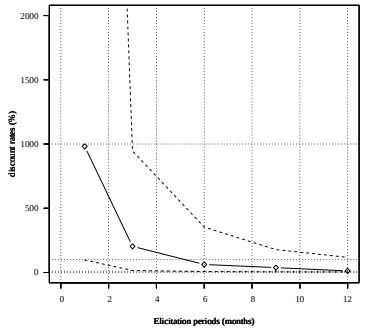

(d) Elicitation over 1, 3, 6, 9, 12 months, 15 positions



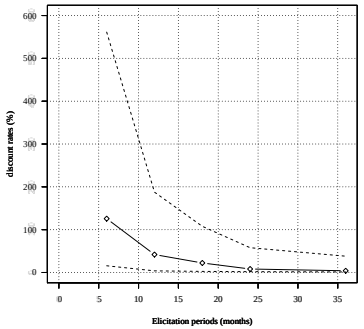

(e) Elicitation over 6, 12,18, 24, 36 months, 15 positions



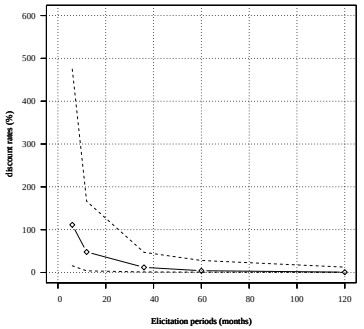

(f) Elicitation over 6, 12, 36, 60, 120 months, 15 positions




(g) Elicitation over 1, 3, 6, 9, 12 months, 25 positions

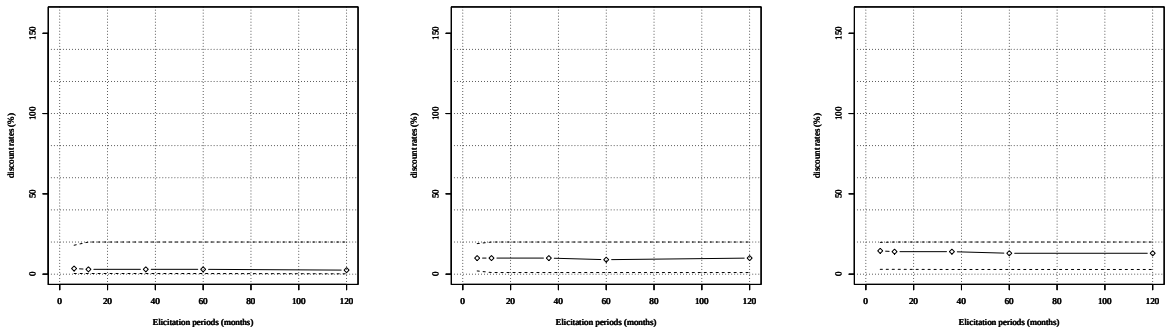



(h) Elicitation over 6, 12,18, 24, 36 months, 25 positions




(i) Elicitation over 6, 12, 36, 60, 120 months, 25 positions

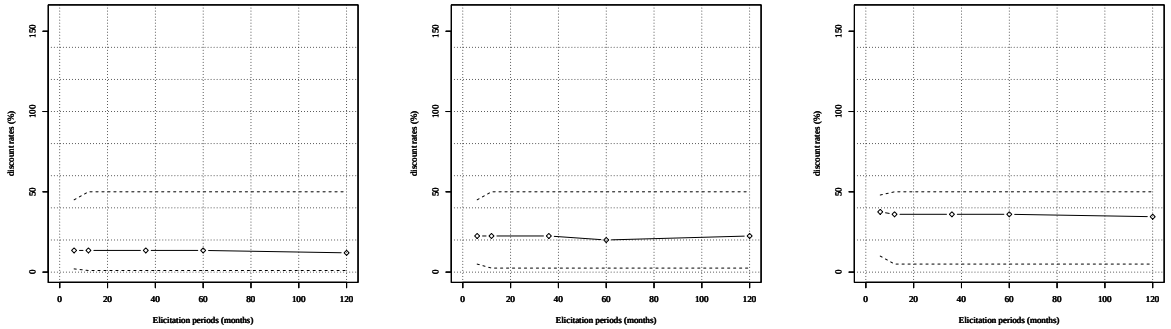
Figure 4: Median discount rates and corresponding 95% confidence interval. %-MPL delay frame for different structures of skewness of interest rates (columns) and bounds of interest rates (rows).




(a) Elicitation over the table with bounds from 1 to 20%, low skew

(b) Elicitation over the table with bounds from 1 to 20%, symmetric.

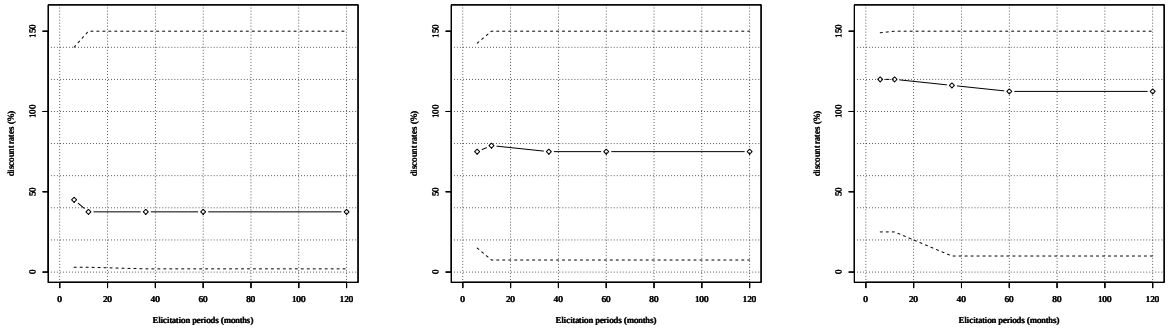
(c) Elicitation over the table with bounds from 1 to 20%, high skew.




(d) Elicitation over the table with bounds from 1 to 50%, low skew.

(e) Elicitation over the table with bounds from 1 to 50%, symmetric.

(f) Elicitation over the table with bounds from 1 to 50%, high skew.




(g) Elicitation over the table with bounds from 1 to 150%, low skew.

(h) Elicitation over the table with bounds from 1 to 150%, symmetric.

(i) Elicitation over the table with bounds from 1 to 150%, high skew.

Figure 5: Median discount rates and corresponding 95% confidence interval. %-MPL delay frame for different structures of skewness of interest rates (columns) and bounds of interest rates (rows).