REFERENCE-DEPENDENT PREFERENCES IN OUTCOME SEQUENCE COMPARISON: THEORY AND EVIDENCE*

Zhihua Li   Songfa Zhong

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Abstract

This paper examines the reference-dependent intertemporal preferences toward outcome sequence, a stream of outcomes to be received at different time points. A reference-dependent intertemporal utility model is proposed on top of the discounted utility model by incorporating an additional gain-loss utility at each time point. The reference-dependent model would predict when people take future-oriented outcome sequence as a reference point, they appear to be more patient, and when people take present-oriented outcome sequence as a reference point, they appear to be more impatient. We conduct an experiment to test these theoretical predictions. In the experiment, we adopt price list design in which one option is fixed on one side of the list, the other options get better from top to bottom on the other side of the list. Our results confirm that subjects see the fixed option in the list as a reference point. And their choice behaviours are consistent with the predictions of the model. We conduct structural estimation of the choice data for the reference-dependent model. The estimated loss aversion parameter is significantly larger than one, suggesting that loss looms larger than gain in the intertemporal setting. We further discuss the implication of observed reference-dependent effect of price list design on recent debates regarding the elicitation of time preference. (JEL C91, D90)

* Zhihua Li: Behavrioal Science Group, Warwick Business School, University of Warwick, CV4 7AL Coventry, UK, zhihua.li@wbs.ac.uk. Songfa Zhong: Department of Economics, Faculty of Arts and Social Science, National University of Singapore, 177570 Singapore, zhongsongfa@gmail.com, +65 65163944 (tel), +65 67752646 (Fax). We thank Soo Hong Chew, Thomas Epper, Lorenz Goette, Rebecca McDonald, Bin Miao, Kirsten Rohde, Changcheng Song, Peter Wakker and seminar and conference participants at the Shanghai University of Finance and Economics, Nanyang Technological University, National University of Singapore, 5th Annual Xiamen University International Workshop on Experimental Economics (2014), and 16th Conference on the Foundations on Utility and Risk (FUR) in Rotterdam (2014), Learning, Decision and Bounded Rationality Workshop in Israel (2013), for helpful comments. This work was supported by the Singapore Ministry of Education Academic Research Fund Tier 1, the start-up grant from the National University of Singapore, the Economic and Social Research Council, UK [grant number ES/K002201/1] and the Leverhulme Trust [grant number RP2012-V-022].

1. Introduction

Reference dependence is one of the leading concepts in behavioural economics. Markowitz (1952) pioneers this notion by proposing a multiply inflected utility function over gains and losses relative to reference point. Kahneman and Tversky (1979) propose the critical role of reference point and suggest that reference dependence underpins a wide range of behavioural anomalies in decision making under risk. Numerous subsequent theories on decision making under risk further incorporate reference points implicitly or explicitly in various manners, including the certainty equivalent in the disappointment aversion model (Bell, 1985; Loomes and Sugden, 1986; Gul, 1991), the unchosen alternatives in regret theory (Bell, 1982; Sugden and Loomes, 1982), and the expectations held in past (Köszegi and Rabin, 2006, 2007).

In the setting of intertemporal choice, reference dependence could also come into play in numerous approaches. One prominent manifestation of intertemporal reference dependence is habit formation, in which the decision maker takes the past consumption as a reference point to evaluate the current one (e.g., Loewenstein and Prelec, 1993; Baucells and Sarin, 2010; Gilboa and Schimeidler, 1999). Alternatively, Lowenstein (1988) compares the willingness to pay to speed up the delayed consumption and the willingness to accept to delay the immediate consumption, and finds that willingness to pay is significantly lower than willingness to accept. The observed behavior suggests that different frames could shift the reference point either toward the immediate or delayed consumption, and affect the intertemporal choice in a different manner. Loewenstein and Prelec (1992) show a number of behavioural anomalies in intertemporal choice could be explained by reference dependence, in which they assume that status quo is the reference point (see also Abdellaoui, Bleichrodt, l'Haridon, 2013). More recently, Köszegi and Rabin (2009) investigate the reference dependent preference in a dynamic setting, in which people are loss averse over the changes in rational beliefs about the present and future consumptions.

In this paper, we aim to examine the intertemporal reference-dependent preference from a different angle. Previous studies investigate reference dependence for consumption within one timeline, taking the consumption at earlier time points as a reference point for consumption at later time points. Departing from this approach, the current research intends to explore the comparison of consumption across multiple timelines, in which consumption in one timeline is taken as a reference point for consumption in another. In other words, we analyse the intertemporal reference-dependent preference in the context of outcome sequences comparison. An outcome sequence is a stream of consumption to be received at different time points over a time interval (e.g., Loewenstein, 1988; Loewenstein and Prelec, 1993). Many real life decisions involve decisions on selecting among outcome sequences. For example, you are a future-oriented person and a conservative spender, and you have planned to save more today and have better life tomorrow. This life plan is an outcome sequence spanning over your entire life. This particular plan, however, may change after you compare your current economical lifestyle with your reference point such as your new neighbor's hedonistic lifestyle. When your neighbor drives a nice car and goes to first-class restaurants, while you are still driving a 10-year old car and eating cold sandwiches, you might experience a sense of loss. Consequently, you may intend to spend more now and save less for the future to reduce such a regretful feeling you have endured after comparing yourself with your neighbour. Your behavioural changes could be explained by the fact that you take your neighbours' consumption at each time point as a reference point. When it comes to choosing between different outcome sequences, the outcomes actualized at the same time point may be compared across different outcome sequences. As a matter of fact, when people compare between different outcome sequences, these alternative outcome sequences can be the reference point of each other. Additionally, people may also take the status quo as a reference point. For another example, you have made a plan for your leisure activities in the following week, a concert on Monday evening and a movie on Saturday night. For some unforeseen reasons, the concert is postponed to Saturday night. In this event, you must reschedule your plan to watch the movie on Monday and go to the concert on Saturday. Aside from other possible reasons, you might feel upset merely due to the change of the plan because you take the original plan as a reference point.

More formally, we consider how a decision maker evaluates an outcome sequence of $C = (c_{0,}c_1)$, receiving c_0 at t_0 (now) and c_1 at t_1 (later), with respect to a reference outcome sequence of $R = (r_{0,}r_1)$, receiving r_0 at t_0 and r_1 at t_1.[1] We model the reference-dependent intertemporal preferences by extending the discounted utility

[1]We present a model for two time points, now and later. Generally speaking, our results could be generalized to settings with multiple time points to accommodate the situations such as present bias and time inconsistency (e.g., Laibson, 1997; O'Donoghue and Rabin, 1999).

model to incorporate an additional gain-loss utility $\mu(\cdot)$, which allows the comparison between the outcomes actualized at the same time point (e.g., comparing c_0 with r_0 as well as c_1 with r_1). Given the outcome sequence $C = (c_0,\ c_1)$ and reference outcome sequence of $R = (r_0, r_1)$, we model the intertemporal utility function as $U(C|R) = U(c_0, c_1, r_0, r_1) = c_0^\alpha + \delta c_1^\alpha + \mu(c_0^\alpha - r_0^\alpha) + \delta\mu(c_1^\alpha - r_1^\alpha)$, where α is the utility curvature, δ is the discount factor between times 0 and 1, and μ captures the gain-loss utility for each period.

Subsequently, we experimentally examine the reference-dependent preferences toward outcome sequences by framing the reference point using the price list design for time preference elicitation (e.g., Coller and Williams, 1999; Sutter et al., 2013; Halevy, 2015). In one of the widely used forms of price list, one option is fixed on one side of the list. We refer to this option as the *fixed option*. Meanwhile, the other option varies on the other side along the list, and it is referred to as the *varying option*. The price list allows the experimenter to infer the indifference relation between the fixed and varying options for the subjects. Under such a design, the fixed option is compared with a range of varying options; and hence it is possible that the fixed option is considered as a reference point. We test this hypothesis by adopting the fixed options versus varying option format in the experiment and examine how different fixed options may affect the choice behaviour in a different manner. Two types of outcome sequence are employed as fixed option. One type of this sequence grants outcome only in the earlier period,$(x_0, 0)$, which is referred to as the *present-oriented* fixed option, while the outcome in the second type of outcome sequence is only received in the later period, $(0, y_1)$, which is pertained to as the *future-oriented* fixed option.

In our experiment, we first elicit the indifference relation between a present-oriented outcome sequence P and a future-oriented outcome sequence F such that $P{\sim}F$. We subsequently use P and F separately as fixed options to elicit the preference relation with another outcome sequence S (z_0, z_1), where the outcomes are received at both time points. Under the standard discounted utility, given $P{\sim}F$, by transitivity, the preference relation between P and S is expected to be similar to that between $F$and S. Nevertheless, our proposed reference-dependent model predicts that a decision maker would discount the future more when the present-oriented fixed option is used, compared to when future-oriented fixed option is used. The model also predicts that the decision maker would exhibit preference reversals and violations of transitivity.

The choice behaviours observed in the experiment support the reference point effect with the price list and are consistent with the predictions of the reference-dependent model. We further conduct structural estimation for the proposed reference-dependent model using the choice data. The results of the structural estimation show that the estimated power utility curvature is slightly concave and close to linearity in the time domain. The estimated annual discount rate is between 20% and 30%. Moreover, the estimated loss aversion parameter is significantly larger than one, which implies that loss looms larger than gain in the intertemporal setting. Overall, the results confirm the proposed model of reference-dependent intertemporal preferences toward outcome sequences.

Our experiment sheds light on recent studies on the elicitation of time preference using price list. First, the price list with outcome sequence used in our experiment allows the joint estimation of utility curvature and discount rate. This contribute to recent literature on the utility curvature over time (Andreoni and Sprenger, 2012a; Abdellaoui et al., 2013; Olea and Strzalecki, 2014; Chueng, 2015). Second, our findings suggest that the decision makers may regard the fixed option in the price list as a reference point, leading to biases in the elicited time preference. This partially explain the reason for the observed higher discount rate elicited using price list (Andreoni and Sprenger, 2012a), as well as the intertemporal subadditivity (Read, 2001; Read and Roelofsma, 2003; Dohmen et al., 2012). These implications are detailed in the Discussion.

The rest of this paper is organized as follows. Following the Introduction, Section 2 details the experimental design. Section 3 presents the reference-dependent intertemporal utility model as well as the theoretical predictions. Section 4 reports our experimental results, including the structural estimations. Section 5 discusses the implications on recent literature regarding the elicitation of time preference, and Section 6 concludes the study.

2. **Experimental Design**

2.1. A motivating example

Our experiment aims to investigate the effect of reference-dependent preferences on outcome sequence comparisons. Each outcome sequence is defined at two time points, namely, the day of the experiment and six months later. We denote the outcome sequences used in our experiment as (x_0, x_1), where x_0 is the amount to be paid on the day of the experiment, and x_1 is the amount to be paid six months later. For instance, *(50, 60)* expresses an outcome sequence that pays the subjects $50 today and $60 six months later.[2]

Intuitively, the decision maker would ask for more to depart from the reference point, compared to when there is no effect of reference point. If *(100, 0)* is taken as a reference point compared with the situation without a reference point effect, the decision maker needs to be compensated more to delay the outcome by six months. Accordingly, when *(100, 0)* is taken as a reference point, the subjects would behave as if they are more impatient. In contrast, if *(0, 110)* is taken as a reference point compared with the situation without a reference point effect, the decision maker would give up less to expedite the outcome to today, behaving as if they are more patient. The effect of reference point may cause different distortions of time discounting, depending on whether the reference point is present-oriented or future-oriented.[3] By relying on this intuition, we consider the following motivating example in which Joe, the decision maker, makes three comparisons among sequences.

[2]When there is only one time point, outcome sequence collapses into a simple option. Any simple option can be represented as an outcome sequence by adding a zero outcome at different time points. The simple option that pays $110 in six months can be represented as an outcome sequence that pays $0 today and $100 in six months over the six-month period (0, 110). The different representation forms can cause some inconsistencies among decision makers. For example, Read and Scholten (2012) observe the hidden zero effect, in which subjects behave differently depending on whether paying $0 is explicitly mentioned. All options considered in this research are represented in the form of outcome sequences for two time points (i.e., today and six months) to avoid the hidden zero effect and to maximize the likelihood of consistency.

[3]Alternatively, the present- and future-oriented fixed options could provide a sense of attentional focus toward the present and future. This is related to recent theoretical work on modelling the psychology of salience. Bordalo, Gennaioli, and Shleifer (2012) consider choice among lotteries in which the decision maker's attention and hence probability weighting depends on the salience of payoffs. They further show that the model could explain of a range of empirical phenomena in decision making under risk. Köszegi and Szeidl (2013) propose a theory of focusing based on the intuition that a person focuses more on and overweighs the attributes in which his/her options differ more. They further show that the model could make numerous novel predictions in the setting of intertemporal choice.

> ***Task PF****: Joe chooses between outcome sequence* ***P*** *(present-oriented) and outcome sequence* ***F*** *(future-oriented).*
> ***P****: (100, 0) versus* ***F****: (0, 110)*
>
> ***Task PS****: Joe chooses between outcome sequence* ***P*** *and outcome sequence* ***S*** *(spread payments between the two time points).*
> ***P****: (100, 0) versus* ***S****: (50, 55)*
>
> ***Task FS****: Joe chooses between outcome sequence* ***F*** *and outcome sequence* ***S****.*
> ***F****: (0, 110) versus* ***S****: (50, 55)*

Assume $P \sim F$ in *task PF*. If $P \sim S$ in *task PS,* by transitivity, the preference relation in *task FS* would be $F \sim S$. If $P \succ S$, we should obtain $F \succ S$, or if $S \succ P$, we must acquire $S \succ F$.

However, if *P* in *tasks PF* and *PS* and *F* in *task FS* are adopted as reference points in each of the three choices, transitivity may not hold because the reference point would influence the elicitation of the preference relation between outcome sequences. Suppose *P (100, 0)* is taken as a reference point in *task PF*. If we ask Joe to state a sequence *F* that is equivalent to *P*, he is more reluctant to give up the $100 now for some future outcome. Joe would then ask for a higher future outcome to compensate the *loss* of the $100 now. Therefore, the $110 in six months in *F(0, 110)* reported by Joe is larger than the amount that would be equivalent to *P* if *P* is not taken as a reference point. This *non-reference point* amount $F_{non\text{-}rp}$ is assumed to be *(0, 105)* for now. Similarly, when *P(100, 0)* is taken as a reference point in *task PS*, the elicited *S(50, 55)* is larger than $S_{non\text{-}rp}$ when *P* is a reference point. For now, let $S_{non\text{-}rp}$ be *(50, 52)*. When it comes to the choice between *F(0, 110)* and *S(50, 55)* in *task FS*, given that both *F* and *S* are elicited based on the influence of *P* as a reference point, *F* and *S* should be amplified to a similar extent, thereby obtaining $F \sim S$. However, if *F* is taken as a reference point, Joe would be less willing to give up his future income to receive the $50 now. It is likely that $F(0, 110) \succ S(50, 55)$.

In sum, if Joe adopts *P*, *P*, and *F* in *tasks PF*, *PS*, and *FS* as reference points, respectively, preference transitivity might be violated. If the decision maker is indifferent between *P* and *F* when *P* is a reference point in *task PF* as well as between *P* and *S* when *P* is a reference point in *task PS*, he/she would likely be indifferent between *F* and *S* when neither *F* nor *S* is a reference point in *task FS*. Nonetheless, *F* would be preferred to *S* when *F* is a reference point in *task FS*. Preference reversal results and transitivity is violated.

The decision problems in the experiment follow the same structure as the three tasks in the motivating example. In particular, the problems that are of the type of *task PF* elicit preference between the present- and future-oriented outcome sequences. The decision problems of the type of *task PS*(*/FS*) elicit preferences between the present (/future)-oriented outcome sequence and spread outcome sequence. The ensuing subsection details how we manipulate the subjects' perception of reference point in the experiment.

Our experiment uses monetary reward to elicit time preference. This approach is commonly applied in most experiments on intertemporal choice. Nevertheless, scholars have been debating whether one should instead use primary rewards to measure time preference in experiments. For example, Cubitt and Read (2007) argue that primary rewards would be a better measure of eliciting time preference because theories are specified based on the intertemporal substitution among consumption utilities than monetary payments. Reuben, Sapienza, and Zingales (2010) suggest that if the discount factor inferred from monetary rewards is substantially correlated with consumption goods, the measurement through monetary reward might be ecologically valid. These researchers elicit discount factors for both monetary and primary rewards (chocolate) and observe a positive and statistically significant correlation between the two. Augenblick, Niederle, and Sprenger (2013) elicit time preference toward monetary rewards and real effort. Consequently, they observe that the subjects tend to be time consistent in monetary choices and exhibit present bias in effort choices. Halevy (2014) discusses the validity of using monetary and primary rewards in measuring time preference and concludes that monetary reward of moderate level is appropriate to inform the structure and properties of intertemporal preferences.

2.2. The Price List design

Table 1 illustrates the price list design adopted in the experiment. In the price list, each row presents a decision between two outcome sequences. The outcome sequence on the right side *(45, 0)* is intentionally kept fixed from top to bottom and is referred to as the *fixed option* for the sake of explanation in this paper. The options on the left side are improved from top to bottom as *(5, x)* with x = 40, 41,…, 59. We collectively call these options, which change from row to row, as the *varying option*. In the experiment, there are always 20 varying options in each price list. The decision makers are asked to mark their choice as either left (L) or right option (R) in the middle column.

[*Insert Table I here*]

In the experiment, we use *(100, 0)* as the present-oriented outcome sequence *P*. A total of twenty future-oriented outcome sequences *F(0, x)* are included, in which x = 100, 102,…, 138. Meanwhile, we also incorporate eighty spread outcome sequences *S* (of four different types), in which twenty are *(10, x)* with x = 90, 92,…, 128, twenty are *(90, x)* with x = 10, 12,…, 48, twenty are *(x, 10)* with x = 90, 92,…, 128, and the remaining twenty are *(x, 90)* with x = 10, 12,…, 48. One price list includes one fixed option and twenty varying options. For *task PF*, *P(100, 0)* is the fixed option, abbreviated as P_{fixed}, and the twenty future-oriented outcome sequences *F(0, x)* are the varying options. Thus, we have one price list for *task PF*. For *task PS*, four price lists are implemented, in which *P(100, 0)* is the fixed option, and four types of twenty spread outcome sequences *S* are used as varying options. For *task PS*, four future-oriented sequences *(0, 102)*, *(0, 112)*, *(0, 122)*, and *(0, 132)* are used as fixed options, which are abbreviated as F_{fixed1}, F_{fixed2}, F_{fixed3}, and F_{fixed4}, respectively. The same four sets of *S* spread outcome sequences are used as varying options for each of the four fixed options. Accordingly, sixteen price lists are used for *task FS*. In sum, twenty-one price lists are implemented for the experiment (Table II).

The four different types of varying options in Table II are constructed as follows: if the amount paid today (six months later) changes in each varying option in the list, we say that the list of varying option is early-focused (late-focused). Moreover, we say that the varying option is of increasing (decreasing) trend if the option pays a larger (smaller) amount six months later than today. This condition leads to four types of varying options, namely, increasing trend and late-focused (IL), decreasing trend and late-focused (DL), increasing trend and early-focused (IE), and decreasing trend and early-focused (DE).

[*Insert Table II here*]

Price list is widely used in many economic experiments because of its simple implementation, and that its incentive mechanism is easy for subjects to understand.

In our experiment, we deliberately use price list to elicit the reference-dependent preferences with several considerations in mind. First, we aim to induce the reference point in a weak form without using any endowment or entitlement type of language. Plott and Zeiler (2005) and Isoni, Loomes, and Sugden (2011) observe that removing confusing words as well as adding practice round and anonymity can reduce the endowment effect for mugs, but not for lotteries. This instance signifies that there are potential confounding factors associated with the willingness-to-pay and willingness-to-accept gap in economic experiments. Therefore, we adopt neither the physical nor verbal endowments to avoid the possible confounding influences.

Second, in most price list design used in economic experiments to elicit time preference, the options on one side of the list are kept fixed, whereas the options on the other side vary from row to row. It has been recently suggested that when subjects make decisions across each row in the price list, they tend to view the fixed option as the reference point. For example, Sprenger (*in press*) and Castillo and Eil (2014) show that the fixed option in the price list could be taken as a reference point for the elicitation of risk preference. In this regard, our experiment also allows us to test whether this format of price list induces reference dependence in the intertemporal settings.

Lastly, in the standard price list design used in the experimental economics to elicit time preference, subjects make binary choices between receiving a smaller sooner payment x_0 at an earlier time t_o and a larger later payment y_1 at $t_1$to obtain an indifference relation of $(x_0, 0) \sim (0, y_1)$. Under the discounted utility model with discount factor δ and power utility parameter α, the preference relation can be presented as $x_0^\alpha = \delta y_1^\alpha$, in which the two parameters δ and α cannot be jointly identified. Our price list design with spread outcome sequence allows us to elicit preference relation $(x_0, x_1) \sim (y_0, y_1)$ such that $x_0^\alpha + \delta x_1^\alpha = y_0^\alpha + \delta y_1^\alpha$, which can be used to jointly estimate the discount factor δ and curvature of utility index α in the time domain.

2.3. Non-adaptive design

In the motivating example, preferences are elicited in three steps. Firstly, preference is elicited between a present-oriented outcome sequence and a future-oriented outcome sequence in *task PF*. Secondly, the present-oriented outcome sequence is compared with a spread outcome sequence in *task PS*. Finally, the future-oriented outcome sequence is compared with the same spread outcome sequence in *task FS*. If the experiment directly follows the structure of the motivating example, the decisions in the experiment become adaptive. In other words, the decision subjects make later in the experiment will depend on the decision they make earlier. The incentive compatibility of the adaptive design has long been a concern. A non-adaptive design is implemented in our experiment to simplify the incentivizing procedure. This subsection explains how we compare preferences across tasks *PF*, *PS*, and *FS* without an adaptive design.

For *task PF*, we can infer the indifference value r_1 such that $P:(r_0,0) \sim F^{\sim}:(0,r_1)$, in which $F^{\sim}$ is the future-oriented outcome sequence indifferent to *P*. For *task PS*, the indifference $P:(r_0,0) \sim S^{\sim P}:(c_0',c_1')$ is directly revealed from the decision of the subjects. For *task FS*, we can infer the indifference that $F^{\sim}:(0,r_1) \sim S^{\sim F}:(c_0'',c_1'')$. According to transitivity, we must observe $S^{\sim P}:(c_0',c_1') \sim S^{\sim F}:(c_0'',c_1'')$. Nevertheless, the decision of the subjects might be influenced by whether the fixed option is present- or future-oriented because the fixed options are likely to be viewed as a reference point. Our aim is to determine whether transitivity holds true by comparing $S^{\sim P}:(c_0',c_1')$ with $S^{\sim F}:(c_0'',c_1'')$.

We take *Subject 70* as an example to illustrate how we conduct the transitivity check at the individual level. From price lists 1 and 2 detailed in Table II, the revealed preferences of Subject 70 are $\mathrm{P}:(100{,}0) \sim \mathrm{F}^{\sim}:(0{,}111)$ and $\mathrm{P}:(100{,}0) \sim \mathrm{S}_{\mathrm{IL}}^{\sim\mathrm{P}}:(10{,}99)$. However, only $(0{,}102), (0{,}112), (0{,}122), (0{,}132)$ (price lists 6, 10, 14, and 18) are used as fixed options in task FS and $(0{,}111)$ is not. Therefore, we cannot directly observe the preference relation between $F^{\sim}:(0{,}111)$ and its indifferent spread sequence $S_{IL}^{\sim F}$. Nevertheless, the preference relation can be inferred from the decisions of the four future-oriented outcome sequences used (Price lists 6, 10, 14, and 18). Table III.A illustrates the relationship among price lists 1, 2, 6, 10, 14, and 18.

[*Insert Table III here*]

Table III.B shows the revealed preference of *Subject 70* from price lists 6, 10, 14, and 18. In this table, we denote the amounts of money to be received six months later in the future-oriented fixed options and spread varying options as $x_i \in X, i \in (1, \ldots 4)$, and $y_i \in Y, i \in (1, \dots 4)$, respectively. A linear relationship is fitted between X and Y such that

$$Y = \beta_1 X + \beta_0.$$

Given that $X = (102,112,122,132)$ and $Y = (93,101,113,123)$, the fitted line is

$$Y = 1.02X - 11.84.$$

Consequently, we obtain that $F^{\sim}$ yields 111 in six months. The fitted line predicts that the indifferent spread outcome sequence to $F^{\sim}$: $(0,111)$ is $S_{IL}^{\sim F}$: $(10,101.38)$ because substituting $X = 111$ into the fitted equation yields $Y = 1.02 * 111 - 11.84 = 101.38$. Accordingly, the following equation is acquired.

$$F^{\sim}: (0,111) \sim S_{IL}^{\sim F}: (10,101.38)$$

We also infer that $P(100,0) \sim F^{\sim}(0,111)$ and $P(100,0) \sim S_{IL}^{\sim P}(10,99)$ from the revealed preferences of Subject 70. $S_{IL}^{\sim F}$: $(10,101.38) \succ S_{IL}^{\sim P}(10,99)$, which produces an intransitive circle $S_{IL}^{\sim P} \sim P \sim F^{\sim} \sim S_{IL}^{\sim F} \succ S_{IL}^{\sim P}$. Similar analysis can also be applied to the other types of varying options (i.e., $S_{IE}, S_{DL},$ and S_{DE}). We adopt this method to check preference transitivity and report it in the Result.

2.4. Recruitment and Procedure

A total of 111 undergraduate students of the National University Singapore (NUS) were recruited. The experiment was conducted in five sessions, in which each session involved 20 to 30 subjects. After arriving at the experimental venue, subjects were given the consent form approved by the NUS Institutional Review Board. Subsequently, general instructions were read out loud to the subjects, followed by the demonstrations of several examples. Subjects were then instructed to complete the decision problems by choosing between two outcome sequences in 21 price lists and by marking the preferred one for each row in each price list (see Online Appendix for experimental instructions). The order and distribution of price lists were completely randomized among subjects.

Each subject received a \$10 flat payment for their participation in the experiment. Moreover, one subject in each session was randomly selected to receive extra payment, which was determined by the outcome of one randomly selected decision he/she made. Once the real payment was determined for this randomly selected subject, half of his/her show-up fee was added to the payment for today determined from the real decision, while the other half was added to the payment for six months later from the real decision. The experimenter issued the randomly selected subject with two Development Bank of Singapore checks. One check permits the amount to be received today, and the other allows the amount to be received six months later. The law in Singapore stipulates that a check cannot be cashed before the specified due date. This mandate ensures that the subject cannot expedite the payment for the delayed payment as described in the decision problems. The transaction cost is kept relatively constant across different time points with the addition of $5 into the amount to be paid at two time points and the use of checks for payment (Andreoni and Sprenger 2012a, b).

3. **Theoretical Framework**

In this section, we first present the theoretical framework of the standard discounted utility and reference-dependent intertemporal utility, and we then examine the theoretical predictions in our experimental setting.

3.1.Theoretical Setup

Without the loss of generalizability, we discuss the theoretical models in a two-period setting. We denote the outcome sequence as $C = (c_{0,}\ c_1)$, in which c_i represent the outcome for t_i for $i \epsilon \{0,1\}$. Under the discounted utility, we obtain the following expression:

$$U(C) = U(c_0, c_1) = u(c_0) + \delta u(c_1), \qquad (1)$$

where $u(c_i)$ captures intertemporal substitution, and δ is the discount factor. Power utility function is commonly used in discounted utility model, in which $u(c_i) = {c_i}^{\alpha}$ with α as utility curvature over time.

We consider the outcome sequence $C = (c_{0,}\ c_1)$ and reference outcome sequence $R = (r_{0,}\ r_1)$ to model reference dependence. We follow the theoretical setup employed by Köszegi and Rabin (2006) and apply it to the intertemporal environment. The utility $U(C|R)$ for outcome C with reference R would be expressed as follows:

$$U(C|R) = u(c_0) + \delta u(c_1) + \mu(u(c_0) - u(r_0)) + \delta\mu(u(c_1) - u(r_1)) \qquad (2)$$

We assume that the overall utility has two components, namely, the outcome utility $u(c_0) + \delta u(c_1)$ and gain-loss utility $\mu(u(c_0) - u(r_0)) + \delta\mu(u(c_1) - u(r_1))$. Gain-loss utility captures the gains or losses from the comparison between the outcome sequence and reference outcome sequence for each time point. For example, an outcome sequence of receiving 0 today and 110 in six months is compared with a reference outcome sequence of acquiring 100 today and 0 in six months. This may induce a mixture of two feelings, which are the loss of 100 today and the gain of 110 in six months. By contrast, given a reference outcome sequence of receiving 0 today and 100 in six months, an outcome sequence of getting 0 today and 110 in six months would not induce such a mixed feeling. We assume that the reference dependence in our study is time separable mostly for simplicity, which is similar to Köszegi and Rabin (2006), in which the reference-dependent preference is state separable.

We also assume that the decision maker experiences the gains and losses at each time point in a universal manner and has therefore the same function of $\mu(.)$ for each time point. The usual assumptions of gain-loss utility $\mu(.)$ are also satisfied as Köszegi and Rabin (2006).

A0. $\mu(x)$ is continuous for all x, twice differentiable for $x \neq 0$, and $\mu(0) = 0$.

A1. $\mu(x)$ is strictly increasing.

A2. If $y > x > 0$, $\mu(y) + \mu(-y) < \mu(x) + \mu(-x)$.

A3. $\mu''(x) \leq 0$ for $x > 0$, and $\mu''(x) \geq 0$ for $x < 0$.

A3$'$. $\mu''(x) = 0$ for $x \neq 0$.

A4. $\frac{\mu'_-(0)}{\mu'_+(0)} \equiv \lambda > 1$, where $\mu'_-(0) \equiv \lim_{x\to 0} \mu'(-|x|)$ and $\mu'_+(0) \equiv \lim_{x\to 0} \mu'(|x|)$.

Based on these assumptions, some theoretical properties could be derived for the reference-dependent specification.

Property. If μ satisfies assumptions A0, A1, A2, A3, and A4, the following properties hold true.

1. For any of the outcome sequences C, R, and R', $U(C|R) \geq U(C|R')$, if R'weakly dominates R in the sense that the outcomes at both time points of R' are greater or equal to those at both time points of R.
2. When μ satisfies A3$'$ for any of the outcome sequences C and C', which are not identical, $U(C|C') \geq U(C'|C')$ implies that $U(C|C) > U(C'|C)$.

The first property signifies that the overall utility is lower if one has a better reference outcome sequence. Meanwhile, the second property implies that if a person is willing to abandon his/her reference outcome sequence for an alternative, then he/she strictly prefers the alternative when it is his/her reference outcome sequence. We provide a proof at the end of the paper.

If we assume that the gain-loss utility satisfies assumption A3′ with a power utility function $u(c_i) = c_i^\alpha$, the following expressions are obtained.[4]

$$U(c_0, c_1, r_0, r_1) = c_0^\alpha + \delta c_1^\alpha + \mu(c_0, r_0) + \delta\mu(c_1, r_1),$$

$$\mu(c_i^\alpha, r_i^\alpha) = \begin{array}{c} \gamma(c_i^\alpha - r_i^\alpha)\ if\ c_i \geq r_i \\ \gamma\lambda(c_i^\alpha - r_i^\alpha)\ if\ c_i < r_i \end{array} \tag{3}$$

where γ captures the weight for gain-loss utility, λ captures the additional weight for loss aversion with $\lambda > 1$, which states that loss looms larger than gain. The model reduces to the standard discounted utility if $\gamma = 0$.

Notice that our model assumes that reference point is exogenously given. Köszegi and Rabin (2006, 2007) propose the equilibrium concepts to endogenize the reference point in risky environment. Under the personal equilibrium, expectation hold in recent past is the reference point, and it is rational. Thus the actual choice is consistent with the expectation. Under the preferred personal equilibrium, decision maker chooses the personal equilibria with the highest ex-ante utility. These equilibrium concepts could be similarly applied to intertemporal decision making to endogenize the reference point. For example, when the decision maker makes a plan, he/she is aware that it would be taken as a reference point. Under personal equilibrium, the decision maker is rational in the sense that he/she fully foresees the future and would actually implement the plan. Under the preferred personal equilibrium, the decision maker compares the personal equilibrium and chooses the one plan with the highest utility. We leave the specific implications of endogenized intertemporal reference point for future studies.

[4] If we follow assumption A3, we will obtain $\mu(c_i, r_i) = \begin{array}{c} \gamma(c_i^\alpha - r_i^\alpha)^\varphi\ if\ c_i \geq r_i \\ -\gamma\lambda(r_i^\alpha - c_i^\alpha)^\varphi\ if\ c_i < r_i \end{array}, i\epsilon\{0,1\}$, where φ reflects the diminishing marginal sensitivity for the gain-loss utility. This more general form will not change our subsequent theoretical predictions.

3.2. Theoretical Predictions

We explore the theoretical predictions for our experimental design in this subsection. In the analysis, we assume that the fixed option in the price list is taken as a reference outcome sequence when subjects choose between the fixed and varying options. Accordingly, we derive the following two theoretical predictions.

Prediction Suppose the decision maker has reference-dependent intertemporal preference of (3) and takes the fixed option in the price list as a reference point.

1. If the standard discounted utility is used to infer the discount factor from the experimental data, the price list with present-oriented fixed option would induce a downward biased discount factor. Contrarily, the price list with future-oriented fixed option would induce an upward biased discount factor.

2. Suppose the decision maker has the following pairs of preference relations: (1) the present-oriented fixed option $(r_{0,}0)$ is indifferent to varying option $(0, r_1)$; (2) the present-oriented fixed option $(r_{0,}0)$ is indifferent to varying option (x_0, x_1^*); (3) the future-oriented fixed option $(0, r_1)$is indifferent to varying option (x_0, x_1^{**}). We will have $x_1^* < x_1^{**}$, and thus preference transitivity would be violated.

For Prediction 1, the decision maker would appear to be more impatient under the standard discounted utility because he/she is less willing to delay if the present-oriented fixed option taken as a reference point. This instance would then lead to a downward biased discount factor. In contrast, when the decision maker is less willing to expedite for the future-oriented fixed option as a reference point, he/she would seem to be more patient under the standard discounted utility. This occurrence would eventually result in an upward biased discount factor. Given that the intuition is purely driven by whether the reference point is present or future oriented, the different types of varying option (e.g., early vs. late focused and increasing trend vs. decreasing trend) do not change the predicted choice patterns. For Prediction 2, intuitively, when the present-oriented fixed option is taken as a reference point, the decision maker is less willing to delay than when there is no reference point effect and therefore asks for a higher $r_1$and x_1^{**}. Contrarily, when the future-oriented fixed option is taken as a reference point, the decision maker is less willing to speed up and asks for a higher x_1^*. Given that x_1^{**} is elicited based on r_1, the overall effect would be that $x_1^{**}$is higher than x_1^*. The detailed proofs for the above analysis are presented at the end of the paper.

4. **Results**

In this section, we test the two theoretical predictions regarding biased discount factor and inconsistency behaviour and conduct structural estimations for the standard discounted utility and the proposed reference-dependent preference model.

4.1. Influence on discount factor

We examine how different fixed options influence the discounting behaviour to test Prediction 1 by estimating the discount factor from the subjects' choices. The special feature of price list allows us to infer the indifferent preference relation as long as the subject switches once in the list.[5] If we use the discounted utility model, the indifferent preference $(x_0, x_1) \sim (y_0, y_1)$ can be represented as $u(x_0) + \delta u(x_1) = u(y_0) + \delta u(y_1)$. With the assumption that the utility function of the outcomes is linear, we can calculate the discount factor as $\delta = \frac{x_0 - y_0}{y_1 - x_1}$. Each subject completes a total of 21 price lists. For each subject, we calculate the discount factor from the preference inferred from each price list, and derive the median discount factor from the 21 price lists for each subject.

[*Insert Figure I here*]

Figure I graphically presents the mean and standard errors for median discount factor of the subjects. The overall discount factor is 0.93, which results in a monthly and yearly discount rate of 1.22% and 15.62%, respectively. Figure I particularly reveals that the discount factor derived from the future-oriented outcome sequence is significantly higher than that from the present-oriented fixed option (p<0.001). At the individual level, the median discount factor derived from the future-oriented outcome sequence of 59% of the subjects is higher than that derived from the present-oriented outcome sequence. However, 25% of the subjects exhibit otherwise. Meanwhile, we cannot estimate the discount factor for 17% of the subjects because they do not switch in some of the price lists. Overall, the above finding supports Prediction 1 that the subjects regard the fixed options as a reference point, and they tend to discount future

[5] In total 111 subjects participated in the experiment, among which 18 subjects made multiple switches at least in one price list in the experiment and are currently eliminated from data analysis. Most subjects made only one multiple switch and in total only 2.8% of price lists has multiple switches.

less and reveal a higher discount factor when the future is the reference point. When the present-oriented fixed option is used, the subjects feel more distant from the future and are more impatient with a smaller discount factor. In other words, when the present-oriented fixed options are used, the subjects form a myopic manner of viewing the outcome sequences. Contrarily, when the future-oriented fixed options are employed, the mind-sets of the subjects are framed significantly closer to the future, and they discount future less. Accordingly, we posit that the subjects with future-framed mind-set think backwards when they evaluate outcome sequences, whereas those with present-framed mind-set look forward.

4.2. Inconsistency Behaviour

This subsection reports the result on whether subjects exhibit intransitive preferences across the three tasks of decision problems (i.e., *PF*, *PS*, and *FS* (Prediction 2)). We conduct the extrapolation as described in Section 2.3 for all subjects, and the percentages of intransitive circles are shown in Table IV. A significant majority of the subjects exhibit inconsistent preferences when the present-oriented outcome sequences are used as fixed options compared to when the future-oriented ones are used. Moreover, majority of the subjects exhibit the preference relation $S^{\sim F} \succ S^{\sim P}$ for different types of S spread outcome sequence, is consistent with our theoretical prediction.

[*Insert Table IV here*]

We run a Logit regression with dependent variables being $S^{\sim F} \succ S^{\sim P}$ coded as 1 and $S^{\sim F} \preccurlyeq S^{\sim P}$ coded as 0 to examine the influence of different types of S spread outcome sequence on the inconsistent patterns. The independent variables are as follows: (1) whether the spread outcome sequence is late focused; (2) whether the spread outcome sequence is increasing; (3) the interaction term between the two. The regression results are presented in Table V. According to the Logit regression, the interaction effect of the two independent variables indicates that all types of outcome sequence (i.e., DL, DE, IL, and IE) would increase the likelihood of $S^{\sim F} \succ S^{\sim P}$, but the extent of the increased likelihood differs. DL and IE incur the most effect, followed by DE. IL exudes the least effect. In general, the above observations are consistent with Prediction 2. Even though the extrapolation of indifference is not a precise measure, it provides a rough idea about the behavioural pattern of subjects.[6]

[*Insert Table V here*]

4.3. Parametric Estimations

In this subsection, we provide structural estimations for the discounted utility and for the reference-dependent model we proposed in Section 3. The choice probability of choosing an outcome sequence $U(x_0, x_1)$ over another $U(y_0, y_1)$ is given by $\mathrm{P}(x_0, x_1, y_0, y_1, W) = \emptyset(\frac{U(x_0,x_1)-U(y_0,y_1)}{mu})$, where $\emptyset$ is the cumulative normal distribution, mu is a 'noise' term, and W represents the set of preference parameters to be estimated. In group estimation, the choices of the N subjects and 420 choices (21 price lists × 20 choices in each price list) are pooled together. Thus, the likelihood function $L(x_0, x_1, y_0, y_1, W)$ is obtained with the below equation.

$$\prod_{i=1}^{\mathrm{N}} \prod_{k=1}^{420} \left\{ P(x_0, x_1, y_0, y_1, W) \times I_{s_{i,k}=1} + [1 - P(x_0, x_1, y_0, y_1, W)] \times I_{s_{i,k}=-1} \right\},$$

where $s_{i,k}$ denotes the k-th choice of Subject i, and it is equal to 1 when Subject i chooses L option; otherwise, it is –1. The maximum likelihood estimation is performed in Stata 10, and the variances are clustered by individuals. We estimate the standard and reference-dependent discounted utilities based on functional forms (1) and (3), respectively. The estimation results are reported in Table VI.

For the discounted utility, the estimated utility curvature $\boldsymbol{\alpha}$ is 0.981, which is significantly smaller than 1 ($p < 0.039$), and it is similar to that obtained by Andreoni and Sprenger (2012a). The estimated discounted factor $\boldsymbol{\delta}$ is 0.903 for 6 months, which is significantly smaller than 1 ($p < 0.001$). The implied annual discount rate is 23% ($^1/_{0.903^2} - 1$). In the study of Andreoni and Sprenger (2012a), the estimated annual

[6]One criticism toward price list is that it sets out boundaries on decision and is prone to biases due to framing. In most economic experiments using price list, subjects often switch their preference from one side to another when they move along the list. The subjects are generally believed to have a tendency to switch in the middle of the price list irrespective of their true preference, so called "middle bias". In our experiment, we use broader boundaries in price list to provide a clearer and better representation of the decision situations. The list is always begun with a strictly dominated decision. Down the list, the dominated option in the starting row is gradually increased to a possibly dominating option at the end row. We check our data and find that subjects in our experiment do not exhibit a clear tendency to switch in the middle of the list.

discount rate is 30%. By applying the convex time budget in Singapore sample, Miao and Zhong (*in press*) estimate the annual discount rate as 34%. Our estimated result is comparable to these findings. Moreover, we further allow different discount factors for present-oriented fixed option and future-oriented fixed option in the structural estimation. The estimated discount factor for the present-oriented fixed option and present-oriented based option is 0.879 and 0.928, respectively. The difference between the two estimated discount factors is highly significant ($p < 0.001$), further supporting Prediction 1.

[*Insert Table VI here*]

For the reference-dependent intertemporal utility, the estimated utility curvature $\boldsymbol{\alpha}$ is 0.957, which is slightly more concave than that estimated with the discounted utility (0.981). Meanwhile, the estimated discount factor $\boldsymbol{\delta}$ for this utility is 0.903, which is similar to that for the discounted utility. The estimated weightage of the gain-loss utility $\boldsymbol{\gamma}$ is 0.073, which is significantly larger than 0 in support of the gain-loss utility in the intertemporal choice. For the loss aversion, the estimated parameter $\boldsymbol{\lambda}$ is 1.375, which is significantly greater than 1, suggesting that loss looms larger than gain in the intertemporal setting. In the literature, the coefficient of loss aversion is often observed to around 2 (e.g., Tversky and Kahneman, 1992). However, some studies also observe lower degree of loss aversion. For example, Beauchamp et al. (2012) report the mean of loss aversion parameters as 1.25 in decision making under risks. The estimated loss aversion in our study is also smaller than 2. This could be either due to the effect of reference point induced by price list is weak, or the effect of loss aversion in the intertemporal setting is weak.

5. Discussion

5.1. *Elicitation of Utility Curvature over Time*

The elicitation of utility curvature over time has long been debated in recent experimental literature. In most experiments, the standard price list elicits an indifference relation $(x_0, 0) \sim (0, y_1)$, implying that the subjects are indifferent between receiving a sooner amount x_0 and a later amount y_1. Under the discounted utility model, the utility curvature and discount factor cannot be jointly identified with the elicitation method. This issue has been addressed in several studies by relying on additional risk tasks for eliciting utility curvature and using the derived utility in the risk domain for estimating the discount factor (e.g., Takeuchi, 2011). Takeuchi (2011) elicits probability p such that receiving x with this probability is indifferent to receiving y, (i.e., $pu(x) = u(y)$). The researcher also elicits delay t such that the subject is indifferent between receiving x in time t and receiving y now (i.e., $\delta u(x) = u(y)$). From these tasks, Takeuchi (2011) infers that the discount factor δ is equal to p. The elicitation assumes that the utility curvature is the same for risk and time preference. This method has been criticized because the utility derived in risk domain may not be appropriate to be used in the intertemporal decision. Numerous recent experimental studies have consistently suggested that utility curvature over time is significantly less concave than that under risk (Andreoni and Sprenger, 2012a, b; Abdellaoui et al., 2013; Chueng, *in press*; Epper, and Fehr-Duda, *in press;* Miao and Zhong, *in press*).

Andreoni and Sprenger (2012a) propose Convex Time Budget (CTB), a novel experimental design, to elicit time preference. Convex Time Budget enables the joint identification of discount factor and utility curvature under the discounted utility model. Under Convex Time Budget, the subjects allocate 100 tokens between sooner and later payments given a certain interest rate r for late payment by choosing an optimal *x* among outcome sequences $(x/(1 + r), (100 – x))$. They estimate the utility curvature to be around 0.90, which is significantly larger than that estimated from risk tasks. Abdellaoui et al. (2013) also separately elicit the utility curvatures for the time and risk domains and report that the utility curvature is almost linear in the time domain and concave in the risk domain. More recently, Olea and Strzalecki (2014) provide an axiomatization for quasi-hyperbolic discounting with the use of annuity compensations that allows the measurement of discount factor independent from the utility curvature over time. Our price list design contributes to resolve the problem by implementing decisions on spread outcome sequences. Our modified price list design also allows the utility curvature over time and discount factor to be collectively estimated. This view is similarly shared by in a recent study by Chueng (2015), which also shows that price list with outcome sequence. In our estimation, we estimate power utility curvature as 0.96, which is comparable to those reported in Andreoni and Sprenger (2012a) as well as Abdellaoui et al., (2013).

5.2. *Elicitation of Discount Rate using Price List*

It has been increasingly recognized that price list could bias elicitation of preference.[7] For example, Beauchamp et al (2012) vary the set of alternative outcomes by holding the lowest and highest outcomes fixed and changing intermediate outcomes in the price list. They find that the manipulations robustly change measured risk preferences. Bosch-Domènech, and Silvestre (2013) show that removal of some items from the lists yields a systematic decrease in risk aversion. Freeman, Halevy, and Kneeland (2014) compare price list and simple binary choice, and show that price list could bias the elicitation of risk preference.

We show that the price list design may induce a reference-dependent behaviour because subjects may take the fixed option as a reference point, leading to biases in the elicited discount rate. Similar results have been reported for price list in the risk domain. In the study of Sprenger (*in press*), subjects are asked to choose between lotteries and sure amounts using price lists. It is shown that subjects appear to be risk averse when the fixed option is a sure amount, whereas they appear to be risk neutral when the fixed option is a lottery. Sprenger hypothesizes that subjects might take the fixed option as a reference point and further shows that the reference-dependent model in Köszegi and Rabin (2007) could rationalize the observed choice behaviour. By altering the fixed option in the price list, Castillo and Eil (2014) observe an endowment effect for risk, which shifts subjects from exhibiting the common ratio effect to exhibiting the reverse common ratio effect. They further show that observations are also consistent with the hypothesis that subjects take the fixed option in the price list as a reference point. All these studies support that fixed option would induce a reference point effect when subjects make decisions in the price list design. Moreover, these studies contribute to the understanding about the nature and validity of the price list as preference elicitation method.

The observation that price list may bias the elicitation of time preference could help reconcile some anomalies observed in the recent related studies. First, a notable feature of price list for time preference is that it generally yields high discount rates,

[7] Similarly, in another popular elicitation of matching design where subjects are asked to write down the amount of money they are willing to pay to get the object, Delquié (1993) conducts several experiments using adaptive matching questions to test framing effects and observes systematic biases from subjects' matching responses.

which are well above the market interest rates (see Frederick, Loewenstein, and O'donoghue, 2002 for a review). In contrast, using the Convex Time Budget design, Andreoni and Sprenger (2012a) observe a significantly lower average annual discount rate varying between 25% and 35%. We argue that this could be partly caused by the biased elicited discount rate in price list. The majority of the previous studies using price list have present-oriented fixed option and future-oriented varying option and they elicit an indifference relation of $(x_0, 0) \sim (0, y_1)$. By applying the standard discounted utility, we have ${x_0}^{\alpha} = \delta' {y_1}^{\alpha}$, and the inferred discount factor would be $\delta' = \frac{{x_0}^{\alpha}}{{y_1}^{\alpha}}$. However, when the decision maker considers the fixed option $(x_0, 0)$ as the reference point, the reference dependent utility model would be a more proper model. Accordingly, we would attain ${x_0}^{\alpha} = \delta {y_1}^{\alpha} + \gamma\lambda(-{x_0}^{\alpha}) + \delta\gamma({y_1}^{\alpha})$, and the elicited discount factor will be $\delta = \frac{{x_0}^{\alpha}(1+\gamma\lambda)}{{y_1}^{\alpha}(1+\gamma)} = \frac{{x_0}^{\alpha}}{{y_1}^{\alpha}} \frac{(1+\gamma\lambda)}{(1+\gamma)} = \delta' \frac{(1+\gamma\lambda)}{(1+\gamma)}$ under the reference-dependent model. Notice that γ is the loss aversion parameter and $\gamma > 1$ such that $\frac{(1+\gamma\lambda)}{(1+\gamma)} > 1$ and $\delta = \delta' \frac{(1+\gamma\lambda)}{(1+\gamma)} > \delta'$. Thus, if the decision maker has reference-dependent preferences, the estimated discount factor using the standard discounted utility would be downward biased by a factor of $\frac{1+\gamma}{1+\gamma\lambda}$, depending on the degree of loss aversion and the weightage for loss-gain utility. In our setting, when we use the present-oriented fixed option, the estimated annual discount rate using the standard discounted utility is 29.4%. By contrast, when we use the reference-dependent utility to conduct the estimation, the estimated annual discount rate is 22.6%.

Another puzzling observation in the literature on elicitation of time preference is the subadditivity (Read, 2001; Read and Roelofsma, 2003; Dohmen et al., 2012). For example, Dohmen et al. (2012) use price list to elicit the discount rate between now and six months, now and 12 months, as well as six months and 12 months, it is observed that subjects tend to have a higher annual discount rate using price list with a shorter duration (between now and six months, between 6 months and 12 months) than using price list with a longer duration (between now and 12 months). Given that the inferred discount factor between now and six months is $\delta'_{0,6}$ under the discounted utility model and the discount factor is $\delta_{0,6}$ under the reference-dependent model, as shown in the last paragraph, we have $\delta'_{0,6} = \frac{1+\gamma}{1+\gamma\lambda} \delta_{0,6}$. Accordingly, the inferred annual discount factor $\delta'_{0,12}$ under the discounted utility model would be $\delta'_{0,12} =$

${\delta'_{0,6}}^2 = \left(\frac{1+\gamma}{1+\gamma\lambda}\right)^2 \left(\delta_{0,6}\right)^2 = \left(\frac{1+\gamma}{1+\gamma\lambda}\right)^2 \delta_{0,12}$ by considering a 6-month duration between now and six months. The inferred annual discount factor from the discounted utility model would be biased by a factor of $\left(\frac{1+\gamma}{1+\gamma\lambda}\right)^2$compared with that from the reference-dependent model. Similarly, the inferred annual discount factor would be ${\delta'_{6,12}}^2 = \left(\frac{1+\gamma}{1+\gamma\lambda}\right)^2 \left(\delta_{6,12}\right)^2$using by employing the period between 6 and 12 months, while the inferred annual discount factor would be $\delta'_{0,12} = \frac{1+\gamma}{1+\gamma\lambda}\delta_{0,12}$ with the period between now and 12 months. Thus, the inferred discount factor would be downward biased by $\frac{1+\gamma}{1+\gamma\lambda}$ using a 12-month duration, while it would be downward biased by $\left(\frac{1+\gamma}{1+\gamma\lambda}\right)^2$ using a 6-month duration. This case incurs the inconsistency between the discount factors elicited from shorter or longer durations.

It is hard to precisely estimate the extent to which reference dependence in price list could account for these phenomena, as different studies also differ in terms of specific designs, instructions, subject pools and culture (see, Frederick, Loewenstein, and O'donoghue, 2002 for a review). For example, it is possible that transaction cost may also lead to the upward biased discount rate (e.g., Holcomb and Nelson, 1992; Benhabib, Bisin, and Schotter, 2010). Moreover, some other behavioural factors could contribute to the occurrence of such observations. For instance, Epper and Fehr-Duda (2014) incorporate the uncertainty inherent of future into the analysis and show that it could help account a number of observations commonly shared for decision making under risk and across time. Epper (2015) examines the role liquidity constraints and income expectations in rationalizing some anomalies in intertemporal choice. In sum, we posit that the reference dependence in price list could bias the elicitation of time preference and could partially account for the aforementioned anomalies.

6. Conclusion

We examine the reference-dependent preference toward outcome sequence comparison, complementing the earlier studies on how reference points can affect intertemporal decisions. In Loewenstein and Thaler (1989), when trading off the size of the reward and delayed time, people are generally willing to delay the reward by asking for some amount of compensation, but they are reluctant to give up the same amount to receive the reward earlier. For another example, people generally prefer increasing outcome sequence over decreasing outcome sequence (e.g., Gigliotti and Sopher, 1997; Loewenstein and Prelec, 1993; Loewenstein and Sicherman, 1991; Read and Powell, 2002). This particular behaviour is not compatible with the positive time discounting assumption in the standard economic theory, in which the delayed outcomes are valued less. The possible explanation for this case is that people take the past outcome/consumption as a reference point, leading to a preference for increasing a sequence over decreasing one. Several theoretical models have been proposed to capture the reference dependent behaviour on time sequences including the cognitive model of individual well-being by Gilboa and Schmeidler (1999), the expectation-based reference-dependent consumption model by Köszegi and Rabin (2009), and the satiation and habit formation by Baucells and Sarin (2010). Loewenstein and Prelec (1992) introduce reference dependence in the intertemporal setting to account for a number of behavioural anomalies, while they assume that status quo is the reference point. In the current research, we examine the comparison of outcome sequences, in which consumption in one sequence is taken as a reference point for consumption in another. The experimental results suggest that the outcomes in different sequences are separately compared at each time point, under which the intertemporal decisions can be affected depending on the different reference points used.

The findings in paper suggest that people behave differently depending on whether they are framed with future-oriented minds or present-oriented minds in the laboratory environment. A natural question is whether and how the reference-dependent intertemporal preferences could be applied to real life situations. As the example given in the Introduction, we deem that people tend to be lured into current pleasure and give up their future plans when their neighbours are present-oriented. Notably, Kuhn et al. (2011) examine social comparison in consumption behaviour and show that people increase their consumption after their neighbour won a Dutch postcode lottery. Moreover, it has been suggested that people regard their plans as reference points (Townsend and Liu, 2012). Following on that, our results also suggest that they are also more inclined to stick to their plans if they view their plan as a reference point. The behavioural insights of reference-dependent intertemporal preferences provides alternative perspective to nudge the self-control problems, including saving, smoking, and exercising behaviours.

Appendix. Theoretical Proofs

Theoretical Properties

Property 1. Given R′weakly dominates R,

$$U(C|R) = U(c_0, c_1, r_0, r_1) = c_0^\alpha + \delta c_1^\alpha + \mu(c_0^\alpha - r_0^\alpha) + \delta\mu(c_1^\alpha - r_1^\alpha)$$
$$\geq c_0^\alpha + \delta c_1^\alpha + \mu(c_0^\alpha - r_0'^\alpha) + \delta\mu(c_1^\alpha - r_1'^\alpha) = U(C|R').$$

The inequality is implied by μ being a strictly increasing function. Q.E.D.

Property 2. To show, if C and C' are not the same, $U(C|C') \geq U(C'|C')$ implies that $U(C|C) > U(C'|C)$. If C weakly dominates C', it would directly imply that $U(C|C) > U(C'|C)$. $U(C|C') \geq U(C'|C')$ implies that C' could not weakly dominate C. Thus we assume $c_0^\alpha \geq c_0'^\alpha$ and $c_1^\alpha \leq c_1'^\alpha$. Note that assumption $A3'$ will imply that $\mu(.)$ is linear as in equation (3).

As $U(C|C') \geq U(C'|C')$, we have

$$U(C|C') - U(C'|C') = c_0^\alpha + \delta c_1^\alpha + \gamma\lambda(c_0^\alpha - c_0'^\alpha) + \delta\gamma(c_1^\alpha - c_1'^\alpha) - c_0'^\alpha - \delta c_1'^\alpha$$
$$= (1 + \gamma\lambda)(c_0^\alpha - c_0'^\alpha) + (\delta + \delta\lambda)(c_1^\alpha - c_1'^\alpha) \geq 0.$$

To show $U(C|C) > U(C'|C)$, we calculate the difference as below,

$$U(C|C) - U(C'|C) = c_0^\alpha + \delta c_1^\alpha - \left(c_0'^\alpha + \delta c_1'^\alpha + \gamma(c_0'^\alpha - c_0^\alpha) + \delta\gamma\lambda(c_1'^\alpha - c_1^\alpha)\right)$$
$$= (1 - \gamma)(c_0^\alpha - c_0'^\alpha) + (\delta - \delta\gamma\lambda)(c_1^\alpha - c_1'^\alpha)$$
$$= U(C|C') - U(C'|C') + \gamma(1 - \lambda)(c_0^\alpha - c_0'^\alpha) + \delta\gamma(\lambda - 1)(c_1^\alpha - c_1'^\alpha)$$
$$> 0.$$

The last inequality holds, as $\gamma > 0$, $\lambda > 1$, $c_0^\alpha \geq c_0'^\alpha$, and $c_1^\alpha \leq c_1'^\alpha$. Similarly, we will have $U(C|C) > U(C'|C)$ for $c_0^\alpha \leq c_0'^\alpha$ and $c_1^\alpha \geq c_1'^\alpha$. Thus, $U(C|C) > U(C'|C)$. Q.E.D.

Theoretical Predictions

Prediction 1. Our design elicits three pairs of preference relations, including the present-oriented fixed option and future-oriented varying option $(r_0, 0) \sim (0, r_1)$, the present-oriented fixed option and spread varying option $(r_0, 0) \sim (x_0, x_1^*)$, and the future-oriented fixed option and spread varying option $(0, r_1) \sim (x_0, x_1^{**})$. By considering the present-oriented fixed option$(r_0, 0)$, we elicit the indifference point r_1 for future-oriented varying option such that $(r_0, 0) \sim (0, r_1)$. The loss and gain are incurred at times 0 and 1, respectively. By applying the reference dependent utility model, we obtain $r_0^\alpha = \delta r_1^{*\alpha} + \gamma\lambda(-r_0^\alpha) + \delta\gamma(r_1^{*\alpha})$, and the indifference point is expressed as follows:

$$r_1^{\alpha} = \frac{1+\gamma\lambda}{\delta(1+\gamma)} r_0^{\alpha}. \quad \text{(i)}$$

Similarly, for $(r_0, 0) \sim (x_0, x_1^*)$, we attain $r_0^{\alpha} = x_0^{\alpha} + \delta x_1^{*\alpha} + \gamma\lambda(x_0^{\alpha} - r_0^{\alpha}) + \delta\gamma(x_1^{*\alpha})$, and the indifference point is obtained with the below formula.

$$x_1^{*\alpha} = \frac{1+\gamma\lambda}{\delta(1+\gamma)} r_0^{\alpha} - \frac{1+\gamma\lambda}{\delta(1+\gamma)} x_0^{\alpha}. \quad \text{(ii)}$$

For $(0, r_1) \sim (x_0, x_1^{**})$, we acquire $\delta r_1^{\alpha} = x_0^{\alpha} + \delta x_1^{**\alpha} + \gamma(x_0^{\alpha}) + \delta\gamma\lambda(x_1^{**\alpha} - r_1^{\alpha})$, and the indifference point is

$$x_1^{**\alpha} = r_1^{\alpha} - \frac{1+\gamma}{\delta(1+\gamma\lambda)} x_0^{\alpha}. \quad \text{(iii)}$$

For Prediction 1, we consider how the present-oriented fixed option could bias the elicited discount factor. For $(r_0, 0) \sim (x_0, x_1^*)$, we elicit an x_1^* with a true discount factor δ in (ii). If we use the standard discounted utility to infer the discount factor δ^*, it would be $\delta^* = \frac{r_0^{\alpha} - x_0^{\alpha}}{x_2^{*\alpha}} = \delta \frac{1+\gamma}{1+\gamma\lambda}$. This implies that the inferred discount factor δ^* using the standard discounted utility would be downward biased relative to the true discount factor δ, as because $\frac{1+\gamma}{1+\gamma\lambda} < 1$. In other words, the decision maker would appear to be more impatient when the present-oriented outcome sequence is used.

Similarly, for $(0, r_1) \sim (x_0, x_1^{**})$, we could elicit an x_1^{**} with true discount factor δ in (iii). If we apply the standard discounted utility to infer the discount factor δ^{**}, it would be $\delta^{**} = \frac{x_0^{\alpha}}{r_1^{\alpha} - x_1^{*\alpha}} = \delta \frac{1+\gamma\lambda}{1+\gamma}$. This condition implies that the inferred discount factor δ^{**} would be upward biased relative to the true discount factor as δ because $\frac{1+\gamma\lambda}{1+\gamma} > 1$. In other words, the decision maker would appear to be more patient when the present-oriented outcome sequence is used. By comparing these cases, we have $\delta^{**} > \delta^*$. Note that x_0 does not influence the inferred discount factor. The same argument applies to the other types of varying option. *Q.E.D.*

Prediction 2. (i) and (iii) together implies that

$$x_1^{**\alpha} = \frac{1+\gamma\lambda}{\delta(1+\gamma)} r_0^{\alpha} - \frac{1+\gamma}{\delta(1+\gamma\lambda)} x_0^{\alpha}. \text{(iv)}$$

By comparing (ii) and (iv), we have $x_1^{**} > x_1^*$, and hence preference transitivity is violated; $(x_0, x_1^{**}) \succ (x_0, x_1^*)$. The gain-loss utility with $\gamma > 0$ and $\lambda > 1$ will would induce a higher r_1, x_1^*, x_1^{**}in (i), (ii), and (iii), respectively, compared when there is no gain-loss utility ($\gamma = 0$). Moreover, given that x_1^{**} in (iii) is based on the increased $r_1$induced by reference dependence, we would have $x_1^{**} > x_1^*$. The same argument stipulates for the other types of varying option. *Q.E.D.*

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Tables

Table I

Illustrative example of price list

<table>
<tr><th rowspan="2">Row</th><th colspan="2">Left Option</th><th colspan="2" rowspan="2">DECISION</th><th colspan="2">Right Option</th></tr>
<tr><th>Today</th><th>6 months</th><th>Today</th><th>6 months</th></tr>
<tr><td>1</td><td>$5</td><td>$40</td><td>L □</td><td>R □</td><td rowspan="10">$45</td><td rowspan="10">$0</td></tr>
<tr><td>2</td><td>$5</td><td>$41</td><td>L □</td><td>R □</td></tr>
<tr><td>3</td><td>$5</td><td>$42</td><td>L □</td><td>R □</td></tr>
<tr><td>4</td><td>$5</td><td>$43</td><td>L □</td><td>R □</td></tr>
<tr><td>⋮</td><td>⋮</td><td>⋮</td><td>L □</td><td>R □</td></tr>
<tr><td>⋮</td><td>⋮</td><td>⋮</td><td>L □</td><td>R □</td></tr>
<tr><td>17</td><td>$5</td><td>$56</td><td>L □</td><td>R □</td></tr>
<tr><td>18</td><td>$5</td><td>$57</td><td>L □</td><td>R □</td></tr>
<tr><td>19</td><td>$5</td><td>$58</td><td>L □</td><td>R □</td></tr>
<tr><td>20</td><td>$5</td><td>$59</td><td>L □</td><td>R □</td></tr>
</table>

Note. This table illustrates an example, in which subjects make choices for each of the 20 rows between the left option and the right option and indicate their choices in the middle column.

Table II

Summary of outcome sequences used in the experiment

No	Task	Varying options	Fixed option
1	***PF***	$\boldsymbol{F}_{\mathrm{IL}}$ (0, 100),….,(0, 138)	$\boldsymbol{P}_{\mathrm{fixed}}$ (100, 0)
2	***PS***	$\boldsymbol{S}_{\mathrm{IL}}$ (10, 90), …., (10, 128)	$\boldsymbol{P}_{\mathrm{fixed}}$ (100, 0)
3	***PS***	$\boldsymbol{S}_{\mathrm{DL}}$ (90, 10), ….,(90, 48)	$\boldsymbol{P}_{\mathrm{fixed}}$ (100, 0)
4	***PS***	$\boldsymbol{S}_{\mathrm{IE}}$ (10, 90), …., (48, 90)	$\boldsymbol{P}_{\mathrm{fixed}}$ (100, 0)
5	***PS***	$\boldsymbol{S}_{\mathrm{DE}}$ (90, 10), …., (128, 10)	$\boldsymbol{P}_{\mathrm{fixed}}$ (100, 0)
6	***FS***	$\boldsymbol{S}_{\mathrm{IL}}$ (10, 90), …., (10, 128)	$\boldsymbol{F}_{\mathrm{fixed1}}$ (0, 102)
7	***FS***	$\boldsymbol{S}_{\mathrm{DL}}$ (90, 10), ….,(90, 48)	$\boldsymbol{F}_{\mathrm{fixed1}}$ (0, 102)
8	***FS***	$\boldsymbol{S}_{\mathrm{IE}}$ (10, 90), …., (48, 90)	$\boldsymbol{F}_{\mathrm{fixed1}}$ (0, 102)
9	***FS***	$\boldsymbol{S}_{\mathrm{DE}}$ (90, 10), …., (128, 10)	$\boldsymbol{F}_{\mathrm{fixed1}}$ (0, 102)
10	***FS***	$\boldsymbol{S}_{\mathrm{IL}}$ (10, 90), …., (10, 128)	$\boldsymbol{F}_{\mathrm{fixed2}}$ (0, 112)
11	***FS***	$\boldsymbol{S}_{\mathrm{DL}}$ (90, 10), ….,(90, 48)	$\boldsymbol{F}_{\mathrm{fixed2}}$ (0, 112)
12	***FS***	$\boldsymbol{S}_{\mathrm{IE}}$ (10, 90), …., (48, 90)	$\boldsymbol{F}_{\mathrm{fixed2}}$ (0, 112)
13	***FS***	$\boldsymbol{S}_{\mathrm{DE}}$ (90, 10), …., (128, 10)	$\boldsymbol{F}_{\mathrm{fixed2}}$ (0, 112)
14	***FS***	$\boldsymbol{S}_{\mathrm{IL}}$ (10, 90), …., (10, 128)	$\boldsymbol{F}_{\mathrm{fixed3}}$ (0, 122)
15	***FS***	$\boldsymbol{S}_{\mathrm{DL}}$ (90, 10), ….,(90, 48)	$\boldsymbol{F}_{\mathrm{fixed3}}$ (0, 122)
16	***FS***	$\boldsymbol{S}_{\mathrm{IE}}$ (10, 90), …., (48, 90)	$\boldsymbol{F}_{\mathrm{fixed3}}$ (0, 122)
17	***FS***	$\boldsymbol{S}_{\mathrm{DE}}$ (90, 10), …., (128, 10)	$\boldsymbol{F}_{\mathrm{fixed3}}$ (0, 122)
18	***FS***	$\boldsymbol{S}_{\mathrm{IL}}$ (10, 90), …., (10, 128)	$\boldsymbol{F}_{\mathrm{fixed4}}$ (0, 132)
19	***FS***	$\boldsymbol{S}_{\mathrm{DL}}$ (90, 10), ….,(90, 48)	$\boldsymbol{F}_{\mathrm{fixed4}}$ (0, 132)
20	***FS***	$\boldsymbol{S}_{\mathrm{IE}}$ (10, 90), …., (48, 90)	$\boldsymbol{F}_{\mathrm{fixed4}}$ (0, 132)
21	***FS***	$\boldsymbol{S}_{\mathrm{DE}}$ (90, 10), …., (128, 10)	$\boldsymbol{F}_{\mathrm{fixed4}}$ (0, 132)

Note. This table summarizes the 21 prices lists used in the experiment for the corresponding tasks (2nd column), varying options (3rd column) and fixed options (4th column).

Table III.A

An illustration of Preference Relations for Subject 70

<table>
<tr><th colspan="5">Price List 1:</th><th></th><th colspan="5">Price List 6, 10, 14, 18</th></tr>
<tr><td colspan="2">Varying option:
$F^{\sim}$</td><td rowspan="3">~</td><td colspan="2">Fixed option:
P_{fixed}</td><td rowspan="3">~</td><td colspan="2">Varying option:
$S_{IL}^{\sim P}$</td><td rowspan="3">?</td><td colspan="2">$F^{\sim}$</td></tr>
<tr><td>Now</td><td>6 m</td><td>Now</td><td>6 m</td><td>Now</td><td>6 m</td><td>Now</td><td>6 m</td></tr>
<tr><td>0</td><td>111</td><td>100</td><td>0</td><td>10</td><td>99</td><td>0</td><td>111</td></tr>
<tr><td colspan="3"></td><th colspan="5">Price List 2:</th><td colspan="3"></td></tr>
</table>

Table III.B

An illustration of Preferences on “future versus spread” for Subject 70

Price List	Future-oriented Fixed option				Spread Varying option		
		Now	Six months			Now	Six months
6	F_{fixed1}	0	102	~	S_{IL1}	10	93
	$F^{\sim}$	0	111	~	$S_{IL}^{\sim F}$	10	?
10	F_{fixed2}	0	112	~	S_{IL2}	10	101
14	F_{fixed3}	0	122	~	S_{IL3}	10	113
18	F_{fixed4}	0	132	~	S_{IL4}	10	123
			x_i				y_i

Table IV

Summary of inconsistent patterns

Inconsistent pattern	$S_{IL}^{\sim F} \succ S_{IL}^{\sim P}$	$S_{DL}^{\sim F} \succ S_{DL}^{\sim P}$	$S_{IE}^{\sim F} \succ S_{IE}^{\sim P}$	$S_{DE}^{\sim F} \succ S_{DE}^{\sim P}$
Percentage	55.2%	80.6%***	80.6%***	64.2%*

Note. Summary percentage of subjects with predicted inconsistent pattern. We examine whether the proportion is significantly different from 50% by conducting a binomial test. ***p-value <0.01, **p-value <0.05, *p-value <0.1

Table V

Logit regression on the inconsistent patterns

	Estimate	Std. Error	z-value	p-value
Intercept	1.42	0.31	4.61	0.00***
Decreasing	-0.84	0.40	-2.1	0.04*
Late-focused	-1.21	0.40	-3.08	0.00**
Decreasing * Late-focused	2.06	0.56	3.66	0.00***

Note. The dependent variable is whether the subject exhibits the predicted inconsistent pattern $S^{\sim F} \succ S^{\sim P}$, and the independent variables are the interaction between whether the spread outcome sequence is late focused and whether the spread outcome sequence is increasing. We report the estimated coefficients (column 2), standard error (column 3), and z- and p-values (column 4).

Table VI

Structural estimation of utility models

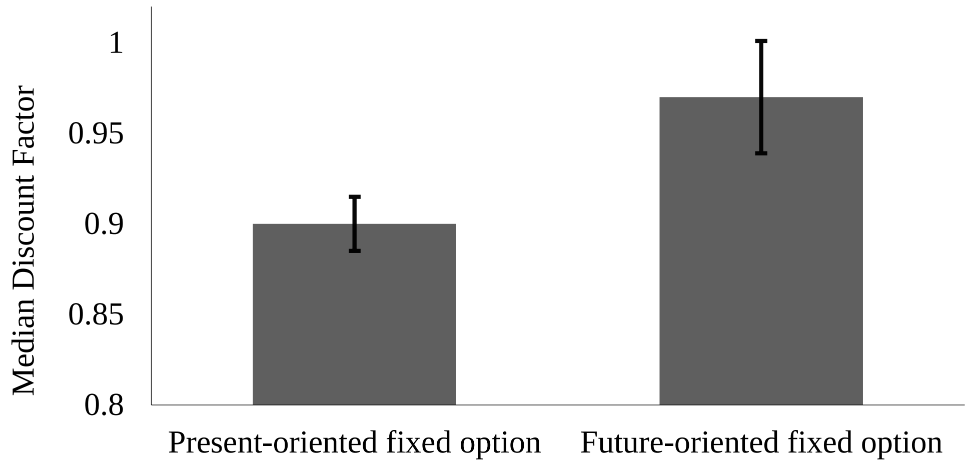
Variable	Estimate	S.E	Z	P	Lower 95%CI	Upper95% CI
Panel A: Discounted Utility, Log-likelihood = -12809.03						
α	0.98	0.01	103.53	0	0.96	1.00
δ	0.90	0.01	89.1	0	0.88	0.92
μ	10.20	0.79	12.96	0	8.66	11.74
Panel B: Reference-dependent Discounted Utility, Log-likelihood = -12727.055						
α	0.96	0.01	89.85	0	0.94	0.98
δ	0.90	0.01	93.39	0	0.88	0.92
γ	0.07	0.01	11.6	0	0.06	0.09
λ	1.38	0.04	37.2	0	1.30	1.49
μ	9.54	0.77	12.38	0	8.03	11.05

Note. The table reports the estimates, robust standard errors, z-value, p-value, lower 95% confidence interval, and upper 95% confidence interval for the discounted utility (Panel A) and reference-dependent discounted utility (Panel B)

Figures

Figure I

Discount factor elicited from present- and future-oriented fixed option



Online Appendix. Experimental Instructions and Sample Decision Sheet

Appendix A. Experimental Instructions

Thank you for participating in our experiment. All information provided by you including your personal information, decisions and earnings will be kept confidential. It is important that you do not communicate with other participants. If you have any questions during the experiment, raise your hand and the experimenter will approach you.

Task

You will be asked to make decisions between two options. Each option is to get some amounts of money in specified date(s). Table 1 provides an example for the choice scenario.

	Left Option		DECISION		Right Option	
Row	TODAY	6 months			TODAY	6 months
1	$5	$41	L □	R □	$45	$0
2	$5	$42	L □	R □		
3	$5	$43	L □	R □		
4	$5	$44	L □	R □		
5	$5	$45	L □	R □		
6	$5	$46	L □	R □		
7	$5	$47	L □	R □		
8	$5	$48	L □	R □		
9	$5	$49	L □	R □		
10	$5	$50	L □	R □		

Table 1

In each row of table 1, there is an option on the left hand side (referred as **L option**) and an option on the right hand side (referred as **R option**). Options always describe money amounts received at two time points. In the above table the two time points are TODAY and 6 months from now. We will take row 2 for an example. In row 2, the R option tells that you can get $45 today while get nothing after6 months. The L option tells that you get $5 today and will also get $42 after6 months.

Besides, the decision situations of L option gets better from row 1 to row 10, while the R option is constant always. You may prefer R option for the first several rows. But when you move down the decision table, L options gets better and better, you may switch your preferences and choose L option in the last few rows of the decision table.

You need to compare the money amount received in two time points in L option with that in the R option for each row, and choose the preferred one by ticking the corresponding box in the middle "Decision" column – L or R – with a tick (√). This decision table consists of 10 rows, which means there are 10 choices to make.

Earnings

Every participant will receive $10 for participating in the experiment. Besides, one subject in the room will be randomly selected to be paid based on one of the decisions he/she makes. The one decision will be selected according to the procedure explained below.

Random Procedure

There are in total 25 decision tables in the experiment and one of the decision tables will be randomly selected. After the one decision table is selected, one row in the selected decision table is randomly selected. Then, the experimenter will look into the decision made by the selected participant for the selected row. The preferred option for that row will be played out for real for the participant. Every choice has an equal chance to be selected. As a consequence, it is in your best interest to treat each choice as real.

Moreover, for the randomly selected participant, the $10 show-up fee is always paid at the two time points of the choice selected with $5 each. The rest of the subjects get the $10 show-up fee at the end of the experiment. We will explain this by the following example.

For example, the following decision table is randomly selected.

	Left Option		DECISION		Right Option	
Row	TODAY	6 months			TODAY	6 months
1	$5	$41	L ☐	R ☑	$45	$0
2	$5	$42	L ☐	R ☑		
3	$5	$43	L ☐	R ☑		
4	$5	$44	L ☑	R ☐		
5	$5	$45	L ☑	R ☐		
6	$5	$46	L ☑	R ☐		
7	$5	$47	L ☑	R ☐		
8	$5	$48	L ☑	R ☐		
9	$5	$49	L ☑	R ☐		
10	$5	$50	L ☑	R ☐		

Table 2

Suppose row 3 of the table is selected to be played for real. The participant chose the R Option for row 3. Therefore, the participant will get $45 immediately while get nothing after 6 months plus the participant can get $5 in each time point. So in total, he/she gets $50 TODAY and $5 after 6 months.

Suppose row 4 is selected to be played for real. The participant chose the L Option. Therefore, the participant will get $5 immediately and will get $44 after 6 months plus the participant can get $5 in each time point. So in total, he/she gets $10 TODAY and $49 after 6 months.

Payment

Since some money is paid in the future, we will sign you cheques with the specified date at the end of today's experiment. Under Singapore banking practices, a cheque can be cashed only on or within 6 months of the date of the cheque.

Please note that each question in this experiment may determine your final earnings. Therefore, it is important to consider each question carefully.

Additional tips on filling out the questionnaire

Instead of ticking for each row as in table 2, you can draw the vertical lines to indicate your preferences as in table 3. You can use either the ticks or the vertical lines to answer the questions in the experiment.

	Left Option		DECISION		Right Option	
Row	TODAY	6 months			TODAY	6 months
1	$5	$41	L ☐	R ☐		
2	$5	$42	L ☐	R ☐		
3	$5	$43	L ☐	R ☐		
4	$5	$44	L ☐	R ☐		
5	$5	$45	L ☐	R ☐	$45	$0
6	$5	$46	L ☐	R ☐		
7	$5	$47	L ☐	R ☐		
8	$5	$48	L ☐	R ☐		
9	$5	$49	L ☐	R ☐		
10	$5	$50	L ☐	R ☐		

Table 3

Appendix B. Sample DECISION SHEET

For each of the20rows in the table below, please indicate your decision in the middle column with a tick (√).

Row	Left Option		DECISION		Right Option	
	TODAY	6 months			TODAY	6 months
1	$0	$100	L □	R □	$100	$0
2	$0	$102	L □	R □		
3	$0	$104	L □	R □		
4	$0	$106	L □	R □		
5	$0	$108	L □	R □		
6	$0	$110	L □	R □		
7	$0	$112	L □	R □		
8	$0	$114	L □	R □		
9	$0	$116	L □	R □		
10	$0	$118	L □	R □		
11	$0	$120	L □	R □		
12	$0	$122	L □	R □		
13	$0	$124	L □	R □		
14	$0	$126	L □	R □		
15	$0	$128	L □	R □		
16	$0	$130	L □	R □		
17	$0	$132	L □	R □		
18	$0	$134	L □	R □		
19	$0	$136	L □	R □		
20	$0	$138	L □	R □		

[Note: Other decision sheets are presented in a similar manner. The decision sheets are presented to each subject in random order.]