An Experimental Study of Money Illusion in Intertemporal Decision Making [*]

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Abstract

To examine the degree to which price fluctuations affect how individuals approach an intertemporal decision making problem, we conduct a laboratory experiment in which subjects spend their savings on consumption over 20 periods. In the control treatment, the commodity price is constant across all periods. In the small (large) price fluctuations treatment, the price rate of change is always 1% (20%). The rate of change of savings is always the same as the commodity price. Therefore, the optimal amount of consumption is the same in all three treatments. Our main findings are threefold. First, the magnitude of misconsumption is significantly high in order of the control, small price fluctuation, and large price fluctuation treatments. Second, in the control treatment, the magnitude of misconsumption shrinks over time, whereas it gradually increases in the small and large price fluctuation treatments. Finally, regardless of the presence of price fluctuations, subjects exhibit under-consumption behavior and the presence of price fluctuations strengthens such a tendency.

Keywords: intertemporal decision making, money illusion, economic experiment
JEL Classification: C91, D91, E31

1. Introduction

Much research has been devoted to examining how people actually approach intertemporal decision making (IDM) problems. IDM is a key formulation of dynamic models in financial theory, operation research, game theory, and micro- and macroeconomic theory, within which agents are usually assumed to be unboundedly rational and able to solve dynamic programming problems. However, the results of previous studies of experiments on IDM suggest that individuals are unable to get the optimal strategy correctly even though they try to solve

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complex decision problems rationally (Johnson et al. 1987, Hey and Dardanoni 1988; Anderhub et al. 2000; Carbone and Hey 2001; Houser and Winter 2004; Hey and Knoll 2011).

The purpose of this paper is to investigate how price fluctuations influence individuals' choices in an intertemporal consumption/savings problem. In real life, people fail to optimize IDM not only because such problems are complex, but also because most transactions are in nominal terms and prices are not always constant; in other words, people may often suffer from "money illusion." Although experimental studies of money illusion have shown that nominal frames often influence individuals' decisions, in most of these works, the underlying decision problems are static or a repetition of a static problem in which the nominal frame changes only once (e.g. Fehr and Tyran 2001). Thus, the question of how ongoing price fluctuations affect individual behavior in IDM problems remains. This study explores whether money illusion influences intertemporal consumption/savings problems. Because the nominal terms that people face change over time in association with a price fluctuating, how do these changing nominal terms influence individuals' consumption/savings behavior? Does the trend or volatility of price fluctuations interfere with individuals' learning for the real values of transactions, and influence individuals' welfare? This study investigates these questions by using a laboratory experiment.

2. Experimental design and hypotheses

We consider a simple IDM problem with a lifetime of 20 periods. At the beginning, a subject possesses $40{,}000$ points (experimental currency units) in his savings account to spend during these 20 periods. Additional money is not credited to his account. In each period, he can spend his savings to buy only one commodity. Let x_t be the amount of the commodity purchased in period t; then, his payoff function is given by $\sum_{t=1}^{20}\sqrt{x_t}$. The money that remains after period 20 is irrelevant to his payoff. The experimental design consists of three treatments. Regardless of the treatment, the commodity price in the first period is 80 points, and over time, the subject's savings remain in his account and the commodity price changes at the same rate. In the control treatment, denoted by C, price is constant across all periods. In the large (small) price fluctuation treatment, denoted by L (S), price increases by 20% (1%), decreases by 20% (1%), or is unchanged at the beginning of each period. Each event occurs with an equal probability. Since price and savings always change at the same rate, price fluctuations are irrelevant to the optimal consumption. Thus, all treatments differ only in their nominal terms.

Let p_t and M_t be the commodity price and amount of money that remains in his savings account in period t, respectively. Then, in any period T, the payoff in the remaining periods, i.e., $\sum_{t=T}^{20}\sqrt{x_t}$, is maximized by the sequence $(x_t)_{t=T}^{20}$ of consumption, in which $x_t = x(m_T) = m_T/(20 - T + 1)$ for all t, where $m_T = M_T/p_T$ is the real value of the savings in T. Optimal consumption does not depend on any nominal variables including future prices.

Our experiment was conducted at the Takasaki City University of Economics. Subjects were undergraduate students that had not participated in any prior IDM experiments; each subject could only participate in one treatment. All treatments were conducted in the same laboratory, and each computer terminal in the laboratory was assigned a computer program associated with one of the treatments. Subjects were seated in front of the computer terminal at random. The total number of subjects who participated in treatment C was 20, in treatment S was 21, and in treatment L was 23. Each subject was asked to read the instructions carefully, which provided all the information about the structure of the treatment to which they had been allocated including the price distribution. Before the actual experiment began, subjects were told to solve the practice problems. No subject could begin the actual experiment unless all problems had been answered correctly. In each period in the actual experiment, each subject was asked to input his expenditure $p_t x_t$ on the commodity for the current period. On the computer screen, each subject could always observe the amount of money he currently held, the current commodity price, and the percentage price change from the previous period. Past consumption and expenditure were also displayed on the screen. Once the expenditure for the current period had been inputted, the next period automatically began. The time for decision making was not restricted. However, it was approximately one hour for most subjects. One point was converted into 14 yen, and a cash reward was paid to each subject privately.

Our analysis focuses on the difference between actual and optimal consumption (hereafter misconsumption) in each treatment. For treatment $\mathrm{A} \in \{\mathrm{C}, \mathrm{L}, \mathrm{S}\}$, let D_t^A be the misconsumption in period t in treatment A and $|D_t^A|$ be its absolute value. D_t^A can be written as $D_t^A = x_t^A - x(m_t)$, where x_t^A is actual consumption in period t in treatment A. We focus on $|D_t^A|$ when analyzing the magnitude of misconsumption and on D_t^A when analyzing its direction. The impact of price fluctuations throughout all periods can be measured by the difference in $|D_t^A|$ in the entire study period between C and L, or S. Thus, we test the following hypothesis that price fluctuations do not affect subjects' behavior on average:

Hypothesis 1 (Money illusion does not matter on average)

$$\sum_{t=1}^{20} (|D_t^H| - |D_t^C|) = 0, and \sum_{t=1}^{20} (|D_t^L| - |D_t^C|) = 0.$$

We also analyze the round effects of price fluctuations in each treatment. If a subject learns the optimal solution over time, $|D_t^A|$ will approach 0. Thus, we test the following hypothesis:

Hypothesis 2 (Learning optimal consumption) $|D_t^A|$ is a decreasing function of t and it converges to 0 for any $\mathrm{A} \in \{\mathrm{C}, \mathrm{L}, \mathrm{S}\}$.

The subjects in our experiment can be mistaken in two directions, namely under-consumption, i.e., $D_t^A < 0$, and over-consumption, i.e., $D_t^A > 0$. We thus also test the following hypothesis that their misconsumption does not tend toward the direction of either:

Hypothesis 3 (Deviations from the optimal solution are random)

$$\sum_{t=1}^{20} D_t^A = 0, \text{for any A } \in \{\text{C, L, S}\}.$$

3. Results

3.1. Tests for Hypothesis 1 and 2

We first focus on the magnitude of misconsumption $|D_t^A|$. Table 1 presents means and standard deviations for each treatment.

Table 1. Mean of the absolute value of misconsumption

	C (Control)	S (1% fluctuation)	L (20% fluctuation)
	Obs.=361	Obs.=399	Obs.=418
Mean (S.D.)	13.91 (25.07)	20.37 (32.44)	27.23 (33.26)

The order of the magnitude of the means is mean(C) < mean(S) < mean(L). The mean transitions of the absolute values of misconsumption by treatment are presented in Figure 1. In earlier periods, there is no large gap among them, while the absolute value of the misconsumption in the L treatment is larger than those of the other two after the 6th period. Toward the end of the study period, the absolute values of the misconsumption of S and L are larger than that of C. We test these observations in the econometric analysis below.

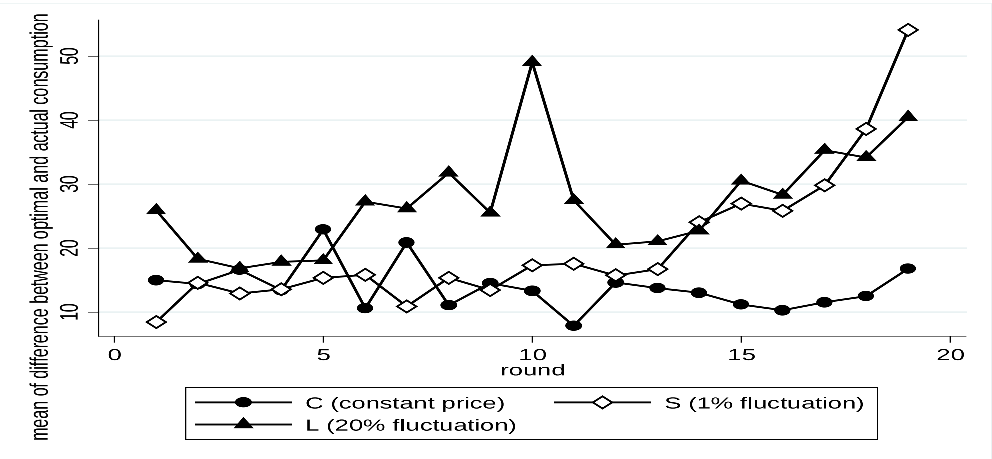

Figure 1. Transitions of the absolute values of misconsumption by treatment

We regress the treatment dummies on the absolute value of misconsumption with controlling for other variables that may influence subjects' intertemporal decisions, such as individual characteristics. In order to obtain subjects' characteristics, a questionnaire survey was conducted at the end of each laboratory experiment. The estimation results for the models, which test Hypothesis 1, are presented in Columns (1) and (2) of Table 2. They show that subjects in the L treatment are likely to misconsume commodities at the 1% significance level relative to those in the C treatment. The coefficients of the S dummy in Columns (1) and (2) also suggest that subjects may make suboptimal intertemporal decisions relative to C. In particular, the magnitude of misconsumption in L is larger than that in S.

We present the results of testing Hypothesis 2 in Columns (3) and (4) of Table 2. The misconsumption in C decreases over period because the signs of the estimated coefficients for period in Columns (3) and (4) are significant and negative. The misconsumption in S increases by period because the summation of the coefficients for period (i.e., -0.809) and interaction terms (i.e., 1.281) is positive in all models. As for L, the summation of the coefficients for period (i.e., -0.809) and interaction terms (i.e., 0.812) is positive but quite close to 0, implying that the increasing speed of the misconsumption is moderate compared to that in S.

Table 2. Estimation results for testing Hypotheses 1 and 2

	(1)	(2)	(3)	(4)
S (1%) dummy	8.789***	4.531*	-4.018*	-8.276***
	(1.124)	(2.553)	(2.120)	(2.690)
L (20%) dummy	9.548***	12.61***	1.429	4.491***
	(0.909)	(1.314)	(1.739)	(1.644)
S (1%) dummy × Period			1.281***	1.281***
			(0.186)	(0.135)
L (20%) dummy × Period			0.812***	0.812***
			(0.166)	(0.113)
Period	-0.0868	-0.0868*	-0.809***	-0.809***
	(0.0665)	(0.0518)	(0.153)	(0.100)
Constant	7.072**	-38.26***	14.29***	-31.04***
	(3.115)	(2.891)	(3.308)	(3.131)
Individual fixed effects	no	yes	no	yes
F-value	27.42***	33.95***	30.95***	41.48***
Adj. R-squared	0.239	0.635	0.289	0.688

Note: Robust standard errors are in parenthesis. ***, ** and * represent 1%, 5% and 10% significance level, respectively. The results of the other variables are omitted in the table.

3.2. Tests for Hypothesis 3

In order to assess whether subjects' misconsumption shows a trend toward under- or over-consumption, we next focus on the results for D_t^A itself. Table 3 shows means, standard deviations, and the results of *t*-test for each treatment for which null hypothesis is that the mean is equal to zero. We find that regardless of the presence of price fluctuations, subjects display under-consumption (over-saving) behavior overall.

Table 3. Mean of the misconsumption

	C (Control)	S (1% fluctuation)	L (20% fluctuation)
	Obs.=361	Obs.=399	Obs.=418
Mean	-3.22**	-13.13***	-9.83***
(S.D.)	(28.50)	(35.99)	(41.87)

Note: ***, ** and * represent 1%, 5% and 10% significance level, respectively.

Furthermore, the existence of price fluctuations seems to strengthen the over-saving behavior of subjects. This observation is confirmed by the Wilcoxon–Mann–Whitney test results in Table 4.

Table 4. Wilcoxon–Mann–Whitney test for Hypothesis 3

		X	
		S (1% flactuation)	L (20% flactuation)
Y	C (constant Price)	-2.41 **	-5.20 ***
	S (1% flactuation)	-	1.76 *

Note: The Wilcoxon statistic is calculated based on the sum of ranks of observations of X.

3.3. Payoff comparison among treatments

In this subsection, we focus on the actual payoffs of the subjects. Table 5 presents means and standard deviations for each treatment.

Table 5. Mean of the actual payoffs

	C (Control)	S (1% fluctuation)	L (20% fluctuation)
	Obs.=19	Obs.=21	Obs.=22
Mean (S.D.)	86.28 (18.66)	78.31 (29.44)	72.16 (22.33)

According to the Wilcoxon–Mann–Whitney test, the actual payoff in C is larger than that in L at the 1% significance level (z = -2.746). The actual payoff in S is also larger than that in L at the 5% significance level (z = -2.041), whereas there are no significant gaps between the other combinations of any two treatments.

4. Concluding remarks

This study conducted a laboratory experiment in which subjects spent their savings on consumption over 20 periods under price fluctuations, in order to study how money illusion affects individual IDM. We first tested the hypothesis that money illusion does not matter. This hypothesis was rejected by the results of our experiment that the magnitude of misconsumption is large when price fluctuations are large. We also tested the hypothesis that subjects learn the optimal solution over time. Shafir et al. (1997) suggested that money illusion is not eliminated with experience. Their suggestion could be supported by our observation that without price fluctuations, subjects may learn the optimal solution, meaning their mistakes shrink over time, whereas with price fluctuations mistakes gradually accumulate.

Johnson et al. (1987) found in their series of experiments that most subjects display over-saving behavior in IDM. Our results also showed that our subjects display under-consumption (over-saving) behavior. Furthermore, we found that price fluctuations strengthen the tendency toward such behavior.

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