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Saving Behavior under the Influence of Income Risk: An Experimental Study

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Abstract

Individual subjects are experimentally tested for precautionary saving. We use a simplified experimental framework and decision supporting tool to show that subject's consumption is consistent with precautionary saving. We find that subjects overact in changing current income. However, those over-reactions cancel each other, and subject's consumption behavior is close to the optimal solutions on average.

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1. Introduction

Precautionary saving is a theory which states that people who maximize the expected utility of consumption increase saving when increasing income risk is anticipated (Leland (1968)). However, most empirical studies have failed to observe a significant degree of precautionary saving (Lusardi (1998) etc.). In the experimental literature, the qualitative features of precautionary saving have been confirmed; when the risk of income is large, subjects' consumption decreases in the initial part of the experiment and increases in the latter part (Ballinger et al. (2003), Carbone and Hey (2004)). However, subject's consumption behavior is not like the solution of dynamic programming, but rather it is myopic. Subjects seem to behave as if the experiment is ending shortly. Subjects tend to over-consume in the earlier stage of the experiment and under-consume in the later stage. For example, the experimental period of Carbone and Hey (2004) was 25 periods. However, the average apparent horizon of subjects was between 5.19 and 6.77 periods, depending on their parameter setting. A natural question for this result is whether or not a subject can solve the dynamic problem if the experiment period is shorter. Therefore, we perform the experiment by using a 6 period binomial model for the income process. In addition, subjects tend to exhibit over-sensitivity in changing current income. This may be due to the fact that subjects decide consumption without clearly understanding the concave relation between consumption and utility. Therefore, we introduce a decision supporting tool which shows the relation between her consumption and utility graphically. We assume this to be a computer based life-cycle financial advice tool similar to those found on the web.

In the next section, we explain our experimental design. In section 3, we explain the results; in both high and low variance income treatment, we still find that subjects over-respond to changes in current income. However, those over-responses cancel out each other and their consumption is close to the optimal solutions on average. Section 4 concludes with a discussion of ongoing work.

2. Experimental Design

A standard model to choose the current consumption C_t maximizes the expected discounted utility, subject to an intertemporal budget constraint: That is

$$\max_{\{c_t\}} u(C_t) + E_t \sum_{s=t+1}^{T} \beta^{(s-t)} \cdot u(C_s) \qquad (1),$$

subject to $A_{s+1} = (1+r)(A_s + Y_s - C_s)$ for all $s = t, t+1, \cdots, T-1$, where $u()$ is a utility function, β is a discount factor, r is a interest rate, A is the value of assets, and Y is the labor income associated with risk. The optimal solution to this problem is found using dynamic programming by backward induction. We implemented this model in the experiment. There were six periods in the experiment. Each subject was given 6 dollars at the beginning of each period 1. Subjects must decide how much of their money they consume or save during each period. Each subject was directed to input integer units of consumption into the computer and the remaining money was automatically considered to be savings[1]. Goods for consumption were explained to be "food". The price of one unit of food was 1 dollar. Each subject obtained "satisfaction points" as they consume food. Subjects were informed of the concave conversion scale from the consumption of food into satisfaction points. The satisfaction point was minus 1 when the subject consumed nothing. It increased sharply for some initial consumption, but increased slowly after a certain amount of additional consumption. Figure 1 shows this conversion scale[2]. It was displayed on the subjects' computer screen during the experiment. The triangular mark in Figure 1 represents the subject's current budget. The square mark represents the subject's current consumption choice. In this case, she could consume up to 6 units of food, her choice was zero units, and the associated satisfaction point was minus one. Those marks changed in real-time when her budget changed or when she chose different units of consumption. During the paid sessions, the subject's satisfaction points were accumulated and she earned 100 Japanese yen (100 JPY is about 1 USD) for each satisfaction point plus 1,000 JPY for participating.

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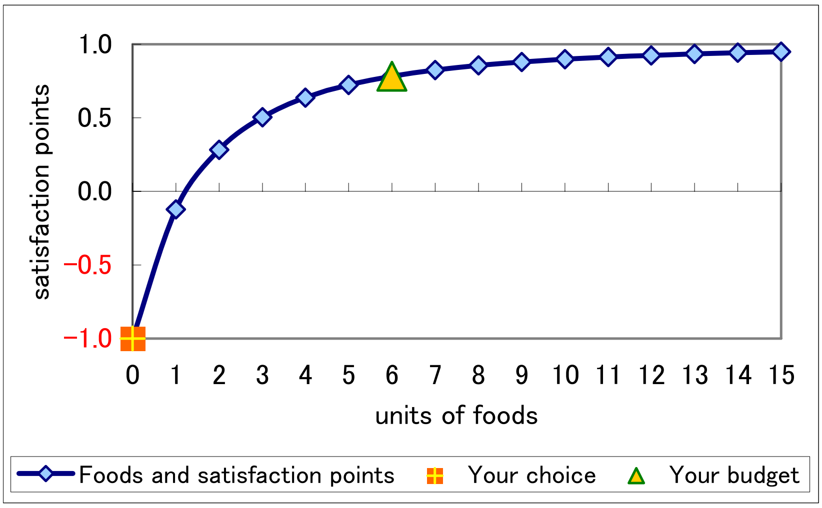
1 We set the interest rate to zero and imposed a blowing constraint.

2 Referring to Ballinger et al. (2003), the actual function we used is $U(C) = \kappa + \theta \cdot (C + \varepsilon)^{1-\lambda} / (1-\lambda)$, where $U(C)$ is the satisfaction points and C is units of consumption. we set $\kappa = 1.0$, $\varepsilon = 3.0$, $\theta = 36.1$, $\lambda = 3.0$.

Figure 1: Relation between Consumption and Satisfaction Points

units of foods	satisfaction points
0	−1.00
1	−0.13
2	0.28
3	0.50
4	0.63
5	0.72
6	0.78
7	0.82
8	0.85
9	0.87
10	0.89
11	0.91
12	0.92



We used a binomial model without re-combining for the income process. It follows either low-variance (LV) treatment or high-variance (HV) treatment.

LV: Income is either 4 dollars (probability=50%), or 6 dollars (p=50%),

HV: Income is either 0 dollars (p=50%), or 10 dollars (p=50%).

A subject may consume differently for the same income treatment whether she knows of existence of anther income risk treatment other than hers. In our experiment, each subject experienced both HV and LV. Some subjects experienced HV in the first half of the day and LV later, while other experienced it in reverse order. By doing this, we anticipated that subjects would consider their consumption strategy more carefully.

For each treatment, there were 32 (=2^5) income path patterns. We performed the experiment on two different days (January 27 and February 24, 2007) for different subjects. There were 16 income path patterns[3] on day1 and the remaining 16 patterns were done on day2. The problem that subjects actually faced could be solved by maximizing the expected prize, which is essentially equivalent to equation (1). We computed the optimal units of consumption for each treatment numerically by integer programming. Subject could earn

[3] Regrettably, we failed to record the result of one income path pattern on day1. The number of the recorded income path patterns on day1 was 15 instead of 16.

more money by following this optimal strategy than any other strategies on an ex ante basis. Subjects were recruited from the student body of Aoyama Gakuin University in Tokyo. The number of subjects was 24 persons on day1 and 24 on day2. We spent 60 minutes for the experimental instruction and practice sessions, and 70 minutes for the paid sessions. The average prize was 6,779 JPY including the payment for participating.

3. Results

Table 1 shows the average of subject's consumption of each period for both HV and LV. As found in the literature, subject's behavior is qualitatively consistent with precautionary saving. For the earlier period, the average consumption in HV is smaller than LV. In contrast, for the later period, it follows the opposite pattern. The differences are statistically significant.

Table 1: Subject's Average Consumption

Treatment	Obs	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6
LV (Std.Err.	371	4.95 (0.04)	4.96 (0.04)	4.91 (0.07)	5.04 (0.05)	5.23 (0.06)	5.80 (0.08)
HV	372	2.78 (0.04)	3.99 (0.13)	4.30 (0.14)	4.67 (0.16)	6.15 (0.20)	8.83 (0.30)
Difference (t-value)		2.16 (36.56**)	0.97 (7.05**)	0.61 (3.94**)	0.37 (2.26*)	-0.92 (-4.35**)	-3.02 (-9.65**)

(Note) ** indicates statistical significance at 1%, * at 5%.

Table 2 shows the overall average deviation (= subject's consumption - optimal solution). For both treatments, the null hypothesis that the overall deviation is zero can not be rejected. This means that, on average overall, the subject's consumption are close to the optimal solutions.

Table 2: Overall Average Deviation from Optimal Solution

Treatment	Obs	Avg	Std.Err.	t-value
LV	2,226	-0.013	0.019	-0.668
HV	2,232	-0.010	0.036	-0.288

However, when we look carefully at the results, we find over-reactions. Appendix shows subject's average consumption and the optimal solution for each income state from period 1 to period 4. The results of period 5 and 6 are omitted due to space constrains, and are available on request. For both treatments, subjects tend to over-consume relative to the optimal solutions when the most recent income is the higher one ($10 for HV and $6 for LV) and under-consume when the most recent income is the lower one ($0 for HV and $4 for LV). To test this tendency formally, we used a random-effects panel regression (Table 3). The dependent variable is the deviation of the subject's consumption from the optimal solutions. All independent variables are dummy variables; DOWN is 1 when the most recent income is the lower income, or 0 otherwise. PERIOD2 is 1 when the period is 2, or 0 otherwise, and so on. For LV, DOWN and CONSTANT are statistically significant, and each PERIOD is not significant. This confirms the over-reaction. However, subjects over-react similarly relative to the periods. For HV, all dependent variables are significant. This indicates that the degree of over-reaction is different from period to period. Subjects tend to exhibit larger over-reactions in the earlier periods.

Table 3: Result of Regression

Treatment	LV			HV		
	Coef. (Robust Std.Err.)			Coef. (Robust Std.Err.)		
DOWN	-0.269	(0.044)	**	-0.844	(0.077)	**
PERIOD2	-0.104	(0.066)		1.760	(0.140)	**
PERIOD3	-0.146	(0.077)		1.114	(0.135)	**
PERIOD4	-0.110	(0.073)		0.823	(0.134)	**
PERIOD5	0.039	(0.068)		0.458	(0.142)	**
CONSTANT	0.194	(0.056)	**	-0.375	(0.122)	**
Wald chi^2		61.68	**		283.20	**
Obs		1,855			1,860	

(Note) ** indicates statistical significance at 1%.

4. Conclusion

We confirmed that subjects exhibit precautionary saving and they over-react in changing current income. However, those over-reactions cancel each other and, on average overall, subject behavior is close to the optimal solutions. This result may be due to the following three factors; we shortened the experiment period, we introduced decision supporting tools such as Figure 1, and/or we used a binomial model which has a symmetric income distribution, and we used all possible income paths in the experiment. We are not able to distinguish which factors are responsible for our results and this will be our theme for future research.

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Appendix: Subject's Average Consumption and Optimal Solution

Period 1

Treat.	LV	HV
Obs	371	372
Avg	4.95	2.78
Opt	5.00	3.00
t-value	-1.36	-4.95**

Period 2

income=u		
Treat.	LV	HV
Obs	194	190
Avg	5.25	6.02
Opt	5.00	4.00
t-value	4.15**	14.2**

income=d		
Treat.	LV	HV
Obs	177	182
Avg	4.64	1.88
Opt	5.00	2.00
t-value	-7.27**	-3.21**

Period 3

income=uu		
Treat.	LV	HV
Obs	96	96
Avg	5.81	7.40
Opt	6.00	7.00
t-value	-1.07	1.99*

income=ud		
Treat.	LV	HV
Obs	98	94
Avg	4.68	3.37
Opt	5.00	4.00
t-value	-3.42**	-6.92**

income=du		
Treat.	LV	HV
Obs	82	85
Avg	5.20	5.47
Opt	5.00	4.00
t-value	2.49*	9.55**

income=dd		
Treat.	LV	HV
Obs	95	97
Avg	3.99	1.10
Opt	4.00	1.00
t-value	-0.28	1.85

Period 4

income=uuu		
Treat.	LV	HV
Obs	47	49
Avg	5.79	8.57
Opt	6.00	9.00
t-value	-1.35	-2.08*

income=uud		
Obs	49	47
Avg	4.94	4.34
Opt	5.00	5.00
t-value	-0.72	-3.60**

income=udu		
Obs	49	47
Avg	5.32	7.00
Opt	5.00	6.00
t-value	2.61*	4.24**

income=udd		
Obs	49	47
Avg	4.61	1.98
Opt	5.00	3.00
t-value	-3.34**	-6.79**

income=duu		
Obs	35	36
Avg	5.69	7.78
Opt	6.00	7.00
t-value	-1.93	3.08**

income=dud		
Obs	47	49
Avg	4.62	3.05
Opt	5.00	3.00
t-value	-2.65*	0.29

income=ddu		
Obs	49	47
Avg	5.27	5.30
Opt	5.00	5.00
t-value	3.26**	1.68

income=ddd		
Obs	46	50
Avg	4.26	0.26
Opt	4.00	0.00
t-value	1.30	4.15**

(Note) "LV" represents the low variance treatment, "HV" represents the high variance treatment, "Obs" represents the number of observations, "Avg" represents the subject's average consumption, and "Opt" represents the optimal solution. "income" represents the income state, for example, "income=uud" means that the income state moved higher at period 2, then higher again at period 3, and finally lower at period 4. ** indicates statistical significance at 1%, * at 5%, for the difference between the subject's average consumption and the optimal solution.