UNIVERSITY OF SIENA

EXPERIMENTAL ECONOMICS LABORATORY

Enrica Carbone

Gerardo Infante

The Effect of a Short Planning Horizon on Intertemporal Consumption Choices

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The Effect of a Short Planning Horizon on Intertemporal Consumption Choices

Enrica Carbone[1] and Gerardo Infante[2]

[1]Seconda Università di Napoli
enrica.carbone@gmail.com
[2]Università degli Studi di Bari
ger.infante@gmail.com

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Abstract

Previous experimental results (Ballinger et al. (2003) and Carbone and Hey (2004)) have found that many agents fail to correctly take into account the length of the planning horizon also finding some support (See Carbone (2006)) for descriptive models, such as the Rolling Model. This paper presents an experimental analysis on the effect of a short planning horizon on intertemporal consumption choices. The purpose of the study is to test whether very short horizons are more easily perceived by agents, allowing them to plan optimally. This experiment tests a somewhat implicit assumption of the Rolling Model, or of similar descriptive approaches, namely that people might be able to use the optimal strategy if they are faced with shorter planning horizons. Moreover, this hypothesis is tested in the cases of decision making under certainty, risk and uncertainty, in order to analyze how these environments may affect the perception of the length of the planning horizon. Results suggest that planning periods have a significant effect on deviations from unconditional optimum in all sequences and all treatments. This finding has been interpreted as evidence of participants not using the optimal strategy. When conditional deviations are considered, results are confirmed only in the case of decision making under uncertainty. This second finding has been interpreted as suggesting that uncertainty on income seems to prevent participants from improving their decision making.

Keywords: Intertemporal Consumer Choice, Life Cycle, Risk, Uncertainty, Laboratory Experiments, Short Planning Horizon

JEL classification: D12, D91, D81, C91, C92

1 Introduction

Several contributions in the literature, including the experimental methodology and empirical analysis, have shown how people may have difficulties in optimally solving intertemporal consumption problems. In the last decades econometric estimations have been directed towards the analysis of the predictions of economic theory, first testing the Life Cycle–Permanent Income Hypothesis[1], then focussing on gathering evidence in order to improve how models represent and explain micro-economic data[2]. This research program has highlighted some "puzzling" results related to consumption and saving behaviour[3], that have prompted modifications of the standard model[4], to incorporate more realistic descriptions of preferences and their parameters. As discussed in Browning and Lusardi (1996) and Brown et al. (2009), results have not rejected the general validity of the theoretical framework of the standard model rather, they have underlined problems of misspecification and the necessity for better specializations of the general model, e.g. taking

[1] A most notable example is Hall (1978)

[2] "facts", in the terminology of Browning and Lusardi, 1996

[3] For a review see, among others, Deaton (1992) or Browning and Lusardi (1996)

[4] Browning and Lusardi (1996) p. 1798–1799 use this expression to refer to the modern interpretation of the Life Cycle and Permanent Income Models (Modigliani and Brumberg, 1954; Friedman, 1957)

better account of precautionary motives[5] or time non separable preferences[6].

Experiments on intertemporal decision making have focussed on different aspects of the theory with the objective of testing the validity of the standard model of intertemporal consumption[7]. On one hand results have generally shown that participants fail to optimize lifetime utility, in some cases deviating significantly from the optimal consumption policy. On the other hand, experiments have shown how learning and cognitive abilities may play an important role in improving intertemporal planning. A typical finding in the experimental literature is that participants do not save enough, consume too much early in the lifecycle, and then under-consume later on[8]. Carbone and Hey (2004) find that subjects seem to overreact to changes of income[9] and may also misperceive the effect of compound interest[10]. As discussed, among others, in Allen and Carroll (2001), the optimization problem that agents have to solve to maximize lifetime utility is not a trivial one. Until recently, economists were not able to find the optimal consumption path "under realistic specifications of uncertainty and plausible assumptions about the utility function"[11]. For this reason, there has been an increasing interest in the cognitive processes that might help agents improve their decision making. In particular, Ballinger et al. (2003) focus on intergenerational learning, designing an experiment in which three consecutive generations had to solve an intertemporal consumption problem. Results have shown that decision

[5] An important evolution of the traditional model is the Buffer Stock hypothesis, described among others in Carroll (1997). In this model agents engage in precautionary savings by building up a stock of wealth to buffer against shocks of income. When the buffer stock is below the target, agents save to increase it; however, when wealth is bigger than the target, agents spend about their average income.

[6] See, among others, Dynan (2000), Guariglia and Rossi (2002), Carrasco, Labeaga and Lopez-Salido (2005)

[7] It should be noted that experiments, similarly to econometric analyses, have considered different variations of the standard framework, from the simple additive model to more complex adaptations.

[8] See Carbone and Hey (2004), Fehr and Zych (1998), Ballinger et al (2003) and Brown et al (2009) for an account.

[9] In that experiment income follow a first order Markov process, to simulate oscillations of income due to the alternation of employment and unemployment periods.

[10] See also Hey (2008) for a discussion on the misperception of compound interest

[11] Allen and Carroll (2001), p.255

making is significantly better for later generations than earlier ones. Brown et al. (2009) find a similar result when investigating a different mechanism of social learning: participants receiving information regarding three previous players, belonging to different categories of planners (highest–earning subjects, lowest–earning subjects and a subject randomly chosen) do significantly better than subjects who did not receive any information[12]. Results of this study suggest that individual learning (operating through the repetition of the task of planning) may be another factor of convergence to optimum, although slower than social learning[13]. Intertemporal consumption problems have also been investigated in a more recent study by Ballinger et al. (2011) where heterogeneity in saving behaviour and performance were found to be significantly correlated with certain measures of cognitive ability, such as Working Span memory.

In the literature, the effect of time on planning has been explored mainly with respect to models of time preference or to investigate issues related to dynamic inconsistency. Researchers have analyzed how agents evaluate instances of consumption at different points in time, reassessing the traditional exponential discounting model in favour of better descriptions of agents' behaviour, such as hyperbolic discounting (Laibson, 1997, 1998)[14]. A related, but different research question, looks at whether people actually make plans and implement them. Hey (2002) and Bone et al. (2009), among others, have shown that a significant number of subjects do not plan or, more generally, do not think ahead. There seems to be significant heterogeneity among people on how their ability to plan ahead is affected, for example, by how dynamic choices are framed (see Hey and Paradiso, 2006) or by the length of the planning horizon (see Hey and Panaccione, 2011 or Hey and Knoll, 2007, 2011).

[12]This study also investigates the effect of immediate and visceral temptations on saving behaviour finding that the more a reward is closer in time, the more subjects tend to overspend.

[13]See also Allen and Carroll (2001) for a discussion on individual learning and the Buffer-Stock model

[14]See Lowenstein and Thaler (1989) and Carbone (2006) for a review.

Ballinger et al. (2003) and Carbone and Hey (2004) include a discussion on the estimation of the planning horizon that participants seem to actually use to solve the intertemporal consumption problem. They conclude that not only may people be short-sighted relative to the optimal planning horizon, but that there seems to be significant variability across subjects[15]. In the specific framework of the intertemporal consumption and saving problem, the use of a shorter horizon (relative to the optimal length) constitutes a non optimal strategy that subjects might use to make planning easier[16]. In other words, when considering a very long lifecycle, people might not have the required computational or cognitive abilities to determine the optimal plan of consumption, or, more generally, they might simply misperceive the true length of the lifecycle and therefore fail to plan ahead. The length of the planning horizon is a crucial variable in the dynamic optimization problem. Although in the literature there is some evidence of myopic behaviour in cases of lifecycles of 25 (Carbone and Hey, 2004) to 60 periods (Ballinger et al., 2003), the relationship between dynamic optimization and a shorter planning horizon is still unclear. Intuitively, shorter planning horizons might allow agents to reach the optimal solution more easily however to date there is no evidence of such a relationship.

This pilot experiment seeks to fill this gap by further exploring how people perceive the planning horizon in the specific case of a very short lifecycle, under three different decision-making contexts (certainty, risk and uncertainty). The implicit hypothesis is that a short planning horizon might be easier to perceive, hence helping to reduce myopic decision making as well as significant deviations from optimal consumption. Although the main objective is to test the significance of the effect of the horizon on planning (which might reveal if participants correctly take it into account), it will also be of interest to gather information on other "decisional" variables, such as the effect of

[15] Carbone and Hey (2004) state "[...] subjects differ in their ability to solve the task [...]" (p. 682).

[16] Sometimes this strategy is referred to as Rolling Strategy. For a discussion, see Carbone (2006).

income, wealth and the rate of interest, as well as the effect of individual learning.

The theoretical background for this study is described in Section 2. Section 3 presents the experimental design while results are analyzed in Section 4 and discussed in Section 5.

2 Theory

Consider an agent living for a discrete number of periods (T) and having intertemporal preferences represented by the Discounted Utility model with a discount rate equal to zero. In each period, she receives utility from consumption; utility is assumed to have a functional form of the CARA type:

$$U(c) = \left(k - \frac{e^{-\rho c}}{\rho}\right)\alpha,$$

where "c" is consumption, α and k are scaling factors and the Arrow-Pratt coefficient of (absolute) risk aversion is equal to

$$ARA(c) = -\frac{U''(c)}{U'(c)} = \rho^{17}.$$

In the case of decision making under risk and under uncertainty, the objective of our agent is then to maximize the expected lifetime utility, that is[18]

$$\max E_t \left[\sum_{t=1}^{T} \beta U(c_t)\right] \tag{1}$$

subject to

$$w_{t+1} = a_{t+1} + y = (1+r)(w_t - c_t) + y$$

[17] In the experiment parameters were set as follows: $\rho = 0.1$, $k = 10$ and $\alpha = 0.45$

[18] Having set the discount rate equal to zero, β equals 1, so the same can be expressed by: $E(U(c_t) + U(c_{t+1}) + \cdots + U(T))$.

where w is available wealth, a represents available assets or savings at the beginning of period $t+1$ and y is income. In each period of her lifecycle, the agent receives either a high or a low income, with probabilities $p = q = 0.5$. The rate of return is known and held fixed during the lifecycle. Also, borrowing is not allowed, that is, wealth must always be greater or at most equal to zero. Finally, the agent has no bequest motives, that is, any savings are lost after the last period (T). The problem is then to choose the sequence of consumption (from period 1 to period T) that maximizes (1).

The standard procedure to solve this kind of problems is to use Dynamic Programming, through Backward Induction. The Bellman Equation of the problem has been determined as

$$V_t(w_t) = U(c_t^*) + E\left[V_{t+1}(w_{t+1}^*)\right] \tag{2}$$

where V_t is the value function, w_t represents available wealth and E is the expectation operator. Equation (2) may also be expressed as

$$V_t(w_t) = U(c_t^*) + E\left[\frac{1}{2}V_{t+1}(w_{t+1}^{*L}) + \frac{1}{2}V_{t+1}(w_{t+1}^{*H})\right] \tag{3}$$

where

$$w_{t+1}^{*L} = (1+r)(w_t - c_t^*) + y^L$$
$$w_{t+1}^{*H} = (1+r)(w_t - c_t^*) + y^H.$$

In other terms, the expectation is resolved by considering the two possible events: low income, y^L, and high income, y^H. Wealth in period $t+1$ is optimal because it is determined by the (optimal) consumption choice in t. The value function establishes a recursive relation between current and future decisions. Using backward induction, the agent starts from the last period (T), where the optimal solution is obviously to consume all wealth, then moves to the second-last period. In that period she has to choose the optimal level of consumption which maximizes the value function of that period. Then she moves to the third-last period, calculates optimal consumption and moves backward. This procedure is repeated until the first period is reached and allows the determination of optimal consumption as a function of wealth (w_t) and time (t).

In the case of certainty, however, the agent knows exactly the distribution of income in all her lifecycle. For this reason she will not have to solve the *expectation* of future utility (since all variables are known and fixed) and will maximize the sum of per-period utility. In other words, since the distribution of income is known, as well as all other relevant variables, the agent is able to plan over her lifecycle and exactly determine how much to consume in each period. In this special case, the solution can be determined either by Backward Induction, in a similar fashion as above or, alternatively, by solving a system of Euler Equations. Following the first approach, in the last period the value function will be equal to

$$V_T = U(c_T^*) = U(w_T).$$

Here the optimal solution is to consume everything ($c_T^* = w_T$). Moving backwards one period ($t = T - 1$), the value function becomes

$$V_{T-1} = U(c_{T-1}^*) + V_T = U(c_{T-1}^*) + U(c_T^*).$$

Using the budget constraint, it is possible to make V_{T-1} depend only on c_{T-1}:

$$V_{T-1} = U(c_{T-1}^*) + U\left[(1+r)(w_{T-1} - c_{T-1}^*) + y\right].$$

where w_{T-1} is the available wealth in period $t = T - 1$, c_{T-1} is consumption in the same period and y is income. At this point the first order condition can be calculated and solved with respect to consumption. This determines the optimal consumption function for that period, which depends on wealth. Using the recursive relation between value functions

$$V_t = U(c_t^*) + V_{t+1}$$

it is then possible to continue moving backwards until the first period is reached. The second approach is based on the Euler Equation which, in this special case, takes the form

$$U'(c_t) = (1 + r)U'(c_{t+1}).$$

To solve the intertemporal consumption problem, a system of Euler Equations plus the budget constraint[19], must be solved.

Some restrictions have been imposed on variables. In particular, as anticipated, borrowing is not allowed ($w_t \geq 0$) and all variables are rounded to the second decimal figure. For this reason, while in the case of certainty it was possible to determine the exact solution of the problem, in the case of risk and uncertainty a numerical solution (also using interpolation) had to be used[20].

3 Experimental Design

Experimental sessions were run at the University of Siena. Thirty undergraduate students took part in three treatments, Certainty, Risk and Uncertainty. Given the nature of a pilot experiment, only 3 sessions were run, one for each treatment. The experiment was programmed and conducted with the software z-Tree (Fischbacher 2007). During the experiment terms referring openly to risk and uncertainty were avoided and instructions were framed so as to minimize the potential of experimenter demand effects. Participants were randomly allocated to computers where they had both a paper and an electronic copy of instructions available. After the experimenter read the instructions aloud, encouraging questions and clarifications, there was a quiz to test the comprehension of the main features of the experiment. Individual explanations were provided to participants who scored wrong answers. Each session was composed of five sequences each one made up of five periods

[19] $\sum_{t=1}^{T} c_t * (1+r)^{-(t-1)} = \sum_{t=1}^{T} y * (1+r)^{-(t-1)}$

[20] The optimization programs were written using Maple

($T = 5$). Instructions explained that sequences were "independent" of one another because decisions in one sequence would not affect results in other sequences. The utility function was presented as a "conversion function" from tokens (Experimental Currency Unit) to money, briefly pointing out some important features, in particular the property of decreasing marginal utility[21]. At the end of the experiment a public procedure was devised to randomly select for payment one of the five sequences played.

In each period of a sequence participants received an amount of tokens (income) that, together with previous savings, would determine the wealth available for conversion[22]. Instructions asked participants to decide how many tokens to convert (consume) knowing that any tokens not converted would yield interest[23]. Instructions also clarified at different points that any savings left at the end of the last period (the fifth) would be worthless[24].

In order to allow participants to check the consequences of their decisions, a calculator was made available in each period[25]. By entering an amount of tokens to be converted, this tool would summarize associated earnings, savings and interest gained. Before beginning the experiment, participants had the possibility to practice with the calculator and, implicitly, with the utility function[26]. At the beginning of each period (except for the first) participants

[21] There was no explicit reference to "decreasing marginal utility" as such, but, rather, to "increments at a decreasing rate".

[22] Of course in period 1 participants had no previous savings and wealth was equal to the income just received.

[23] Given the very short length of the sequence, the interest rate was set at $r = 0.4$ to incentivize savings.

[24] This solution was selected so that all observations could be used in the data analysis. As will be described later on, in some cases participants did not pay attention to this rule and ended a sequence with positive wealth. These observations were dropped. In other studies, for example Brown et al. (2009), the decision in the last period was computerized. However, this implies dropping all of those observations which is undesirable in a study with such a limited number of participants.

[25] Participants were also provided with tables showing some examples of conversions and of the interest mechanism.

[26] Participants were encouraged to try several conversions and to simulate different wealth situations. The objective was to get participants to familiarize themselves as much as possible with the calculator and the utility function.

saw on the screen a summary of the previous period including their decision and its consequences. Similarly, at the end of each sequence participants had the chance to look at a summary showing income, available wealth, conversion, interest and earnings, period by period.

As anticipated in the previous section, in the risk and uncertainty treatments participants received their income, high (15 tokens) or low (5 tokens), with a probability of 0.5. This probability was public knowledge in the case of risk, and totally unknown in the case of uncertainty. In each period, income was determined by a random draw from a non-see-through bag. In particular, the two events were colour coded and the bag contained equal numbers of coloured balls. In the case of risk, at the beginning of the experiment, one participant was asked to publicly open the bag and count the balls, so that it would be obvious to the group that there was no deception involved. In the case of uncertainty this procedure was simply omitted. When drawing a ball, participants were asked to shuffle the content of the bag and then to pick one ball and show it to everybody. After that, the ball was placed back into the bag so as to not alter the probability of future draws. Of course this procedure was not implemented in the certainty treatment, in which income was fixed to ten tokens throughout the experiment. As anticipated, conversions were not restricted to integers and participants could enter numbers with up to two decimal digits.

As noted earlier, the final payoff of each participant corresponded to the result of one sequence, determined by a random mechanism. In particular, since in the experiment there was a direct conversion from ECU into money, the payoff was simply the total accumulated at the end of the selected sequence.

4 Analysis of results

Table 1 presents a summary of the experiment showing, for each treatment, three different types of information. In the top part of the table there is a comparison between the theoretical maximum utility (labeled "Opt. Ut.") and the average total utility achieved by participants in that treatment (along with its standard deviation). Results show, as expected[27], that all deviations are negative. More interestingly, the second part of Table 1 shows that they are also all statistically significant, according to parametric and non-parametric tests (t-test and signed rank test), which suggests that participants, on average, did not maximize utility. When comparing treatments with respect to deviations from maximum utility, there seems not to be any dramatic difference. However, deviations in the case of decision making under uncertainty are generally slightly greater than those in other treatments. The following analysis of results will show that participants making decisions under uncertainty seem to have deviated consistently more from the optimal path than participants in other treatments. Moreover, deviations show a similar pattern of variability across treatments: usually higher in the first sequence and lower in the following repetitions. It is interesting to note how this decreasing pattern is more evident in case of risk and uncertainty. A possible explanation for this might be related to the nature of the distribution of income: while in the case of certainty it is known a priori, probably encouraging a sort of experimentation with different strategies across sequences, this is not true in the case of risk and uncertainty. Finally, the third part of Table 1 shows the root mean squared deviation for each sequence and each treatment, in the cases of unconditional and conditional optimum. The main difference here is the point of reference: while unconditional optimum represents the solution to the intertemporal problem (otherwise known as "absolute" optimum) and is calculated on optimal wealth (hence assuming optimal behaviour throughout the lifecycle), conditional optimum is computed based on actual wealth, and is traditionally assumed to incorporate a measure of improvement of behaviour[28].

[27]This result is to be expected in particular because the benchmark used is the maximum utility achievable. This excludes, by definition, any positive deviations. At most one could achieve "zero deviations", although this is somewhat unrealistic, given that deviations are computed using "average" total utility.

[28]Further discussions on the concepts of conditional and unconditional optima can be found in Ballinger et al (2003) or Carbone and Hey (2004).

Table 1: Summary of Treatments

	Certainty				
	Seq 1	Seq 2	Seq 3	Seq 4	Seq 5
Opt. UT	15.0512	15.0512	15.0512	15.0512	15.0512
AVG UT	13.0315	13.4179	14.0075	14.6501	14.3830
s.d.	2.8566	1.9157	1.5755	0.2788	0.7570
Deviation	-2.0197	-1.6333	-1.0437	-0.4011	-0.6682
	H0: AVG UT=Opt.UT				
t-test (t=)	**-2.2359**	**-2.6962**	**-2.0949**	**-4.5500**	**-2.7913**
signed rank (z=)	**-2.8030**	**-2.8030**	**-2.8030**	**-2.8030**	**-2.8030**
	RMSD				
unc.opt.	10.62	10.66	9.22	3.85	4.64
cond.opt.	9.11	6.45	5.19	2.32	2.97
	Risk				
	Seq 1	Seq 2	Seq 3	Seq 4	Seq 5
Opt. UT	16.2700	16.0500	15.5800	15.2300	14.4200
AVG UT	13.0700	14.7528	15.0037	14.5218	13.1952
s.d.	3.0791	0.8527	0.8205	0.7353	0.7713
Deviation	-3.2000	-1.2972	-0.5763	-0.7082	-1.2248
	H0: AVG UT=Opt.UT				
t-test (t=)	**-3.2829**	**-4.8105**	**-2.2213**	**-3.0457**	**-5.0212**
signed rank (z=)	**-2.8050**	**-2.8030**	**-1.7840**	**-2.8050**	**-2.8050**
	RMSD				
unc.opt.	18.01	7.29	6.87	6.58	5.51
cond.opt.	10.14	4.20	3.95	3.76	3.45
	Uncertainty				
	Seq 1	Seq 2	Seq 3	Seq 4	Seq 5
Opt. UT	16.0501	16.0974	12.2909	13.9571	15.2293
AVG UT	12.6472	12.9356	10.2075	12.8590	13.8737
s.d.	3.1820	1.6900	0.8572	0.9386	0.8564
Deviation	-3.4029	-3.1618	-2.0834	-1.0981	-1.3555
	H0: AVG UT=Opt.UT				
t-test (t=)	**-3.3819**	**-5.9162**	**-7.6862**	**-3.6998**	**-5.0053**
signed rank (z=)	**-2.8030**	**-2.8030**	**-2.8030**	**-2.4970**	**-2.8030**
	RMSD				
unc.opt.	20.41	8.97	5.00	7.64	6.30
cond.opt.	13.36	6.98	3.90	4.59	3.70

Significant results reported in bold

The root mean squared deviation (RMSD) can be interpreted as a measure of how close the observations are to the benchmark. As Table 1 shows, this index tends to decrease across sequences, suggesting an improvement in strategy during the experiment. Interestingly, when comparing treatments (as shown in Table 2), the patterns of RMSD suggest that while at the very beginning of the experiment (sequence 1), decision makers under certainty seem to be closer to the optimal path than those under risk or uncertainty, the situation quickly changes in the following sequences (excluding the last two)[29]. Again, a possible explanation for this might be the correlation between the variability of income (in terms of knowledge of its distribution) and learning across sequences. In other words, when knowing exactly the distribution of income in a sequence (as in the certainty treatment), participants might have been more willing to "experiment" with different strategies, removing any potential significant effect of learning. If that was the case, regressions would show no statistical effect of learning in case of certainty, at least in some sequences. Regressions on deviations from optimum seem to confirm this hypothesis: there seems to be no statistical effect of learning in the case of certainty while the situation is completely different for the other two treatments.

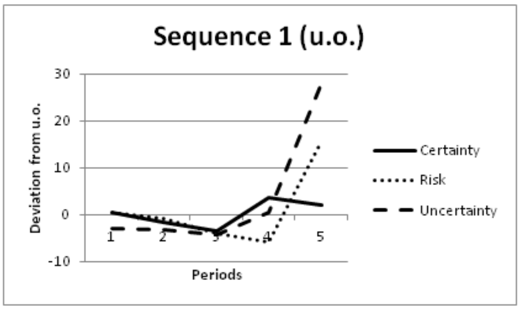
Table 2: Comparison of Treatments with respect to RMSD

Treatment	**Type of dev.**	***1***	***2***	***3***	***4***	***5***	**SEQ**
Certainty	Uncond. Opt.	10.6167	10.6648	9.21946	3.85127	4.64468	
	Cond. Opt	9.11026	6.45207	5.18958	2.31798	2.96517	
Risk	Uncond. Opt.	18.0082	7.2858	6.86701	6.57757	5.51156	
	Cond. Opt	10.1415	4.2012	3.9515	3.7629	3.44531	
Uncertainty	Uncond. Opt.	20.4112	8.97233	4.99648	7.64328	6.30073	
	Cond. Opt	13.3557	6.9786	3.90063	4.58708	3.69656	

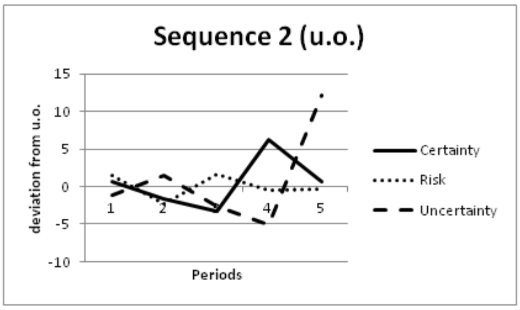
Figures 1 and 2 show a comparison of the treatments, sequence by sequence, with respect to the deviations from *unconditional* (sub-figures 1a to 1e) and *conditional* (sub-figures 2a to 2e) optimum. Graphs suggest that there might be no dramatic difference among treatments with respect to *unconditional* deviations, as none of the patterns stand out as being completely

[29]This observation applies to both definitions of optimum.

different from the others.



(a)



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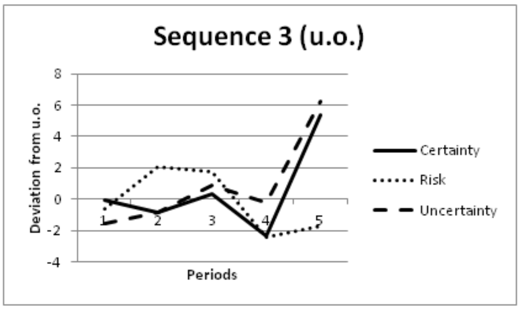

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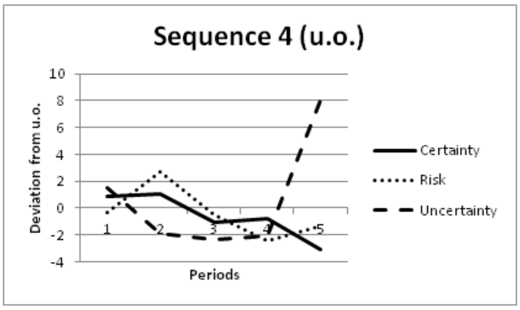

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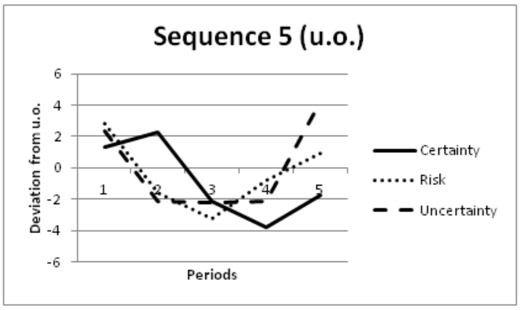
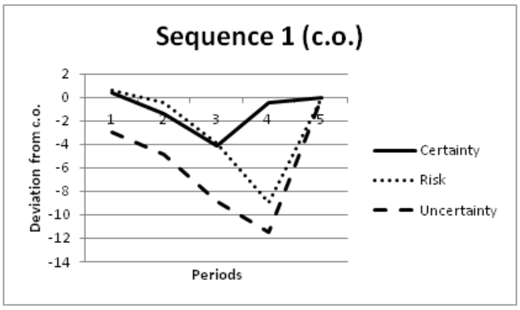


(e)

Figure 1: Deviations from Unconditional Optimum

However, it should be noted how the case of uncertainty has a very high "peak" in the last period, caused by consistent under-consumption in previous periods. This pattern is confirmed when looking at deviations from conditional optimum (Figure 2), where the case of uncertainty is consistently below the others. This also suggests that uncertainty might have triggered more savings for precautionary motives. The following analysis will be focussed on the deviations from the optimal path of consumption, with respect to unconditional and conditional optima.



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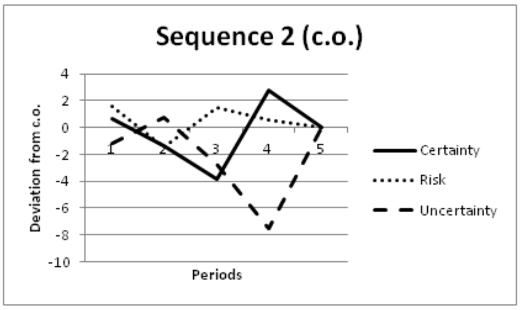
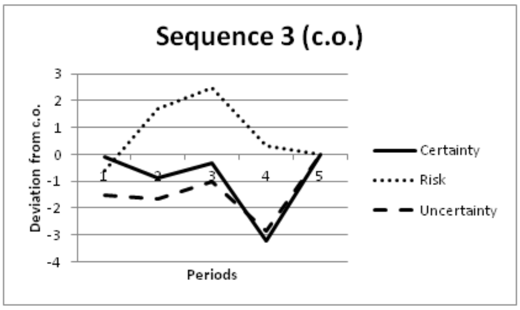


(b)



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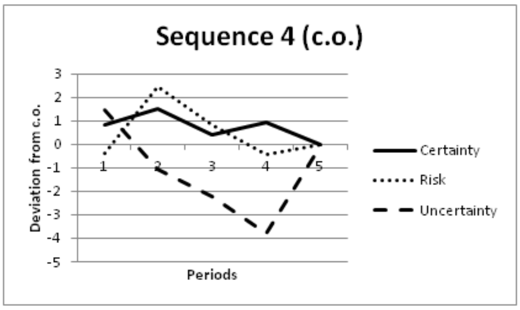
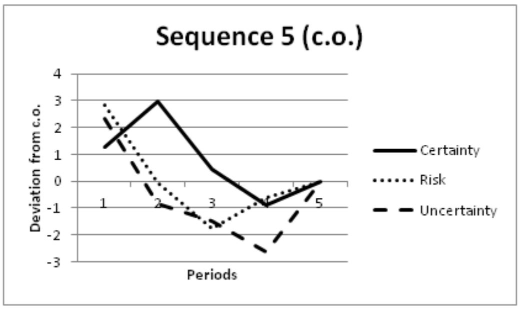


(d)



(e)

Figure 2: Deviations from Conditional Optimum

4.1 Comparing first and last sequences

A way to start investigating whether a short planning horizon makes intertemporal optimization easier to achieve, is to check the frequency and significance of deviations from optimum in a sequence. In particular, in what follows, the first and the last sequence of each treatment are compared, assuming that they are an effective representation of behaviour of participants in a treatment. Each of the following tables report the deviations from unconditional/conditional optima, the average deviation in each period, an estimation of the confidence interval and two statistical tests on the Null Hypothesis that the average equals zero (no significant deviation from optimum).

Table 3: Deviations from Uncond.Optimum (Certainty - Sequence 1)

	Sequence 1				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	0.5693	-1.7955	-3.1602	-0.5249	9.6604
	-1.6807	-5.4655	1.5898	-0.7749	19.4204
	-5.4307	-8.7955	-12.1602	55.4751	-8.8896
	0.5693	1.3045	-0.1502	-1.4749	-3.4096
	3.0693	0.4045	-12.1602	-12.5249	-14.3896
	1.5693	-2.7955	0.8398	5.4751	-7.6696
	-0.4307	4.2045	-1.1602	-3.5249	-2.8896
	-2.4307	-5.7955	-4.1602	4.4751	27.1204
	4.0693	0.8645	-2.5002	-5.0249	-6.0696
	3.5693	2.2045	-1.6602	-5.4749	-8.8896
Average	0.3443	-1.5665	-3.4682	3.6101	0.3994
s.e.	0.937231	1.301581	1.550482	5.985849	4.327104
t-stat.	1.96	1.96	1.96	1.96	1.96
c.i. Lower	-1.49267	-4.1176	***-6.50715***	-8.12216	-8.08172
c.i. Upper	2.181274	0.984598	***-0.42925***	15.34236	8.880524
			Signed Rank (H0: Mean=0)		
z=	0.561	-0.968	***-2.193***	-0.459	-0.153
			t-test (H0: Mean=0)		
t=	0.3674	-1.2035	***-2.2369***	0.6031	0.0923

Significant results are reported in bold

Analysing single treatments first, Tables 3, 4 and 5 show deviations from *unconditional* optimum in the case of *certainty*. Table 3 and Table 4 both refer to sequence 1, the only difference being that observations of participant 5 were dropped because she did not consume everything in the last period[30].

Table 4: Deviations from Uncond.Opt. (Cert. - Seq. 1, subject 5 dropped)

	Sequence 1 Restricted (dropping sbj 5)				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	0.5693	-1.7955	-3.1602	-0.5249	9.6604
	-1.6807	-5.4655	1.5898	-0.7749	19.4204
	-5.4307	-8.7955	-12.1602	55.4751	-8.8896
	0.5693	1.3045	-0.1502	-1.4749	-3.4096
	1.5693	-2.7955	0.8398	5.4751	-7.6696
	-0.4307	4.2045	-1.1602	-3.5249	-2.8896
	-2.4307	-5.7955	-4.1602	4.4751	27.1204
	4.0693	0.8645	-2.5002	-5.0249	-6.0696
	3.5693	2.2045	-1.6602	-5.4749	-8.8896
Average	0.041522	-1.7855	-2.50242	5.402878	2.042622
s.e.	0.991671	1.434465	1.356129	6.385172	4.47544
t-stat.	1.96	1.96	1.96	1.96	1.96
c.i. Lower	-1.90215	-4.59705	-5.16043	-7.11206	-6.72924
c.i. Upper	1.985197	1.026051	0.15559	17.91782	10.81448
	Signed Rank (H0: Mean=0)				
z=	0.178	-1.125	*-1.955*	-0.059	0.178
	t-test (H0: Mean=0)				
t=	0.0419	-1.2447	*-1.8453*	0.8462	0.4564

Significant results are reported in bold

In t=3 both tests have a p-value slightly above the 5% confidence level

[30] When this happens there is a potential risk that the whole strategy employed in the sequence might be biased. For this reason two tables are presented, one with those observations and one without.

As the tables show, in both cases there are almost no significant deviations, except for period 3. When dropping the observations of participant 5, the average deviation in that period is only *slightly* not significant (i.e. in the acceptance region). Considering these results, it seems likely that although participants in sequence 1 were very close to the optimal path, they *did not* employ the *optimal* planning horizon, otherwise average deviations in *all* periods would have been statistically not significant[31].

Table 5: Deviations from Unconditional Optimum (Certainty, Seq. 5)

	Sequence 5				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	0.5693	0.2045	-0.1602	-0.5249	-1.6996
	-4.4307	13.2045	-3.1602	-11.9449	3.7004
	4.5693	-2.7955	-5.1602	-7.5249	10.6104
	0.5893	2.7045	-0.6602	-4.0249	-2.7596
	2.5693	3.9945	-4.1602	-3.5249	-7.7496
	2.5693	-0.7955	-4.1602	-1.5249	2.6004
	2.5693	2.0045	-1.1602	-3.0049	-8.8896
	0.5693	-1.7955	-1.1602	2.4751	1.5404
	-1.1007	4.7045	0.4998	-2.8649	-5.6496
	4.3693	1.4545	-2.1502	-5.5249	-8.8796
Average	1.2843	2.2885	-2.1432	-3.7989	-1.7176
s.e.	0.850601	1.434635	0.608485	1.247672	2.017307
t-stat.	1.96	1.96	1.96	1.96	1.96
c.i. Lower	-0.38288	-0.52339	***-3.33583***	***-6.24434***	-5.67152
c.i. Upper	2.951479	5.100385	***-0.95057***	***-1.35346***	2.236322
	Signed Rank (H0: Mean=0)				
z=	1.483	1.478	***-2.603***	***-2.497***	-0.866
	t-test (H0: Mean=0)				
t=	1.5099	1.5952	***-3.5222***	***-3.0448***	-0.8514

Significant results are reported in bold

[31] Although one might argue that the results of Table 4 (when some observations are dropped) would support the conclusion that the optimal planning horizon was used, it could be equally observed that the evidence is not sufficiently clear to support such a claim.

Moving to the fifth sequence (Table 5), results show that this time there are two cases of significant deviations (periods 3 and 4)[32]. Again, this must be interpreted as suggesting that on average participants did not employ the optimal planning horizon. The situation changes only slightly when considering deviations from conditional optimum (Tables 6, 7 and 8).

Table 6: Deviations from Conditional Optimum (Certainty, Seq. 1)

	Sequence 1				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	0.569255	-1.48763	-3.78861	-4.24737	-0.0084
	-1.68075	-6.37436	-3.33083	-8.41573	-0.00248
	-5.43075	-11.7322	-22.4807	26.7953	-0.056
	0.569255	1.612366	1.172398	0.805134	-0.0024
	3.069255	2.06428	-9.20127	-17.0804	**-42.8576**
	1.569255	-1.94687	0.463132	5.476634	-0.0008
	-0.43075	3.9716	1.106435	-0.3547	-0.216
	-2.43075	-7.10993	-9.94934	-9.43937	-0.0092
	4.069255	3.065046	1.629334	0.435234	-0.00016
	3.569255	4.134663	2.872123	1.402968	-0.0476
Average	0.344255	-1.38031	-4.15074	-0.46223	-4.32006
s.e.	0.937231	1.715628	2.485323	3.679496	4.281999
t-stat	1.96	1.96	1.96	1.96	1.96
c.i. Lower	-1.49272	-4.74294	-9.02197	-7.67404	-12.7128
c.i. Upper	2.181228	1.982324	0.720497	6.749586	4.072655
	Signed Rank (H0: Mean=0)				
	0.561	-0.357	-1.274	-0.255	***-2.803***
	t-test (H0: Mean=0)				
	0.3673	-0.8045	-1.6701	-0.1256	-1.0089

Significant results are reported in bold

In particular, when considering sequence 1 there seem to be no statistically significant deviations, both when all observations are included (Table 6) and when dropping some of them (Table 7).

[32]This time no observations were dropped as all participants consumed their total wealth in the last period.

Table 7: Deviations from Cond.Opt. (Certainty, Seq. 1, dropping sbj5)

	Sequence 1 - Restricted (dropping sbj 5)				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	0.569255	-1.48763	-3.78861	-4.24737	-0.0084
	-1.68075	-6.37436	-3.33083	-8.41573	-0.00248
	-5.43075	-11.7322	-22.4807	26.7953	-0.056
	0.569255	1.612366	1.172398	0.805134	-0.0024
	1.569255	-1.94687	0.463132	5.476634	-0.0008
	-0.43075	3.9716	1.106435	-0.3547	-0.216
	-2.43075	-7.10993	-9.94934	-9.43937	-0.0092
	4.069255	3.065046	1.629334	0.435234	-0.00016
	3.569255	4.134663	2.872123	1.402968	-0.0476
Average	0.041477	-1.76304	-3.58957	1.384234	-0.03812
s.e.	0.991671	1.869791	2.706916	3.558313	0.023319
t-stat	1.96	1.96	1.96	1.96	1.96
c.i. Lower	-1.9022	-5.42783	-8.89512	-5.59006	-0.08382
c.i. Upper	1.985151	1.901753	1.715991	8.358529	0.007589
	Signed Rank (H0: Mean=0)				
z=	0.178	-0.652	-0.889	0.178	***-2.666***
	t-test (H0: Mean=0)				
t=	0.0418	-0.9429	-1.3261	0.389	-1.6346

Significant results are reported in bold

In the last sequence, however, there is one significant deviation in period 2 (Table 8). These results suggest that participants used the optimal strategy in the first sequence but were not able to follow the optimal consumption path in the last one. This also suggests that there might be a significant "sequence" effect between the first and following sequences[33].

[33]During regression analysis, this could be identified as "learning" (i.e. an improvement in behavior caused by repetitions) or its opposite, depending on the sign and significance of the coefficient of the first sequence.

Table 8: Deviations from Cond.Opt. (Certainty, Seq.5)

	Sequence 5				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	0.569255	0.512366	0.470105	0.489301	-0.0004
	-4.43075	10.80854	1.246251	-6.5207	-0.0044
	4.569255	-0.32457	-2.89357	-7.62137	-0.156
	0.589255	3.023181	1.561121	-0.52869	-0.00357
	2.569255	5.383897	0.617572	1.757201	-0.00744
	2.569255	0.593897	-2.39705	-1.71937	-0.0012
	2.569255	3.393897	2.36515	2.451968	0
	0.569255	-1.48763	-1.78861	0.385968	-0.0084
	-1.10075	4.109287	2.490776	1.160188	-0.00027
	4.369255	3.817276	2.614985	1.375834	-0.05272
Average	1.284255	2.983013	0.428673	-0.87697	-0.02344
s.e.	0.850601	1.114933	0.655818	1.099884	0.015557
t-stat	1.96	1.96	1.96	1.96	1.96
c.i. Lower	-0.38292	***0.797745***	-0.85673	-3.03274	-0.05393
c.i. Upper	2.951433	***5.168282***	1.714077	1.278807	0.007051
	Signed Rank (H0: Mean=0)				
	1.483	***2.293***	0.561	-0.051	***-2.756***
	t-test (H0: Mean=0)				
	1.5098	***2.6755***	0.6536	-0.7973	-1.5068

Significant results are reported in bold

The comparison between sequences in the case of risk, is reported in Tables 9 and 10 (unconditional optimum) and Tables 11 and 12 (conditional optimum). Results suggest that, on average, in the first sequence participants did not deviate from *unconditional* optimum in a statistically significant way (Table 9)[34]. However, Table 10 shows that in the last sequence, at least in one period (period 3) the average deviation was significantly different than zero[35].

[34] Table 9 shows only one significant deviation, according to the t-test; however, the same average deviation is not significant, according to the signed rank test. In this case, given the limited number of observations (just ten) it seems advisable to consider the latter result as more accurate.

[35] In this case there are at least 2 periods (period 1 and 2) in which the t-test and the signed rank test give different results. As explained above, the signed rank test is

Table 9: Deviations from Unconditional Optimum (RISK, Seq. 1)

	Sequence 1				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	-5.72	-11.82	6.4	10.55	27.09
	3.28	9.68	-9.6	-9.05	-7.68
	-5.72	-10.32	16.4	0.55	17.37
	8.28	2.68	-8.6	-9.45	-9.08
	-3.72	2.68	-11.6	0.55	28.89
	-1.72	6.68	1.4	-8.45	-2.64
	6.28	2.68	-6.6	-11.45	-2.52
	8.28	2.68	-8.6	-9.45	-9.08
	-6.72	-12.32	-13.6	-14.45	106.5
	3.28	-0.32	-4.6	-8.45	9.12
Average	0.58	-0.77	-3.9	-5.91	15.797
s.e.	1.891795	2.492712	2.951647	2.370757	11.07419
t-stat.	1.96	1.96	1.96	1.96	1.96
c.i. Lower	-3.12792	-5.65571	-9.68523	**-10.5567**	-5.90841
c.i. Upper	4.287918	4.115715	1.885229	**-1.26332**	37.50241
	Signed Rank (H0: Mean=0)				
z=	0.7208	-0.051	-1.377	-1.685	1.275
	t-test (H0: Mean=0)				
t=	0.3066	-0.3089	-1.3213	***-2.4929***	1.4265

Significant results are reported in bold

Table 10: Deviations from Unconditional Optimum (RISK, Seq. 5)

	Sequence 5				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	3.78	-1.56	-3.07	-3.84	1.15
	8.28	-3.41	-4.77	-5.68	-5.15
	-4.72	-5.41	-5.77	19.32	17.23
	3.28	3.59	-4.77	-5.68	-5.15
	0.78	1.59	-6.77	1.32	4.06
	6.28	-2.41	-5.25	-2.48	-3.75
	-2.72	0.59	5.23	-0.68	-0.48
	8.28	-3.41	-4.77	-5.68	-5.15
	4.28	-2.52	-1.68	-4.79	0.47
	0.78	-2.91	-0.77	0.32	6.05
Average	2.83	-1.586	-3.239	-0.787	0.928
s.e.	1.377296	0.857612	1.106691	2.380484	2.202905
t-stat.	1.96	1.96	1.96	1.96	1.96
c.i. Lower	***0.1305***	-3.26692	***-5.40811***	-5.45275	-3.38969
c.i. Upper	***5.5295***	0.094919	***-1.06989***	3.878748	5.245693
	Signed Rank (H0: Mean=0)				
z=	1.786	-1.479	***-2.095***	-1.38	0.051
	t-test (H0: Mean=0)				
t=	***2.0548***	***-1.8493***	***-2.9267***	-0.3306	0.4213

Significant results are reported in bold

The situation is very similar when considering deviations from *conditional* optimum (Tables 11 and 12): in the first sequence the average deviation is significant on one occasion (period 4), while in the last one deviations are all not significant[36].

considered more accurate in this specific case.

[36]See footnote 34 above

Table 11: Deviations from Conditional Optimum (RISK, Sequence 1)

	Sequence 1				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	-5.72	-14.92	-6.06	-6.96	0
	3.28	11.48	-0.62	-0.62	0
	-5.72	-13.42	4.84	-7.02	0
	8.28	7.18	0.38	0.08	0
	-3.72	0.68	-13.24	-11.85	-0.01
	-1.72	5.78	4.08	-2.42	0
	6.28	6.08	0.56	-3.69995	0
	8.28	7.18	0.38	0.08	0
	-6.72	-15.92	-27.32	-50.38	0
	3.28	1.48	-1.92	-7.32	0
Average	0.58	-0.44	-3.892	-9.011	-0.001
s.e.	1.891795	3.269618	3.076203	4.758425	0.001
t-stat	1.96	1.96	1.96	1.96	1.96
c.i. Lower	-3.12792	-6.84845	-9.92136	-18.3375	-0.00296
c.i. Upper	4.287918	5.968451	2.137358	0.315512	0.00096
	Signed Rank (H0: Mean=0)				
z=	0.357	0.051	-0.867	***-2.499***	-1
	t-test (H0: Mean=0)				
t=	0.3066	-0.1346	-1.2652	***-1.8937***	-1

Significant results are reported in bold

Table 12: Deviations from Conditional Optimum (RISK, Sequence 5)

	Sequence 5				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	3.78	0.53	-0.74732	-2.02	0
	8.28	1.08	0.38	0.08	0
	-4.72	-7.92	-13.3	0.890192	-0.01
	3.28	5.38	0.38	0.08	0
	0.78	1.98	-5.12	-1.1	0
	6.28	0.98	-1.22	0.58	0
	-2.72	-0.92	3.22	-0.06	-0.01
	8.28	1.08	0.38	0.08	0
	4.28	-0.23	0.482679	-2.14019	0
	0.78	-2.52	-1.92	-2.32	0
Average	2.83	-0.056	-1.74646	-0.593	-0.002
s.e.	1.377296	1.087217	1.450559	0.378423	0.001333
t-stat	1.96	1.96	1.96	1.96	1.96
c.i. Lower	**0.1305**	-2.18694	-4.58956	-1.33471	-0.00461
c.i. Upper	**5.5295**	2.074945	1.096631	0.14871	0.000613
	Signed Rank (H0: Mean=0)				
z=	1.786	0.561	-0.971	-0.766	-1.414
	t-test (H0: Mean=0)				
t=	***2.0548***	-0.0515	-1.204	-1.567	-1.5

Significant results are reported in bold

The analysis of deviations from *unconditional* optimum, in case of decision making under uncertainty is reported in Tables 13 and 15. In the first sequence participants seem to have significantly deviated from optimum four times out of five (Table 13). However, when removing the observations of one subject[37], the number of significant deviations drops to two (Table 14)[38].

[37]Similar to the case of certainty, in this treatment there was one subject who did not consume everything in the last period.

[38]In Table 14 there are two other instances of "conflict" between results of the signed rank test and t-test. As discussed in footnote 34, the signed rank test is considered more accurate. If one picked the t-test, the number of significant deviations from unconditional optimum would be four.

Table 13: Deviations from Uncond. Opt. (UNCERTAINTY, Seq.1)

	Sequence 1				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	0.78	-0.66	-0.27	-0.98	0.71
	-3.72	-3.41	-3.27	-5.98	38.42
	-6.72	6.59	7.73	-5.98	0.95
	-2.44	-2.69	-0.77	-4.34	24.34
	-6.72	-3.41	-7.27	-7.98	60.59
	-6.72	-8.41	-14.27	65.98	-15.51
	-3.72	-7.41	-11.27	-17.98	81.88
	3.28	-5.41	-5.27	-10.98	-15.51
	-2.72	-2.91	-4.27	-6.98	36.57
	-0.72	-4.81	-3.67	-0.98	24.53
Average	-2.942	-3.253	-4.26	0.38	23.697
s.e.	1.063723	1.312523	1.922409	7.453884	10.13802
t-stat.	1.96	1.96	1.96	1.96	1.96
c.i. Lower	**-5.0269**	**-5.82554**	**-8.02792**	-14.2296	**3.826482**
c.i. Upper	**-0.8571**	**-0.68046**	**-0.49208**	14.98961	**43.56752**
	Signed Rank (H0: Mean=0)				
z=	**-2.096**	**-1.989**	**-1.988**	-1.786	**2.091**
	t-test (H0: Mean=0)				
t=	**-2.7658**	**-2.4784**	**-2.216**	0.051	**2.3374**

Significant results are reported in bold

Table 14: Deviations from Uncond. Opt. (UNCERT. Seq.1 - Sbj 8 dropped)

	Sequence 1 (sbj 8 dropped)				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	0.78	-0.66	-0.27	-0.98	0.71
	-3.72	-3.41	-3.27	-5.98	38.42
	-6.72	6.59	7.73	-5.98	0.95
	-2.44	-2.69	-0.77	-4.34	24.34
	-6.72	-3.41	-7.27	-7.98	60.59
	-6.72	-8.41	-14.27	65.98	-15.51
	-3.72	-7.41	-11.27	-17.98	81.88
	-2.72	-2.91	-4.27	-6.98	36.57
	-0.72	-4.81	-3.67	-0.98	24.53
Average	-3.63333	-3.01333	-4.14778	1.642222	28.05333
s.e.	0.903856	1.442773	2.145653	8.213342	10.23485
t-stat.	1.96	1.96	1.96	1.96	1.96
c.i. Lower	**-5.40489**	**-5.84117**	-8.35326	-14.4559	**7.993019**
c.i. Upper	**-1.86178**	**-0.1855**	0.057702	17.74037	**48.11365**
	Signed Rank (H0: Mean=0)				
z=	**-2.439**	-1.838	-1.836	-1.602	**2.31**
	t-test (H0: Mean=0)				
t=	**-4.0198**	**-2.0886**	**-1.9331**	0.1999	**2.741**

Significant results are reported in bold

In the last sequence, as shown in Table 15, the situation does not seem to change much as there are still significant deviations in two periods, according to the signed rank test (which becomes four, according to the t-test).

Table 15: Deviations from Unconditional Opt. (UNCERT. Seq. 5)

	Sequence 5				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	0.28	-0.21	-1.57	-2.48	6.05
	0.28	-1.41	-1.77	-1.48	8.32
	3.28	-8.41	5.23	0.52	-0.51
	0.48	1.51	-1.37	-1.48	-1.23
	4.28	-4.41	-6.77	-6.48	17.97
	1.14	-0.55	-1.91	1.36	-1.04
	3.28	0.59	-2.77	-4.48	-2.53
	8.28	-3.41	-4.77	-1.48	-11.03
	-2.22	-3.41	-2.77	-4.98	30.27
	4.28	-1.41	-3.77	-0.82	-4.04
Average	2.336	-2.112	-2.224	-2.18	4.223
s.e.	0.935463	0.917593	0.984087	0.780678	3.820877
t-stat.	1.96	1.96	1.96	1.96	1.96
c.i. Lower	**0.502492**	**-3.91048**	**-4.15281**	**-3.71013**	-3.26592
c.i. Upper	**4.169508**	**-0.31352**	**-0.29519**	**-0.64987**	11.71192
	Signed Rank (H0: Mean=0)				
z=	**2.298**	-1.888	-1.887	**-2.402**	0.459
	t-test (H0: Mean=0)				
t=	**2.4972**	**-2.3017**	**-2.26**	**-2.7924**	1.1052

Significant results are reported in bold

Deviations from *conditional* optimum are reported in Tables 16 and 18. In the first sequence, even when dropping some observations (Table 17), results suggest that subjects deviated significantly from optimum three times out of five. In the last sequence, however, the frequency of significant deviations drops to one (Table 18)[39].

[39]Significant deviations from *conditional* optimum were not counted in the last period, because these deviations were checked and determined to be due mainly to rounding.

Table 16: Deviations from Conditional Optimum (UNCERT. Seq.1)

	Sequence 1				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	0.78	-0.27	0.027304	-0.70981	-0.01
	-3.72	-5.42	-8.74	-18.44	-0.01
	-6.72	2.98	5.98	-2.88	0
	-2.44	-4.01	-4.62	-11.98	-9.9E-14
	-6.72	-7.02	-15.32	-28.58	0
	-6.72	-12.02	-25.52	33.98	0
	-3.72	-9.42	-19.24	-41.59	-0.01
	3.28	-3.62	-5.82	-16.16	**-43.46**
	-2.72	-4.42	-8.48	-18.12	-0.01
	-0.72	-5.22	-7.32	-10.62	0
Average	-2.942	-4.844	-8.90527	-11.51	-4.35
s.e.	1.063723	1.342274	2.898219	6.299031	4.345556
t-stat	1.96	1.96	1.96	1.96	1.96
c.i. Lower	**-5.0269**	**-7.47486**	**-14.5858**	-23.8561	-12.8673
c.i. Upper	**-0.8571**	**-2.21314**	**-3.22476**	0.83613	4.167289
	Signed Rank (H0: Mean=0)				
z=	**-2.096**	**-2.599**	**-2.293**	-1.886	**-2.405**
	t-test (H0: Mean=0)				
t=	**-2.7658**	**-3.6088**	**-3.0727**	-1.8273	-1.001

Significant results are reported in bold

Table 17: Deviations from Conditional Optimum (UNCERT. Seq.1, sbj 8 dropped)

	Sequence 1				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	0.78	-0.27	0.027304	-0.70981	-0.01
	-3.72	-5.42	-8.74	-18.44	-0.01
	-6.72	2.98	5.98	-2.88	0
	-2.44	-4.01	-4.62	-11.98	-9.9E-14
	-6.72	-7.02	-15.32	-28.58	0
	-6.72	-12.02	-25.52	33.98	0
	-3.72	-9.42	-19.24	-41.59	-0.01
	-2.72	-4.42	-8.48	-18.12	-0.01
	-0.72	-5.22	-7.32	-10.62	0
Average	-3.63333	-4.98	-9.24808	-10.9933	-0.00444
s.e.	0.903856	1.492985	3.21756	7.0188	0.001757
t-stat	1.96	1.96	1.96	1.96	1.96
c.i. Lower	**-5.40489**	**-7.90625**	**-15.5545**	-24.7501	**-0.00789**
c.i. Upper	**-1.86178**	**-2.05375**	**-2.94166**	2.763547	**-0.001**
	Signed Rank (H0: Mean=0)				
z=	**-2.439**	**-2.429**	**-2.192**	-1.718	**-2.214**
	t-test (H0: Mean=0)				
t=	**-4.0198**	**-3.3356**	**-2.8743**	-1.5663	**-2.5298**

Significant results are reported in bold

Table 18: Deviations from Conditional Optimum (UNCERT. Seq.5)

	Sequence 5				
	t=1	*t=2*	*t=3*	*t=4*	*t=5*
	0.28	-0.02	-1.42	-3.52	0
	0.28	-1.22	-2.4	-4.05269	-0.01
	3.28	-6.62	2.78	0.46	-0.01
	0.48	1.78	-0.02	-0.12	0
	4.28	-2.12	-5.76	-10.16	-0.03
	1.14	0.04	-1.25025	1.04	-0.01
	3.28	2.38	0.48	-0.8	-0.01
	8.28	1.08	0.38	3.98	0
	-2.22	-4.62	-6.9	-14.74	-0.02
	4.28	0.88	-0.86	1.38	0
Average	2.336	-0.844	-1.49702	-2.65327	-0.009
s.e.	0.935463	0.911676	0.922313	1.821486	0.003145
t-stat	1.96	1.96	1.96	1.96	1.96
c.i. Lower	**0.502492**	-2.63089	-3.30476	-6.22339	**-0.01516**
c.i. Upper	**4.169508**	0.942886	0.310709	0.916839	**-0.00284**
	Signed Rank (H0: Mean=0)				
z=	**2.298**	-0.459	-1.478	-0.968	**-2.405**
	t-test (H0: Mean=0)				
t=	**2.4979**	-0.9258	-1.6231	-1.4567	**-2.862**

Significant results are reported in bold

Tables 19 and 20 and Tables 21 and 22 show a comparison of all treatments, with respect to the results discussed in the last paragraphs (numbers in bold represent significant deviations). When considering deviations from unconditional optimum (Table 19 and Table 20), there seems to be no evident effect of learning between sequence 1 and sequence 5 in almost all treatments. In general it seems that subjects in the uncertainty treatment have higher and more frequent deviations from optimum. Moreover, the existence of significant deviations in all treatments suggests that, in general, participants did not use the optimal planning horizon.

Table 19: Deviations from Unconditional Optimum - SEQUENCE 1

Treatment		***1***	***2***	***3***	***4***	***5***	**Period**
Certainty Restricted	avg. dev.	0.04152	-1.7855	**-2.5024**	5.40288	2.04262	
	s.d.	*0.99*	*1.43*	*1.36*	*6.39*	*4.48*	
Risk	avg. dev.	0.58	-0.77	-3.9	-5.91	15.797	
	s.d.	*1.89*	*2.49*	*2.95*	*2.37*	*11.07*	
Uncertainty Restricted	avg. dev.	**-3.6333**	-3.0133	-4.1478	1.64222	**28.0533**	
	s.d.	*0.90*	*1.44*	*2.15*	*8.21*	*10.23*	

In "Certainty Restricted" observations of subject no.5 are dropped
In "Uncertainty Restricted" observations of subject no.8 are dropped
Significant results are reported in bold

Table 20: Deviations from Unconditional Optimum - SEQUENCE 5

Treatment		***1***	***2***	***3***	***4***	***5***	**Period**
Certainty	avg. dev.	1.2843	2.2885	**-2.1432**	**-3.7989**	-1.7176	
	s.d.	*0.85*	*1.43*	*0.61*	*1.25*	*2.02*	
Risk	avg. dev.	2.83	-1.586	**-3.239**	-0.787	0.928	
	s.d.	*1.38*	*0.86*	*1.11*	*2.38*	*2.20*	
Uncertainty	avg. dev.	**2.336**	-2.112	-2.224	**-2.18**	4.223	
	s.d.	*0.94*	*0.92*	*0.98*	*0.78*	*3.82*	

Significant results are reported in bold

The situation seems slightly better, at least in the case of decision making under certainty and risk, when looking at *conditional* deviations (Table 21 and Table 22). Again, at least in the first sequence, subjects in the uncertainty treatment seem to have deviated consistently more from conditional optimum than participants in other treatments.

Table 21: Deviations from Conditional Optimum - SEQUENCE 1

Treatment		***1***	***2***	***3***	***4***	***5***	**Period**
Certainty Restricted	avg. dev.	0.04148	-1.763	-3.5896	1.38423	-0.0381	
	s.d.	*0.99*	*1.87*	*2.71*	*3.56*	*0.02*	
Risk	avg. dev.	0.58	-0.44	-3.892	**-9.011**	-0.001	
	s.d.	*1.89*	*3.27*	*3.08*	*4.76*	*0.00*	
Uncertainty Restricted	avg. dev.	**-3.6333**	**-4.98**	**-9.2481**	-10.993	-0.0044	
	s.d.	*0.90*	*1.49*	*3.22*	*7.02*	*0.00*	

In "Certainty Restricted" observations of subject no.5 are dropped
In "Uncertainty Restricted" observations of subject no.8 are dropped
Significant results are reported in bold

Table 22: Deviations from Conditional Optimum - SEQUENCE 5

Treatment		***1***	***2***	***3***	***4***	***5***	**Period**
Certainty	avg. dev.	1.28425	**2.98301**	0.42867	-0.877	-0.0234	
	s.d.	*0.85*	*1.11*	*0.66*	*1.10*	*0.02*	
Risk	avg. dev.	2.83	-0.056	-1.7465	-0.593	-0.002	
	s.d.	*1.38*	*1.09*	*1.45*	*0.38*	*0.00*	
Uncertainty	avg. dev.	**2.336**	-0.844	-1.497	-2.6533	-0.009	
	s.d.	*0.94*	*0.91*	*0.92*	*1.82*	*0.00*	

Significant results are reported in bold

4.2 Estimated planning horizon

Following Ballinger et al. (2003) and Carbone and Hey (2004) the apparent planning horizon used by participants in all treatments has been estimated, sequence by sequence. As explained in those papers, if the optimal planning horizon is used then consumption in each period is determined by the relevant (and correct) function of optimal consumption for that period. If a subject uses a shorter planning horizon, say n instead of the true T, then in each period t she behaves as if period $t+n-1$ is the last one. A person with a planning horizon of one period, for example, will act as if each period was the last one; a subject using a two period planning horizon will consume as if period t was the "last-but-one" period and the following $(t+1)$ was the last one[40]. Acting using the "as if" heuristics means that consumption is determined using a consumption function relevant to the specific *reference* point, except for when $t+n-1$ is greater than the true length of the lifecycle (T, known by participants). Hence, a subject with a "one-period" planning horizon will always use the optimal consumption function of the last period whereas a person using a "two-period" planning horizon will use the "last-but-one" consumption function in period t and the function of the last period in $t+1$, except for the last period, when she correctly perceives that she is in the last period of the lifecycle ($t+n-1$ greater than T). Following the cited contributions, the apparent horizons have been estimated in two stages. First, the optimal path for each possible planning horizon has been calculated using the optimal consumption functions (those determined by solving the intertemporal problem). The apparent planning horizon was then identified as the one minimizing the mean squared deviation from optimal consumption (i.e. the mean squared difference between actual and optimal consumption). This procedure was carried out for both definitions of optimal consumption considered in this study. Table 23 shows these estimations in the case of certainty. The last row of each table contains the average planning horizon of a sequence. Results show that the average planning horizon is always shorter than optimal. Statistical tests[41] (Signed Rank and t-test) support the conclusion that in the case of certainty the average apparent horizon is always significantly shorter than the optimal planning horizon. A very similar result is found when considering decision making under risk (Table 24): the average of the apparent horizon is significantly different than 5 (length of the optimal planning horizon) both when using the signed rank test and the t-test[42].

[40]See Carbone and Hey (2004), p. 678.
[41]The tests are reported in the Appendices A.1 and A.2
[42]See Appendices A.3 and A.4

Table 23: Estimated Planning Horizons (CERTAINTY)

Estimated Planning Horizon (CERTAINTY)											
	Absolute Optimum					Conditional Optimum					
Seq	***1***	***2***	***3***	***4***	***5***	***1***	***2***	***3***	***4***	***5***	***Seq***
	4	5	5	5	5	4	4	4	4	4	
	4	4	5	4	3	5	5	5	3	2	
	5	5	4	5	4	5	4	5	4	3	
	5	2	2	5	2	3	3	2	3	3	
	1	5	4	1	1	3	4	5	2	1	
	5	3	5	5	3	4	3	4	5	3	
	2	5	1	2	1	3	5	2	3	2	
	4	5	4	5	5	5	5	5	4	4	
	2	1	2	2	2	2	2	3	2	2	
	1	1	1	1	1	1	1	1	1	1	
Average	3.3	3.6	3.3	3.5	2.7	3.5	3.6	3.6	3.1	2.5	Average

Table 24: Estimated Planning Horizons (RISK)

Estimated Planning Horizon (RISK)											
	Absolute Optimum					Conditional Optimum					
Seq	***1***	***2***	***3***	***4***	***5***	***1***	***2***	***3***	***4***	***5***	***Seq***
	5	5	5	5	3	5	5	5	3	3	
	2	1	1	1	1	1	1	1	1	1	
	5	5	5	5	5	5	5	5	5	5	
	1	1	2	2	2	1	1	2	2	2	
	5	5	4	5	5	5	5	4	5	3	
	2	4	2	1	1	2	4	2	2	2	
	1	1	5	5	5	2	2	5	5	5	
	1	1	1	1	1	1	1	1	1	1	
	5	3	2	2	3	5	3	2	2	3	
	4	5	5	5	5	3	5	5	5	4	
Average	3.1	3.1	3.2	3.2	3.1	3	3.2	3.2	3.1	2.9	Average

Finally, Table 25 shows the case of decision making under uncertainty. The average planning horizon estimated in this case seems to be longer than the one used in other treatments. Indeed, statistical tests confirm that there is no statistical difference with the optimal horizon in the first *three* sequences, when considering unconditional optimum[43]. However, in the case of conditional optimum there are *three* sequences in which the actual (estimated) planning horizon is significantly shorter than optimal (sequences 2, 4 and 5)[44]. These results do not change even when dropping the observations related to subject number 8 (who did not consume all of her wealth in the last period in four sequences out of five)[45].

Table 25: Estimated Planning Horizons (UNCERTAINTY)

Estimated Planning Horizon (UNCERTAINTY)											
	Absolute Optimum					**Conditional Optimum**					
Seq	***1***	***2***	***3***	***4***	***5***	***1***	***2***	***3***	***4***	***5***	***Seq***
	4	5	5	4	5	4	5	5	4	5	
	5	5	2	5	5	5	5	1	5	5	
	5	2	5	4	4	5	2	5	4	4	
	5	5	5	2	4	5	5	5	2	5	
	5	5	5	4	4	5	4	4	4	3	
	5	5	5	1	4	5	2	5	2	4	
	5	5	5	3	2	5	5	5	2	2	
	1	1	1	3	1	4	3	5	4	1	
	5	5	5	5	5	5	5	5	5	5	
	5	3	5	5	3	5	3	5	5	3	
Average	4.5	4.1	4.3	3.6	3.7	4.8	3.9	4.5	3.7	3.7	Average

Comparing treatments with respect to the actual planning horizon reveals that in the case of decision making under uncertainty, participants seem to be more far-sighted than their colleagues under certainty or risk, especially when looking at deviations from unconditional optimum. However, since extreme values (especially very short planning horizons) have a heavy influence on averages, Table 26 shows only the frequency of estimated planning horizons longer than three periods. The table confirms that the proportion of

[43] See Appendix A.5
[44] See Appendix A.7
[45] See Appendices A.6 and A.8

far-sighted individuals is consistently higher in the case of uncertainty than in other treatments. This result is somewhat at odds with previous findings, suggesting that in the case of decision making under uncertainty participants deviated more from maximum utility and more frequently within the first and the last sequences. A possible explanation for this could be the existence of a correlation between estimated planning horizons and specific strategies generating those estimations. In other words, given the very short length of the lifecycle, some (possibly extreme) strategies might cause biased estimations. An "informal" analysis of this hypothesis has highlighted that there are actually some specific strategies that seem to cause a very high estimation of the actual planning horizon[46]. In particular, it seems that saving "aggressively" (i.e. most or all of available wealth) in the first/second periods results in an estimated planning horizon of four/five periods. This phenomenon seems to be more evident when looking at data from the risk and uncertainty treatments. For this reason and in order to investigate the existence of regularities that influenced the estimation of actual planning horizons, the distribution of the fraction of consumption over available wealth, for all treatments will be analyzed.

4.3 Consumption-to-wealth ratios

Table 27 reports, for each treatment and each sequence, the comparison between the optimal consumption-to-wealth ratio (c^*/w^*) and the average of actual ratios (standard deviations are also reported). The same data is also presented in the form of graphs, one for each sequence, in which treatments are compared with respect to deviations from optimal ratios (Figures 3a, 3b, 3c, 3d and 3e). In these graphs the "x-axis" represents a deviation equal to zero, while positive and negative values can be interpreted as instances of over– and under–consumption. An interesting finding, immediately visible from the graphs, is that in the case of uncertainty, ratios are consistently be-

[46]This is the case, for example, of participant no.3 in sequence 1, participant no. 5 in sequences 2 and 3 (certainty) and participant no.1 in sequence 1 (Risk).

Table 26: Frequency of horizons with length greater than 3 periods

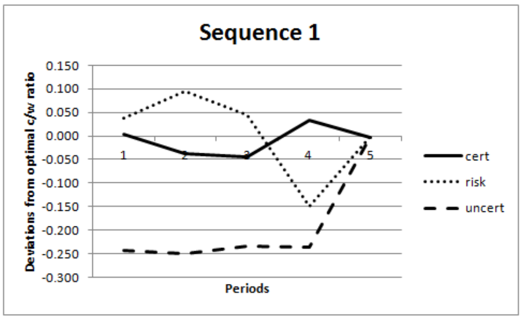
Treatment	Type of Dev.	*1*	*2*	*3*	*4*	*5*	SEQ
Certainty	Uncond. Opt.	6	6	6	6	3	
	Cond. Opt	5	6	6	4	2	
Risk	Uncond. Opt.	5	5	5	5	4	
	Cond. Opt	4	5	5	4	3	
Uncertainty	Uncond. Opt.	9	7	8	6	7	
	Cond. Opt	10	6	9	7	6	
Uncertainty Restricted	Uncond. Opt.	9	7	8	6	7	
	Cond. Opt	9	6	8	6	6	

low zero (implying an average under-spending with respect to optimum) and consistently below the other two treatments. This finding, together with the pattern described at the end of the previous subsection, might help explain the apparent contradiction between deviations from optimum and estimated planning horizons. In other words, if strategies implying significant savings[47] cause an overestimation of the actual planning horizon, the consumption–to–wealth ratios show that this problem affects mainly data coming from decision making under uncertainty. For this reason, those estimations do not seem to represent a reliable indication of whether participants used the optimal planning horizon.

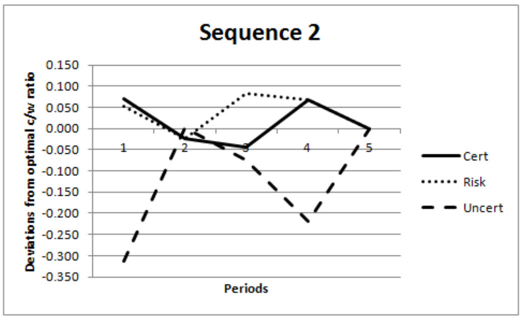
[47]Including also extreme strategies such as saving everything until the last period

Table 27

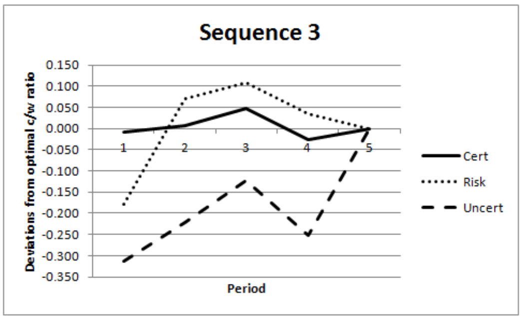
		CERTAINTY					RISK					UNCERTAINTY				
		1	*2*	*3*	*4*	*5*	*1*	*2*	*3*	*4*	*5*	*1*	*2*	*3*	*4*	*5*
seq 1	opt	0.543	0.536	0.589	0.710	1.000	0.448	0.463	0.544	0.690	1.000	0.448	0.507	0.539	0.654	1.000
	avg	0.547	0.498	0.545	0.744	0.997	0.487	0.559	0.589	0.541	1.000	0.206	0.256	0.305	0.418	1.000
	s.d.	*0.298*	*0.345*	*0.308*	*0.232*	*0.005*	*0.399*	*0.414*	*0.355*	*0.321*	*0.000*	*0.181*	*0.187*	*0.226*	*0.283*	*0.000*
	dev	***0.004***	***-0.039***	***-0.044***	***0.034***	***-0.003***	***0.039***	***0.095***	***0.045***	***-0.150***	***0.000***	***-0.242***	***-0.251***	***-0.234***	***-0.236***	***0.000***
seq 2	opt	0.543	0.536	0.589	0.710	1.000	0.448	0.507	0.539	0.654	1.000	0.644	0.501	0.538	0.683	1.000
	avg	0.613	0.512	0.545	0.778	0.999	0.500	0.482	0.622	0.722	1.000	0.332	0.501	0.462	0.463	0.999
	s.d.	*0.360*	*0.351*	*0.312*	*0.252*	*0.002*	*0.317*	*0.332*	*0.196*	*0.213*	*0.000*	*0.320*	*0.173*	*0.152*	*0.214*	*0.001*
	dev	***0.070***	***-0.024***	***-0.044***	***0.069***	***-0.001***	***0.052***	***-0.025***	***0.083***	***0.068***	***0.000***	***-0.312***	***0.001***	***-0.076***	***-0.220***	***0.000***
seq 3	opt	0.543	0.536	0.589	0.710	1.000	0.644	0.501	0.538	0.654	1.000	0.644	0.655	0.723	0.859	1.000
	avg	0.534	0.543	0.637	0.682	0.999	0.467	0.572	0.645	0.689	1.000	0.332	0.435	0.600	0.608	1.000
	s.d.	*0.291*	*0.313*	*0.238*	*0.273*	*0.003*	*0.436*	*0.233*	*0.177*	*0.208*	*0.000*	*0.270*	*0.309*	*0.225*	*0.321*	*0.000*
	dev	***-0.009***	***0.006***	***0.048***	***-0.027***	***-0.001***	***-0.177***	***0.071***	***0.108***	***0.035***	***0.000***	***-0.312***	***-0.221***	***-0.123***	***-0.251***	***0.000***
seq 4	opt	0.543	0.536	0.589	0.710	1.000	0.644	0.501	0.538	0.654	1.000	0.448	0.507	0.594	0.744	1.000
	avg	0.628	0.669	0.680	0.800	0.998	0.570	0.660	0.649	0.708	1.000	0.533	0.413	0.504	0.538	0.998
	s.d.	*0.188*	*0.218*	*0.180*	*0.177*	*0.005*	*0.362*	*0.263*	*0.243*	*0.204*	*0.000*	*0.271*	*0.338*	*0.260*	*0.294*	*0.004*
	dev	***0.085***	***0.132***	***0.091***	***0.091***	***-0.002***	***-0.074***	***0.159***	***0.112***	***0.054***	***0.000***	***0.085***	***-0.094***	***-0.089***	***-0.206***	***-0.002***
seq 5	opt	0.543	0.536	0.589	0.710	1.000	0.448	0.507	0.594	0.744	1.000	0.448	0.507	0.594	0.677	1.000
	avg	0.672	0.756	0.705	0.723	0.999	0.637	0.650	0.644	0.772	1.000	0.560	0.459	0.515	0.575	1.000
	s.d.	*0.269*	*0.195*	*0.184*	*0.246*	*0.002*	*0.290*	*0.297*	*0.309*	*0.182*	*0.000*	*0.148*	*0.229*	*0.182*	*0.173*	*0.000*
	dev	***0.128***	***0.219***	***0.116***	***0.013***	***-0.001***	***0.189***	***0.143***	***0.050***	***0.028***	***0.000***	***0.112***	***-0.048***	***-0.079***	***-0.102***	***0.000***



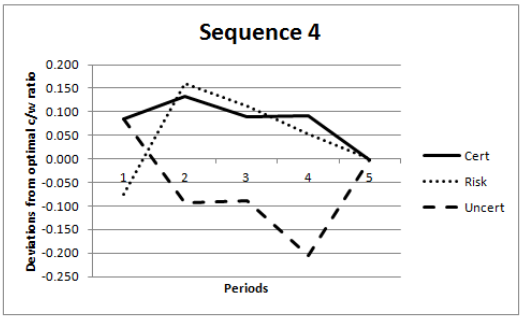
(a)



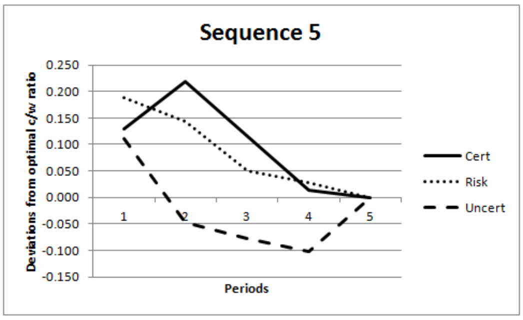
(b)



(c)



(d)



(e)

Figure 3: Deviations from optimal c to w ratio

4.4 Regression analysis

To briefly summarize the main findings discussed in the previous sub-sections, results seem to suggest that *a*) subjects did not maximize utility; *b*) participants did not use the optimal strategy; *c*) in the case of uncertainty, deviations from both definitions of optimum (within a sequence) seem to be slightly more frequent than in other treatments; *d*) uncertainty seems to have determined a pattern of under–consumption, probably a form of "precautionary savings"[48].

In order to assess whether on average participants employed the optimal planning horizon and to identify the influence of other variables on actual choices, regressions of the deviation from optimum have been carried out. Estimations include dummy variables for sequences (to detect the effect of the repetitions), a set of interaction terms between these dummy variables and planning periods (to estimate the effect of the planning horizon in each sequence), the square of planning periods (when significant), wealth, a dummy for changes of income[49], lagged consumption, lagged utility[50] and time used to make a decision[51]. As during the descriptive analysis, two alternative definitions of deviation have been used: from *unconditional* and from *conditional* optimum[52]. In all estimations observations of participants who did not consume everything in the last period of a sequence were dropped. In particular, since conversions could be decimal numbers, a "leftover" of wealth in the last period was frequently noted, in the magnitude of few cents or less. For this reason observations in the last period where the difference between wealth and consumption was greater or equal to *one* full token were dropped[53]. In all estimations standard errors corrected by clustering on subjects were also used to simultaneously control for serial correlation and heteroskedastic-

[48] This is more visible when looking at deviations from conditional optimum (Figures 2a to 2e) and the graph of the consumption-to wealth ratio (Figures 3a to 3e).

[49] This variable takes a value of zero in the case of low income and one in the case of high income. It only makes sense to use it in cases of risk and uncertainty.

[50] Models in Tables 28 and 29 have been estimated using both lagged consumption and lagged utility, dropping both of them and using just one of them alternatively. Results do not change substantially; for each estimation the Variance Inflation Factor (VIF) has been calculated and it is always well below the values usually considered critical for multicollinearity.

[51] This estimation uses 250 observations (10 participants, 5 periods, 5 sequences). However, at least 50 observations are lost because of the use of lagged variables. Moreover, in each treatment, some observations have been dropped, as explained below.

[52] The dependent variable has been defined as a simple deviation from optimum $(c - c*)$

[53] This occurred twice in the case of decision making under certainty and under risk, and 4 times in the case of decision making under uncertainty.

ity. Moreover, in each case statistical tests were carried out to discriminate between Pooled OLS, Random Effects and Fixed Effects[54]. In general, if participants used the optimal strategy, regressors would have no significant effect and errors be considered "white noise" (as all variations would be random)[55].

Table 28 shows the regressions of the deviation from *unconditional* optimum, for all treatments. In the case of certainty a model with Fixed Effects[56] has been estimated, while in the case of risk[57] and in the case of uncertainty[58] Pooled OLS was used.

The dummies for sequences are meant to capture potential learning effects developing across lifecycles. As results suggest, in the case of certainty there seems to be no statistically significant improvement of behaviour across sequences. In particular, all sequences are not significantly different than the first one, showing that behaviour did not change substantially across these lifecycles. The F-test on the dummy variables accepts the null hypothesis that there is no statistical difference among sequences, i.e. there is no "sequence" effect[59]. The situation is different when looking at decision making under risk; in this case results suggest that there is a significant effect of sequences on the deviation from optimum. Although there are only two sequences (three and four) that are significantly different than the reference group (sequence one), when considering the effect of sequences individually, results show that, except for sequence three, all other lifecycles have a statistically significant effect of the deviation from optimum. Moreover, a F-test on the Null Hypothesis that all dummies are equal, rejects it ($F(4,9) = 4.76$; p-

[54]These tests will be reported when discussing specific tables.

[55]For a similar discussion see Carbone and Hey (2004).

[56]Breusch-Pagan LM test: $\chi^2_1 = 0.80$ (p-value= 0.3711); F-test (Fixed Effects against Pooled OLS): $F(9,174) = 2.28$ (p-value= 0.0195); Hausman test: $\chi^2_{14} = 32.49$ (p-value= 0.0034)

[57]Breusch-Pagan LM test: $\chi^2_1 = 0.39$ (p-value= 0.5309; Pooled OLS preferred to R.E.); F-test: $F(9,174) = 1.15$ (p-value= 0.3319); Hausman Test: $\chi^2_{14} = 11.18$ (p-value= 0.6720; R.E. preferred to F.E.)

[58]Breusch-Pagan LM test: $\chi^2_1 = 0.06$ (p-value= 0.8077; Pooled OLS preferred to R.E.); F-test: $F(9,171) = 1.44$ (p-value= 0.1765)

[59]$F(4,9) = 1.55$ (p-value= 0.2681).

value= 0.0243), supporting the hypothesis of a significant effect of sequences. Similarly, in the case of uncertainty results show that behaviour has significantly changed across lifecycles. In particular, sequences two, three and five seem to cause a significant deviation from optimum[60]. Again, the F-test on these dummy variables rejects the Null Hypothesis of no "sequence" effect ($F(4, 9) = 5.37$: p-value= 0.0173).

The effect of the planning horizon on errors is captured by the variables representing planning periods ("Periods" and its square, "Period Sq."). In general, if participants used, on average, the optimal planning horizon, then periods should not have any significant effect on the deviation from optimum. In order to check for the effect of the planning horizon for each sequence, interaction terms between the sequence dummies and the variable Period have been used[61]. The square of periods, used to detect potential non–linearities, enters the specification with no interaction; in other terms it represents an average effect over all sequences. Results in Table 28 seem to confirm the findings of previous sub-sections, suggesting that on average participants did not employ the optimal planning horizon; the effect of planning periods is statistically significant in all treatments and always negative while the squared term is positive, suggesting a convex relationship between deviations and planning periods. Using a *ceteris paribus* interpretation, this negative relationship might suggest that the deviation from optimum decreases through time[62]. Whether this also means that participants over-consumed early in the lifecycle and under-consumed later on, depends on the effect of other variables that significantly affect the deviation from optimum (e.g. wealth, changes of income or lagged variables).

Table 29 shows the regressions of the second definition of deviation, that

[60]Also, these sequences are statistically different than the first one (which is however not significant).

[61]This generates the "slope" effect for each sequence, with respect to planning periods. In order to avoid collinearity, I have not included the variable "Period" in the estimation

[62]Given the definition of the dependent variable (difference between actual and optimal consumption), this does not imply that the deviation tends toward zero as time increases. Rather, it suggests that the deviations become "smaller in negative numbers".

Table 28: Regressions of Deviation from Unconditional Optimum

	(1) Certainty	(2) Risk	(3) Uncertainty
Sequence 2	0.562	16.11	24.91**
	(0.12)	(1.79)	(3.54)
Sequence 3	2.639	26.53*	16.30**
	(1.34)	(2.71)	(3.54)
Sequence 4	6.060	20.56*	8.384
	(2.02)	(2.67)	(1.47)
Sequence 5	7.679	13.25	14.78*
	(2.10)	(1.25)	(2.50)
Seq. 1 * Periods	-18.52**	1.404	-23.05**
	(-4.25)	(0.75)	(-3.61)
Seq.2 * Periods	-18.43**	-3.318**	-28.55**
	(-3.64)	(-3.76)	(-4.32)
Seq. 3 * Periods	-19.17**	-6.587***	-24.60**
	(-3.98)	(-5.51)	(-3.67)
Seq. 4 * Periods	-19.60**	-4.550***	-23.58**
	(-4.01)	(-5.75)	(-3.70)
Seq. 5 * Periods	-19.83**	-0.985	-25.59**
	(-3.98)	(-1.01)	(-3.89)
Period Sq.	2.382*		3.741**
	(3.23)		(3.80)
Wealth	0.936***	0.609***	0.678***
	(8.11)	(9.97)	(10.36)
Lagged c	-0.125	0.0735	-0.135
	(-1.65)	(0.32)	(-2.23)
Lagged U	4.341**	2.515	0.885
	(3.53)	(1.54)	(1.74)
Time	-0.00541	0.0487*	0.0131
	(-0.71)	(2.35)	(0.66)
Income		0.226	-8.461***
		(0.11)	(-5.20)
Constant	3.319	-32.38*	10.77
	(0.46)	(-3.24)	(1.04)
N	198	198	196
R^2	0.632	0.575	0.640

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 29: Regressions of Deviation from Conditional Optimum

	(1) Certainty	(2) Risk	(3) Uncertainty
Sequence 2	-0.826	2.672	12.63*
	(-0.20)	(0.46)	(2.86)
Sequence 3	2.878	6.806	6.125
	(1.76)	(1.06)	(1.82)
Sequence 4	5.333	3.708	6.258
	(2.01)	(0.71)	(1.68)
Sequence 5	6.803	3.940	7.714
	(2.03)	(0.59)	(1.93)
Seq.1 * Periods	-0.0825	-0.0481	-10.35
	(-0.09)	(-0.04)	(-2.25)
Seq.2 * Periods	0.358	-0.492	-12.90*
	(0.49)	(-0.95)	(-2.81)
Seq.3 * Periods	-0.923	-1.875*	-10.95*
	(-1.65)	(-2.34)	(-2.33)
Seq.4 * Periods	-1.187**	-0.936	-11.09*
	(-3.44)	(-1.65)	(-2.40)
Seq.5 * Periods	-1.580***	-0.875	-11.35*
	(-5.57)	(-1.16)	(-2.44)
Wealth	0.00994	-0.141***	-0.0135
	(0.11)	(-5.18)	(-0.13)
Lagged c	-0.0847	-0.167	-0.00405
	(-2.05)	(-1.37)	(-0.07)
Lagged U	2.124	2.742*	-0.00612
	(1.98)	(2.41)	(-0.01)
Time	0.0102	0.0192	0.0139
	(1.23)	(1.23)	(1.20)
Income		4.445*	-1.292
		(2.37)	(-1.69)
Periods Sq.			1.660*
			(2.40)
Constant	-6.605	-7.663	7.308
	(-1.67)	(-1.45)	(0.85)
N	198	198	196
R^2	0.107	0.392	0.205

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

is, from *conditional* optimum. In the cases of certainty[63] and risk[64] Pooled OLS was used while in the case of uncertainty[65] a Fixed Effects model has been employed. As already discussed, in this case actual choices are compared to a "benchmark" calculated on *actual* (as opposed to *optimal*) wealth. If participants were actually choosing optimally, but made some mistakes in certain points of the sequence, the *unconditional* optimum would signal this in the form of significant deviations. However, under the second definition of deviation, mistakes in some periods of the lifecycle are considered only because they determine actual wealth. This means that if participants are actually choosing optimally (with respect to *conditional* optimum), estimated coefficients would not be statistically significant. Indeed, results in Table 29 show that in all treatments there is only a small number of significant variables. This time, sequences seem not to have a significant effect on deviations from optimum[66] (compared to the first one) in any of the treatments. In particular, the difference from Table 28 is striking when looking at estimations of decision making under risk and under uncertainty. Of course this difference is directly affected by the definition of the dependent variable, more specifically by the information about the improvement of behaviour implied by the deviation from conditional optimum. These results can be interpreted as suggesting that although participants in some sequences deviated significantly from the optimal solution (as shown in Table 28), their behaviour was substantially the same across sequences.

The fact that participants failed to optimize, and did not use the optimal planning horizon can be extrapolated from the effect of planning periods, defined again using the interaction between sequence dummies and the variable

[63]Breusch-Pagan LM test (Pooled OLS against Random Effects): $\chi^2_1 = 0.37$ (p-value= 0.5406); F-test (Fixed Effects against Pooled OLS): $F(9, 175) = 2.09$ (p-value= 0.0331); Hausman Test: $\chi^2_{13} = 20.18$ (p-value= 0.0908; R.E. preferred to F.E.)

[64]Breusch-Pagan LM test: $\chi^2_1 = 0.63$ (p-value= 0.4279); F-test (Fixed Effects against Pooled OLS): $F(9, 174) = 0.83$ (p-value= 0.5898)

[65]Breusch-Pagan LM test: $\chi^2_1 = 5.62$ (p-value= 0.0177); F-test (Fixed Effects against Pooled OLS): $F(9, 171) = 2.68$ (p-value= 0.0061); Hausman Test: $\chi^2_{15} = 45.18$ (p-value= 0.0001; F.E. preferred to R.E.)

[66]The only exception is sequence 2 in the uncertainty treatment.

"Periods". These specifications also include an estimation (when significant) of the average effect (across sequences) of non-linearities associated with planning periods. In general there seems to be a decrease of the number of significant coefficients, especially in cases of certainty and risk. However, in the case of decision making under uncertainty, results seem to confirm some of the conclusions of the descriptive analysis, namely that participants in this treatments seem to have deviated more frequently from optimum[67]. These results can also be used to shed more light on the apparent contradiction raised by the estimation of the actual planning horizon discussed above. Given that participants have consistently deviated from optimum, it is unlikely they have employed the optimal horizon, as those estimations suggested[68].

4.5 Other regressors

This paragraph will briefly discuss the effects of the other regressors included in the estimations on the deviations from optimum. Table 28 shows that the effect of wealth is always significant and positive. This means that, on average, the deviation increases as wealth grows larger.Table 29 shows that in the case of deviation from conditional optimum, the effect of wealth is significant (and negative) only in the "risk" treatment. The difference of signs between Table 28 and Table 29 is a consequence of the nature of the reference points considered and can be interpreted as suggesting that on average participants were under-spending relative to the conditional optimum. This might also suggest that the average pattern of deviations from optimum (over the experiment) be downward sloped, as hinted in Figure 2.

The effect of an increase of income (from "low" to "high") has been estimated, obviously only for decision making under risk and under uncertainty,

[67]See, for example, the discussion regarding the comparison between the first and the fifth sequence in the previous sections.

[68]It is however very interesting to note how extreme strategies, as those described when presenting the estimations of the actual planning horizons, had such a significant impact in this case.

using a dummy variable coded zero for low income and one otherwise. In the case of "risk", income seems to have no significant effect on deviations from *unconditional* optimum (Table 28) while it has a significant and positive coefficient when considering *conditional* optimum (Table 29). In other words, it seems that having "fresh" money (not savings) through a higher income, leads to higher consumption. In the case of uncertainty, regressions show that the effect of income is significant and *negative* on deviations from unconditional optimum (Table 28), while it is not significant when considering the alternative definition of optimum (Table 29). This result suggests that, in the case of uncertainty, participants might have used the higher income to increase savings for precautionary reasons, hence causing a decrease of the deviation from optimum.

Regressions suggest that in none of the treatments there seems to be a significant effect of past consumption[69]. However, estimations have also taken into consideration the possibility that decisions on consumption might be influenced by *past utility* ("Lagged U"). In a sense, it is only a matter of which reference point subjects take to make their decision; is the quantity consumed (or the share of available wealth spent) determined with reference to last period's consumption or to last period's utility? Results suggest that participants might have taken "lagged utility" as a reference point to make their consumption decisions. However, care must be used in the interpretation of this finding: the estimated coefficients, both in cases of certainty and risk[70], are positive and may imply that participants try to maintain a similar level of utility between contiguous periods so that, the higher the utility in the previous period (hence, the higher consumption in that period) the higher present consumption (which leads to an increase of deviations from optimum).

[69] In this experiment past consumption was not included in the utility function. Its effect was estimated as the effect of consumption in the previous period (consumption lagged one period).

[70] In the case of certainty, the coefficient of lagged utility is significant with respect to the deviation from *unconditional* optimum (Table 28). In the case of risk, the variable in question is significant with respect to the deviation from *conditional* optimum (Table 29).

Finally, the time used by participants to make a decision usually has no significant effect on deviations, the only exception being the regression of the deviation from unconditional optimum, in case of risk (Table 28). In the dataset time was defined as the number of seconds until the end of the period. A positive coefficient (0.0487) means that the higher the time left (i.e. the less time is employed to think about a decision), the higher the deviation.

5 Discussion

Several contributions in the literature, either through the experimental approach or empirical analysis, have shown how people may have difficulties in solving intertemporal consumption problems. Researchers have identified several factors that affect, positively or negatively, the deviation from the optimal path of consumption. Ballinger et al. (2003) and Carbone and Hey (2004) include a discussion on the estimation of the planning horizon, which participants actually seem to use to solve this type of problem. They conclude that not only do many people seem to be short-sighted relative to the optimal planning horizon, but also that there seems to exist significant variability across subjects. This pilot experiment further explores how people perceive the planning horizon in the specific case of a very short lifecycle, under three different decision-making contexts (certainty, risk and uncertainty). The implicit hypothesis is that a short planning horizon might be easier to perceive, hence helping to reduce myopic decision making as well as significant deviations from optimal consumption.

Results seem to tell two different stories. When consumption choices are compared to absolute (or unconditional) optimum the effect of planning periods is almost always significant (as regressions in Table 28 show). This suggests that participants were not able to optimally solve the intertemporal problem and did not use the correct (optimal) planning horizon. However, if learning within a sequence is considered, by changing the reference point to the conditional optimum, results show an increase in the number of cases in which planning periods are non significant (see Table 29), particularly in cases of decision making under certainty and under risk. In the case of decision making under uncertainty results show persistent and significant deviations from optimum.

The combination of these results can be interpreted as suggesting that even in the case of a very short lifecycle (only five periods), the intertemporal consumption problem might be too complex to be solved optimally. However, the unusually short length of the planning horizon seems also to allow for a significant improvement of strategy, with some exceptions. First, results show that uncertainty might be an important factor preventing participants from benefitting from this kind of learning. Second, also in cases of decision making under certainty and under risk, there are some instances of a significant effect of the planning horizon on deviations from conditional optimum[71]. It is not clear why there would be a switch of statistical significance of the planning horizon, as in Table 29. A possible explanation for this could be that participants, at some point in the experiment, tried new strategies, probably with the objective of improving their outcome with respect to previous sequences. If that was the case, however, a significant learning effect across sequences[72] would have also been expected, as a consequence of a significant change in behaviour. Results indicate that although participants did not optimize, their behaviour was not significantly different across lifecycles (as suggested by the comparison of the effect of sequences on conditional deviations, Table 29).

Deviations from the optimal path of consumption are also significantly determined by wealth (Table 28). This might imply that participants did not correctly take into account the effect of the interest rate or that, as in the case of decision making under risk (Table 29), participants over-spended

[71] Sequences 4 and 5, in the case of certainty and sequence 3, in the case of risk (Table 29).

[72] As described earlier, this effect is measured by the dummy variables for sequences.

early in the lifecycle and under-spended later on. A similar result is found with respect to the effect of income. In this case results suggest that a higher income might cause over-consumption (as in the case of risk, Table 29) or precautionary savings (as in the case of uncertainty, Table 28). Experimental results also show how, in some cases, past decisions might have affected current ones. In particular, although the effect of past consumption is never significant, past utility seems to affect current decisions, at least in cases of certainty and risk. In the experiment, past utility had a positive effect on deviations from optimum, suggesting that participants were trying to keep the same level of utility in contiguous periods.

Given the nature of a pilot experiment, the main limitation of this study was obviously the small number of participants and, consequently, the limited power of statistical analysis. Taking a deeper look into the structure of the experiment, there are some variations of the design that might be worth exploring. First, there is the possibility that imposing a conversion from tokens directly into money might create some distortions of decision making, due to the fact that euro–cents might be perceived as being a negligible amount of money[73]. This problem could be alleviated by introducing an intermediate conversion, for example from tokens into points, using a scaling factor on the utility function in order to make small differences (in money) more significant (in terms of points). This way the payoff would then be equal to the conversion into money of the total points accumulated during the experiment.

A second potential improvement might be on the mechanism determining income, under risk and uncertainty. In other studies income has been determined, in each period of a sequence, in many different ways; some have used a bingo cage[74], others have used methods such as a function with specific statistical properties (Brown et al., 2009). In this study however, the choice of using a very simple mechanism for the determination of income was mo-

[73]Participants might also perceive the difference between cents as being negligible (e.g. the difference between 0.20 and 0.30 cents of Euro).

[74]Ballinger et al (2003) and Hey et al (2007, 2008)

tivated by the intention of not focussing specifically on risk and uncertainty but, rather, on the effect of a short lifecycle on planning. For this reason, the effect of risk and uncertainty is somewhat subtle; only two possible levels of income with two associated probabilities[75]. In future, this mechanism might be made more complex, for example by increasing the number of "levels" of income or by using different probabilities (other than the $50-50$ distribution). Another possibility would be to use a function, similar to that used in Brown et al. (2009), although, on principle, the use of a mathematical function to determine income under uncertainty would be inappropriate due to concerns related to ensuring all participants were operating under *true* uncertainty[76].

On a similar note, a further improvement might involve the control for risk attitudes. As discussed, among others, in Ballinger et al. (2003), economic agents are identified by their individual coefficient of risk aversion and "[...] different values [of this coefficient] generate different paths [...]" (p. 924) of income distribution. Although researchers have not come to an agreement on which procedure is best used to reliably estimate individual preferences for risk, a pre-experiment or post-experiment estimation (as in Hey and Dardanoni, 1988) or the use of other elicitation mechanisms (as in Ballinger et al., 2003) would without a doubt improve the characterization of the utility function, making results more precise[77].

Future research might also be directed towards the study of decision making on lifecycles of different lengths. This could shed light on the hypothesis that an "incremental" approach (i.e. starting from a very short lifecycle and then solving the same problem for longer ones) might improve decision making. Such an experiment would necessarily imply a specific design to

[75]It is interesting to note, however, how despite this apparent simplicity, results show that there has been a significant difference between treatments.

[76]For example, if a subject has a good knowledge of math or statistics, she might be able to predict income with some precision, which would *not* put her in a situation of decision making under uncertainty.

[77]It is also true, however, that these procedures, and the associated benefits, must be measured against other variables, such as the length of experimental sessions.

control and disentangle the effects of learning across sequences. As discussed above, in this study estimations of actual planning horizons seemed to be unreasonably "inflated" as a consequence of extreme strategies (e.g. excessive under-spending early in the lifecycle). For this reason, further research, could focus on potential alternatives to estimate the actual planning horizon when the lifecycle is particularly short.

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Appendices

Appendix A Statistical Tests

The following sections report the statistical tests on the estimated planning horizons discussed in Section 2.4.2. In general, the Null Hypothesis under test is that the average planning horizon equals the optimal horizon ($H_0 : h_{AVG} = h_{OPT}$). In the case of the t-test the Alternative Hypothesis is one-tailed ($H_1 : h_{AVG} < h_{OPT}$). In the case of the Signed-Rank Test the Alternative Hypothesis is two-tailed ($H_1 : h_{AVG} \neq h_{OPT}$)

A.1 Certainty - Unconditional Optimum

- Sequence 1
  - t-test: t= -3.2852 (p= 0.0047)
  - signed-rank test: z= -2.554 (p= 0.0106)
- Sequence 2
  - t-test: t= -2.5849 (p= 0.0147)
  - signed-rank test: z= -2.204 (p= 0.0276)
- Sequence 3
  - t-test: t= -3.2852 (p= 0.0047)
  - signed-rank test: z= -2.554 (p= 0.0106)
- Sequence 4
  - t-test: t= -2.6656 (p= 0.0129)
  - signed-rank test: z= -2.205 (p= 0.0274)
- Sequence 5
  - t-test: t= -4.6414 (p= 0.0006)
  - signed-rank test: z= -2.678 (p= 0.0074)

A.2 Certainty - Conditional Optimum

- Sequence 1
  - t-test: t= -3.5032 (p= 0.0033)
  - signed-rank test: z= -2.553 (p= 0.0107)
- Sequence 2
  - t-test: t= -3.2796 (p= 0.0048)
  - signed-rank test: z= -2.553 (p= 0.0107)
- Sequence 3
  - t-test: t= -2.9406 (p= 0.0082)
  - signed-rank test: z= -2.392 (p= 0.0168)
- Sequence 4
  - t-test: t= -5.0186 (p= 0.0004)
  - signed-rank test: z= -2.772 (p= 0.0056)
- Sequence 5
  - t-test: t= -7.3193 (p= 0.0000)
  - signed-rank test: z= -2.821 (p= 0.0048)

A.3 Risk - Unconditional Optimum

- Sequence 1
  - t-test: t= -3.2426 (p= 0.0051)
  - signed-rank test: z= -2.397 (p= 0.0165)
- Sequence 2
  - t-test: t= -3.1425 (p= 0.0059)
  - signed-rank test: z= -2.405 (p= 0.0162)

- Sequence 3
  - t-test: t= -3.2504 (p= 0.0050)
  - signed-rank test: z= -2.397 (p= 0.0165)
- Sequence 4
  - t-test: t= -2.9459 (p= 0.0082)
  - signed-rank test: z= -2.210 (p= 0.0271)
- Sequence 5
  - t-test: t= -3.3529 (p= 0.0042)
  - signed-rank test: z= -2.397 (p= 0.0165)

A.4 Risk - Conditional Optimum

- Sequence 1
  - t-test: t= -3.4641 (p= 0.0036)
  - signed-rank test: z= -2.397 (p= 0.0165)
- Sequence 2
  - t-test: t= -3.1387 (p= 0.0060)
  - signed-rank test: z= -2.395 (p= 0.0166)
- Sequence 3
  - t-test: t= -3.2504 (p= 0.0050)
  - signed-rank test: z= -2.397 (p= 0.0165)
- Sequence 4
  - t-test: t= -3.4754 (p= 0.0035)
  - signed-rank test: z= -2.397 (p= 0.0165)
- Sequence 5

- t-test: t= −4.5826 (p= 0.0007)
- signed-rank test: z= −2.678 (p= 0.0074)

A.5 Uncertainty - Unconditional Optimum

- Sequence 1
  - t-test: t= −1.2457 (p= 0.1222)
  - signed-rank test: z= −1.412 (p= 0.1579)
- Sequence 2
  - t-test: t= −1.8676 (p= 0.0473)
  - signed-rank test: z= −1.725 (p= 0.0845)
- Sequence 3
  - t-test: t= −1.4812 (p= 0.0863)
  - signed-rank test: z= −1.412 (p= 0.1579)
- Sequence 4
  - t-test: t= −3.2796 (p= 0.0048)
  - signed-rank test: z= −2.553 (p= 0.0107)
- Sequence 5
  - t-test: t= −3.0736 (p= 0.0066)
  - signed-rank test: z= −2.561 (p= 0.0104)

A.6 Uncertainty - Unconditional Optimum (Sbj 8 dropped)

- Sequence 1
  - t-test: t= −1 (p= 0.1733)
  - signed-rank test: z= −1 (p= 0.3173)

- Sequence 2
  - t-test: t= -1.4744 (p= 0.0893)
  - signed-rank test: z= -1.412 (p= 0.1580)
- Sequence 3
  - t-test: t= -1 (p= 0.1733)
  - signed-rank test: z= -1 (p= 0.3173)
- Sequence 4
  - t-test: t= -2.8284 (p= 0.0111)
  - signed-rank test: z= -2.378 (p= 0.0174)

A.7 Uncertainty - Conditional Optimum

- Sequence 1
  - t-test: t= -1.5000 (p= 0.0839)
  - signed-rank test: z= -1.414 (p= 0.1573)
- Sequence 2
  - t-test: t= -2.7035 (p= 0.0121)
  - signed-rank test: z= -2.205 (p= 0.0274)
- Sequence 3
  - t-test: t= -1.2457 (p= 0.1222)
  - signed-rank test: z= -1.412 (p= 0.1579)
- Sequence 4
  - t-test: t= -3.2844 (p= 0.0047)
  - signed-rank test: z= -2.568 (p= 0.0102)
- Sequence 5

  - t-test: t= -2.8988 (p= 0.0088)
  - signed-rank test: z= -2.392 (p= 0.0168)

A.8 Uncertainty - Conditional Optimum

- Sequence 1
  - t-test: t= -1.0000 (p= 0.1733)
  - signed-rank test: z= -1.000 (p= 0.3173)
- Sequence 2
  - t-test: t= -2.2678 (p= 0.0265)
  - signed-rank test: z= -1.980 (p= 0.0477)
- Sequence 3
  - t-test: t= -1.0000 (p= 0.1733)
  - signed-rank test: z= -1.412 (p= 0.1580)
- Sequence 4
  - t-test: t= -3.0237 (p= 0.0082)
  - signed-rank test: z= -2.387 (p= 0.0170)

Appendix B Instructions

B.1 Decision Making Under Certainty

Benvenuti!

In questo esperimento dovrete prendere delle decisioni. L'esperimento durerà circa un'ora e mezza. Leggete le istruzioni con attenzione poiché avete la possibilità di guadagnare a seconda delle decisioni prese. Se avete domande per favore alzate la mano. Lo sperimentatore vi risponderà in privato. Non dovete parlare con gli altri partecipanti all'esperimento.

L'esperimento consiste in 5 "sequenze" indipendenti, ciascuna composta da 5 periodi. Le sequenze sono *indipendenti* perché **non c'è alcuna relazione** tra loro. Questo significa che le vostre scelte in una sequenza **non influenzeranno** le sequenze successive. E' tuttavia importante notare che, **all'interno di una sequenza**, le decisioni prese in un periodo influenzeranno i periodi successivi (i.e. la decisione presa nel periodo 1 avrà conseguenze sul periodo 2 e così via).

All'inizio di ciascun periodo riceverete un numero di **gettoni** che saranno a vostra disposizione. Dovrete decidere quanti gettoni volete convertire in moneta. Potete convertire un numero di gettoni compreso fra 0 (zero) ed il totale a vostra disposizione. La funzione di conversione dei gettoni in euro è illustrata in **Figura 1** (materiale allegato). Questa figura mostra graficamente come i gettoni possono essere convertiti in euro, in un intervallo continuo. E' anche possibile consultare la **Tabella 1** (materiale allegato), nella quale sono forniti alcuni esempi di conversione. Si noti che il risultato monetario della conversione (gli euro che derivano dalla conversione) è crescente al crescere dei gettoni convertiti in ogni periodo, ma questo incremento avviene con un **tasso decrescente**: la differenza nei guadagni monetari nel convertire 6 piuttosto che 5 gettoni è pi grande della differenza nei guadagni nel convertire 16 piuttosto che 15 gettoni. Infine si noti che più gettoni si convertono in ogni periodo, meno gettoni risparmiati saranno disponibili per conversioni in periodi successivi. Nei periodi *precedenti* il periodo 5 (l'ultimo periodo), i gettoni non convertiti saranno risparmiati per il periodo successivo. I risparmi frutteranno degli interessi, quindi incrementando la vostra disponibilità di gettoni nel periodo successivo. Quando si raggiunge il periodo 5, l'ultimo periodo, i gettoni avanzati, cioè non convertiti, non avranno alcun valore.

Il vostro risultato finale, alla fine dell'esperimento, sarà calcolato in base alle decisioni prese in **UNA** delle sequenze descritte in precedenza. Tale sequenza sarà estratta casualmente fra le 5 sequenze giocate. Questo significa che il vostro pagamento sarà calcolato sulla base delle decisioni prese nei 5 periodi che compongono la sequenza estratta.

Periodi e decisioni

All'inizio di ciascun periodo riceverete 10 gettoni.

Dal periodo 1 al periodo 4, i gettoni non convertiti sono risparmiati e fruttano interessi al **tasso del** 40% ($r = 0.4$). Il risparmio, incrementato degli interessi, aumenterà la vostra disponibilità di gettoni nel periodo successivo. Si prega di ricordare che ogni gettone non convertito alla fine del periodo 5 non avrà pi alcun valore. La **Tabella 2** (materiale allegato) a vostra disposizione, riporta alcuni esempi relativi al calcolo degli interessi.

All'inizio di ciascun periodo vi sarà comunicato, sullo schermo, il totale dei gettoni a disposizione, composti da:

1. Gettoni attribuiti nel periodo: 10
2. Gettoni risparmiati nel periodo precedente S
3. Interessi guadagnati sui risparmi: S x **0.4**

4. Gettoni disponibili per la conversione: 1)+2)+3)
5. Guadagno Cumulativo: quanto si è guadagnato complessivamente, a partire dal periodo 1

Ovviamente nel periodo 1 non ci saranno risparmi, né interessi da ricevere, quindi la vostra disponibilità sarà uguale a 10 gettoni.

All'interno di questa schermata riassuntiva, vi sarà chiesto di digitare il numero di gettoni che desiderate convertire in moneta. E' possibile cambiare idea in ogni momento *prima* di premere il pulsante di conferma. Quando il pulsante è premuto la propria decisione diviene irrevocabile. Nel prendere la vostra decisione potrete utilizzare un calcolatore per verificare le conseguenze della vostra scelta. A seconda del numero inserito, è possibile osservare il conseguente risparmio, gli interessi che tale risparmio frutterà nel periodo successivo ed il guadagno in moneta derivante dalla scelta di conversione. In nessun caso l'utilizzo del calcolatore renderà la vostra decisione irrevocabile.

Una volta completata la prima sequenza di 5 periodi, inizierà la sequenza successiva. Come spiegato in precedenza, l'esperimento comporta prendere decisioni per 5 sequenze.

<u>Informazioni</u> Nei periodi successivi al primo, oltre alle informazioni già descritte, sarà visibile la decisione presa nel periodo precedente e le relative conseguenze. Saranno quindi riportate: la disponibilità *del periodo precedente*, quanto si è risparmiato, quanto si è convertito ed il guadagno in moneta del periodo precedente.

Al termine di ciascuna sequenza, sarà proposta una tabella riassuntiva delle scelte compiute nei 5 periodi giocati.

<u>Guadagni</u>

Quando tutte le 5 sequenze sono state completate, il vostro pagamento sarà determinato. Una sequenza sarà estratta casualmente e ricevere il corrispondente guadagno cumulativo.

Se avete domande, per favore alzate la mano ed uno sperimentatore sarà felice di aiutarvi.

Materiale Allegato

Figura 1 - Funzione di Conversione:

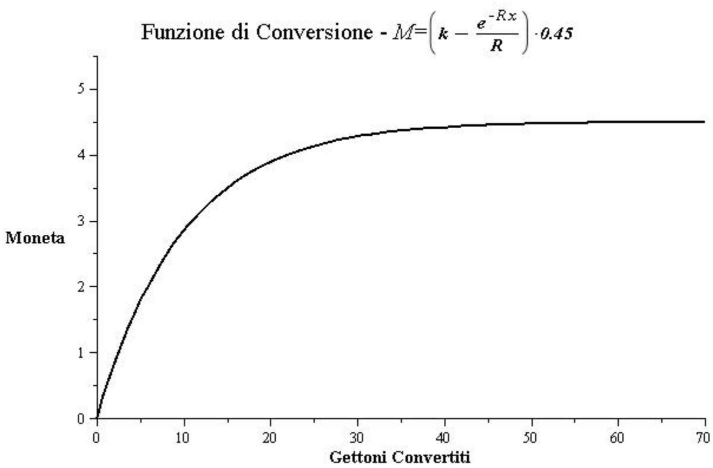

TABELLA 1

Gettoni	Moneta Guadagnata (Euro)
0	0
1	0.428231619
2	0.815711611
3	1.166318007
4	1.483559793
5	1.770612031
6	2.030347638
7	2.265366133
8	2.478019661
9	2.670436531
10	2.844542515
11	3.002080123
12	3.144626046
13	3.273606931
14	3.390313662
15	3.495914279
16	3.591465669
17	3.677924142
18	3.756155003
19	3.826941213
20	3.890991225
⋮	⋮
50	4.469679239
⋮	⋮
100	4.4997957
⋮	⋮
150	4.499998623
⋮	⋮
200	4.499999991

$Euro = 4.5 - 4.5 * e^{-0.1*C}$

C=Gettoni Convertiti

TABELLA 2

Gettoni Risparmiati	Interessi sui gettoni risparmiati	Gettoni Risparmiati + Interessi
0	0	0
1	0.4	1.4
2	0.8	2.8
3	1.2	4.2
4	1.6	5.6
5	2	7
6	2.4	8.4
7	2.8	9.8
8	3.2	11.2
9	3.6	12.6
10	4	14
11	4.4	15.4
12	4.8	16.8
13	5.2	18.2
14	5.6	19.6
15	6	21
16	6.4	22.4
17	6.8	23.8
18	7.2	25.2
19	7.6	26.6
20	8	28
⋮	⋮	⋮
50	20	70
⋮	⋮	⋮
100	40	140
⋮	⋮	⋮
150	60	210
⋮	⋮	⋮
200	80	280

$Interessi = 0,4 * S$

S = Gettoni Risparmiati

B.2 Decision Making Under Risk[78]

Benvenuti!

In questo esperimento dovrete prendere delle decisioni. L'esperimento durerà circa un'ora e mezza. Leggete le istruzioni con attenzione poiché avete la possibilità di guadagnare a seconda delle decisioni prese. Se avete domande per favore alzate la mano. Lo sperimentatore vi risponderà in privato. Non dovete parlare con gli altri partecipanti all'esperimento.

L'esperimento consiste in 5 "sequenze" indipendenti, ciascuna composta da 5 periodi. Le sequenze sono *indipendenti* perché **non c'è alcuna relazione** tra loro. Questo significa che le vostre scelte in una sequenza **non influenzeranno** le sequenze successive. E' tuttavia importante notare che, **all'interno di una sequenza**, le decisioni prese in un periodo influenzeranno i periodi successivi (i.e. la decisione presa nel periodo 1 avrà conseguenze sul periodo 2 e così via).

All'inizio di ciascun periodo riceverete un numero di **gettoni** che saranno a vostra disposizione. Dovrete decidere quanti gettoni volete convertire in moneta. Potete convertire un numero di gettoni compreso fra 0 (zero) ed il totale a vostra disposizione. La funzione di conversione dei gettoni in euro è illustrata in **Figura 1** (materiale allegato). Questa figura mostra graficamente come i gettoni possono essere convertiti in euro, in un intervallo continuo. E' anche possibile consultare la **Tabella 1** (materiale allegato), nella quale sono forniti alcuni esempi di conversione. Si noti che il risultato monetario della conversione (gli euro che derivano dalla conversione) è crescente al crescere dei gettoni convertiti in ogni periodo, ma questo incremento avviene con un **tasso decrescente**: la differenza nei guadagni monetari nel convertire 6 piuttosto che 5 gettoni è pi grande della differenza nei guadagni nel convertire 16 piuttosto che 15 gettoni. Infine si noti che più gettoni si

[78]The material referred to as "materiale allegato" will not be attached again, since it is identical to subsection 1 - Decision Making under Certainty

convertono in ogni periodo, meno gettoni risparmiati saranno disponibili per conversioni in periodi successivi. Nei periodi *precedenti* il periodo 5 (l'ultimo periodo), i gettoni non convertiti saranno risparmiati per il periodo successivo. I risparmi frutteranno degli interessi, quindi incrementando la vostra disponibilità di gettoni nel periodo successivo. Quando si raggiunge il periodo 5, l'ultimo periodo, i gettoni avanzati, cioè non convertiti, non avranno alcun valore.

Il vostro risultato finale, alla fine dell'esperimento, sarà calcolato in base alle decisioni prese in **UNA** delle sequenze descritte in precedenza. Tale sequenza sarà estratta casualmente fra le 5 sequenze giocate. Questo significa che il vostro pagamento sarà calcolato sulla base delle decisioni prese nei 5 periodi che compongono la sequenza estratta.

Periodi e decisioni

All'inizio di ciascun periodo riceverete un numero di gettoni, determinato in modo casuale. Tale numero di gettoni potrà essere "alto" (**15** gettoni) o "basso" (**5** gettoni). Avrete il 50% di probabilità di ricevere un numero "alto" e il 50% di ricevere un numero "basso" di gettoni. E' molto importante sottolineare che l'aver ricevuto un certo numero di gettoni in un periodo **non influenza** l'ammontare ricevuto nel periodo successivo.

Dal periodo 1 al periodo 4, i gettoni non convertiti sono risparmiati e fruttano interessi al **tasso del** 40% ($r = 0.4$). Il risparmio, incrementato degli interessi, aumenterà la vostra disponibilità di gettoni nel periodo successivo. Si prega di ricordare che ogni gettone non convertito alla fine del periodo 5 non avrà pi alcun valore. La **Tabella 2** (materiale allegato) a vostra disposizione, riporta alcuni esempi relativi al calcolo degli interessi.

All'inizio di ciascun periodo vi sarà comunicato, sullo schermo, il totale dei gettoni a disposizione, composti da:

1. Gettoni attribuiti nel periodo: 10
2. Gettoni risparmiati nel periodo precedente S
3. Interessi guadagnati sui risparmi: S x **0.4**
4. Gettoni disponibili per la conversione: 1)+2)+3)
5. Guadagno Cumulativo: quanto si è guadagnato complessivamente, a partire dal periodo 1

Ovviamente nel periodo 1 non ci saranno risparmi, né interessi da ricevere, quindi la vostra disponibilità sarà uguale a 10 gettoni.

All'interno di questa schermata riassuntiva, vi sarà chiesto di digitare il numero di gettoni che desiderate convertire in moneta. E' possibile cambiare idea in ogni momento *prima* di premere il pulsante di conferma. Quando il pulsante è premuto la propria decisione diviene irrevocabile. Nel prendere la vostra decisione potrete utilizzare un calcolatore per verificare le conseguenze della vostra scelta. A seconda del numero inserito, è possibile osservare il conseguente risparmio, gli interessi che tale risparmio frutterà nel periodo successivo ed il guadagno in moneta derivante dalla scelta di conversione. In nessun caso l'utilizzo del calcolatore renderà la vostra decisione irrevocabile.

Una volta completata la prima sequenza di 5 periodi, inizierà la sequenza successiva. Come spiegato in precedenza, l'esperimento comporta prendere decisioni per 5 sequenze.

<u>Informazioni</u> Nei periodi successivi al primo, oltre alle informazioni già descritte, sarà visibile la decisione presa nel periodo precedente e le relative conseguenze. Saranno quindi riportate: la disponibilità *del periodo precedente*, quanto si è risparmiato, quanto si è convertito ed il guadagno in moneta del periodo precedente.

Al termine di ciascuna sequenza, sarà proposta una tabella riassuntiva delle scelte compiute nei 5 periodi giocati.

Guadagni

Quando tutte le 5 sequenze sono state completate, il vostro pagamento sarà determinato. Una sequenza sarà estratta casualmente e ricevere il corrispondente guadagno cumulativo.

Se avete domande, per favore alzate la mano ed uno sperimentatore sarà felice di aiutarvi.

B.3 Decision Making Under Uncertainty[79]

Benvenuti!

In questo esperimento dovrete prendere delle decisioni. L'esperimento durerà circa un'ora e mezza. Leggete le istruzioni con attenzione poiché avete la possibilità di guadagnare a seconda delle decisioni prese. Se avete domande per favore alzate la mano. Lo sperimentatore vi risponderà in privato. Non dovete parlare con gli altri partecipanti all'esperimento.

L'esperimento consiste in 5 "sequenze" indipendenti, ciascuna composta da 5 periodi. Le sequenze sono *indipendenti* perché **non c'è alcuna relazione** tra loro. Questo significa che le vostre scelte in una sequenza **non influenzeranno** le sequenze successive. E' tuttavia importante notare che, **all'interno di una sequenza**, le decisioni prese in un periodo influenzeranno i periodi successivi (i.e. la decisione presa nel periodo 1 avrà conseguenze sul periodo 2 e così via).

All'inizio di ciascun periodo riceverete un numero di **gettoni** che saranno

[79] The material referred to as "materiale allegato" will not be attached again, since it is identical to subsection 1 - Decision Making under Certainty

a vostra disposizione. Dovrete decidere quanti gettoni volete convertire in moneta. Potete convertire un numero di gettoni compreso fra 0 (zero) ed il totale a vostra disposizione. La funzione di conversione dei gettoni in euro è illustrata in **Figura 1** (materiale allegato). Questa figura mostra graficamente come i gettoni possono essere convertiti in euro, in un intervallo continuo. E' anche possibile consultare la **Tabella 1** (materiale allegato), nella quale sono forniti alcuni esempi di conversione. Si noti che il risultato monetario della conversione (gli euro che derivano dalla conversione) è crescente al crescere dei gettoni convertiti in ogni periodo, ma questo incremento avviene con un **tasso decrescente**: la differenza nei guadagni monetari nel convertire 6 piuttosto che 5 gettoni è pi grande della differenza nei guadagni nel convertire 16 piuttosto che 15 gettoni. Infine si noti che più gettoni si convertono in ogni periodo, meno gettoni risparmiati saranno disponibili per conversioni in periodi successivi. Nei periodi *precedenti* il periodo 5 (l'ultimo periodo), i gettoni non convertiti saranno risparmiati per il periodo successivo. I risparmi frutteranno degli interessi, quindi incrementando la vostra disponibilità di gettoni nel periodo successivo. Quando si raggiunge il periodo 5, l'ultimo periodo, i gettoni avanzati, cioè non convertiti, non avranno alcun valore.

Il vostro risultato finale, alla fine dell'esperimento, sarà calcolato in base alle decisioni prese in **UNA** delle sequenze descritte in precedenza. Tale sequenza sarà estratta casualmente fra le 5 sequenze giocate. Questo significa che il vostro pagamento sarà calcolato sulla base delle decisioni prese nei 5 periodi che compongono la sequenza estratta.

Periodi e decisioni

All'inizio di ciascun periodo riceverete un numero di gettoni, determinato in modo casuale. Tale numero di gettoni potrà essere "alto" (**15** gettoni) o "basso" (**5** gettoni). La probabilità di ricevere l'uno o l'altro è **sconosciuta**. E' molto importante sottolineare che l'aver ricevuto un certo numero di gettoni in un periodo **non influenza** l'ammontare ricevuto nel periodo successivo. Il numero di gettoni sarà determinato attraverso l'estrazione di una pallina colorata da un sacchetto. Ci sono solo due colori. Il sacchetto impedirà di conoscere la distribuzione di questi due colori. Ad ogni colore sarà attribuito un numero di gettoni (alto o basso). L'estrazione determinerà il numero di gettoni ricevuti da TUTTI i partecipanti in quel periodo.

Dal periodo 1 al periodo 4, i gettoni non convertiti sono risparmiati e fruttano interessi al **tasso del** 40% ($r = 0.4$). Il risparmio, incrementato degli interessi, aumenterà la vostra disponibilità di gettoni nel periodo successivo. Si prega di ricordare che ogni gettone non convertito alla fine del periodo 5 non avrà pi alcun valore. La **Tabella 2** (materiale allegato) a vostra disposizione, riporta alcuni esempi relativi al calcolo degli interessi.

All'inizio di ciascun periodo vi sarà comunicato, sullo schermo, il totale dei gettoni a disposizione, composti da:

1. Gettoni attribuiti nel periodo: 10
2. Gettoni risparmiati nel periodo precedente S
3. Interessi guadagnati sui risparmi: S x **0.4**
4. Gettoni disponibili per la conversione: 1)+2)+3)
5. Guadagno Cumulativo: quanto si è guadagnato complessivamente, a partire dal periodo 1

Ovviamente nel periodo 1 non ci saranno risparmi, né interessi da ricevere, quindi la vostra disponibilità sarà uguale a 10 gettoni.

All'interno di questa schermata riassuntiva, vi sarà chiesto di digitare il numero di gettoni che desiderate convertire in moneta. E' possibile cambiare idea in ogni momento *prima* di premere il pulsante di conferma. Quando il pulsante è premuto la propria decisione diviene irrevocabile. Nel prendere la vostra decisione potrete utilizzare un calcolatore per verificare le conseguenze della vostra scelta. A seconda del numero inserito, è possibile osservare il conseguente risparmio, gli interessi che tale risparmio frutterà nel periodo successivo ed il guadagno in moneta derivante dalla scelta di conversione. In nessun caso l'utilizzo del calcolatore renderà la vostra decisione irrevocabile.

Una volta completata la prima sequenza di 5 periodi, inizierà la sequenza successiva. Come spiegato in precedenza, l'esperimento comporta prendere decisioni per 5 sequenze.

Informazioni Nei periodi successivi al primo, oltre alle informazioni già descritte, sarà visibile la decisione presa nel periodo precedente e le relative conseguenze. Saranno quindi riportate: la disponibilità *del periodo precedente*, quanto si è risparmiato, quanto si è convertito ed il guadagno in moneta del periodo precedente.

Al termine di ciascuna sequenza, sarà proposta una tabella riassuntiva delle scelte compiute nei 5 periodi giocati.

Guadagni

Quando tutte le 5 sequenze sono state completate, il vostro pagamento sarà determinato. Una sequenza sarà estratta casualmente e ricevere il corrispondente guadagno cumulativo.

Se avete domande, per favore alzate la mano ed uno sperimentatore sarà felice di aiutarvi.

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LABSI EXPERIMENTAL ECONOMICS LABORATORY
UNIVERSITY OF SIENA
PIAZZA S. FRANCESCO, 7 53100 SIENA (ITALY)
http://www.labsi.org labsi@unisi.it