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Money Illusion Matters for Consumption-Saving Decision-Making: An Experimental Investigation

Yasufumi Gemma*

Abstract

By means of an economic experiment, this paper examines the effects of money illusion on consumption-saving decision-making. In the experiment, subjects make sequential consumption-saving decisions in economic situations where nominal values of economic variables are displayed differently but there is no difference in their real values in that an optimal real consumption path is the same. Nevertheless, the experimental results show that a nominal difference arising from a higher positive rate of inflation causes subjects to consume more in early periods of the experiment and less in later periods. Moreover, given the utility function assumed in the experiment and the estimated relationship between the slope of the consumption path and the inflation rate, such money illusion results in a higher level of utility for a subject who confronts a higher positive rate of inflation if the level of the inflation rate is modest. In deflationary situations, a nominal difference stemming from a lower negative rate of inflation generates a similar effect to that from a higher positive rate in terms of the consumption path. These findings suggest that in making consumption-saving decisions, subjects react to a rise of the inflation rate differently in inflationary situations and in deflationary situations, regardless of no change in the real interest rate.

Keywords: Consumption-saving decision-making; Money illusion; Economic experiment
JEL classification: C90, D91, E21, E31, E40

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1. Introduction

Consumption-saving decision-making constitutes one of the most fundamental parts of economics. In a standard dynamic theory of consumer choices, an optimal consumption path is derived from optimality conditions, including an Euler equation, which determine how much of current income is spent on contemporaneous consumption and how much is saved for future consumption. Such an optimal path, however, does not necessarily coincide with actual consumption-saving behavior. Previous studies, such as Johnson *et al.* (1987) and Hey and Dardanoni (1988), conduct an economic experiment and show that consumption-saving behavior observed in the experiment is not consistent with a theoretically derived optimal consumption path. This inconsistency has been addressed in subsequent experimental studies, which focus on various economic aspects, such as the status of income or employment (Carbone and Hey, 2004), demographic characteristics (Carbone, 2005), heuristics in decision-making (Hey and Knoll, 2011), social information (Carbone and Duffy, 2014), and probability updating processes (Anderhub *et al.*, 2000).[1]

In addition to the above economic aspects, a monetary aspect can be considered. However, it has not been investigated in most of the previous experimental studies. As Fisher (1928) points out, money illusion may matter in economic decision-making. That is, people are likely to be confused by a monetary change and make a suboptimal decision.[2] Shafir *et al.* (1997) provide a typical example of money illusion. Consider the following two cases. In one case, nominal income grows at a rate of 2 percent per year with no inflation. In the other case, nominal income grows at a rate of 5 percent per year with an inflation rate of 4 percent. Thus, the real income growth rate is 2 percent in the former case and only 1 percent in the latter. While the former case is more desirable in terms of economics, people tend to answer that the latter case is preferable, because they have a tendency to focus on the nominal values of economic variables rather than

[1] For a survey of experimental studies on consumption-saving decision-making and other related topics, see Duffy's (2008) section on optimal consumption-saving decisions.

[2] Fisher (1928) provides several examples in which people are confused by a price change due to inflation or exchange rate fluctuations. Shafir *et al*. (1997) use a questionnaire survey to show that respondents tend to be affected by money illusion. Moreover, money illusion is regarded as one of the most interesting topics in neuroscience (Weber *et al.,* 2009).

their real values. Therefore, to analyze actual consumption-saving behavior, a monetary aspect is worth introducing in an economic experiment.[3]

This paper examines the effects of money illusion on consumption-saving decision-making, using an economic experiment.[4] This experiment can follow, for the most part, those of the aforementioned studies, which investigate a variety of boundedly rational decision-making, by assuming that money illusion can also result from bounded rationality. Thus, it is similar to the previous studies, except that a monetary aspect is introduced in the experimental setting for the purpose of examining money illusion.[5] Specifically, subjects are supposed to make sequential consumption-saving decisions in economic situations where nominal values of economic variables are displayed differently but there is no difference in their real values in that an optimal real consumption path is the same. Then, the comparison of the consumption paths chosen by subjects who face differing situations in the nominal values enables us to identify the effects of money illusion on consumption-saving decision-making.[6] In addition, this paper considers effects of money illusion on the level of the subjects' utility achieved by their decision-making. Moreover, the experiment treats deflationary situations as well as inflationary situations.

The experimental results show that a nominal difference arising from a higher

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[3] In macroeconomics and finance, money illusion has been used to explain the gap between an economic observation and theory. For example, money illusion is regarded as a potential source of nominal rigidities (Trevithick, 1975; Akerlof and Yellen, 1987), while it can be considered to delude investors in stock markets (Modigliani and Cohn, 1979; Cohen *et al.*, 2005) and those in housing markets (Brunnermeier and Julliard, 2008).

[4] To investigate effects of money illusion on price setting, Fehr and Tyran (2001, 2007) and Noussair *et al.* (2012) conduct an economic experiment.

[5] To the best of my knowledge, there is no other study that incorporates a monetary aspect in a consumption-saving decision experiment and examines effects of money illusion, except for Yamamori *et al.* (2014). These authors investigate money illusion by comparing situations with and without nominal changes arising from random fluctuations in prices and the nominal interest rate, keeping the real interest rate constant in their experimental setting, whereas the present paper considers situations with nominal changes arising from distinct levels of inflation, where constant rates of inflation are assumed. Besides, Yamamori *et al.* suppose that the real interest rate is set at zero, so that the optimal consumption path is flat, while the current paper assumes a real interest rate of 5 percent, and thus the optimal consumption path has a positive slope, following Carbone and Duffy (2014). Therefore, the experimental settings are quite different between Yamamori *et al.* and the present paper with regard to how nominal differences occur and with regard to an optimal consumption path.

[6] Therefore, money illusion investigated in this experiment refers to the definition by Patinkin (1965), who considers money illusion to be any deviation from decision-making in completely real terms.

positive rate of inflation causes subjects to consume more in early periods of the experiment and less in later periods. This provides positive support for the presence of money illusion in consumption-saving decision-making. Moreover, given a utility function assumed in the experiment and the estimated relationship between the slope of the consumption path and the inflation rate, such money illusion results in a higher level of utility for a subject who confronts a higher positive rate of inflation. In deflationary situations, a nominal difference stemming from a lower negative rate of inflation generates a similar effect to that from a higher positive rate in terms of the consumption path: subjects facing deeper deflation consume more in early periods and less in later periods. These findings suggest that in making consumption-saving decisions, subjects react to a rise of the inflation rate differently in inflationary situations and in deflationary situations, regardless of no change in the real interest rate.

The remainder of the paper proceeds as follows. Section 2 describes an experimental design (under inflationary situations). Section 3 proposes this paper's hypotheses. Section 4 shows results of the experiment and related analysis. Section 5 presents additional analysis on deflationary situations. Section 6 discusses the results by comparing them with those of previous studies. Section 7 concludes.

2. Experimental Design

This section begins by presenting a sequential consumption-saving decision-making problem faced by subjects in the experiment, and then describes economic situations assigned to subjects, as well as the experimental procedure.

The experimental procedure follows the ones proposed in the previous studies. Especially, for the most part of experimental settings including parameter choices, this paper refers to Carbone and Duffy's (2014) consumption-saving decision-making experiment, except introducing monetary aspects and specific settings for the purpose of examining money illusion, which are detailed later. An important point in the previous studies is that in the experiment subjects are motivated to solve a utility maximization problem assumed in the consumption-saving model: any deviations from theoretically optimal behavior, therefore, can be considered as bounded rationality. In this paper, it is assumed, following another experimental study which examines money illusion (Fehr and Tyran, 2008), that money illusion is a result from boundedly rational decision-making.[7] Thus, effects of money illusion can be examined by conducting an experiment referring to the experimental procedure used in the previous consumption-saving experiments.

2.1 Sequential Consumption-Saving Decision-Making Problem

In the experiment of this paper, each subject is supposed to make sequential consumption-saving decisions during her hypothetical lifetime (hereafter, the subject's hypothetical lifetime in this experiment is called simply *lifetime*) over a finite horizon T. Specifically, in every period of her lifetime, she determines consumption c_t and nominal savings s_t to maximize the lifetime utility function

$$\sum_{t=1}^{T} u(c_t) \tag{1}$$

subject to the budget constraint

$$p_t c_t + s_t = y_t + (1 + i_{t-1}) s_{t-1},\ \ t = 1, \cdots, T, \text{ and } \ s_0 = s_T = 0, \tag{2}$$

where p_t is the price of a consumption good, y_t is nominal income, and i_{t-1} is the nominal interest rate on previous-period nominal savings s_{t-1}.[8] For the sake of simplicity, the experiment assumes that the nominal interest rate i_t, the inflation rate of the price p_t, and the growth rate of nominal income y_t are all constant over time (i.e., $i_t = i,\ p_{t+1}/p_t = 1 + \pi,\ y_{t+1}/y_t = 1 + g$). Then, under the normalization $p_1 = 1$, the price and nominal income in period t can be given respectively by $p_t = (1 + \pi)^{t-1}$ and $y_t = (1 + g)^{t-1} y_1$. Note that in the lifetime utility function (1), there is no time discounting in order to avoid complexity in the experimental setting.[9]

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[7] For primary literature relevant to bounded rationality, Simon (1990) mentioned money illusion as an example of boundedly rational behavior.

[8] The level of lifetime utility achieved by each subject determines her monetary rewards for participation in the experiment, which gives her incentives to properly solve the utility maximization problem.

[9] Previous studies on intertemporal decision-making, such as Loewenstein and Prelec (1992), Laibson (1998), and Angeletos *et al.* (2001), have argued that people discount their happiness deeply in the distant future, that is, they have a hyperbolic discount function. This paper does not take account of this argument in the experiment for two reasons. First, the current experiment lasts less than one hour; thus it is considered that subjects do not feel any time discounting. Second, subjects do not in fact obtain happiness in each period of their hypothetical lifetime in the experiment; they

Under the assumptions, the optimal real consumption path $\{c_t\}_{t=1}^{T}$ that solves the utility maximization problem is determined by the following conditions:

$$u'(c_t) = (1+r)u'(c_{t+1}), \quad t = 1, \cdots, T-1, \tag{3}$$

$$\sum_{t=1}^{T} \frac{c_t}{(1+r)^{t-1}} = \sum_{t=1}^{T} \frac{y_t/p_t}{(1+r)^{t-1}}, \tag{4}$$

where r denotes the real interest rate given by $1+r = (1+i)/(1+\pi)$ and thus it is constant because the nominal interest rate i and the inflation rate π are both constant. The condition (3), which is the so-called consumption Euler equation, is the first-order condition for optimal consumption choices $\{c_t\}_{t=1}^{T-1}$, while the condition (4) is the lifetime budget constraint in real terms, which can be derived from the summation of (2) over all the lifetime periods.

To make the optimal real consumption path $\{c_t\}_{t=1}^{T}$ computable, the experiment follows Carbone and Duffy (2014) to assume that the period utility function takes the form of constant absolute risk aversion

$$u(x) = \alpha \left(\kappa - \frac{1}{R} e^{-Rx}\right), \tag{5}$$

and to set $\kappa = 15$ and $R = 0.1$. The parameter α determines the level of monetary rewards for participation in the experiment and is set at $\alpha = 0.02$. Moreover, the length of lifetime is set to be 25 periods, i.e., $T = 25$. From the Euler equation (3) and the period utility function (5), it follows that, given initial-period consumption c_1, the optimal real consumption path can be computed as

$$c_t = c_1 + \frac{\log(1+r)}{R}(t-1). \tag{6}$$

Thus, the slope of the optimal real consumption path depends on the level of the real interest rate r: the higher the real interest rate, the steeper the slope. Hence, a higher rate of real interest makes rational people consume less and save more in early periods, thereby increasing consumption in later periods with a large amount of savings held

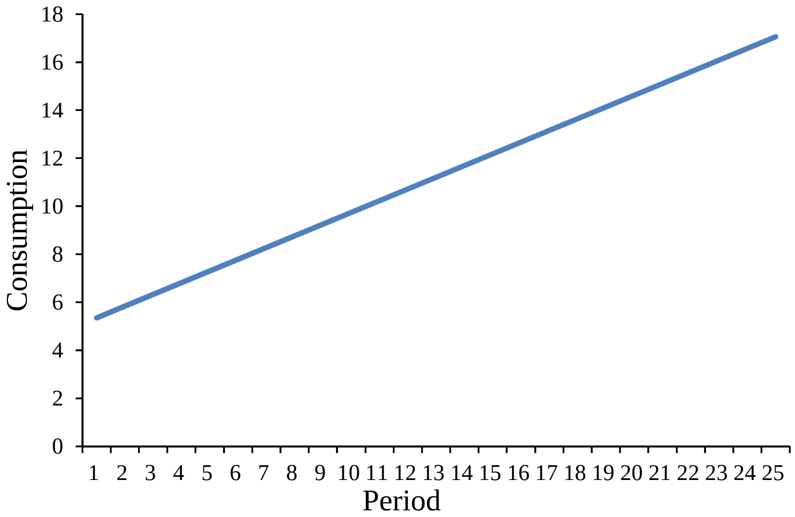
receive monetary rewards corresponding to the level of lifetime utility after the experiment. For a more realistic condition in the experiment, the presence of time discounting in the lifetime utility function may be necessary, but this would make it more difficult and complicated for subjects to solve the consumption-saving decision-making problem.

since the early periods. Moreover, from the lifetime budget constraint (4), it follows that initial-period consumption c_1 is given by

$$c_1 = \frac{1 - 1/(1+r)}{1 - 1/(1+r)^T} \sum_{t=1}^{T} \frac{y_t/p_t}{(1+r)^{t-1}} - \frac{\log(1+r)}{rR}\left[1 - \frac{rT}{(1+r)^T - 1}\right]. \quad (7)$$

Thus, the level of initial-period consumption c_1 depends not only on the level of the real interest rate r but also on the initial-period value of lifetime real income, i.e., $\sum_{t=1}^{T}[(y_t/p_t)/(1+r)^{t-1}]$. Figure 1 illustrates the optimal real consumption path when the real interest rate and the initial-period value of lifetime real income are set respectively at $r = 0.05$ and $\sum_{t=1}^{T}[(y_t/p_t)/(1+r)^{t-1}] = \sum_{t=1}^{25}[10/(1+0.05)^{t-1}]$.

Figure 1: Optimal real consumption path



2.2 Economic Situations Faced by Subjects in the Experiment

To investigate the effects of money illusion on consumption-saving decision-making, each subject is supposed to be faced with one of the following experimental economic situations where nominal values of economic variables are displayed differently but there is no difference in their real values in that an optimal real consumption path is the same. From (6) and (7), such a path depends on the real interest rate r and the initial-period value of lifetime real income $\sum_{t=1}^{T}[(y_t/p_t)/(1+r)^{t-1}]$, the latter of which can be rewritten as $\sum_{t=1}^{T}[(y_t/p_t)/(1+r)^{t-1}] = y_1 \sum_{t=1}^{T}[(1+g)/(1+i)]^{t-1}$ under the assumptions mentioned above. Then, as long as the levels of the real interest rate $r = (1+i)/(1+\pi) - 1$ and the initial-period value of lifetime real income

$y_1 \sum_{t=1}^{T}[(1+g)/(1+i)]^{t-1}$ are constant, the combination of the nominal interest rate i, the inflation rate π, the nominal income growth rate g, and initial-period nominal income y_1 has no impact on the optimal real consumption path. Thus, as shown in Table 1, the experiment supposes the six economic situations in which the real interest rate and the initial-period value of lifetime real income are identical respectively at $r = 0.05$ and $\sum_{t=1}^{T}[(y_t/p_t)/(1+r)^{t-1}] = \sum_{t=1}^{25}[10/(1+0.05)^{t-1}]$ but the combination of the nominal interest rate, the inflation rate, the nominal income growth rate, and initial-period nominal income (i, π, g, y_1) differ.[10] Situation A is a zero-inflation situation where economic variables are identical both in real and nominal values; on the other hand, Situations B to F are inflationary situations where nominal values of economic variables are displayed differently from their real values.[11]

Table 1: Six economic situations in the experiment

Situation	i (percent)	π (percent)	g (percent)	y_1 (unit)
A	5.0	0.0	0.0	10
B	7.1	2.0	1.0	11
C	7.8	2.7	3.8	9
D	8.6	3.4	4.5	9
E	9.2	4.0	2.9	11
F	13.4	8.0	8.0	10

2.3 Decision-making Task

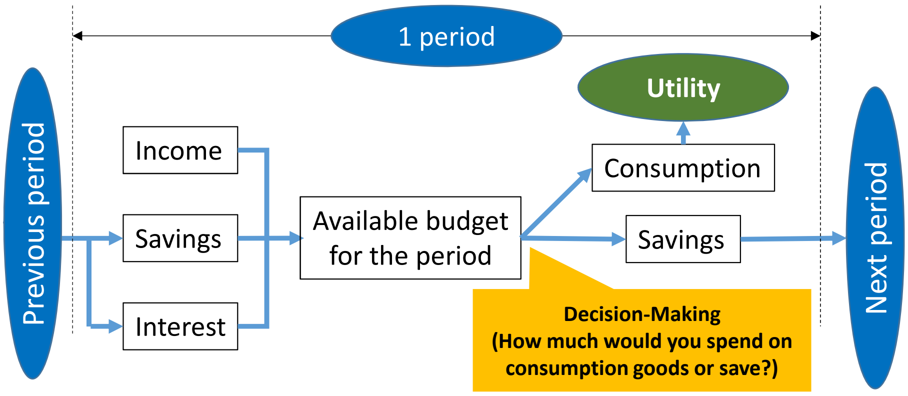
In the experiment, each subject is asked to do a decision-making task to solve the sequential consumption-saving decision-making problem, described in Section 2.1, under a given economic situation from Table 1. She is supposed to receive nominal income y_t in terms of a hypothetical currency at the beginning of every period. She

[10] Note that i, π, and g are chosen to the first decimal place, while y_1 is set as an integer for simplicity to avoid confusing participants. For this reason, some situations are not exactly the same in real value due to the limited decimal places; to minimize these differences, the parameter values are chosen such that the differences become sufficiently small.

[11] The real income growth rates are different among these economic situations. The experiment in this paper is designed for series of investigation about effects of money illusion and, in addition, those of the real income profile on consumption-saving decision-making. According to results of analysis on the latter, there are no findings to be mentioned about effects of real income profile. As shown in the following sections, the present study, therefore, focuses on and discusses only investigation about money illusion.

also brings nominal savings from the previous period and earns interest on the savings in terms of the hypothetical currency. Note that she has neither savings nor interest earnings in the initial period $t = 1$. Then, she decides the level of consumption within the available budget that consists of the income, savings, and interest earnings. If she does not spend all available units of currency for consumption, then the rest is saved for the next period. She repeats this consumption-saving decision until period $t = 25$. Figure 2 presents the process of a consumption-saving decision-making in a certain period and each subject repeats this twenty-five times as a decision-making task.

Figure 2: Process of the decision-making task



2.4 Experimental Procedure

Participant subjects were recruited from students at the University of Exeter, whose majors were related to economics or finance. They did not have any prior experience of a similar kind of economic experiment.

The experiment was conducted as an on-line type experiment.[12] That is, subjects participated in the experiment on a computer with experimental materials provided by the experimenter via e-mail in advance. The experimental materials consisted of an application file and a document file containing reference information. The experiment began when each subject ran the application file. After completing required tasks, the subject returned the file containing the result to the experimenter. The entire procedure of the experiment was designed to take approximately one hour at most.

[12] Existing literature has conducted the same type of experiment. Carbone (2005) carried out an on-line based experiment on consumption-saving decision-making.

The whole experiment included the instruction session, quiz session, and decision-making task session. In the instruction session, each subject was asked to read instructions carefully. The sentences are shown in the Appendix. The instructions explained all necessary information on the rules of the experiment, excluding the parameters of the experimental situation to be assigned, which were made available at the beginning of a decision-making task. The instructions clearly described the form of the utility function for the amount of consumption chosen in every period as shown in equation (5).[13] In the instructions, some important rules were carefully explained. The instructions explained that, for example, the more amount of money one saved, the more interest received; on the other hand, the marginal utility of consumption decreased with the amount of consumption. It was also carefully explained that the savings made in the final period ($t = 25$) became worthless.

After reading all instructions, the experiment moved to the quiz session where the subjects were asked to answer several questions to check their understanding of the experiment rules. Note that whether the subject correctly answered the quiz did not have any effect on either the following experiment procedure or the subject's monetary rewards. The questions are also shown in the Appendix.

After the quiz session, the decision-making task session began. The session consisted of two 25-period decision-making tasks, which is described in Section 2.3. At the beginning of each decision-making task, one of the six economic situations presented in Table 1 was assigned to each subject.[14] Then, the subject started a decision-making task. For each period of a decision-making task, the subject made a decision by inputting how much to spend for purchasing the consumption good in a specified place on the decision-making worksheet and clicking on a submit button.[15]

[13] To encourage a better understanding of the rule, the instructions presented not only the functional form of the utility function but also a table and a figure both of which show the relationship between the amount of consumption and the corresponding level of utility.

[14] Note that all information about the utility maximization problem (e.g., the parameters of the utility function; the levels of the nominal interest rate, initial-period nominal income, the nominal income growth rate, and the initial-period price and the inflation rate of the consumption good) are known at the start of her life in the experiment. Besides, the length of lifetime in the experiment is not stochastic. Therefore, it is possible for subjects to calculate the deterministic optimal consumption path. This deterministic approach is adopted in this paper to prevent subjects from being biased by probability calculations and to focus on the effects of nominal differences.

[15] To help the subjects to make a decision carefully, the worksheet has several features. First, when

After the first 25-period decision-making task was completed, the second task started automatically. Note that a new situation for the second task was assigned completely at random; it was not necessarily the same situation as for the first task.

When each subject had finished two 25-period decision-making tasks, she was notified of the amount of her monetary rewards from her participation in the experiment. It was an amount corresponding to her lifetime utility achieved in the experiment and a participation fee of 5 pounds. If the subject chose exactly the optimal real consumption path in the experiment, she received 10.75 pounds sterling.[16]

Finally, subjects were asked to return the saved file containing the result to the experimenter. After confirming the saved file, the experimenter paid rewards with an Amazon Voucher to each subject.

3. Hypotheses and Analytical Methods

This section presents this paper's hypotheses and then explains methods for analyzing them.

3.1 Presence of Money Illusion

This paper, first, examines the presence of money illusion in subjects' consumption-saving behavior by the following way. This part investigate whether a situation where nominal values of economic variables are displayed differently from their real values results in differing consumption-saving behavior relative to a situation where the nominal and real values are the same. Specifically, 25 periods of the experimental lifetime are divided into three parts: early (periods 1 to 8), middle (periods 9 to 17), and later (periods 18 to 25). Then, for each part, average consumption is

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the subject input how much to spend for consumption on the worksheet, the amount of the consumption good to be purchased and the level of utility obtained brought about by the consumption were automatically calculated and displayed on the worksheet. The subject was allowed to change her decision before clicking the submit button on the confirmation window. Also, she could review her decision-making history, including consumption and savings chosen in the past periods, until completing a 25-period decision-making task.

[16] Note that this was not the sum of the lifetime utility of two 25-period decision-making tasks. The computer randomly chose one of the two tasks, and the subject's monetary rewards were determined by the lifetime utility value of the chosen task. This treatment was applied to ensure that subjects made an effort in both of the decision-making tasks.

compared between the zero-inflation situation (Situation A in Table 1) and the inflationary situations (Situations B to F in Table 1). Note that a subject cannot keep her consumption larger for the entire lifetime in the experiment than other subjects, because the lifetime budget constraint is identical among the experimental situations. Hence, if a subject consumes more in early periods, she needs to consume less in later periods. Then, if subjects facing a inflationary situation consume more (or less) in early periods and less (or more) in later periods relative to those facing the zero-inflation situation, this may indicate that the difference in situations generates different consumption-saving patterns. Since the zero-inflation situation and inflationary situations are identical in real values of economic variables, different consumption-saving patterns among them indicate that subjects tend to be affected by nominal values. In other words, money illusion is observed in the experiment.

HYPOTHESIS 1 (THE PRESENCE OF MONEY ILLUSION): THE AMOUNTS OF CONSUMPTION DIFFER BETWEEN SUBJECTS ASSIGNED TO A ZERO-INFLATION SITUATION AND THOSE ASSIGNED TO AN INFLATIONARY SITUATION FOR EACH PART OF THE LIFETIME PERIODS.

Moreover, if money illusion due to nominal values displayed differently from real values changes consumption patterns, it may affect the level of lifetime utility that each subject receives as a result of her decisions. This can be investigated by comparing subjects assigned to a zero-inflation situation with subjects confronting an inflationary situation with respect to the level of lifetime utility. If a significant difference is observed, then it can be concluded that money illusion has impacts on the level of lifetime utility.

HYPOTHESIS 2 (EFFECTS OF MONEY ILLUSION ON THE LEVEL OF LIFETIME UTILITY): THE LEVELS OF LIFETIME UTILITY DIFFER BETWEEN SUBJECTS ASSIGNED TO A ZERO-INFLATION SITUATION AND THOSE ASSIGNED TO AN INFLATIONARY SITUATION.

3.2 Marginal Effects of nominal differences on Consumption-Saving Behavior

For further understanding of money illusion and consumption-saving behavior, this part considers another approach. That is, by using a regression analysis, the effects of money illusion is investigated as marginal effects of nominal differences arising from distinct rates of inflation on the slope of the consumption path. A basic regression model is analyzed here as given by

$$C_{j,t} = \beta_0 + \beta_1 \pi_j + \beta_2 t + \beta_3 \pi_j \times t + \beta_4 y_{j,t} + u_{j,t} \, , \tag{8}$$

where t denotes the period of decision-making ($t = 1, \cdots, 25$), $C_{j,t}$ denotes consumption of subject *j* at period *t*, π_j denotes the inflation rate assigned to subject *j*, and $\pi_j \times t$ denotes the interaction term of the assigned inflation rate and period.[17] $y_{j,t}$ denotes the income of subject *j* at period *t*, which is included into the regression model to control the effects of the level of nominal income.[18] $u_{j,t}$ is an error term. Note that variables concerned with the nominal interest rate are not included, because of its approximately linear relationship with the inflation rate.

Factorizing equation (8) with respect to *t*, the model results in

$$C_{j,t} = \beta_0 + \beta_1 \pi_j + (\beta_2 + \beta_3 \pi_j) t + \beta_4 y_{j,t} + u_{j,t} \, . \tag{9}$$

Here, $\beta_2 + \beta_3 \pi_j$ indicates the slope of the consumption path over the lifetime periods. Hence, the coefficient on the interaction term, β_3, indicates marginal effects of nominal differences on the slope of the consumption path. If β_3 is significantly positive, a higher positive inflation rate, followed by a higher nominal interest rate to keep the real interest rate constant, results in a steeper consumption path, that is, consumption is less in early periods and more in later periods. By contrast, significantly negative β_3 expresses a moderate slope of the consumption path, which means overconsumption in early periods and underconsumption in later periods. Therefore, we consider the following hypothesis about the marginal effects of nominal differences.

HYPOTHESIS 3 (MARGINAL EFFECTS OF NOMINAL DIFFERENCES): THE COEFFICIENT ON THE INTERACTION TERM OF THE PERIOD AND THE NOMINAL INTEREST RATE (β_3) DOES NOT EQUAL ZERO.

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[17] For regression analysis, the inflation rate is used as a logarithmic form, $\log(1 + \pi_j)$.

[18] As some empirical research has pointed out co-movement between levels of current consumption and income (see Angeletos *et al.*, 2001), consumers are likely to focus too much attention on the level of the nominal income at the moment of decision-making.

4. Findings

4.1 Data

The experiment was conducted from June 3 to 14, 2014 and a total of 58 students took part in it. A total of 96 observations of 25-period decision-making behavior from 50 subjects are included in a dataset analysed in this section.[19] The numbers of observed consumption paths for each experimental situation appear in Table 2. For monetary rewards in the experiment, subjects received, on average, 10.3 pounds sterling.

Table 2: Numbers of observed consumption paths

Situation	Number of observations		
	Session 1	Session 2	Total
A	7	8	15
B	6	9	15
C	12	10	22
D	9	9	18
E	8	6	14
F	4	8	12

4.2 Presence of Money Illusion

First, the presence of money illusion is examined. Table 3 presents results of a statistical test which compares the average amount of consumption chosen by subjects facing an inflationary situation (Situations B to F) with that chosen by subjects facing a zero-inflation situation (Situation A) for the early (periods 1 to 8), the middle (periods 9 to 17) and the later (periods 18 to 25) parts, respectively.[20]

[19] In fact, 58 subjects participated in the experiment and the experimenter obtained, in total, 116 observations of the consumption path. However, some observations are eliminated from the dataset analyzed in this study, because some subjects unfortunately seem not to have fully understood the rules of the experiment at some sessions: the eliminated observations have shown unnatural amounts of savings in period 25, even though all remaining savings became worthless after period 25.

[20] Note that, in the following statistical tests, Pooled data consisting of observations from both two tasks was used. One might think that learning effects from the first decision-making task would impact the second one. On this point, it can be assumed that there is no role of experience on the money illusion tendency (Shafir *et al.*, 1997). However, to be sure, analyses in this paper control the difference of the first and second observations by doing comparison tests separately or introducing control variables for regression analysis.

Table 3: Average consumption and comparison test results

	Average consumption (standard error) [sample size] under:		Welch test result: p-value [Alternative hypothesis]
	Zero-inflation situation (x)	Inflationary situation (y)	
Early part (periods 1 to 8)	5.22 (0.457) [120]	8.38 (0.245) [648]	0.000 [$x < y$]
Middle part (periods 9 to 17)	8.28 (0.985) [135]	10.35 (0.290) [729]	0.023 [$x < y$]
Later part (periods 18 to 25)	26.53 (7.15) [120]	14.10 (1.22) [648]	0.044 [$x > y$]

According to the results, the subjects in the inflationary situation significantly encouraged more consumption in the early and middle parts of the lifetime and then less consumption in the later part, in comparison with the subjects in the zero-inflation situation. Hence, it can be said that we observed a significant difference for consumption decision-making between the zero-inflation and inflationary situations, which means that money illusion was present in the experiment. Moreover, the inflationary situation appears to cause overconsumption first and underconsumption later.[21]

Next, consider effects of money illusion on the level of the lifetime utility. Table 4 shows a result of a statistical test which compares the level of lifetime utility achieved by subjects who face an inflationary situation with that achieved by subjects who confront the zero-inflation situation.

[21] By conducting the same test for data of the first and second sessions individually, the same tendency was found for both cases as for the pooled data. Thus, it can be assumed that no learning effect exists here. Also, for each period, the observations of consumption consist of groups of eight or nine observations from each subject. One might consider that the groups are correlated. To confirm this point, the amount of consumption was regressed on the inflation dummy that equals one if the observation is under an inflationary situation or zero otherwise. With standard errors clustered by subject, the coefficients of the inflation dummy in the three regressions (for the early, middle, and later periods) were significant. In addition, the results of the regressions showed the same result as above (positive coefficients for the early and middle periods and negative coefficients for the later period).

Table 4: Average lifetime utility and comparison test result[22]

Average lifetime utility (standard error) [sample size] under:		Mann-Whitney test result: p-value [Alternative hypothesis]
Zero-inflation situation (*x*)	Inflationary situation (*y*)	
4.65 (1.17) [15]	5.36 (0.660) [81]	0.002 [$x < y$]

The level of lifetime utility received by subjects confronting the zero-inflation situation is significantly less than their counterparts, which indicates that money illusion has an impact on the level of the lifetime utility and the money illusion arising from a presence of positive inflation, in particular, works better for the level of lifetime utility in this experiment.

This result shows that money illusion does not necessarily have a negative effect in terms of the level of lifetime utility, whereas previous studies point out that money illusion can have inefficient consequences (Fisher, 1928; Fehr and Tyran, 2007). A possible implication of this result is that the subjects in the inflationary situation make relatively better decisions, while it is hard to trace an optimal real consumption path even in a zero-inflation situation. In fact, even existing research, which does not treat the monetary aspect, argues that it is difficult for people to solve an intertemporal utility maximization problem in a rational manner (e.g. Johnson *et al.*, 1987; Hey and Dardanoni, 1988). Hence, it can be considered that this result means that the presence of positive inflation mitigates the failure in choosing a consumption path.

[22] For a limited sample size, A Mann-Whitney test, a non-parametric method, is applied to compare the difference of the two groups.

4.3 Marginal Effects of Nominal Differences

The regression result for equation (9)[23] is summarized in Table 5.

Table 5: Regression result for consumption[24]

Dependent variable: *consumption* $C_{j,t}$ (2,400 observations)			
explanatory variables	coefficient[25]		(standard error)
$\ln(1+\pi_j)$ <*inflation rate* (logarithm)>	β_1	306.93 **	(144.11)
t < *period* >	β_2	1.31 ***	(0.411)
$t \times \ln(1+\pi_j)$ < *interaction term* >	β_3	–32.46 **	(13.12)
$y_{j,t}$ < *income* >	β_4	0.604 **	(0.243)
constant	β_0	–13.50	(8.62)

According to the results, the coefficient on the interaction term between the period and the inflation rate, β_3, significantly differs from zero, and its sign is negative, which means nominal differences arising from a greater positive inflation rate makes the consumption path more moderate.[26] Note that the significantly positive coefficient on the inflation rate, β_1, supports the fact that the higher positive rate of inflation, the more

23 A random-effect Tobit regression with robust standard errors clustered by subject is used here.

24 Variables in the regression model were included to control the effects of the differences of the first and second session, but they showed no significant effect.

25 ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. The same expression applies hereafter.

26 This result may indicate that subjects, while the inflation rate commoves with the nominal interest rate for the constant real interest rate, tend to pay special attention to the level of the inflation rate, rather than the level of the nominal interest rate. The reason for this tendency is not clear. As a possible hypothesis, the concept of *loss aversion*, introduced primarily by Tversky and Kahneman (1991), which implies that people tend to react sensitively to losses than to gains, may relate to this tendency. That is, when subjects pay attention to the level of the inflation rate and choose a flatter consumption path, it is considered that they are motivated to avoid losses arising from soaring prices in the future; on the other hand, when they pay attention to the level of the nominal interest rate and choose a steeper consumption path, it is considered that they are motivated to obtain gains as interests on savings in the future. The concept of loss aversion emphasizes that the former motivation is stronger than the latter. Hence, in the case that subjects confront a high rate of inflation and a high rate of the nominal interest at the same time, it could be considered that they pay more attention to the level of the inflation rate.

moderate consumption path. This is because it means the initial level of the consumption path is larger when the inflation rate is higher. Since the budget constraint is identical for all experimental situations, a moderate consumption path must start from a relatively high level at $t = 1$.

According to the above analysis, it is observed that the slope of the consumption path becomes moderate as nominal differences increase due to higher inflation rate and nominal interest rate. Based on this finding, consider the relationship between the level of utility and the inflation rate in this experiment in the following way.

Based on the regression model (9) and its regression result described in Table 5, it can be assumed that a certain rate of inflation π determines the slope of the consumption path $\hat{\theta}$ as follows:

$$\hat{\theta}(\pi) = \hat{\beta}_2 + \hat{\beta}_3 \ln(1 + \pi), \tag{10}$$

where $\hat{\beta}_2$ and $\hat{\beta}_3$ are estimated coefficients of β_2 and β_3 in Table 5. Given this slope $\hat{\theta}(\pi)$, a consumption path satisfied the lifetime budget constraint, $\{\hat{c}_t(\pi)\}_{t=1}^{T}$, is calculated by:

$$\hat{c}_t(\pi) = \hat{c}_1(\pi) + \hat{\theta}(\pi)(t-1) \text{ for all } t = 1, 2, \cdots, T \tag{11}$$

and

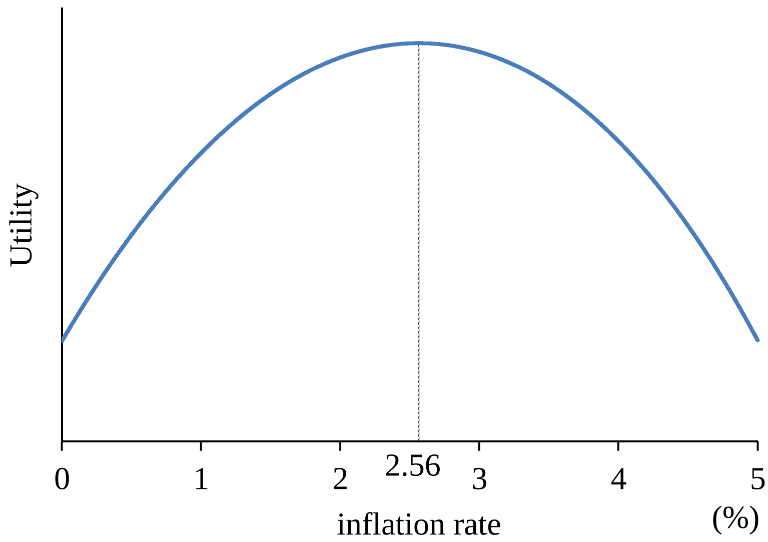
$$\hat{c}_1(\pi) = \frac{1 - 1/(1+r)}{1 - 1/(1+r)^T} \sum_{t=1}^{T} \frac{y_t/p_t}{(1+r)^{t-1}} - \frac{\hat{\theta}(\pi)}{r}\left(1 - \frac{rT}{(1+r)^T - 1}\right), \tag{12}$$

where $r = 0.05$, $T = 25$ and $\sum_{t=1}^{T}[(y_t/p_t)/(1+r)^{t-1}] = \sum_{t=1}^{25}[10/(1+0.05)^{t-1}]$. Hence, the level of utility achieved by this consumption path $\hat{c}(\pi)$ is given by:

$$\hat{U}(\pi) = \sum_{t=1}^{T} u(\hat{c}_t(\pi)), \tag{13}$$

where $u(\cdot)$ is given by equation (5). Then, Figure 3 presents the level of utility calculated as above with respect to the level of the inflation rate.

Figure 3: Utility $\widehat{U}(\pi)$ and inflation rate π given estimated relationship between slope of consumption path and inflation rate



This figure shows that when the level of the inflation rate is modest, a rise in the inflation rate, which increases nominal differences and then make the consumption path flatter, contributes to a higher level of utility; on the other hand, it worsen the level of utility when the level of the inflation rate is much high. This implies that the consumption path is much steeper than the optimal one under a very low inflation rate; but as the path becomes moderate with increasing nominal differences, the slope gets close to the optimal one and hence the level of utility becomes better; when the inflation rate is greater than a certain threshold, however, increasing nominal differences makes the consumption path more moderate than the optimal one and thus the level of utility decreases.

5. Additional Analysis

The previous sections have focused only on effects of money illusion arising from positive rates of inflation. In this section, deflationary situations are introduced in addition to inflationary situations to check whether the same implication is found or whether other deflation-specific effects exist.

The experimenter recruited other students of the University of Exeter, in the same way as described in Section 2.4, to analyze effects of the deflationary environment on consumption-saving decision-making. The experimental procedure was the same as that for the original experiment.[27] The students were automatically assigned to one of the deflationary situations as well as the control treatment (a zero-inflation situation, the same as in Situation A). The parameters of the additional Situations G and H were as follows (Table 6). Note that these situations were introduced based on the same experimental design idea: they are defined by distinct nominal values but are identical in real values with other situations (Situations A to F) in the sense that they have an identical optimal real consumption path. To investigate effects of deflationary situations, 17 observations of the consumption path (six under Situation H and five under Situation G as well as six under a zero-inflationary situation) from 11 students recruited are added for regression analysis.[28]

Table 6: Deflationary situations in the additional experiment

Situation	i (percent)	π (percent)	g (percent)	y_1 (unit)
G	1.0	–3.8	–2.8	9
H	2.9	–2.0	–3.0	11

The regression analysis in this part introduces a dummy variable, d, which equals one if the subject is assigned to one of the deflationary situations (Situations G and H) and equals zero otherwise, as well as interaction terms between the dummy, the period variable and the inflation rate into a regression model as follows:

$$\begin{aligned} C_{j,t} &= \beta_0 + \beta_1 \pi_j + \beta_2 d \times \pi_j + \beta_3 t + \beta_4 \pi_j \times t + \beta_5 d \times \pi_j \times t \\ &\quad + \beta_6 y_{j,t} + \beta_7 d \times y_{j,t} + u_{j,t} \\ &= \beta_0 + (\beta_1 + \beta_2 d)\pi_j + \big(\beta_3 + (\beta_4 + \beta_5 d)\pi_j\big)t + (\beta_6 + \beta_7 d)y_{j,t} + u_{j,t}. \end{aligned} \quad (14)$$

This formulation enables us to look at reactions of the slope of the consumption path to deflationary situations. That is, if $\beta_4 + \beta_5 > 0$, then, a negative π_j contributes to a

[27] Strictly speaking, the experimental materials used for this part were different in several points: the application file and the information document file, mentioned in Section 2.4, were partly modified to suit the deflationary situation experiment.

[28] Some observations are not included here for the same reason as described in Section 4.1.

moderate slope of the consumption path; by contrast, if $\beta_4 + \beta_5 < 0$, a negative π_j makes the slope steeper. The regression analysis result is summarized in Table 7. [29]

Table 7: Regression result including deflationary situations[30]

Dependent variable: *consumption* $C_{j,t}$ (2,825 observations)				
explanatory variables	coefficient			(standard error)
$\ln(1+\pi_j)$ <*inflation rate* (logarithm)>	β_1	254.58	**	(118.16)
$d \times \ln(1+\pi_j)$ < *interaction term* >	β_2	–470.68	*	(257.70)
t < *period* >	β_3	1.14	***	(0.345)
$t \times \ln(1+\pi_j)$ < *interaction term* >	β_4	–27.95	**	(11.55)
$t \times d \times \ln(1+\pi_j)$ < *interaction term* >	β_5	45.12	**	(20.89)
$y_{j,t}$ < *nominal income* >	β_6	0.554	**	(0.235)
$d \times y_{j,t}$ < *interaction term* >	β_7	–0.0661		(0.653)
constant	β_0	–10.61		(7.32)

The results show that the coefficient on the interaction term of the inflation rate and period, β_4, is significant and the same sign as the result in Table 5. Hence, this implies robustness of the previous results: the consumption path becomes more moderate with a higher positive rate of inflation even in this regression model. Moreover, according to the F-test result, $\beta_4 + \beta_5$ is significantly positive (p-value = 0.0035), which indicates that the deflationary situation can make the consumption path more moderate. In addition, the coefficient on the interaction between the deflation dummy and the inflation rate, β_2, is significantly negative. This means that deflation lifts up the starting point of the consumption path, which coincides with a moderate consumption path with a negative rate of inflation under the same budget constraint over the experimental situations.

[29] A random effect Tobit regression is used for equation (14) with standard errors clustered by subject.

[30] As well as the regression analysis in Section 4.3, although variables to control the effects of the differences of the sessions were included, no significant effect appears for different sessions.

This result implies that the reactions of subjects in terms of the consumption path to a rise of the inflation rate in the case of the positive inflation rate differ from those in the case of the negative inflation rate. That is, the consumption path becomes moderate with a rise of the inflation rate in the inflationary environment; on the other hand, it does so with a fall in the inflation rate in deflationary environment (or a deepening deflation).[31]

6. Discussion

This section discusses the results of the present paper by comparing them with those of previous studies: in particular, papers using similar experimental settings such as Carbone and Duffy (2014) and Yamamori *et al*. (2014). The present paper shows, first, a consumption path that is steeper relative to the optimal one in a case of zero (or lower) inflation: a slope coefficient is 1.14 (β_3 in Table 7) while that of the optimal path is $\log(1+\mathrm{r})/\mathrm{R} = \log(1.05)/0.1 = 0.49$. In contrast, Carbone and Duffy report a more moderate consumption path in an experimental situation without inflation (an estimated slope coefficient is 0.23, regardless of the same optimal path). Because this paper and theirs are based on different methodologies in data preparation and estimation due to different research motivation,[32] it is hard to evaluate uniformly such different results of the two papers. However, if the data employed in this paper is analyzed in a similar manner to Carbone and Duffy, the result shows a slope coefficient of 0.399, which means a moderate consumption path relative to the optimal one (the left column in

[31] This result may imply that subjects react more to the level of the nominal interest rate rather than the level of the inflation rate since a lower interest rate, in general, contributes to a flatter consumption path whereas a lower inflation rate makes consumption path steeper. Therefore, the reactions of subjects to distinct levels of the inflation rate differ between in inflationary situations and in deflationary situations. Because more saving generates losses when the nominal interest rate decreases, it is considered that subjects consume more rather than save more in early period to avoid such losses. Hence, these findings may also indicate a consequence of loss aversion.

[32] Regarding the dataset, the current analysis does not include subjects whose savings perish in the last lifetime period, while the analysis by Carbone and Duffy (2014) does include them. Regarding the estimation method, the current analysis uses an explanatory variable of income $y_{j,t}$, while Carbone and Duffy use a wealth variable $w_{j,t} = y_{j,t} + (1+i_j)s_{j,t-1}$, which is the amount of virtual currency that consists of not only income but also savings and interest. In the present study, it is considered that these differences could contribute to a steeper consumption path.

Table 8) and coincides with findings by Carbone and Duffy. Hence, it is quite probable that the different results in the two papers derive from different methodologies and research motivations, and it can be said rather simply that the papers find a common fact: a consumption path is likely to deviate from the optimal one even in a situation of zero-inflation.

Table 8: Regression analysis with alternative sample set and model for comparison with a prior study (3,275 observations)

explanatory variables	*Consumption* $C_{j,t}$ coefficient (standard error)		*Deviation from optimal path* $C_{j,t} - C_t^*$ coefficient (standard error)	
$\ln(1+\pi_j)$	59.33	***	59.44	***
< *inflation rate* (logarithm) >	(18.05)		(17.98)	
$d \times \ln(1+\pi_j)$	–2.43		–1.39	
< *interaction term* >	(66.64)		(66.27)	
t	0.399	***	–0.134	**
< *period* >	(0.0674)		(0.0640)	
$t \times \ln(1+\pi_j)$	–5.53	***	–4.64	***
< *interaction term* >	(1.42)		(1.28)	
$t \times d \times \ln(1+\pi_j)$	9.22	*	7.07	
< *interaction term* >	(5.51)		(5.40)	
$w_{j,t}$	0.0533	**	0.0557	***
< *wealth* >	(0.0216)		(0.0214)	
$d \times w_{j,t}$	0.0745		–0.0751	
< *interaction term* >	(0.0632)		(0.0632)	
Constant	3.27	***	–1.59	*
	(0.952)		(0.949)	

Second, as a result of analyses referring to prior papers, it is found that this paper shares similar properties of decision-making behavior in consumption-savings proposed by the prior studies. Using a dependent variable of deviation between an actual consumption path and the optimal one, $C_{j,t} - C_t^*$, a regression results indicate that the level of consumption in the first period is largely below the optimal level; moreover, the coefficient on the period variable is significantly positive (the left column in Table 9). This indicates some evidences for learning behavior as found by Carbone and Duffy, in the sense that an initial deviation from the optimal level is corrected from period to period. Note that although there is a difference in the reverse sign for the two results, a similar result can be found if the analytical method is modified to match methodologies used in their paper (the right column in Table 8), thus, this difference simply reflects the different research methodology and motivation. Next, consider a regression analysis with a dependent variable of deviations in an actual consumption path from a conditionally optimal path $\{C_{j,t}^{cond.}\}_{t=1}^{T}$ (an optimal consumption path for a subject, calculated at each period, given the subject's past consumption history[33]). The results are shown in the right column in Table 9, which also indicates some evidence for learning behavior, and hence this result is similar to Carbone and Duffy.

Table 9: Regression analysis using alternative dependent variables
(2,825 observations)

explanatory variables	*Deviation from optimal path* $C_{j,t} - C_t^*$ coefficient (standard error)		*Deviation from conditionally optimal path* $C_{j,t} - C_{j,t}^{cond.}$ coefficient (standard error)	
$\ln(1+\pi_j)$	189.38	**	–114.68	**
<*inflation rate* (logarithm)>	(80.43)		(56.49)	
$d \times \ln(1+\pi_j)$	–322.26		252.35	***
< *interaction term* >	(197.21)		(91.34)	
t	0.510	*	–0.803	**
< *period* >	(0.294)		(0.332)	
$t \times \ln(1+\pi_j)$	–24.06	**	23.42	*
< *interaction term* >	(11.13)		(12.97)	
$t \times d \times \ln(1+\pi_j)$	38.23	*	–40.55	*
< *interaction term* >	(19.61)		(22.27)	
$y_{j,t}$	0.509	*	–0.630	**
< *income* >	(0.268)		(0.297)	
$d \times y_{j,t}$	0.191		–0.188	
< *interaction term* >	(0.159)		(0.278)	
Constant	–10.68	**	12.76	***
	(5.41)		(4.39)	

[33] Mathematically, $C_{j,t}^{cond.} = c_{j,t}^{**}$ of

$$\{c_{j,\tau}^{**}\}_{\tau=t}^{T} = \underset{\{c_{j,\tau}\}_{\tau=t}^{T}}{\text{argmax}} \sum_{\tau=t}^{T} u(c_{j,\tau})$$

subject to $p_\tau c_{j,\tau} + s_{j,\tau} = y_{j,\tau} + (1+i_j)s_{j,\tau-1}$ for all $\tau = t, \cdots, T$, and $s_T = 0$.

Third, consider comparison between the current result and Yamamori *et al*. (2014), in which money illusion is investigated in an experimental study and it is pointed out that money illusion arising from different nominal situations increases the deviations between an actual consumption path and the optimal one. Therefore, they found that money illusion decreases the level of the subject's utility. This seems to be a quite different consequence from that of the present research, but such a different effect of money illusion can be considered instead to indicate an important role of stationary situation. Regarding experimental settings, in Yamamori *et al*., nominal changes occur randomly and discontinuously. In addition, such changes move prices either upward (inflation) or downward (deflation). By contrast, the present experiment assumes that prices change at a constant rate throughout each subject's experimental lifetime. Thus, a comparison between Yamamori *et al*. and the present investigation might indicate that subjects show inefficient behavior under nominal changes through random fluctuations in inflation and the nominal interest rate; by contrast, they might take more efficient paths under stationary nominal changes through a constant rate of inflation and the nominal interest rate.

Therefore, as discussed above, the present research results support prior findings about consumption-saving behavior in economic experiments. Moreover, based on results presented previously, the current study generates a new finding based on the prior studies: effects of money illusion derived from nominal changes can contribute to better consumption-saving decision-making as well as different reactions of the consumption path between in inflationary and deflationary situations.[34]

7. Conclusion

This paper has investigated effects of money illusion on consumption-saving decision-making, using an economic experiment. In experimental situations, the paper has introduced a monetary aspect, where nominal values of economic variables are

[34] According to Table 9, the coefficients on these effects are significant and the sign indicates an improvement in the quality of decision-making through behavior affected by nominal changes in constant inflation or deflation, which supports the findings presented in the previous sections.

displayed differently but their real values are identical in that an optimal real consumption path is the same. Since there is no difference in real values among the situations, a standard dynamic theory of consumer choices suggests an identical consumption path for each situation. The experimental studies, however, show that a nominal difference arising from higher positive inflation causes subjects to consume more in early periods of the experimental lifetime and less in later periods relative to a consumption path chosen by subjects who face a situation with zero inflation. Moreover, given a utility function assumed in the experiment and the estimated relationship between the slope of the consumption path and the inflation rate, such effects of money illusion on the consumption path ameliorate the level of utility of subjects who confront a situation with a higher positive rate of inflation if the level of the rate is not so high. The paper has also treated deflationary situations. In such situations, a lower negative rate of inflation (a deeper deflation) also induces more consumption in early periods and less in later periods This suggested that in consumption-saving decision-making, subjects react to a rise of the inflation rate differently in inflationary situations and in deflationary situations, regardless of no change in the real interest rate.

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Appendix: Instructions, Quiz and Reference Information

The following documents are included in the experimental materials: (1) instructions for explaining the experimental procedure, (2) quizzes to check each subject's degree of understanding of the procedure, and (3) reference information. The sentences presented below were used for subjects who joined in experiments with a positive rate of inflation; for those who joined in experiments with a deflationary situation, alternative expressions and pictures that coincide with deflationary situations were used.

Instructions

Overview

Welcome to this experiment in economics and decision-making. Please read these instructions carefully, as they explain how you earn money from the decisions you make in this experiment. If you have a question, please send an e-mail and your question will be answered in private.

In this experiment, you play two decision-making sessions. Each session consists of 25 "periods" of decision-making.

At the start of each period, you get income: a certain number of "Exeter dollars" (EXDs, virtual currency in this experiment). Also, you have savings from the previous period and interest earned on the savings (at period 1, there are neither savings nor interest). The sum of these amounts is your available budget in the period.

You are required to decide how many EXDs you will spend to purchase convertible goods and how many EXDs you will save for the next period. The goods you purchase will have monetary value derived from a function on the number of goods in each period. Your earnings through participation will be determined based on the sum total of this monetary value in every decision-making period.

(For more details, see the attached document, "Reference Information.")

1. Income

At the beginning of each period, you will be awarded a certain amount of income in EXDs (virtual currency in this experiment). The income increases from period to period at a certain rate called the *income growth rate*. This income growth rate does not change in a sequence of 25 periods and is presented to you at the start of each game.

(For more details, see Key point 1 in the attached "Reference information.")

2. Available budget for decision-making

Each period, you will have some amount of EXDs available to you, and you will decide how much you spend to purchase goods. Your decision screen will report the maximum EXDs you can spend, breaking it down according to

(1) Income of the period: M

(2) Savings from the last period: S

(3) Interest earned on savings: $S \times r$ (interest rate)

The total EXDs you can spend on goods or save during the period will be the sum of these three numbers: $M + S + S \times r = M + S \times (1 + r)$.

3. Purchasing convertible goods

After viewing the amount of EXDs available to you, you must decide how much of these EXDs you wish to spend to purchase convertible goods at the price of the period.

You can spend any number of EXDs from zero on up to the maximum amount of EXDs, and you can choose to spend fractions of EXDs up to four decimal places. You can confirm the number of goods purchased with the amount of EXDs you decide to spend before fixing your decision.

Type the number of EXDs you wish to spend to purchase convertible goods (up to four decimal places) in the blue input box on your decision screen. Then click the "Submit" button to confirm your decision. You can change your mind any time prior to clicking the "submit my decision" button shown in the confirmation window.

4. Price of goods

The price of the goods in the first period is 1 EXD, and in period 2, . . . , 25, the price grows at a certain rate named the *inflation rate*. This inflation rate does not change in a sequence of 25 periods and is presented to you at the start of each session.

Note that if the inflation rate is greater than zero, the number of goods you can purchase with a certain amount of EXDs declines from period to period since the price rises.

(For more details, see Key points 2 and 3 in the attached "Reference information.")

5. Convergence of goods into money

In each period, goods you have purchased are automatically converted into money. You cannot save the goods for the next period. When you make a decision, you can see the amount of money you get from the convergence of goods on your decision screen.

Table 1 presents various amounts of money that you can earn from converting goods each period. Notice that only some numbers of goods (0, 1, 2, . . . , 25, 50, 100, 200, 300) are shown in Table 1. The formula for converting goods into money is given at the top of Table 1. Figure 1 illustrates this formula graphically, showing how many goods convert into money over a more continuous range of goods converted each period.

Notice that money payoffs are initially increasing in the number of goods converted each period but this increase occurs at a diminishing rate: for example, the difference in your earnings from converting six rather than five goods is larger than the difference in your earnings from converting 16 rather than 15 goods.

(For more details, see Key point 4 in the attached "Reference information.")

6. Savings and interest

If the 25th period has not yet been reached, the EXD that you do not spend each period will be saved for your use in the next period, and these savings will earn interest at a certain rate named the *interest rate*. This interest rate does not change in a sequence of 25 periods and is shown to you at the start of each game.

In the case that the interest rate, for example, is 5 percent, if in the period you saved $S > 0$ EXDs then at the start of the next period you would have $S \times 1.05$ EXDs available to you, in addition to the amount of EXDs you receive as income.

Note that the more EXDs you spend in any period, the fewer saved EXDs you have available to pay for goods in future periods. Also, note that additional saved EXDs earn interest in terms of additional EXDs available to you in the next period. Also note that in the 25th period, any EXDs you do not spend for purchasing (that is, savings in the 25th period) will become worthless.

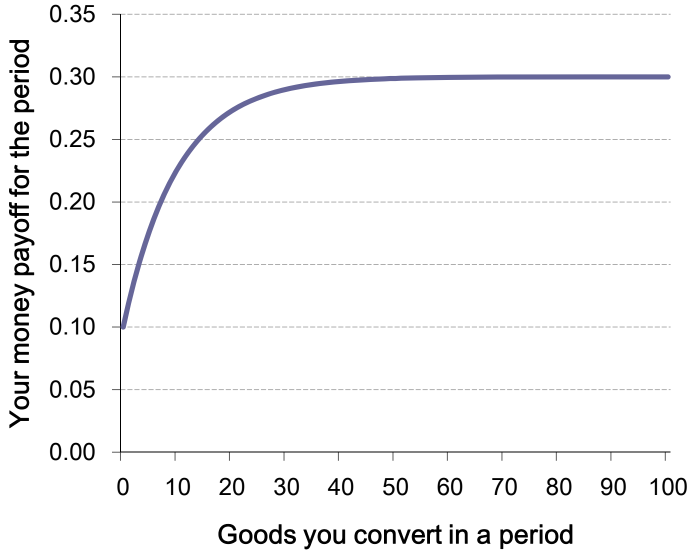
(For more details, see Key point 5 in the attached "Reference information.")

Table 1

$$Money\ payoff = 0.3 - 0.2e^{-0.1\,C}$$
$$C = the\ number\ of\ goods\ you\ purchase$$

Goods converted	Monetary payoff
0	0.10
1	0.12
2	0.14
3	0.15
4	0.17
5	0.18
6	0.19
7	0.20
8	0.21
9	0.22
10	0.23
11	0.23
12	0.24
13	0.25
14	0.25
15	0.26
16	0.26
17	0.26
18	0.27
19	0.27
20	0.27
21	0.28
22	0.28
23	0.28
24	0.28
25	0.28
50	0.30
100	0.30
200	0.30
300	0.30

Figure 1



7. After finishing the first 25-period sequences

Once the first 25-period session has been completed, you will begin playing the second 25-period session. The rules for this second session are exactly the same, but conditions such as initial income, the income growth rate, the interest rate, and the inflation rate will differ from the first game. These new conditions are presented to you at the start of the second game.

8. Earnings

After the second 25-period session has been completed, the computer program will randomly select one of the two results of games you have played. Both results have an equal chance of being chosen. You will be paid the sum total of the monetary value of 25 periods from the one chosen game. In addition, you will receive 5 pounds for participating in this session.

Note: Your earnings in this session depend only on your own decisions and are not affected by the decisions of any other participant.

Quiz

Before continuing on to the experiment, we ask that you complete the following quiz. In answering these questions, feel free to consult the instructions. Your performance on this quiz does not affect your payoff in any way. Check your answer for each multiple choice question where prompted. If any questions are answered incorrectly, you will see the answer key.

For the following quiz, suppose you are informed the following things at the start of the 25-period decision-making game:

Initial income: 10 EXDs
Income growth rate: 5 percent
Interest rate: 3 percent
Inflation rate: 1 percent

1. You will participate in _(1)_ decision-making sessions. Each session consists of (2) periods.

(1)	a. One	b. Two	c. Three
(2)	a. 25	b. 15	c. 30

Answer: (1) b (2) a

Answer key: You will participate in two decision-making sessions. Each session consists of 25 periods.

2. You will be endowed with __(3)__ EXDs at the start of period 1. Then, at the start of period 2, you will be endowed with __(4)__ EXDs.

(3)	a. 5	b. 10	c. 20
(4)	a. 10.8	b. 12	c. 10.5

Answer: (3) b (4) c

Answer key: The initial income is 10, and income growth rate is 5 percent. Hence, the income in period 2 will be 10 × 1.05=10.5.

3. Suppose you are in period 1. What is the maximum amount of EXDs you can spend to purchase goods this period? __(5)__. What is the minimum amount of EXDs you can spend to purchase goods this period? __(6)__

(5)	a. 5	b. 10	c. 20
(6)	a. 0	b. 1	c. 5

Answer: (5) b (6) a

Answer key: You can choose the entire amount of EXDs available to you. Also, you can choose not to spend any EXD.

4. Suppose you saved 2 EXDs in period 1. The interest you will receive in period 2 is __(7)__. How many EXDs will you have available at the start of period 2, including interest and the amount of EXDs you get as the income of period 2? __(8)__

(7)	a. 2.06	b. 2.1	c. 1.9
(8)	a. 2.06	b. 10.5	c. 12.56

Answer: (7) a (8) c

Answer key: Interest will be 2 × (1 + 0.03) = 2.06. Income in period 2 will be initial income × (1 + income growth rate), that is, 10 × (1 + 0.05)=10.5. In total, available EXDs at the start of period 2 will be 2.06 + 10.5 = 12.56.

5. Suppose it is period 25. If you choose to save some of your available EXDs in period 25, will they have any future value to you? __(9) Yes or No?__

(9) a. Yes b. No

Answer: (9) b

Answer key: In the 25th period, any EXDs you do not spend for purchasing goods will become worthless.

6. True or false: Your earnings will depend on your cumulative earnings total from one of the two 25-period sessions you play, but you will not know which game will be chosen until the end of the session. __(10) True or False?__

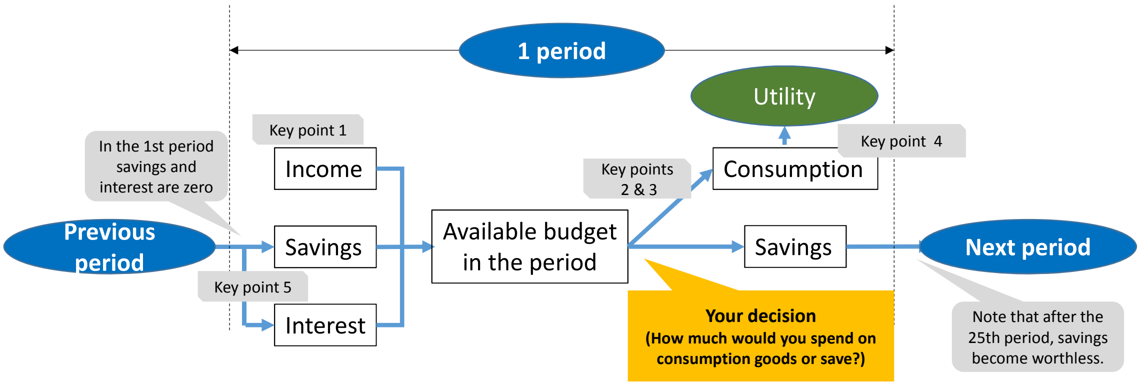
(10) a. True b. False

Answer: (10) a

Answer key: You will be paid your cumulative money earnings from the one game result the computer randomly chose.

Reference Information

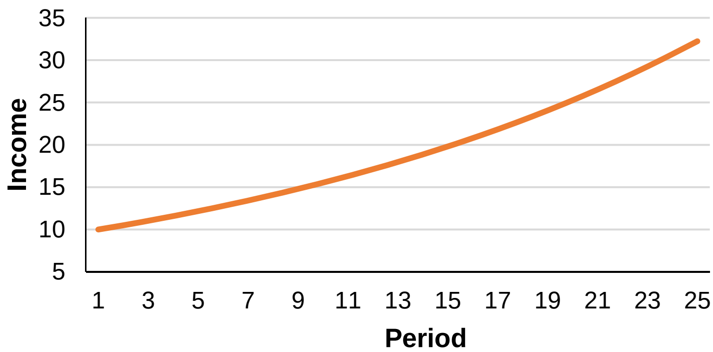
▼ Overview of the experiment



In each session, you are required to complete a 25-periods of decision-making task. You repeat this task twice overall.

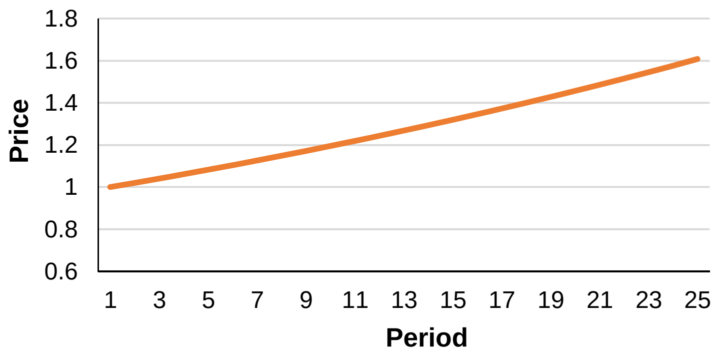
▼ Key points

Key point 1: Income grows at the income growth rate.



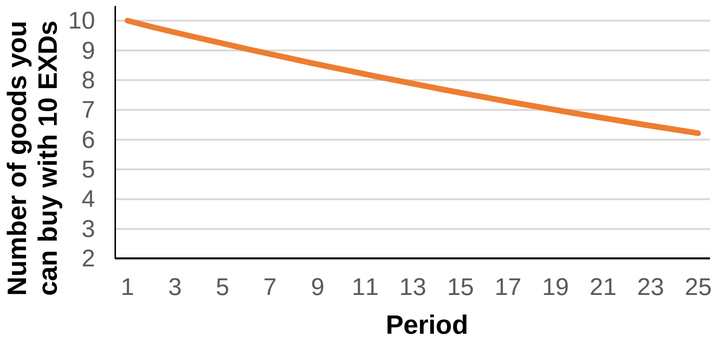
(Figure showing the case that initial income is 10 EXD and income growth rate is 5 percent.)

Key point 2: Price of goods grows at the inflation rate.



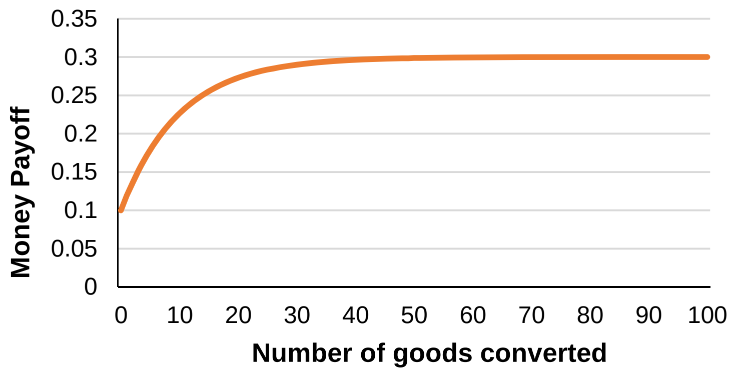
(Figure showing the case that the initial price is one and the inflation rate is 2 percent.)

Key point 3: Because of inflation, for a certain amount of EXDs, the number of goods you can purchase declines from period to period.



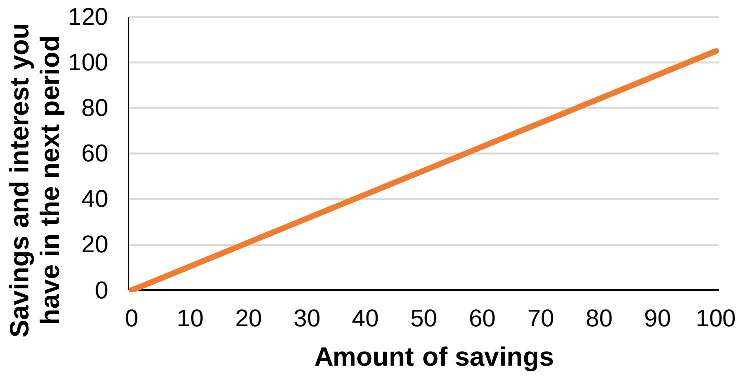
(Figure showing the case that the inflation rate is 2 percent and you spend 10 EXDs constantly in each period.)

Key point 4: The money payoff increases with the number of goods, but this increase occurs at a diminishing rate.



$$Money\ Payoff = 0.3 - 0.2e^{-0.1\,C}, \quad where\ C = number\ of\ goods\ converted.$$

Key point 5: The less you spend for purchasing (or the more you save), the more you get in savings and interest in the following period.



$$Savings\ and\ interest = S \times (1 + interest\ rate), \quad where\ S = EXDs\ you\ saved$$

(Figure showing the case when the interest rate is 5 percent.)

Note: after the 25th period, savings become **worthless**.