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Anomaly, impulsivity, and addiction

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ABSTRACT

There are two behavioral approaches to addiction: rational and irrational. The rational approach assumes that addicts have higher time preference rates and lower risk-aversion coefficients—parameters that are interpreted as impulsive preferences. On the other hand, the irrational approach argues that addiction is a consequence of anomalies such as non-expected utility and hyperbolically discounted utility. This paper integrates these two approaches and concludes that anomaly and impulsivity complementarily account for addiction.

1. Introduction

Why do people suffer from such addictions as smoking and gambling? We analyze this problem with the help of the following two models.[1] The first is the rational addiction model advocated by Becker and Murphy (1988), where a consumer is assumed to think that an addictive product such as cigarettes increases her current satisfaction but decreases her future utility by damaging her health, and then determine the optimum consumption levels. The rational addiction model is compatible with traditional economic models such as the discounted and expected utility schemes. Ida and Goto (2009b) verified empirically that impulsive people—those with higher time preference rates and lower risk-aversion coefficients—were more likely to be addicted to smoking. We call this the *weak rationality* approach to addiction.

The second is the irrational addiction model, such as the one incorporated in the study by Gruber and Koszegi (2001), where the exponentially discounted and expected utility hypotheses are systematically violated; individuals neither recognize the true difficulty of quitting nor search for self-control devices to help them quit. Gruber and Koszegi developed a new model of addictive behavior that incorporated anomalies such as time-inconsistency,[2] and also included strikingly different normative implications, since government policy should consider not only the externalities that smokers impose on others but also the internalities imposed by smokers on themselves. We call this the *irrationality* (or *bounded rationality*) approach.

Are the two approaches related? Are they complementary or substitutes, if related? These questions will be investigated in this paper. It is also important to verify whether an addict is both impatient and time-inconsistent; and whether a risk seeker is likely to violate the expected utility hypothesis. Very few studies, however, have been conducted in this vein. An exception is Blondel et al. (2007), who compared the behavior of drug addicts with that of a control group and discovered that the decisions of the drug users, over time and under risk, were not less consistent with standard decision-making theories. Furthermore, they found no differences in the estimated discount rates between the drug users and the control group, but the former did appear to be more risk seeking. These conclusions are interesting, although the size of the sample was only 34. Expanding on the work of Blondel et al. (2007), we draw a large population to examine the relation between the irrationality (anomaly) and the weak rationality (impulsivity) approaches.

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[1] Tomer (2001) also discussed addiction from a socio-economic perspective. We will come back to the socio-economic model, based on our estimation results.

[2] Wong (2008) found that time-inconsistent behavior is associated with the inferior class performance of university students.

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This paper establishes three hypotheses. First, we investigate whether anomalies such as non-discounted and non-expected utilities are associated with higher time preference rates or higher risk-aversion coefficients. We conclude that discounted utility anomalies can be explained by the immediacy effect, resulting in higher time preference rates; expected utility anomalies can be interpreted as outcomes of the certainty effect, resulting in higher risk-aversion coefficients.

Second, we investigate whether smokers who exhibit discounted and expected utility anomalies have higher time preference rates and lower risk-aversion coefficients than non-smokers who show evidence of the same anomalies. We obtain the expected results. Ida and Goto (2009b) reported that time preference rates were higher and risk-aversion coefficients were lower for smokers. This result holds when the discounted and expected utility anomalies are observed. We thus conclude that anomaly (i.e., time-inconsistency) and impulsivity (i.e., myopia) are complementary rather than alternating.

Third, we apply our analysis to such forms of gambling as pachinko (a type of Japanese pinball) in order to examine instances of process dependence, as opposed to the substance dependence inspected earlier. We obtain results similar to those for smoking while measuring the time preference rates of pachinko players. We thus conclude that the complementarities between anomaly and impulsivity apply widely for addictive behaviors, although we see different results in the case of the risk-aversion coefficients. This is probably because the discounted utility anomaly is associated with the immediacy effect (higher time preference rates), while the expected utility anomaly is related to the certainty effect (lower risk-aversion coefficients).

This paper is organized as follows. Section 2 explains the discounted and expected utility anomalies, and Section 3 presents our adopted anomaly survey. Section 4 explains a method that simultaneously measures time preference rates and risk-aversion coefficients. Section 5 displays the estimation results. Section 6 illustrates the relationship between anomaly and impulsivity for all samples. Sections 7 and 8 discuss the relationships between smokers and pachinko players. Section 9 elaborates on the socio-economic type argument for irrational addiction on the basis of the estimation results. Section 10 outlines our conclusions.

2. Expected and discounted utility anomalies

2.1. The discounted utility anomaly

First, we explain the discounted utility anomaly. The standard theory of decision-making over time is the exponentially discounted utility model advocated by Samuelson (1937).[3] Its key assumption is a *stationarity* axiom, which means that if and only if the utility of JPY 100,000 at present is indifferent to the utility of JPY 150,000 in 1 year, then the utility of JPY 100,000 in 10 years is indifferent to the utility of JPY 150,000 in 11 years.

Given that X and Y denote payoffs ($X < Y$) and t and s denote time delay ($t < s$), *stationarity* is more formally defined as follows:

$$(X, t) \geq (Y, s) \Leftrightarrow (X, t+\varepsilon) \geq (Y, s+\varepsilon).$$

Note that ε is a positive constant.

At this point, the discounted utility model demonstrates $U(X)/(1+r)^t \geq U(Y)/(1+r)^s$ for t and s.[4] However, the discounted utility anomaly of a present-smaller reward being excessively preferred to a delayed-larger reward indicates the following inconsistent preference orders:

$$(X, t) \geq (Y, s) \Leftrightarrow (X, t+\varepsilon) \leq (Y, s+\varepsilon).$$

This anomaly is called *time-inconsistency* (Strotz, 1956),[5] which is interestingly observed even for animals, including pigeons (Ainslie, 1975).

We asked respondents two questions in order to investigate the discounted utility anomaly:

Question 1
Alternative 1: Receive JPY 100,000 *immediately*.
Alternative 2: Receive JPY 150,000 *in X years*.
What X makes the two alternatives indifferent?

Question 2
Alternative 1: Receive JPY 100,000 *in 1 year*.
Alternative 2: Receive JPY 150,000 *in Y years*.
What Y makes the two alternatives indifferent?

Note that given US\$1 = JPY 110, JPY 100,000 equals US\$909, while JPY 150,000 is US\$1364.

Based on the exponentially discounted utility model, when the utility of JPY 100,000 at present equals the utility of JPY 150,000 *in X* years, we obtain the following equation:

$$\text{Utility of JPY } 100,000 = \text{Utility of JPY } 150,000/(1+r)^X.$$

Note that r denotes the annual time preference rate.

On the other hand, when the utility of JPY 100,000 *in 1* year equals the utility of JPY 150,000 *in Y* years, we obtain the following equation:

$$\text{Utility of JPY } 100,000/(1+s) = \text{Utility of JPY } 150,000/(1+s)^Y.$$

If the time preference rate is constant ($r = s$), as the exponentially discounted utility model assumes, then $X = Y - 1$ holds. However, the discounted utility anomaly $X/(Y-1) < 1$ is frequently observed, so the time preference rate decreases for time delay ($r > s$). A main reason for this is the *immediacy effect* in which people tend to lay more emphasis on an immediate reward as opposed to a delayed one (Frederick et al., 2002). In Question 1, since Alternative 1 includes an immediate reward, Alternative 2 requires that X be a relatively small figure (for example, 1 year). On the other hand, in Question 2, since Alternative 1 includes a 1-year-delayed reward, Alternative 2 requires that Y be a large figure (for example, 3 years). Thus, it follows that $X/(Y-1) = 0.5$.

2.2. Expected utility anomaly

Next we explain the expected utility anomaly. The standard theory of decision-making under risk is the expected utility model advocated by Von Neumann and Morgenstern (1953). The key assumption of this theory is the *independence* axiom, which means that if lottery X is preferred to lottery Y, mixing lotteries X and Y by third irrelevant lotteries W and Z with a common probability $1-P$, preserves the preference orders:

$$(X, P; Z, 1-P) > (Y, P; Z, 1-P) \Leftrightarrow (X, P; W, 1-P) > (Y, P; W, 1-P).$$

We asked respondents two questions to investigate the expected utility anomaly:

[3] The exponentially discounted utility model was axiomatically defined by Koopmans (1960) and Fishburn and Rubinstein (1982).

[4] For continuous time, the exponentially discounted utility model is represented by $\exp(-rt)U(X) \geq \exp(-rs)U(Y)$.

[5] A model considers a decreasing discount rate as hyperbolically discounting, which is represented by $U(X)/(1+t)^r$.