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Time and risk preference parameters and the success of smoking cessation

Rei Goto

Faculty of Economics, Konan University, Kobe 658-8501, Japan

reigoto@center.konan-u.ac.jp

Yuko Takahashi

Health Service, Nara Women's University, Nara 630-8506, Japan

takahahi@cc.nara-wu.ac.jp

Shuzo Nishimura

Graduate School of Economics, Kyoto University, Kyoto 606-8501, Japan

shuzo@econ.kyoto-u.ac.jp

Takanori Ida+

Graduate School of Economics, Kyoto University, Kyoto 606-8501, Japan

ida@econ.kyoto-u.ac.jp

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+Corresponding author: Takanori Ida, Graduate School of Economics, Kyoto University, Yoshida, Sakyo, Kyoto 606-8501, Japan; Tel. & Fax: +81-75-753-3477; E-mail: ida@econ.kyoto-u.ac.jp

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Shuzo Nishimura

Graduate School of Economics, Kyoto University, Kyoto 606-8501, Japan

shuzo@econ.kyoto-u.ac.jp

Takanori Ida[+]

Graduate School of Economics, Kyoto University, Kyoto 606-8501, Japan

ida@econ.kyoto-u.ac.jp

Abstract

Objective: To identify whether the time and risk parameters and the factors analysed in previous research predict the success of smoking cessation.

Design: A longitudinal survey for smokers who recently started to quit. Time and preference parameters are individually estimated using a discrete choice experiment

[+]Corresponding author: Takanori Ida, Graduate School of Economics, Kyoto University, Yoshida, Sakyo, Kyoto 606-8501, Japan; Tel. & Fax: +81-75-753-3477; E-mail: ida@econ.kyoto-u.ac.jp

(DCE).

Setting: Japan, 2007.

Participants: A total of 689 smokers who began quitting smoking within the last month.

Main outcome measures: Time discount rate, the coefficient of risk aversion, and duration of smoking cessation.

Results: Within a proportional hazards regression model, the high time discount rate is associated with failure to quit (hazard ratio: 1.17, 95% confidence interval: 1.10 to 1.24, P < 0.001). The high coefficient of risk aversion improves the overall success of smoking cessation (0.20, 0.07 to 0.53, P = 0.001). Among the conventional variables analysed in previous research, the high self-efficacy of quitting (0.87, 0.79 to 0.95, P = 0.003), the use of nicotine replacement therapy (0.68, 0.49 to 0.96, P = 0.029) and high nicotine dependence are associated with successful cessation. Inexperienced quitters are significantly more likely to fail to quit (3.35, 1.61 to 7.00, P = 0.001). Age, gender, health status and mood variations have no significant effect.

Conclusions: Our study indicated that those who emphasize future rewards (time-patient preference) and those who give more importance to rewards that are certain (more risk-averted preference) were significantly more likely to continue to abstain from smoking. Time and risk preference parameters were good predictors of cessation.

Introduction

Smoking cessation provides health benefits to smokers.[1] It also reduces the societal costs incurred because of smoking, such as health expenditures due to tobacco-related diseases.[2] Many smokers wish to quit smoking.[3] However, despite professional support provided by physicians, less than half of the quitters succeed in quitting smoking.[4 5] The majority of smokers attempt to quit by themselves, and it is well known that the success rate of these self-quitters is very much lower than that of the guided quitters.[6] For the management of smoking cessation, it is very important to understand the factors that predict the success of individual smoking cessation.

Only a few studies have examined the predictors of smoking cessation using samples from the general public rather than from those who adopted cessation support. With regard to factors associated with successful cessation, previous studies have pointed out factors such as nicotine dependence,[3 7-12] self-efficacy,[3 9] past quitting attempts,[7 13 14] and outcome expectancy of quitting,[3] as well as socio-demographic factors such as age, gender, education and income.

In the field of economics, researchers have focused on time and risk preference parameters to analyse smoking behaviour. These studies are based on the hypothesis that smokers and non-smokers are different in terms of preferences concerning delay and probability. These differences arise because of the differences in weights they place on present and future rewards and those with certainty and risk. Theoretically, smokers who focus more on possible health damage in the future than on present enjoyment choose to quit smoking.[15]

To gain the same satisfaction or utility, future and risky gains are weighted less than present and certain gains. This procedure is referred to as discounting, and discounting is of two types: time discounting and probability discounting. Time discounting may be more popular among health professionals because future costs and effects are discounted using time discount rates in the economic evaluation of health care.[16]

With regard to smoking behaviour, the parameters of time and probability discounting have been empirically measured. Much research on time preference has reported that smokers are more impatient than non-smokers and that they more frequently choose rewards that are smaller and obtained earlier over those that are larger and obtained later. This pattern is apparent in those who smoke more tobacco daily[17 18] and those who intake more nicotine.[18] On the other hand, the results of research on risk preference[17 19] are controversial, and sufficient evidence has not been accumulated to determine whether smoking is associated with a risk-prone preference. To our knowledge, there are few studies that have investigated the association of time and risk parameters related to the success of quitting behaviour.

The main aim of this paper is to identify the predictors of smoking cessation on the basis of a longitudinal survey of quitters. In particular, we focus on the relationship between individual differences in time and risk parameters and the factors analysed in previous research.

Methods

Data

The data were gathered from May 2007 onwards in the following two stages. In the first stage, we surveyed Japanese adults registered with a consumer monitoring investigative company that has about 85,900 monitors. We obtained 854 replies from individuals who had begun quitting smoking within the last month. They were asked to reply to a questionnaire that included a discrete choice experiment for measuring the time and risk preferences parameters and the Fagerström Test for Nicotine Dependence (FTND) test for measuring nicotine dependency.[20] After excluding invalid respondents and respondents who had smoked less than 100 cigarettes thus far,[21] we finally obtained 689 samples (response rate = 80.7%). In the second stage, we began a follow-up survey intended for these 689 samples for five months. During each follow-up, we asked whether the smokers had abstained from smoking since the last follow-up. Our definition of success of cessation was that the smokers should have abstained from 'even-a-puff' in that period.

This survey was approved by the ethical committee of Nara Women's University.

Measuring time and risk preferences

It is a common practice in economic evaluations to discount future costs and benefits in economic evaluations. Questionnaire surveys are used to measure the time discount rate empirically. A simple example is 'How many pounds that you can gain one year later do you feel are equivalent to gaining £100 now?' In this case, the time discount rate is 10% if £110 one year later is equivalent to £100 now. The higher the amount, the larger the time discount rate, and the more weight they place on present rewards. A larger time discount rate corresponds to more time-impatience or myopic time preference.

Similarly, we can measure the risk preference parameter by asking 'How many pounds would you want to gain with a probability of 50% that you feel would be equivalent to a certain gain of £100?' The higher the amount, the larger the weight they place on rewards they are certain to gain. We can determine the coefficients of risk aversion based on the answers to these questions. A larger coefficient of risk aversion corresponds to a more risk-averted preference.

It is problematic to measure the time and risk preferences using the above-mentioned questions. First, the open-ended questions that enquire about the amounts of money impose a cognitive load on respondents. Answering choice questions similar to daily choices is easier than answering questions based on an amount of money. Second, the time and risk preferences are correlated with each other.[22] For example, questions related to future rewards inevitably include risk questions if one believes that future rewards always involve risks. Hence, measuring two preference parameters separately cannot help in distinguishing the time and risk preferences.

To solve these problems, we simultaneously measure the time and risk preference parameters by using discrete choice experiments (DCEs). DCEs are attribute-based measures of benefit. Any good or service is described on the basis of the bundle of its attributes or characteristics. The extent to which an individual values a good or a service is evaluated on the basis of the selection of hypothetical choices imitating the daily decision making process. This technique has been applied in healthcare settings,[23 24] and the outcomes have revealed that DCE results have internal validity and consistency.[25]

Details about how to measure the two preferences using DCE are provided elsewhere.[26] We identified three attributes: the amount of reward, winning probability and time delay. Respondents were asked to choose eight pairs that are different in levels of each attribute. Figure 1 depicts a representative questionnaire. The estimation method of individual preference parameters is presented in the appendix.

< Figure 1 >

Other predictor variables

The core set of predictor variables other than the preference parameters is as follows. These variables are those that have been analysed in previous literature.

- Age (in years): 30–39, 40–49, 50 and above
- Gender: Female dummy
- Self-efficacy of quitting: On the basis of the categories of the answer to 'How certain are you that you would succeed?', the variables were coded from 1 (extremely weak) to 7 (extremely strong).
- Health status: This variable was created from the answer to 'How did you feel about your health before this quitting attempt?' The variables were coded from 1 (extremely well) to 5 (extremely bad).
- Mood variation: This variable was based on the answer to 'How has your mood been changed after quitting? Has it become comfortable or irritating?' The variable was coded from 1 (very comfortable) to 5 (very irritated).
- Inexperienced quitter: This variable was based on the question 'Have you tried to quit before?' Those who had never attempted quitting were coded as 1, otherwise, 0.
- Nicotine replacement therapy: By March, 2008, nicotine gum was provided as an over-the-counter medicine and nicotine patches were a prescription drug in Japan. Those who opted for nicotine replacement therapy, regardless of professional

support are coded as 1, otherwise, 0.

- FTND: By aggregating the responses to the FTND, we define the respondents scoring a total of zero to three points as having low nicotine dependence, a total of four to six points as middle nicotine dependence and a total of seven or more points as displaying high nicotine dependence.[27]

Survival analysis

To analyse whether the above-mentioned factors predict the success of smoking cessation, we used Cox's proportional hazard model with a time-dependent covariate.[28] Stata 10 (Stata Corp., College Station, TX, USA) was used for the survival analysis. We used NLOGIT3.0 (Econometric Software, Inc., Plainview, NY, USA) for the analysis of the DCE and for the estimation of the time and risk parameters. We calculated 95% intervals and considered $P < 0.05$ to be significant.

Results

Descriptive statistics of 689 samples aged from 20 to 77 are reported in Table 1. Most of the respondents were in their 30s, followed by those in their 20s. The mean age was 34.7, and the proportion of females was 44.6%. The national figures of Japanese smokers show that 26% of smokers in their 20s are female and that the proportion of female smokers decreases in older generations.[29] Hence, more young and female smokers are included in our samples.

< Table 1 >

Furthermore, 81.3% of the total number of smokers in our sample attempted to quit earlier. Although 136 (19.7%) quitters used nicotine replacements such as gum and patches, only 21 (3.0%) were provided with support by physicians. 484 (70.3%) smokers attempted to quit by themselves. Thus, most subjects in the sample were self-quitters. In Japan, nicotine replacement therapy with professional support has been reimbursable in line with standard national health insurance practice since April 2006. This therapy may not yet be popular among smokers.

The mean score of the FTND is 3.52. The ratios of classification of nicotine dependence are 50.7% for low dependence, 40.4% for middle dependence and 9.0% for high dependence, respectively.

The sample mean of the time discount rate is 6.86% per month. Furthermore, the 5 and 95 percentiles are 2.05% and 9.39% respectively. Those with a higher time discount rate tend to emphasize present rewards and have a myopic preference in terms of delay. The coefficient of risk aversion (sample mean = 0.19), which is not shown in the percentage, increases as preference becomes more risk-averse. A person's risk preference is classified as being risk-averse if the coefficient of risk aversion is positive; as risk-neutral, if it is zero; and as risk-prone, if it is negative. In sum, 529 (76.8%) have a risk-averse preference.

Furthermore, 321 (46.6%) smokers succeeded in quitting smoking at the time of the final survey that was conducted five months later. The number of failures decreased as the continuation time progressed. The conditional probability of failure was 21.2%, 11.4%, 7.9%, 4.7%, and 4.7% from the first month to the fifth month, respectively. Moreover, 81 (11.8%) respondents from the initial sample opted out from the survey

(Table 2).

< Table 2>

Among the conventional variables analysed in previous research, those with high self-efficacy of quitting are significantly more likely to abstain from smoking (hazard ratio: 0.87, 95% confidence interval: 0.79 to 0.95, P = 0.003). The use of nicotine replacement therapy (0.68, 0.49 to 0.96, P = 0.029) and high nicotine dependence (7 ≤ FTND score ≤ 10) also significantly increases the probability of continuing to quit (0.35, 0.14 to 0.87, P = 0.023). Inexperienced quitters are significantly more likely to fail to quit (3.35, 1.61 to 7.00, P = 0.001). Age, gender, health status and mood variations have no significant effect (Table 3).

The Cox's proportional hazard regression model shows that those with a high time discount rate are significantly more likely to fail to quit (hazard ratio: 1.17, 95% confidence interval: 1.10 to 1.24, P < 0.001). Moreover, the high coefficient of risk aversion improves the overall continuation of smoking cessation (0.20, 0.07 to 0.53, P = 0.001). It indicates that those who emphasize future rewards (patient preference) and those who place more weight on rewards that are certain (risk-averted preference) are significantly more likely to continue to abstain from smoking (Table 3).

< Table 3>

The model that includes only the previously analysed variables is also estimated. Mood variation changes from non-significant to significant (P = 0.010). In contrast, high nicotine dependence becomes a non-significant factor in this model (Table 4). These variables may correlate with the time and risk preference parameters. Both parameters concerning the time and risk preferences have a high level of significance (Table 3). Thus, these two parameters are independent predictors of cessation continuation.

< Table 4>

We estimate Cox's proportional hazard model with time-dependent variables. We test the assumption of proportional hazard for each variable using Shoenfeld residuals.[28] The negative effect of inexperienced quitters on the success of cessation decreases from the first survey onwards (β coefficient: –0.322, 95% confidence interval: –0.058 to –0.06, P = 0.015). The positive effect of high nicotine dependence on the succession of cessation decreases over time (0.379, 0.06 to 0.70, P = 0.02). On the whole, those with a high coefficient of risk aversion are more likely to continue to abstain from smoking. This effect intensifies over time (–1.10, –1.53 to –0.67, P < 0.001). The proportional hazard assumptions of other variables are not rejected (Table 5).

< Table 5>

Discussion

In this study, we conducted a five-month-long longitudinal survey for samples in which most of the quitters did not seek help. To determine the predictors for the continuation of smoking cessation, we analysed the time and risk preference parameters, which have been focused on in economics, as well as other factors that have been studied previously.

There were three main findings from our study: (1) the time and risk preference parameters were good predictors of cessation. Patience and risk-aversion were associated with successful cessation, (2) conventional factors such as self-efficacy of quitting, past cessation experience and the use of nicotine replacement therapy were also found to be associated with the continuation of quitting, and (3) the effect of several variables changed as the follow-up period lapsed.

The main result that the time and risk parameters strongly predict the success of attempts is very interesting. Previous literature from economics and psychology determined the difference in the time preference between smokers and non-smokers.[17 18 30-32] Our research discovered that the variations in time preferences are also very important among smokers attempting to quit smoking. In addition, risk and time preferences are also important factors for cessation. A higher time discount rate or a more myopic time preference has been found in not only nicotine dependence but also in other forms of addiction such as substance use, alcohol and pathological gambling.[33] However, it is not clear as to what originates first, myopic preference or addiction.[34] A detailed investigation of causality is required.

Previous studies also pointed out that the time and risk preferences were associated with social behaviour such as buying life insurance policies and being involved in speculative investment,[35] as well as preventive behaviours like exercises and a healthy diet.[36] Detailed social history, on the basis of which one can infer a patient’s time and risk preferences, may be helpful in providing effective cessation support by determining the risk of a relapse for quitters.

The effects of most conventional factors such as self-efficacy are consistent with previous literature.[3 7 9 13 14] However, our research reveals that highly dependent smokers were more likely to continue to abstain from smoking. This result was in contrast to that of the previous studies that reported a negative linear relationship between nicotine dependence and successful quitting.[3 7-12] The possible interpretations of these results are as follows. First, it is difficult to compare these results directly because the indexes of nicotine dependence are diverse. Second, our samples were obtained from quitters who had begun to stop smoking within the last month. Many of them mortified the early withdrawal, the most common cause of relapse.[37] Even highly nicotine dependent smokers may be willing to continue to abstain from smoking once they overcome the early withdrawal period.

Inexperienced quitters are more likely to fail in their endeavour to quit. This overall negative effect falls in later periods. This indicates that inexperienced quitters gradually learn to prevent a relapse. Careful long-term support for these people is necessary.

There are several limitations in our research. First, the overall success rate of cessation for five months is 46.6% in this research. Only 3–5% of self-quitters are reported to achieve prolonged abstinence for six to 12 months, and most relapses are reported to occur the within first eight days after a given quit attempt.[38] This research mostly analysed the long term abstinence for quitters who had successfully abstained from smoking in the first week. More research on predictors of successful quitting will be needed to focus on the incipient period of smoking cessation.

Second, many samples were obtained from young and less-dependent smokers.

However, these smokers also faced difficulties in quitting, regardless of their strong desire to quit.[39] Undoubtedly, cessation support for these people is essential before their health is adversely affected. Third, we should conduct an international comparison to analyse whether the findings in this paper are relevant in different cultures and countries.

References

1. Doll R, Peto R, Boreham J, Sutherland I. Mortality in relation to smoking: 50 years' observations on male British doctors. *BMJ* 2004;328(7455):1519-1527.
2. Sloan FA, Ostermann J, Picone G, Conover C, Donald H. Taylor J. *The Price of Smoking*. Cambridge: MIT press, 2004.
3. Hyland A, Borland R, Li Q, Yong HH, McNeill A, Fong GT, et al. Individual-level predictors of cessation behaviours among participants in the International Tobacco Control (ITC) Four Country Survey. *Tob Control* 2006;15 Suppl 3:iii83-94.
4. Kawai H, Shibayama T, Tada A, Kawahara S, Soda R, Takahashi K. [Factors affecting the success or failure of smoking cessation using nicotine patches]. *Nihon Kokyuki Gakkai Zasshi* 2005;43(3):144-9.
5. Akkaya A, Ozturk O, Cobanoglu H, Bircan HA, Simsek S, Sahin U. Evaluation of patients followed up in a cigarette cessation clinic. *Respirology* 2006;11(3):311-6.
6. Aveyard P, West R. Managing smoking cessation. *BMJ* 2007;335(7609):37-41.
7. Hellman R, Cummings KM, Haughey BP, Zielezny MA, O'Shea RM. Predictors of attempting and succeeding at smoking cessation. *Health Educ Res* 1991;6(1):77-86.
8. Venters MH, Kottke TE, Solberg LI, Brekke ML, Rooney B. Dependency, social factors, and the smoking cessation process: the doctors helping smokers study. *Am J Prev Med* 1990;6(4):185-93.
9. Borland R, Owen N, Hill D, Schofield P. Predicting attempts and sustained cessation of smoking after the introduction of workplace smoking bans. *Health Psychol* 1991;10(5):336-42.
10. West R, McEwen A, Bolling K, Owen L. Smoking cessation and smoking patterns in the general population: a 1-year follow-up. *Addiction* 2001;96(6):891-902.
11. Hyland A, Li Q, Bauer JE, Giovino GA, Steger C, Cummings KM. Predictors of cessation in a cohort of current and former smokers followed over 13 years. *Nicotine Tob Res*

2004;6 Suppl 3:S363-9.
12. Siahpush M, Borland R, Scollo M. Factors associated with smoking cessation in a national sample of Australians. *Nicotine Tob Res* 2003;5(4):597-602.
13. Honda K. Psychosocial correlates of smoking cessation among elderly ever-smokers in the United States. *Addict Behav* 2005;30(2):375-81.
14. Zhu SH, Sun J, Billings SC, Choi WS, Malarcher A. Predictors of smoking cessation in U.S. adolescents. *Am J Prev Med* 1999;16(3):202-7.
15. Becker G, Murphy DA. A theory of rational addiction. *Journal of Political Economy* 1988;96:675-700.
16. Brouwer WB, Niessen LW, Postma MJ, Rutten FF. Need for differential discounting of costs and health effects in cost effectiveness analyses. *BMJ* 2005;331(7514):446-8.
17. Reynolds B, Richards JB, Horn K, Karraker K. Delay discounting and probability discounting as related to cigarette smoking status in adults. *Behav Processes* 2004;65(1):35-42.
18. Ohmura Y, Takahashi T, Kitamura N. Discounting delayed and probabilistic monetary gains and losses by smokers of cigarettes. *Psychopharmacology (Berl)* 2005;182(4):508-15.
19. Chesson H, Viscusi WK. The heterogeneity of time-risk tradeoffs. *Journal of Behavioral Decision Making* 2000;13:251-258.
20. Heatherton TF, Kozlowski LT, Frecker RC, Fagerstrom KO. The Fagerstrom Test for Nicotine Dependence: a revision of the Fagerstrom Tolerance Questionnaire. *Br J Addict* 1991;86(9):1119-27.
21. WHO. *Guidelines for controlling and monitoring the tobacco epidemic.*, 1998.
22. Rachlin H, Raineri A, Cross D. Subjective probability and delay. *J Exp Anal Behav* 1991;55(2):233-44.
23. Ryan M, Hughes J. Using conjoint analysis to assess women's preferences for miscarriage management. *Health Econ* 1997;6(3):261-73.
24. Hall J, Kenny P, King M, Louviere J, Viney R, Yeoh A. Using stated preference discrete choice modelling to evaluate the introduction of varicella vaccination. *Health Econ* 2002;11(5):457-65.
25. Viney R, Lanscar E, Louviere J. Discrete choice experiments to measure preference for health and heatlh care: expert review. *Pharmacoeconomics Outcomes Res* 2002;2:319-326.
26. Ida T, Goto R. Simulatenous measurement of time and risk preferences: Stated preference discrete choice modeling analysis depending on smoking behavior. *forthcoming in International Economic Review* 2009.

27. Haberstick BC, Timberlake D, Ehringer MA, Lessem JM, Hopfer CJ, Smolen A, et al. Genes, time to first cigarette and nicotine dependence in a general population sample of young adults. *Addiction* 2007;102(4):655-65.

28. Kleinbaum DG, Klein M. Extension of the Cox proportional hazards model for time-dependent variables. *Survival Analysis*: Springer, 2005.

29. Ministry of Health Labour and Welfare. National Health and Nutrition Survey 2004 , *in Japanese " Kokumin Kenko Eiyo Tysa"*, 2006.

30. Mitchell SH. Measures of impulsivity in cigarette smokers and non-smokers. *Psychopharmacology (Berl)* 1999;146(4):455-64.

31. Odum AL, Madden GJ, Bickel WK. Discounting of delayed health gains and losses by current, never- and ex-smokers of cigarettes. *Nicotine Tob Res* 2002;4(3):295-303.

32. Baker F, Johnson MW, Bickel WK. Delay discounting in current and never-before cigarette smokers: similarities and differences across commodity, sign, and magnitude. *J Abnorm Psychol* 2003;112(3):382-92.

33. Bickel WK, Miller ML, Yi R, Kowal BP, Lindquist DM, Pitcock JA. Behavioral and neuroeconomics of drug addiction: competing neural systems and temporal discounting processes. *Drug Alcohol Depend* 2007;90 Suppl 1:S85-91.

34. Bickel WK, Yi R. What came first? Comment on Dom et al. (2006). *Addiction* 2006;101(2):291-297.

35. Barsky RB, Juster FT, Kimball MS, Shapiro MD. Preference Parameters and Behavioral Heterogeneity: An Experimental Approach in the Health and Retirement Study *Quarterly Journal of Economics,* 1997;112(2):537-579.

36. Kenkel D. The demand for preventive medical care. *Applied Ecnomics* 1994;26(4):313-325.

37. Hughes JR. Effects of abstinence from tobacco: valid symptoms and time course. *Nicotine Tob Res* 2007;9(3):315-27.

38. Hughes JR, Keely J, Naud S. Shape of the relapse curve and long-term abstinence among untreated smokers. *Addiction* 2004;99(1):29-38.

39. DiFranza JR, Wellman RJ. Sensitization to nicotine: how the animal literature might inform future human research. *Nicotine Tob Res* 2007;9(1):9-20.

40. McFadden D, Train KE. Mixed MNL models of discrete choice models of discrete response. *Journal of Applied Econometrics* 2000;15:447-470.

41. Train KE. *Discrete Choice Methods with Simulation*: Cambridge University Press, 2003.

42. Louviere JJ, Hensher DA, Swait JD. *Stated Choice Methods*: Cambridge University Press, 2000.

43. Hencher DA, Rose JM, Greene WH. *Applied Choice Analysis -A primer*: Cambridge

University Press, 2005.

APPENDIX

Here, we explain the discounted and expected utility models that form the basis for estimating the time preference rate and risk aversion coefficient. Let the utility of alternative *i* be V_i (reward$_i$, probability$_i$, timedelay$_i$). The exponential discounted utility model and the (linear in probability) expected utility model are used for the functional form of *i* be V_i.

Discounted utility: exp(–*TIME**timedelay$_i$)*utility(reward$_i$),

where parameter *TIME* denotes the time discount rate.

Expected utility: probability$_i$*utility(reward$_i$).

Accordingly, rewriting V_i, we obtain

V_i(reward$_i$, probability$_i$, timedelay$_i$)

= exp(–*TIME**timedelay$_i$)*probability$_i$*utility(reward$_i$).

At this point, we simply specify the functional form of utility as the *RISK*-th power of reward. Such a utility function is of the constant relative risk-aversion form, where the coefficient of the relative risk aversion is denoted by 1–*RISK*. Taking logarithms of both sides, we obtain:

ln V_i(reward$_i$, probability$_i$, timedelay$_i$)

= –*TIME**timedelay$_i$+ ln probability$_i$ + *RISK**ln reward$_i$.

Two points should be noted here: first, a greater level of impatience implies a larger *TIME*; second, because a risk-averse attitude means 1–*RISK* $\in$ [0,1], a greater level of risk-aversion implies a larger 1–*RISK*.

In the estimation of the discrete choice model, conditional logit (CL) models, which assume independent and identical distribution (IID) of random error terms, have been widely used in past studies. However, the independence of irrelevant alternatives (IIA) property derived from the IID assumption of the CL model is too strict to allow flexible substitution patterns. The most prominent approach is a mixed logit (ML) model that accommodates differences in the variance of random components (or unobserved heterogeneity). These models are flexible enough to overcome the limitations of CL models by allowing random taste variation, unrestricted substitution patterns, and the correlation of random error terms over time.[40]

Assuming that parameter β_n is distributed with density function $f(\beta_n)$ [41 42], the ML specification allows for repeated choices by each sampled decision maker in such a way that the coefficients vary over people but are constant over choice situations for each person. The logit probability of decision maker *n* choosing alternative *i* in choice situation *t* is expressed as:

$$L_{nit}(\beta_n) = \prod_{t=1}^{T} [\exp(V_{nit}(\beta_n)) / \sum_{j=1}^{J} \exp(V_{njt}(\beta_n))],$$

which is the product of normal logit formulas, given parameter β_n, the observable portion of utility function V_{nit}, and alternatives $j=1, \ldots, J$ in choice situations $t = 1, \ldots, T$. Therefore, the ML choice probability is a weighted average of logit probability $L_{nit}(\beta_n)$ evaluated at parameter β_n with density function $f(\beta_n)$, which can be written as:

$$P_{nit} = \int L_{nit}(\beta_n) f(\beta_n) d\beta_n .$$

In the linear-in-parameter form, the utility function can be written as

$$U_{nit} = \gamma' x_{nit} + \beta_n' z_{nit} + \varepsilon_{nit},$$

where x_{nit} and z_{nit} denote observable variables, γ denotes a fixed parameter vector, β_n denotes a random parameter vector, and ε_{nit} denotes an independently and identically distributed extreme value (IIDEV) term.

Because the ML choice probability is not expressed in closed form, simulations need to be performed for the ML model estimation.[41] We can also calculate the estimator of the conditional mean of the random parameters, conditioned on individual specific choice profile y_n, given as:

$$h(\beta \mid y_n) = [P(y_n \mid \beta) f(\beta)] / \int P(y_n \mid \beta) f(\beta) d\beta .$$

Here, we assume that the preference parameters regarding time and risk follow normal distributions:

TIME (time discount rate),

RISK (coefficient of relative risk aversion represented by 1–*RISK*).

The random utility that person *n* obtains from choosing alternative *i* in choice situation *t* can be written as follows:

$$U_{nit} = -\alpha * TIME * timedelay_{nit} + \alpha * \ln\ probability_{nit} + \alpha * RISK * \ln\ reward_{nit} + \varepsilon_{nit},$$

where α is a scale parameter that is not separately identified from free parameters and is normalized to one.[43]

Figure 1: Representative questionnaire

	ALTERNATIVE 1	ALTERNATIVE 2
REWARD	JPY 100,000	JPY 250,000
TIME DELAY	NOW	1 MONTH LATER
WINNING PROBABILITY	100%	80%
	↓	↓
CHOOSE ONE		

Table 1 Descriptive statistics

		Whole samples (n = 689)
Age (years)	20–29	34.3%
	30–39	39.3%
	40–49	18.1%
	50 and over	8.3%
Gender	Female	44.6%
	Male	55.4%
Inexperienced quitter	Yes	18.3%
	No	81.7%
Use of nicotine replacement therapy	Yes	19.7%
	No	80.3%
Self-efficacy of quitting		5.38 (1.29)
Health status (before quitting)		2.93 (0.88)
Mood variation		3.09 (0.80)
FTND		3.52 (2.71)
Time discount rate (%)		6.86 (2.60)
Coefficient of risk aversion		0.19 (0.21)

Note: For variables below self-efficacy of quitting, sample means and standard deviations (in parenthesis) are reported.

Table 2 Success and failure of smoking cessation

		Total n = 689 (100%)
Time taken for failure of smoking cessation	First month	146 (21.2%)
	Second month	62 (9.0%)
	Third month	38 (5.5%)
	Forth month	21 (3.1%)
	Fifth month	20 (2.9%)
Success of cessation after the fifth month		321 (46.6%)
Drop out		81 (11.8%)

Table 3 Cox's proportional hazards model for continuation of smoking cessation with time and risk preference parameters

		β coefficient	P value	Hazard ratio	95% CI
Age	30–39	0.011	0.941	1.011	0.76 to 1.34
	40–49	0.277	0.117	1.319	0.93 to 1.86
	50 and over	–0.186	0.439	0.831	0.52 to 1.33
Gender (female dummy)		–0.433	0.063	0.649	0.41 to 1.02
Self efficacy of quitting		–0.140	0.003	0.869	0.79 to 0.95
Health status		0.016	0.814	1.016	0.89 to 1.16
Mood variation		0.100	0.227	1.105	0.94 to 1.30
Inexperienced quitter		1.209	0.001	3.351	1.61 to 7.00
Nicotine replacement therapy		–0.380	0.029	0.684	0.49 to 0.96
FTND	Middle ($4 \leq$ FTND score ≤ 6)	–0.080	0.543	0.923	0.71 to 1.19
	High ($7 \leq$ FTND score ≤ 10)	–1.065	0.023	0.345	0.14 to 0.87
Time discount rate (%)		0.158	<0.001	1.172	1.10 to 1.24
Coefficient of risk aversion		–1.614	0.001	0.199	0.07 to 0.53
No. of samples		689			
Log likelihood		–1693.608			

Note: For FTND, the low dependent group was set as the reference group. Results of time-dependent variables are reported in Table 5.

Table 4 Cox's proportional hazards model for continuation of smoking cessation without time and risk preference parameters

		β coefficient	P value
Age	30–39	–0.085	0.952
	40–49	0.169	0.332
	50 and over	0.005	0.985
Gender (female dummy)		–0.162	0.193
Self efficacy of quitting		0.142	0.001
Health status		0.090	0.208
Mood variation		0.208	0.010
Inexperienced quitter		0.475	0.009
Nicotine replacement therapy		–0.350	0.042
FTND	Middle ($4 \leq$ FTND score ≤ 6)	–0.198	0.130
	High ($7 \leq$ FTND score ≤ 10)	–0.442	0.069
No of samples		689	
Log likelihood		–1787.318	

Note: For FTND, the low dependent group was set as the reference group.

Table 5 Cox's proportional hazard model for continuation of smoking cessation with time dependent variables

	β coefficient	P value	95% CI
Gender (female dummy)	0.187	0.056	–0.004 to 0.38
Inexperienced quitter	–0.322	0.015	–0.58 to –0.06
High nicotine dependence ($7 \leq$ FTND score ≤ 10)	0.379	0.020	0.06 to 0.70
Coefficient of risk aversion	–1.10	<0.001	–1.53 to –0.67
No. of samples	689		
Log likelihood	–1693.608		

Note: The figures shown above are related to the interaction terms between the time-dependent variables and the time elapsed after the beginning of the survey.