Discussion Papers In Economics And Business

Does time preference affect smoking behavior?
A dynamic panel analysis

Takahiro Miura

Discussion Paper 16-16-Rev.

Graduate School of Economics and
Osaka School of International Public Policy (OSIPP)
Osaka University, Toyonaka, Osaka 560-0043, JAPAN

Does time preference affect smoking behavior?
A dynamic panel analysis

Takahiro Miura

Discussion Paper 16-16-Rev.

June 2017

Graduate School of Economics and
Osaka School of International Public Policy (OSIPP)
Osaka University, Toyonaka, Osaka 560-0043, JAPAN

Does time preference affect smoking behavior? A dynamic panel analysis *

Takahiro Miura †

Abstract

I analyze the effect of time preference on smoking behavior while controlling for the effect of past smoking behavior, using a dynamic panel analysis. I use nationwide micro panel data from Japan and make three main findings. First, as in the previous literature, without controlling for the effect of past smoking behavior, I find positive associations between time preference and smoking behavior, with the association significant for male. Second, by using a dynamic panel analysis, I find that time preference affects smoking behavior significantly for female but not for male. Third, male smokers who have a low discount rate are more likely to want to quit or reduce smoking behavior, whereas female smokers with a low discount rate are no more likely to want to quit or reduce smoking behavior. This result implies that while male smokers are concerned about the future consequences of smoking, they cannot manage to quit.

JEL Classification: D90, I12

Keywords: Time preference, Smoking, Dynamic panel analysis, State dependence

*I thank Yoko Ibuka, Shinsuke Ikeda, Fumio Ohtake, and Masaru Sasaki as well as the two anonymous reviewers for their useful comments. This research utilizes the micro data from the Preference Parameters Study of Osaka Universitys 21st Century COE Program Behavioral Macrodynamics Based on Surveys and Experiments and its Global COE project Human Behavior and Socioeconomic Dynamics. I acknowledge the program/projects contributors: Yoshiro Tsutsui, Fumio Ohtake, and Shinsuke Ikeda. I would like to thank Editage (www.editage.jp) for English language editing.

†Graduate School of Economics, Osaka University, 1-7, Machikaneyama, Toyonaka, Osaka, 560-0042, Japan. u304898i@ecs.osaka-u.ac.jp OCRID:0000-0002-5926-0945

1 Introduction

Smoking behavior is an intertemporal decision because it provides immediate satisfaction for smokers but increases their future health risk. The field of economics has tried to explain smoking behavior in the context of an intertemporal decision problem (Becker and Murphy, 1988; Gruber and Köszegi, 2001). One prominent model used is the rational addiction model proposed by Becker and Murphy (1988). According to their model, people with a high discount rate tend to smoke because they place minimal value on the future consequences of smoking. Because people with a high discount rate place more weight on the present than on the future, the effect of increasing tobacco prices is larger than for people with a low discount rate. Therefore, knowing what kinds of people smoke is important for effective tobacco control policymaking.

Many empirical studies examine the association between smoking behavior and time preference; however, their results are mixed. For instance, a significant difference in time preference is observed between current smokers and nonsmokers but not between former smokers and nonsmokers (Bickel et al., 1999). Further, the observed discount rate is significantly associated with smoking behavior except for a female subsample (Harrison et al., 2010; Kang and Ikeda, 2014). However, Khwaja et al. (2007) use three elicitation methods of time preference, with three different questions concerning time preference appearing in each. All their results show an insignificant association between time preference and smoking status. Further, Grignon (2009) finds no significant difference in the probability of smoking between patient people (i.e., those with a lower discount rate) and impatient people (i.e., those with a higher discount rate).

Most studies that examine the association between smoking behavior and time preference assume that individuals' time preferences are invariant or unaffected by past smoking behavior. However, some economic theories argue that time preference is endogenous (Becker and Mulligan, 1997; Bommier, 2006; Orphanides and Zervos, 1998). According to these theories, past smoking behavior may increase time preference directly or indirectly. Some empirical studies support those theories. Yi et al. (2008), for example, find a significant decrease in current time preference in samples who reduced cigarette smoking, whereas samples who did not reduce smoking behavior did not decrease their current time preferences significantly. Secades-Villa et al. (2014) use samples who want to abstain from smoking. At the 12-month follow-up, the authors observe a significant decrease in the current time preferences for samples who had continued to abstain from smoking at the follow-up but not for those who had resumed smoking.

Another characteristic of smoking behavior is its persistence; current smokers tend to smoke in the future. This property is called state dependence. The theory of smoking behavior and its state dependence is also well discussed (Becker and Murphy, 1988; Gruber and Köszegi, 2001). The findings of empirical research support the state dependence of smoking behavior based on analysis using rational addiction models (Becker et al., 1994; Chaloupka, 1991; Labeaga, 1993; Yen and Jones, 1996) and other models (Christelis and Sanz-de Galdeano, 2011; Gilleskie and Strumpf, 2005).

According to the literature, past smoking behavior affects current time preference and current smoking behavior through its state dependence. Therefore, without controlling for the effect of past smoking behavior, the association between current time preference and current smoking behavior is overestimated because of omitted variable bias; however, previous studies have not addressed the presence of such omitted variable bias. In this study, to address the possibility of omitted variable bias, I analyze the effect of current time preference on current smoking behavior by controlling for the effect of past smoking behavior. To my best knowledge, this is the first study to verify the effect of time preference on smoking behavior while controlling for the effect of past smoking behavior. I use the Wooldridge conditional maximum likelihood (CML) estimator, which is one of the estimators of dynamic panel models (Wooldridge, 2005). Additionally, I use the random effect probit model in a static model (i.e., without controlling for the effect of past smoking status) to compare the result with that derived from a dynamic model.

To track the transition of individual smoking behavior, I use the fourth wave of the Japan Household Panel Survey on Consumer Preferences and Satisfaction (JHPS) that contains nationwide representative micro panel data from Japan. The JHPS questionnaire includes questions on smoking status, time preference, demographic variables, and other preferences. By using 5,568 observations, I analyze the effect of current time preference on current smoking status. Some studies use smoking status as a proxy for time preference or an instrument of time preference because measuring individual time preference is difficult (Fersterer and Winter-Ebmer, 2003; Munasinghe and Sicherman, 2006). The present study also verifies the validity of using smoking behavior as a proxy for time preference.

The findings of this study are threefold. First, as in the previous literature, without controlling for the effect of past smoking behavior, I find positive associations between time preference and smoking behavior, with the association significant for the male subsample. Second, by using a dynamic panel analysis, I find that time preference affects smoking behavior significantly for the female subsample but not for the male subsample. This result is robust under several model specifications. Third, male smokers who have a low discount rate are more likely to want to quit smoking or reduce smoking behavior, whereas female smokers with a low discount rate are no more likely to want to quit smoking or reduce smoking behavior. This result implies that while male smokers are concerned about the future consequences of smoking, they cannot manage to quit.

The remainder of this paper is organized as follows. In Section 2, I explain the data and show the summary statistics. In Section 3, I discuss the Wooldridge CML estimator, which is an estimation method for nonlinear dynamic panel models. I show the results in Section 4 and the robustness check and discussion of the results are in Section 5. The conclusion is presented in Section 6.

2 Data and variables

I use the fourth wave (2009 to 2013) of JHPS data for the analysis in this study. Each survey is collected during January and February of each year, and the sample size of each is approximately 4,000 to 6,000. The sampling procedure is designed to be representative. The purpose of the JHPS is to verify the preference and utility assumptions applied in economics. Therefore, the questionnaires include questions on socioeconomic status and behavioral properties such as smoking status as well as respondent preferences such as time and risk preferences. The questionnaire changes each year; some questions are added or deleted and the phrasing of some questions is changed.[1] The fourth wave of the JHPS begins in 2009; however, the questions, particularly those on time preference, are different before 2010 and after 2011. To avoid measurement error from the different questions, I thus use the data from 2011 to 2013 principally.[2] I drop samples from the analysis of those who did not answer all the questions related to the estimation. In addition, because smokers are exposed to a greater health risk than nonsmokers, respondents who smoked in the previous year, particularly older respondents, tended to be dropped from the survey. Doll et al. (2004) show that the health risk for smokers aged over 55 years old is high. To address this sample selection problem, I drop the sample that excludes 55-year-olds as well as older samples. Therefore, I use 5,568 observations.

2.1 Smoking behavior

The fourth wave of the JHPS asked respondents about their smoking behavior; however, the number of possible responses to the question changed after the 2011 survey. In the 2010 survey, the choices were the following: (1) Don't smoke at all, (2) Hardly smoke, (3) Smoke sometimes, (4) About 10 cigarettes a day, (5) About a pack a day, (6) More than two packs a day, and (7) I used to smoke, but have quit. After the 2011 survey, the number of possible responses increased to 10, and the choices were as follows: (i) Never smoked, (ii) Hardly smoke, (iii) Occasionally smoke, (iv) I smoke about one to five cigarettes a day, (v) I smoke about six to 10 cigarettes a day, (vi) I smoke about 11 to 20 cigarettes a day, (vii) I smoke about 21 to 30 cigarettes a day (viii), I smoke about 31 to 40 cigarettes a day, (ix) I smoke 41 cigarettes or more a day, and (x) I used to smoke, but I quit. For the 2010 survey, I define respondents who choose (1) or (7) as nonsmokers and the others as current smokers. In the 2011 to 2013 surveys, I define respondents who choose (i) or (x) as nonsmokers and the others as current smokers. The definition of current smokers is relatively broad compared

[1] The data, questionnaire, sampling design, and details of the survey are available at http://www.iser.osaka-u.ac.jp/index-e.html.

[2] I use smoking status in 2010 for the dynamic panel analysis and discuss the reason for this in Section 3.

with the literature to avoid the bias caused by changing the number of possible responses.[3]

Table 1: The frequency of current smokers

	2010	2011	2012	2013
Total	706	562	485	432
	(30.8)	(27.8)	(26.2)	(25.4)
Male	484	394	339	299
	(46.6)	(42.3)	(40.1)	(39.3)
Female	222	168	146	133
	(17.7)	(15.5)	(14.6)	(14.1)

Note: The proportions of current smokers are reported in parentheses.

Table 1 shows the frequencies and proportions of current smokers for each year. Approximately 27% of the sample are current smokers, with the proportion of male smokers three times greater than that of female smokers in each year (41% for male and 15% for female).

Table 2 shows the pattern of smoking behavior for the sample in the sample period. In the full sample, the majority—66%—are nonsmokers in all periods (In Table 2, "0000" represents that group); by contrast, the second biggest group in the sample—20.7%—represents current smokers in all periods (In Table 2, "1111" represents that group). This finding implies that smoking behavior has strong persistence. The male and female subsamples show a similar pattern: The majority of the sample—49.6% in the male subsample and 79.2% in the female subsample—are nonsmokers in all periods and the second biggest group—33.1% in the male subsample and 10.7% in the female subsample—are current smokers in all periods.

2.2 Time preference and control variables

Time preference is measured by using the multiple price list method for the questionnaires. This popular method is used to elicit time preference. Respondents make several intertemporal decisions; they choose their preference between an immediate monetary reward, JPY X in t days, and

[3]For example, Christelis and Sanz-de Galdeano (2011) define daily smokers as current smokers and thus include occasional smokers within nonsmokers.

Table 2: The pattern of smoking behavior

Smoking Pattern	Total	Male	Female
0000	1334	447	887
0001	17	6	11
0010	8	3	5
0011	11	8	3
0100	19	12	7
0101	2	2	0
0110	6	2	4
0111	21	11	10
1000	85	42	43
1001	9	7	2
1010	4	3	1
1011	21	14	7
1100	24	17	7
1101	12	10	2
1110	30	19	11
1111	419	299	120
N	2022	902	1120

Note: Each number in the "Smoking Pattern" columns represents personal smoking behavior from 2010 (left) to 2013 (right); the number "0" indicates a nonsmoker and "1" indicates a smoker.

a delayed reward, JPY Y in $t + 7$ days. With fixed t, respondents answered nine related questions with varying values for X and Y. The annual interest rate of the delayed reward based on the immediate reward ranges approximately from -10% to 5111%. I expect respondents to answer the questions according to their discount rate. Specifically, they choose the immediate reward if their discount rate is higher than the interest rate of the question; otherwise, they choose the delayed reward. Therefore, if a respondent switches from the immediate reward to the delayed reward, then the respondent's discount rates are between the highest interest rate among the questions for which they chose the immediate reward and the lowest interest rate among the questions for which they chose the delayed reward. For example, suppose a person chose the immediate reward when the interest rate of the delayed reward was 0%, while the person chose the delayed reward when the interest rate of the delayed reward increased to 10%. Then, the person's discount rate is between 0% and 10%. Because the personal discount rate is not uniquely determined in this design, I use the interval regression to calculate the expected discount rate. I drop the samples who chose the delayed reward for a question but the immediate reward despite a higher interest rate than that of the question as well as those who did not answer all the questions.

The JHPS prepared two conditions for t: today and in 90 days. I elicit respondents' discount rates in each condition and combine two of the standardized discount rates. I then use the combined discount rate as the personal discount rate, *Discount*, in this analysis.[4]

The JHPS also asked respondents to describe their risk preference. They were asked whether they would buy a lottery ticket with a 50% chance of winning JPY 100,000 at a certain price. Respondents answered eight related questions that provided a variety of prices for the lottery ticket, ranging from JPY 10 to JPY 50,000.[5] The estimation method is the same as that used for the time preference analysis. I follow Cramer et al. (2002) approach to compute the degree of absolute risk aversion. Then, by using the range of the logarithm of the degree of absolute risk aversion, I use the expected logarithm of absolute risk aversion from the result of the interval regression. I also

[4] The interest rates of the questions are not the same within the surveys. I thus adjust the interest rates to address the measurement error.

[5] Precisely, the prices of the lottery tickets were JPY 10, 2,000, 4,000, 8,000, 15,000, 25,000, 35,000, and 50,000.

drop the samples who chose to buy a lottery ticket at a certain price but who decided not to buy a lottery when the price fell.

In addition to risk preference, I use control variables to identify the effect of time preference on smoking behavior: age, squared age, a dummy for education, marital status, a dummy for those with children, categorical dummies for household income, a dummy for sex, year dummies, occupation dummies, self-assessed stress level, and a dummy for negative change in self-assessed health from the last year.[6][7][8]

Table 3 shows the summary statistics of time preference and the control variables according to smoking status. The differences in preferences and characteristics by smoking status are observed from a mean comparison test. Current smokers have a higher discount rate than nonsmokers. Income and education level are lower for current smokers than nonsmokers.

Figure 1 shows the within difference of *Discount*. Time preference for the most of the sample does not vary by over one-half unit of standard deviation in one year. The samples who did not smoke in the last year but smoke in the year of the survey (In Figure 1, "01" represents that group) tend to decrease their discount rate from the last year. On the contrary, the samples who smoked in the last year but do not smoke in the year of the survey (In Figure 1, "10" represents that group), particularly female samples, tend to increase their discount rate from the last year.

Table 3 and Figure 1 therefore imply that time preference is associated with smoking behavior and that past smoking behavior affects current time preference. I research these relationships more precisely by using nonlinear panel analysis.

[6] Cigarette tax increased in October 2010. This price effect is therefore captured by the year dummies. Further, excise tax increased in April 2014 (the announcement was October 2013). Therefore, this increase in excise tax does not affect my sample because surveys were collected during January and February.

[7] Lerner et al. (2012) show that stress increases the discount rate.

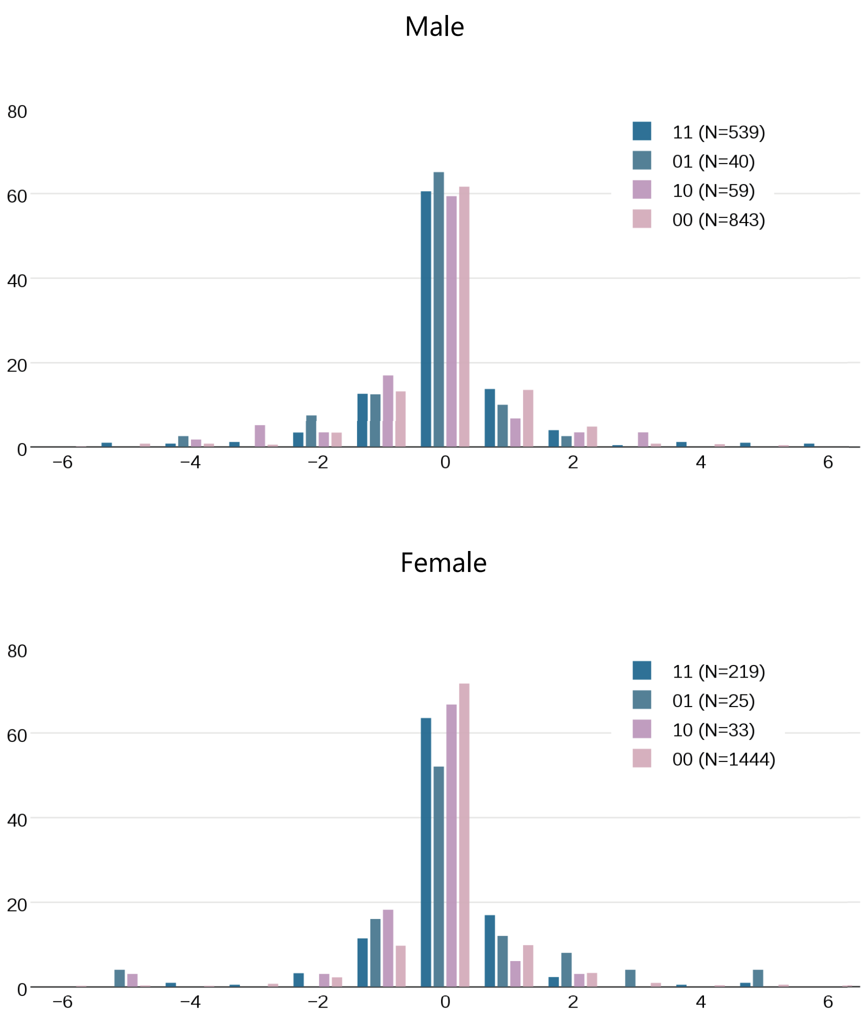
[8] Sundmacher (2012) shows that negative health shocks affect smoking behavior as well as change time preference according to the endogenous time preference model. The dummy for negative health shocks thus captures the third effect.

Table 3: Summary statistics

	Male		Female	
	Nonsmoker	Smoker	Nonsmoker	Smoker
Discount	−0.09	0.1***	−0.24	0.02***
	(0.99)	(1.15)	(0.92)	(1.16)
Riskaverse	−11.31	−11.21	−11.71	−11.58
	(1.66)	(1.29)	(1.8)	(1.7)
Age	43.78	43.8	43.31	42.97
	(7.55)	(7.36)	(7.59)	(6.84)
Income	4.94	4.72***	4.81	4.3***
	(1.81)	(1.84)	(1.82)	(1.86)
Education	0.59	0.49***	0.59	0.31***
	(0.49)	(0.5)	(0.49)	(0.46)
Marry	0.76	0.76	0.78	0.77
	(0.43)	(0.43)	(0.41)	(0.42)
Children	0.5	0.51	0.55	0.58
	(0.5)	(0.5)	(0.5)	(0.49)
Health change	0.27	0.24*	0.24	0.25
	(0.44)	(0.43)	(0.43)	(0.43)
Stress	2.6	2.61	2.57	2.48
	(1.02)	(1.03)	(1.03)	(1.09)
N	1507	1032	2583	447

Note: Standard deviations are reported in parentheses.
* $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$ denote the statistical significance of the difference of nonsmokers.

Figure 1: The within difference of *Discount*



Note: Each number in the legends represents personal smoking behavior in the last year (left) and in the year of the survey (right); the number "0" indicates a nonsmoker and "1" indicates a smoker.
Note that the sample period in this figure is only from 2012 to 2013 because individuals' time preferences are not elicited in the 2010 survey.

3 Estimation method

In this section, I explain the estimation method used in this study. Consider a latent model with AR(1). The latent variable for individual i at time t is as follows:

$$y^*_{it} = \rho y_{i,t-1} + \beta Discount_{it} + \vec{X}_{it}\vec{\beta} + c_i + u_{it}, \tag{1}$$

where $y_{i,t-1}$ is the observed variable for individual i at time $t-1$; $Discount$ is the standardized discount rate; $\vec{X}_{it}$ is the control variable; c_i is unobserved individual heterogeneity, and u_{it} is the error term. The relationship between latent variable y^*_{it} and observed variable y_{it} is as follows:

$$y_{it} = \begin{cases} 1 & \text{if } y^*_{it} > 0, \\ 0 & \text{otherwise.} \end{cases} \tag{2}$$

Then, the conditional joint probability of the observed variable can be written as follows:

$$P\left(y_{i0}, y_{i1}, ..., y_{iT}|\vec{X}_i, c_i\right) = \left[\prod_{i=1}^{T} P\left(y_{it}|y_{i,t-1}, \vec{X}_{it}, c_i\right)\right] P(y_{i0}|\vec{X}_i, c_i). \tag{3}$$

If the initial value y_{i0} and unobserved individual heterogeneity c_i are independent, then c_i can be integrated out from the above equation by using numerical integration; hence, the random effect probit estimation is valid for consistency under the assumption that the error term and unobserved individual heterogeneity follow a normal distribution. In the context of smoking behavior, unobserved individual heterogeneity can arise through the linking of smoking, preferences, and the environment; therefore, the independence assumption between the initial value and unobserved individual heterogeneity is implausible. Wooldridge (2005) proposes using the estimation method if the independence assumption is violated, suggesting modeling unobserved individual heterogeneity given the initial value instead of modeling the initial value given unobserved heterogeneity. Wooldridge (2005) also proposes that assuming unobserved individual heterogeneity given the initial value follows a normal distribution. Therefore, unobserved individual heterogeneity decomposes into two parts: one part is correlated with the initial value and the other part is independent of the initial value. Then, unobserved individual heterogeneity can be rewritten as follows:

$$c_i = \alpha_0 + \alpha_1 y_{i0} + \alpha_i,\ \alpha_i \sim N(0, \sigma_\alpha^2). \tag{4}$$

By substituting the above equation into equation (1), the latent variable for individual i at time t can be rewritten as follows:

$$y_{it}^* = \rho y_{i,t-1} + \beta Discount_{it} + \vec{X}_{it}\vec{\beta} + \alpha_0 + \alpha_1 y_{i0} + \alpha_i + u_{it}. \tag{5}$$

Then, the random effect probit estimation using equation (5) is valid. I use smoking status from the 2010 survey, *Smoke2010*, as the initial value.

4 Results

This section presents the estimation results. All the estimations are run separately by gender. I change the coefficient to the average partial effect in all results. Table 4 shows the average partial effects in the static and dynamic models.

In all models, the individual discount rate, *Discount*, is positively associated with the probability of smoking; these results are consistent with the hypothesis that current smokers place minimal value on the future consequences of smoking. In the static models, model (1), the significant association between the discount rate and smoking behavior in the male subsample is observed; however, no significant association between those in the female subsample is observed. These results are consistent with those of Harrison et al. (2010) and Kang and Ikeda (2014). Quantitatively, a one-unit increase in the standard deviation of the discount rate increases the probability of smoking by approximately 3.7 percentage points for the male subsample and 0.02 percentage points for the female subsample.

In the dynamic model, model (2), the discount rate affects smoking behavior insignificantly for

Table 4: The average partial effects on smoking

	Male		Female	
	Static	Dynamic	Static	Dynamic
	(1)	(2)	(1)	(2)
Discount	0.037**	0.002	0.0002	0.010***
	(0.016)	(0.002)	(0.0002)	(0.003)
Smoke at t-1		0.018		0.100**
		(0.013)		(0.039)
Smoke2010		0.146***		0.098***
		(0.046)		(0.018)
N	2538	2538	3030	3030
AIC	980.7	1307.0	1489.8	939.6
σ_α	1.834	2.001	5.969	0.756

Note: Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
σ_α is the standard deviation of unobservable individual heterogeneity.

the male subsample but significantly for the female subsample. Qualitatively, a one-unit increase in the standard deviation of the discount rate increases the smoking probability by approximately 0.2 percentage points for the male subsample and approximately 1.0 percentage point for the female subsample. In contrast to the male subsample result and hypothesis from the endogenous time preference model, the coefficient of *Discount* in the female subsample is higher than that in the static model. One explanation for this result for the female subsample is the difference in the variance in unobserved individual heterogeneity between the static and dynamic models. The difference in the estimated standard deviation of unobserved individual heterogeneity in the female subsample is large: about 5.97 in the static model and 0.76 in the dynamic model. However, the difference in the estimated standard deviation of unobserved individual heterogeneity in the male subsample is small: about 1.83 in the static model and 2.00 in the dynamic model. Therefore, the large standard deviation of unobserved individual heterogeneity pushed down the magnitude of *Discount* in the static model.

The state dependencies of smoking behavior are observed for the female subsample but not for the male subsample. The coefficients of smoking status in the initial period, *Smoke2010*, are significant for both genders. This finding implies that unobserved individual heterogeneity is not independent of smoking status in the initial period.[9]

5 Robustness check

In this section, I check the robustness of the results presented in the previous section and discuss the results.

5.1 Former smokers

Table 4 shows that unobserved individual heterogeneity is related to smoking status in the initial period. In the estimation in Table 4, smoking status in the initial period is categorized according to current smokers and nonsmokers. Moreover, nonsmokers can be separated into two types: those who have never smoked and former smokers. It is plausible that the unobserved individual heterogeneity of former smokers differs from the unobserved individual heterogeneity of those who have never smoked. Because respondents who answered question (1) concerning their smoking status in the 2010 survey or (i) in the 2011 to 2013 surveys can be regarded as having never smoked, I separated nonsmokers into those who have never smoked and former smokers; in the initial period, 25.9% of nonsmokers in the whole sample, 47.9% of nonsmokers in the male subsample, and 14.1% of nonsmokers in the female subsample were former smokers. In the estimation, I include a dummy for former smokers in the initial period, *Smoked2010*, in the dynamic model, and the result is reported in Table 5. The coefficients of *Smoked2010* are significant for both the male subsample and the female subsample. This finding implies that unobserved individual heterogeneity is also

[9] I also run the estimation by using the Chamberlain–Mundlak (Chamberlain, 1980; Mundlak, 1978) approach that includes the within mean of the explanatory variables to capture the correlation between the explanatory variables and unobserved individual heterogeneity. The result is similar except for the insignificant effect of time preference on smoking behavior in the static model for the male subsample. Some studies argue that time preference is correlated with unobserved individual heterogeneity such as intelligence (Shamosh and Gray, 2008). However, Burks et al. (2012) show an association between time preference and smoking behavior when IQ score is controlled for. As shown in Figure 1, the within variation of time preference is not large. Therefore, the difference in the result from Table 4 in the static model for the male subsample is caused by the insufficient variation in time preference rather than omitted variable bias.

different between those who have never smoked and former smokers. The other results are similar to those in Table 4.

Table 5: The results for former smokers

	Male	Female
Discount	0.002	0.010***
	(0.002)	(0.003)
Smoke at t-1	0.022	0.101***
	(0.017)	(0.034)
Smoke2010	0.197***	0.125***
	(0.063)	(0.026)
Smoked2010	0.056**	0.065***
	(0.023)	(0.012)
N	2538	3030
AIC	1284.5	900.2
σ_α	1.915	0.757

Note: Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
σ_α is the standard deviation of unobservable individual heterogeneity.

5.2 Strength of state dependence

The JHPS asked a question concerning the consumption of smokers. The extent of the state dependence of smoking may depend on cigarette consumption, while the effect of past smoking status on time preference also depends on past cigarette consumption. To address the strength of state dependence, I separated the lag of smoking status into three variables by cigarette consumption. Respondents who answered question (6) in the 2010 survey, or either (viii) or (ix) in the 2011 to 2013 surveys, are considered to have high consumption. Those who answered questions (4) or (5) in the 2010 survey, or (v), (vi), or (vii) in the 2011 to 2013 surveys, are considered to have medium consumption. Those who answered questions (2) or (3) in the 2010 survey or (ii), (iii), or (iv) in the 2011 to 2013 surveys, are considered to have low consumption. The variables *High smoker*, *Medium smoker*, and *Low smoker* correspond to the dummy variables for high, medium, and low consumption, respectively. Table 6 shows that the share of the high consumption group is less than 10%, that of the medium consumption group is approximately 70% to 80%, and that of the low consumption group is approximately 15% to 25%. I then separate the initial period dummy into three dummy variables according to smoking behavior in the initial period, *Low smoker 2010*, *Medium smoker 2010*, and *High smoker 2010*, as well as include a dummy for former smokers in the initial period *Smoked2010*.

Table 6: Share of cigarette consumption

	2010	2011	2012	2013
Total				
High smoker	4.1	4.8	5.4	6.0
Medium smoker	74.4	69.6	76.9	75.9
Low smoker	21.5	25.6	17.7	18.1
Male				
High smoker	5.2	6.3	7.1	7.0
Medium smoker	77.5	71.1	77.6	74.9
Low smoker	17.4	22.6	15.3	18.1
Female				
High smoker	1.8	1.2	1.4	3.8
Medium smoker	67.6	66.1	75.3	78.2
Low smoker	30.6	32.7	23.3	18.0

Consistent with my hypothesis, the strength of state dependence increases with cigarette consumption (Table 7). Further, state dependence is observed for the male subsample except for low consumption at $t-1$. Because the number of high-consuming female smokers is small, *High smoker at* $t-1$ is not statistically significant. Therefore, state dependence exists for both the male and the female subsamples; however, the extent of state dependence for male is lower than that for female. The other interpretations of the results are the same as those in Table 4.

5.3 Present bias

Behavioral economists argue that time preference for some individuals does not hold stationarity; people also distinguish between today and later and discount later utility additionally. This model

Table 7: Strength of state dependence

	Male	Female
Discount	0.002	0.010***
	(0.003)	(0.003)
High smoker at t-1	0.073**	0.034
	(0.037)	(0.059)
Medium smoker at t-1	0.041**	0.090***
	(0.019)	(0.032)
Low smoker at t-1	0.011	0.060**
	(0.014)	(0.026)
High smoker 2010	0.257***	0.185***
	(0.042)	(0.059)
Medium smoker 2010	0.262***	0.129***
	(0.030)	(0.021)
Low smoker 2010	0.196***	0.090***
	(0.026)	(0.017)
Smoked 2010	0.074***	0.058***
	(0.019)	(0.011)
N	2538	3030
AIC	1233.6	838.0
σ_α	1.783	0.909

Note: Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
σ_α is the standard deviation of unobservable individual heterogeneity.

is called a quasi-hyperbolic time preference model. According to the model, time preference can be separated into two parts: one part is the discount rate, which is used in economics, and the other is present bias, which distinguishes between now and later (Gruber and Köszegi, 2001; Laibson, 1997; O'Donoghue and Rabin, 1999, 2001). In the JHPS questionnaire, with respect to time preference, two conditions relate to the timing of the receipt of an immediate reward: today and 90 days from today. Therefore, present bias can be captured if the discount rate is measured by using the question on whether the timing of the receipt of an immediate reward today is higher than that in 90 days. Hence, I include a dummy for present bias, *Present bias*, in the models.

Table 8: Quasi-hyperbolic time preference model

	Male		Female	
	Static	Dynamic	Static	Dynamic
	(1)	(2)	(1)	(2)
Discount	0.034**	0.002	0.0002	0.102***
	(0.016)	(0.003)	(0.0005)	(0.003)
Present bias	0.0002	−0.002	−0.00002	0.008
	(0.0039)	(0.006)	(0.00008)	(0.009)
Smoke at t-1		0.038		0.135***
		(0.024)		(0.033)
Smoke2010		0.172***		0.083***
		(0.040)		(0.015)
N	2165	2165	2561	2561
AIC	197.8	1091.6	1324.4	787.1
σ_α	1.939	1.859	7.275	0.407

Note: Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
σ_α is the standard deviation of unobservable individual heterogeneity.

Table 8 shows that present bias is not significantly associated with smoking behavior in all models, while the other findings for time preference and the state dependence of smoking are the same as those in Table 4.[10]

[10] As in Kang and Ikeda (2014), *Present bias* may have measurement error. To address the measurement error, according to Kang and Ikeda (2014), I created a proxy for present bias by using a retrospective question concerning the completion of childhood assignments in the 2013 survey: When you were a child and were given an assignment during the school vacation, how early did you usually finish the assignment? (i) Got it done right away, (ii) Tended to

5.4 Smoking intention

From the results in Table 4 for the male subsample, time preference is significantly associated with smoking behavior in the static model, but not in the dynamic model (i.e., when I control for the effect of past smoking behavior). This result can be interpreted as that male smokers are unconcerned about the future consequences of smoking behavior. However, Grignon (2009) reports that 57% of current smokers fail to quit smoking. Kan (2007) also shows that current smokers who want to quit are more likely to support tobacco control policy. Therefore, an alternative interpretation is that male smokers who have a low discount rate want to quit smoking but cannot manage to do so. I test the latter interpretation next.

In 2012 and 2013 surveys, the JHPS asked about smokers' intention to quit. The choices were as follows: (i) I want to quit smoking, (ii) I want to reduce the amount of cigarettes I smoke, (iii) I don't want to quit smoking, (iv) I don't know, and (v) I don't smoke. Table 9 shows the result of a probit analysis of intention to quit smoking for current smokers. The dependent variable is the dummy for wanting to quit smoking or reduce tobacco consumption (answering questions (i) or (ii)). The results show that male smokers who have a lower discount rate are more likely to want to quit smoking or reduce tobacco consumption than those who have a higher discount rate. On the contrary, female smokers with a low discount rate are no more likely to want to quit smoking or reduce tobacco consumption. [11] This result implies that male smokers are concerned about the future consequences of smoking, but cannot manage to quit. Hence, providing commitment tools such as those proposed by Giné et al. (2010) may work for male smokers.

---

get it done early, before the due date, (iii) Worked on it daily up until the due date, (iv) Tended to get it done toward the end, (v) Got it done at the last minute, (vi) Got it done after the deadline, (vii) Did not do it, and (viii) There was no assignment. I created an indicator variable as a proxy for present bias, which takes one if the answer was (iv), (v), (vi), or (vii) and zero otherwise. I dropped samples who answered (viii). Although Kang and Ikeda (2014) find a strong relationship between the proxy of present bias and smoking behavior, I find no such statistically significant relationship.

[11] A weakly significant association between time preference and the intention to quit smoking was observed for the female subsample when the quasi-hyperbolic time preference model was used. Moreover, present bias was negatively statistically significant.

Table 9: Intention to quit smoking

	Male	Female
Discount	-0.035^{**}	-0.037
	(0.017)	(0.026)
N	624	251
AIC	824.6	296.3

Note: Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6 Conclusion

In this study, I analyzed the effect of time preference on smoking behavior while controlling for the effect of past smoking behavior, using a dynamic panel analysis. I also compare the results with those derived by adopting a static model. The findings of this study are threefold. First, as in the previous literature, without controlling for the effect of past smoking behavior, I find positive associations between time preference and smoking behavior, with the association significant for the male subsample. Second, by using a dynamic panel analysis, I find that time preference affects smoking behavior significantly for the female subsample but not for the male subsample. This result is robust under several model specifications. Third, male smokers who have a low discount rate are more likely to want to quit smoking or reduce smoking behavior, whereas female smokers with a low discount rate are no more likely to want to quit smoking or reduce smoking behavior. This result implies that while male smokers are concerned about the future consequences of smoking, they cannot manage to quit. In addition, providing a commitment tool such as that proposed by Giné et al. (2010) may work for male smokers.

This study has some limitations. First, the sample period is relatively short and thus a more precise estimation of state dependence is needed. Second, this study does not focus on the effect of increasing tobacco prices on people who want to quit smoking. Future research is therefore required to tackle these limitations.

References

Becker, Gary S, and Casey B Mulligan (1997) 'The endogenous determination of time preference.' *The Quarterly Journal of Economics* 112(3), 729–758

Becker, Gary S, and Kevin M Murphy (1988) 'A theory of rational addiction.' *Journal of political Economy* 96(4), 675–700

Becker, Gary S, Michael Grossman, and Kevin M Murphy (1994) 'An empirical analysis of cigarette addiction.' *The American Economic Review* pp. 396–418

Bickel, Warren K, Amy L Odum, and Gregory J Madden (1999) 'Impulsivity and cigarette smoking: delay discounting in current, never, and ex-smokers.' *Psychopharmacology* 146(4), 447–454

Bommier, Antoine (2006) 'Uncertain lifetime and intertemporal choice: risk aversion as a rationale for time discounting.' *International Economic Review* 47(4), 1223–1246

Burks, Stephen, Jeffrey Carpenter, Lorenz Götte, and Aldo Rustichini (2012) 'Which measures of time preference best predict outcomes: Evidence from a large-scale field experiment.' *Journal of Economic Behavior & Organization* 84(1), 308–320

Chaloupka, Frank (1991) 'Rational addictive behavior and cigarette smoking.' *Journal of political Economy* 99(4), 722–742

Chamberlain, Gary (1980) 'Analysis of covariance with qualitative data.' *The Review of Economic Studies* 47(1), 225–238

Christelis, Dimitris, and Anna Sanz-de Galdeano (2011) 'Smoking persistence across countries: a panel data analysis.' *Journal of health economics* 30(5), 1077–1093

Cramer, Jan S, Joop Hartog, Nicole Jonker, and C Mirjam Van Praag (2002) 'Low risk aversion encourages the choice for entrepreneurship: an empirical test of a truism.' *Journal of economic behavior & organization* 48(1), 29–36

Doll, Richard, Richard Peto, Jillian Boreham, and Isabelle Sutherland (2004) 'Mortality in relation to smoking: 50 years' observations on male british doctors.' *Bmj* 328(7455), 1519

Fersterer, Josef, and Rudolf Winter-Ebmer (2003) 'Smoking, discount rates, and returns to education.' *Economics of Education Review* 22(6), 561–566

Gilleskie, Donna B, and Koleman S Strumpf (2005) 'The behavioral dynamics of youth smoking.' *Journal of Human Resources* 40(4), 822–866

Giné, Xavier, Dean Karlan, and Jonathan Zinman (2010) 'Put your money where your butt is: a commitment contract for smoking cessation.' *American Economic Journal: Applied Economics* 2(4), 213–235

Grignon, Michel (2009) 'An empirical investigation of heterogeneity in time preferences and smoking behaviors.' *The Journal of Socio-Economics* 38(5), 739–751

Gruber, Jonathan, and Botond Köszegi (2001) 'Is addiction rational? theory and evidence.' *The Quarterly Journal of Economics* 116(4), 1261–1303

Harrison, Glenn W, Morten I Lau, and E Elisabet Rutström (2010) 'Individual discount rates and smoking: Evidence from a field experiment in denmark.' *Journal of health economics* 29(5), 708–717

Kan, Kamhon (2007) 'Cigarette smoking and self-control.' *Journal of health economics* 26(1), 61–81

Kang, Myong-Il, and Shinsuke Ikeda (2014) 'Time discounting and smoking behavior: evidence from a panel survey.' *Health economics* 23(12), 1443–1464

Khwaja, Ahmed, Dan Silverman, and Frank Sloan (2007) 'Time preference, time discounting, and smoking decisions.' *Journal of health economics* 26(5), 927–949

Labeaga, José M (1993) 'Individual behaviour and tobacco consumption: a panel data approach.' *Health Economics* 2(2), 103–112

Laibson, David (1997) 'Golden eggs and hyperbolic discounting.' *The Quarterly Journal of Economics* 112(2), 443–478

Lerner, Jennifer S, Ye Li, and Elke U Weber (2012) 'The financial costs of sadness.' *Psychological science* p. 0956797612450302

Munasinghe, Lalith, and Nachum Sicherman (2006) 'Why do dancers smoke? smoking, time preference, and wage dynamics.' *Eastern Economic Journal* 32(4), 595–616

Mundlak, Yair (1978) 'On the pooling of time series and cross section data.' *Econometrica: journal of the Econometric Society* pp. 69–85

O'Donoghue, Ted, and Matthew Rabin (1999) 'Doing it now or later.' *American Economic Review* pp. 103–124

_ (2001) 'Choice and procrastination.' *The Quarterly Journal of Economics* 116(1), 121–160

Orphanides, Athanasios, and David Zervos (1998) 'Myopia and addictive behaviour.' *The Economic Journal* 108(446), 75–91

Secades-Villa, Roberto, Sara Weidberg, Olaya García-Rodríguez, José R Fernández-Hermida, and Jin Ho Yoon (2014) 'Decreased delay discounting in former cigarette smokers at one year after treatment.' *Addictive behaviors* 39(6), 1087–1093

Shamosh, Noah A, and Jeremy R Gray (2008) 'Delay discounting and intelligence: A meta-analysis.' *Intelligence* 36(4), 289–305

Sundmacher, Leonie (2012) 'The effect of health shocks on smoking and obesity.' *The European Journal of Health Economics* 13(4), 451–460

Wooldridge, Jeffrey M (2005) 'Simple solutions to the initial conditions problem in dynamic, nonlinear panel data models with unobserved heterogeneity.' *Journal of applied econometrics* 20(1), 39–54

Yen, Steven T, and Andrew M Jones (1996) 'Individual cigarette consumption and addiction: a flexible limited dependent variable approach.' *Health economics* 5(2), 105–117

Yi, Richard, Matthew W Johnson, Louis A Giordano, Reid D Landes, Gary J Badger, and Warren K Bickel (2008) 'The effects of reduced cigarette smoking on discounting future rewards: An initial evaluation.' *The Psychological Record* 58(2), 163