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TIME DISCOUNTING
AND SMOKING BEHAVIOR
UNDER TAX HIKES

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Time Discounting and Smoking Behavior under Tax Hikes[*]

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Abstract

By combining our broad panel survey of Japanese adults from 2005 to 2008 and actual cigarette tax data, we investigate how smoking behavior including responses to tax hikes depends on time discounting and its biases, such as hyperbolic discounting and the sign effect. Cigarette consumption displays significantly positive correlations with discount rates and the procrastinating tendency, and negative correlations with the sign effect. Hyperbolic, procrastinating, and naïve respondents decrease their after-tax-hike cigarette consumption more than the others, implying that, irrespective of the preannouncement of a future tax hike, they postpone smoking moderation until the tax hike actually takes place. Finally, the government's revenue from cigarette tax peaks at a JPY 29.92 (around USD 0.28 using the conversion rate [107.16] in February 2008) higher tax per cigarette than the present actual level.

Keywords: smoking, cigarette tax, time preference, discount rate, hyperbolic discounting, procrastination, the sign effect

JEL classification: I18, Z00

1.   Introduction

By analyzing our broad survey of Japanese adults from 2005 to 2008, the purpose of this paper is to examine empirically the effects of time discounting and its behavioral biases on smoking behavior, and their responses to a hike in cigarette taxes. We incorporate two time discounting biases that has been reported in dynamic choice theory: (i) *hyperbolic discounting,* under which a person discounts the immediate future more intensively than the distant future, and thereby makes time-inconsistent decisions; and (ii) the *sign effect,* by which a person discounts positive future payoffs more intensively than negative future payoffs (for the empirical validity of the biases and their implications, see, e.g., Thaler, 1981; Benzion *et al.*, 1989; Prelec and Loewenstein, 1991; Ainslie, 1992; Khwaja *et al.*, 2007). We hypothesize that hyperbolic discounters smoke more than exponential discounters; that reductions in cigarette consumption after a tax hike amongst naïve hyperbolic smokers are larger than those amongst the others; and that decreases in cigarette consumption after a tax hike amongst hyperbolic smokers are larger than those amongst exponential smokers.

The novelty of the present research is in the following two points. First, we identify respondents' types by whether discounting is exponential or hyperbolic and by whether decision making is sophisticated or naïve. We estimate differences in smoking behavior among the distinct types of respondents. Second, by using the actual time series data of the cigarette tax, which is exogenously determined by the Japan's government, we quantify how the natural experiment of cigarette tax hikes in 2006 affects smoking behavior of each type of respondents. To do so, we use our four-year panel survey data, in which roughly three to five thousands of Japanese adults each year reply to questionnaires on preferences and various attributes.

The main results of this article are as follows: Firstly, discount rates and time discounting biases relate to cigarette consumption. Discount rates, the procrastinating tendency, and naiveness have significantly positive associations with cigarette consumption and the sign effect has significantly negative correlations to smoking behavior. Secondly, tax hikes decrease ex-post smoking. In particular, hyperbolic, procrastinating, or naïve respondents decrease their after-tax-hike cigarette consumption more than others,

implying that they postpone smoking moderation in response to future tax hikes and thereby adjust cigarette consumption mainly after the tax hike. Thirdly, other factors, e.g., gender, degree of risk aversion, education, household income, age, and existence of children significantly relate to smoking behavior. Finally, the government's revenue from cigarette tax peaks at a JPY 29.92 (around USD 0.28 using the conversion rate [107.16] in February 2008) higher tax per cigarette than the present actual level.

In the present research, we follow Ikeda *et al*. (2010) in constructing data for discount rates, hyperbolic discounting or procrastination, and the sign effect from response data to questions on various hypothetical intertemporal decisions including choices between a small amount of present money and a larger amount of future money. In addition, naïve and sophisticated respondents are identified by using response data to two questions regarding procrastination in doing homework assignments: one regarding when they used to *plan to do* homework in summer vacations in their school days; and the other regarding when they *in effect* used to *do* homework. Respondents are classified as naïve if they used to procrastinate doing homework more than they planned whereas they are classified as sophisticated otherwise.

There are many empirical studies which investigate smoking behavior from the viewpoint of intertemporal decision makings (e.g., Mitchell, 1999; Bickel *et al*., 1999; Odum *et al*., 2002; Baker *et al*., 2003; Sato and Ohkusa, 2003; Reynolds *et al*., 2004; Ohmura *et al*., 2005; Khwaja *et al*., 2007; Ida and Goto, 2009) and by using rational addiction models (e.g., Chaloupka, 1990, 1991; Keeler *et al*., 1993; Becker *et al*., 1994; Bardsley and Olekalns, 1998; Luo *et al*., 2003; Wan, 2006). Despite many attempts, however, the existing literature has not incorporated the effects of time discounting biases that behavioral economics has been reporting as important determinants of seemingly irrational behaviors such as time-inconsistent impulsive consumption of drugs and cigarettes (see, e.g., Ainslie, 1992).

Our research is closely related in spirit to Gruber and Koszegi (2001), which quantified by calibrations the welfare–enhancing effects of cigarette taxation under hyperbolic discounting. Although they emphasized the critical role that time-inconsistent preferences played in smoking-decision making, for their result to be empirically valid, it should be empirically examined how hyperbolic discounting affects smoking behavior, including responses to tax hikes, and how cigarette consumption differs between naïve and sophisticated smokers.[1]

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[1] In pararel with our research, Ida (2009) examines correlations between implusiveness (hyperbolic

The remainder of the paper is structured as follows: in section 2, our hypotheses of relations between time preferences and smoking are discussed. Section 3 presents a description of the data. Section 4 reports the estimation results about the determinants of smoking. Section 5 shows the differences of responses to tax hikes among types of time discounting and presents the policy implications of tax hikes. Finally, section 6 concludes the paper.

2. Time discounting and smoking

2.1. Discount rates

As shown by the theory of rational addiction (Becker and Murphy, 1988), persons with high discount rates can raise present utility by consuming addictive goods even if it induces future disutility by accumulating addiction, and thus they would smoke more than others. Indeed, significantly positive correlations between the amount of smoking and discount rates has been reported in literature (e.g., Bickel *et al.*, 1999; Mitchell, 1999; Odum *et al.*, 2002; Baker *et al.*, 2003; Sato and Ohkusa, 2003; Reynolds *et al.*, 2004; Ohmura *et al.*, 2005; Ida and Goto, 2009). Therefore, it can be hypothesized that persons with higher discount rates tend to smoke more than others.

2.2. Hyperbolic discounting

Hyperbolic discounting, under which a person discounts the immediate future more intensively than the distant future, induces the present bias, and thereby likely lead consumers to smoke excessively by underweighting the resulting future disutility. Sophisticated hyperbolic discounters, who are well aware of their procrastinating tendency due to hyperbolic discounting, smoke time-consistently by choosing

discounting) and smoking by eliciting discount rates and risk preferences simultaneously from cross-section data. He does not distinguish sophisticated and naïve respondents, incorporate sign effects, nor analyze the effect of tax hikes.

sequences of such high cigarette consumption levels that future selves would also choose under the same present bias. On the other hand, naïve hyperbolic discounters, who are unaware of their hyperbolic discounting, do not take into account their time-inconsistency problem in the smoking decision and therefore, smoke more than the sophisticated.

From the same logic, when the cigarette tax rises, hyperbolic discounters are likely to reduce cigarette consumption later than exponential discounters. Insofar as hyperbolic discounters are forward-looking optimizers, they start decreasing cigarette consumption when the preannouncement of a future tax hike takes place. Sophisticated hyperbolic discounters, however, choose such a small decrease in earlier period that future selves can consistently support. It is only after the tax and hence the cigarette price actually rises when they decrease cigarette consumption largely. In sum, sophisticated hyperbolic discounters procrastinate to moderate cigarette consumption until the tax hike is actually introduced. Naïve hyperbolic discounters procrastinate time-inconsistently the moderation of the consumption with a high discount rate for immediate future disutility. Thus, we hypothesize that hyperbolic discounters tend to smoke more than exponential discounters, and that even when a tax hike is pre-announced, they are likely to moderate cigarette consumption substantially after the tax hike is actually implemented.[2]

2.3. The sign effect

The sign effect, by which a person discounts positive payoffs more intensively than negative payoffs, leads to moderation in current addictive consumption because future disutility through the harmful effects of addiction is overvalued (e.g., Baker *et al.*, 2003). Therefore, we hypothesize that person with the sign

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[2] In the context of rational addiction, hyperbolic agents behave forward-lookingly take into account future utility/disutility of addictive consumption (Gruber and Koszegi, 2002). However, it is difficult to analytically show whether hyperbolic discounters genarally smoke more than exponential discounters. Laibson (1997, 1998) shows that, under certain conditions, the effective discount rate which is obtained by transforming the hyperbolic discounting function into the exponential one is greater than the pure exponential discount rate. Accordingly, we hypothesize that persons with hyperbolic discounting or procrastination tend to smoke more than ones with exponential discounting.

effect smoke less than others.

3. The data

Our empirical research is based on the annual panel data of the Japan Household Panel Survey on Consumer Preferences and Satisfaction (hereafter, JHPS) from 2005 to 2008. Table1 summarizes the number of samples and respondents. The JHPS was set up in 2004 as a project of the COE program in Osaka University using a random sample by a placement method and it had 4,224 respondents in 2004 and 2,987 in 2005. Excluding 108 individuals lost from the respondents in 2005, 2,000 new random-sampled individuals were added to the survey sample, and 3,763 individuals responded in 2006 and 3,112 in 2007. The number of respondents was 4,018 in 2008, with 2,731 being continuous respondents from the previous year and 1,287 mailing their poll responses. All surveys were conducted in February, except in 2006 when the survey was conducted in February and March.

Insert Table 1:

The number of samples and frequencies of responses

3.1. Tax hikes and cigarette consumption

3.1.1. Cigarette consumption

The JHPS asks respondents about their smoking habits saying, "How many cigarettes do you smoke regularly? Select a proximal option from the following; (i) Never smoke at all; (ii) Hardly smoke; (iii) Smoke sometimes; (iv) About 10 cigarettes a day; (v) About a pack a day; (vi) More than 2 packs a day." In 2007 and 2008, option "(vii) I used to smoke but have quit" is added.

To quantify cigarette consumption, we categorize respondents who select option (i), (ii) or (vii) as nonsmokers, (iii) as smokers consuming 0 to 5 cigarettes a day, (iv) 5 to 15, (v) 15 to 40, and (vi) as more

than 40. By using the category data, we apply the method developed by Kimball *et al.* (2005) to estimate a log normal distribution for the distribution of the respondents' cigarette consumption of each year, from which each respondent's cigarette consumption is estimated as an expected value conditional on his or her categorical level of smoking.

Insert Table 2:

Summary statistics of smoking behavior

Insert Figure 1:

Transition graphs of smoking behavior

The summary statistics of cigarette consumption and smoking rates are shown in Table 2 and the transition graphs are described in Figure 1, where SMOKING represents the cigarette consumption estimated above. Male smokers smoke more than a pack per day and the amounts of smoking and smoking rates decreased during the entire investigation. On the other hand, the reported smoking amounts for females are around 15 per day and the amounts increased over time from 2005 to 2007 and decreased in 2008, although their smoking rates decrease throughout the entire period. These trends are consistent with the reported data of the National Survey of Health and Nutrition (NSHN) conducted by the Ministry of Health, Labour and Welfare, Japan: According to NSHN data from 2004 to 2005, the smoking amounts for male smokers decreased from 21.5 to 21.0 per day and the rates of regular smoking declined from 43.3% to 39.3%. As for females, smoking amounts increased from 14.6 to 15.6 per day and their rates of regular smoking decreased from 12.0% to 11.3%.

3.1.2. Tax hikes

We can examine the effect of the tax hike on smoking behavior because a change of taxation policy on cigarettes arose during our sample period. The Japanese Government raised the cigarette tax from JPY 7.892 (around USD 0.074 using the conversion rate [107.16] in February 2008) to JPY 8.744 (around USD

0.082) per cigarette on July 1st, 2006.[3] Our survey in 2006 was conducted in February, which is after the Cabinet meeting on January 17th adopted the outline of revisions in the taxation system, and before the Diet on March 27th that passed the bill.

Our data are not frequent enough to detect the preannouncement effect of tax hikes unlike in Becker *et al*. (1994) which use monthly data. Therefore we limit our attention to smoking moderation after the tax hikes.[4] To examine post-tax hike behavior, we define a tax variable, named TAX, which represents the tax levels in each year.

3.2. Eliciting discount rates and its behavioral biases

In the JHPS, the respondents' discount rates were measured by asking five questions about intertemporal choice under alternative conditions. As in the previous survey research (e.g., Harrison *et al*., 2002; and Borghans and Golsteyn, 2006), the respondents were told to choose a preferable option from two options "A" and "B," e.g., "A" receiving JPY 10,000 (around USD 93.32) in two days; and "B" receiving JPY 10,000 plus a certain amount of JPY α, say JPY 10,038 (around USD 93.67), in nine days, where choosing the delayed receipt "B" instead of "A" implies receiving 20% of the annual interest rate. In each question, eight such problems were posed in the form of a payoff table, with alternative α values, from small to large, and hence with alternative imputed interest rates, from low to high.

Table 3 shows QUESTION 1, where the amount of receipt for option "A" is specified as JPY 10,000 and the imputed interest rate for option "B" changes from -10% to 300%. Respondents are expected to choose option "A" at low interest rates whereas, as the imputed interest rate goes up, to switch to "B" at some critical high rate. The individual respondents' discount rates can be inferred by estimating the interest rate at which the delayed receipt of "B" is indifferent to the more immediate receipt of "A". The elicited discount rates are associated with the particular choice conditions, e.g., two days vs. nine days, JPY 10,000

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[3] The price of Mild Seven Super Lights, which has hold the largest share of the Japanese market, has been risen from JPY 270 (around USD 2.52) per 20-cigarette pack to JPY 300 (around USD 2.80) following the tax hike.

[4] Announcement of the Cabinet approval for the still unpassed bill is weak as information about the tax hike, and the date when our survey was conducted, Feb., 2006, is far from the execution date, Jul. 1st, 2006.

for option "A" in QUESTION 1.

Insert Table 3:

Question to elicit discount rates: An example (QUESTION 1 for DR)

To test for time discounting biases, five questions were designed by controlling for: (i) money amounts for option "A" as JPY 10,000 or JPY 1 million (around USD 9331.84); (ii) time horizons for "A" as two days, one month, or ninety days; (iii) time delays as seven days or 12 months; and (iv) receipt or payment. In "payment" question 5, the respondents were asked to choose: "A" paying JPY 1 million in one month; or "B" paying JPY 1 million plus some amount in 13 months, from which acceptable interest rate payments to delay a JPY 1 million payment for 12 months were measured.

From each question, we obtain raw response data in the form of category numbers, which tell us between which interest rates each respondent's choice switched from option "A" to "B" if any switch takes place. Some subjects did not switch their choices from "A" for all offered interest rates. By using the raw category data, we apply the method developed by Kimball *et al.* (2005) to estimate a log normal distribution for the cross-respondent distribution of gross discount rates, from which each respondent's gross discount rate for a certain question, i.e., a certain payoff table, is estimated as an expected value conditional on his or her switch taking place at a certain observed category. Descriptive statistics of elicited discount rates, together with the choice conditions under which they were elicited, are summarized in Table 4, where DR_i ($i = 1, \cdots, 5$) represents the discount rate estimated from question i.

Insert Table 4:

Elicited discount rates under alternative choice conditions

To test for the effect of impatience on cigarette consumption, we construct DISCRATE, which represents the simple average of the standardized values of the elicited discount rates $DR_{i,t}$ ($i = 1, \cdots, 5$, $t = 2005, \cdots, 2008$):

$$DISCRATE_t = (1/5)\sum_{i=1}^{5} \left[(DR_{i,t} - E_t(DR_{i,t}))/\sigma_t(DR_{i,t}) \right] \quad (1)$$

where $E_t(DR_{i,t})$ and $\sigma_t(DR_{i,t})$ represent sample means and standard deviations of $DR_{i,t}$ (see table 4). It is hypothesized that, with other things being equal, the respondents' cigarette consumption depends positively on the impatience index DISCRATE.

Table 5 shows the simple correlation of time discounting variables with SMOKING.. Consistent with our hypothesis mentioned above, column 1 shows a significantly positive correlation betwwwn DISCRATE and cigarette consumption. [5]

Insert Table 5:

Correlation coefficients of time discounting variables with SMOKING

Table 6 summarizes the definitions, summary statistics of variables and hypothesized signs of variables that are used in the analysis below.[6] [7]

Insert Table 6:

Definitions, summary statistics, and hypothesized signs of variables

3.2.1. Time discounting biases

By comparing the mean values of the elicited discount rates, we examine whether our average respondent displays the aforementioned two biases of time discounting. First, in any years, hyperbolic discounting or the immediacy effect is not observed on average since the mean of discount rate DR , imputed from the

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[5] More detailed correlation coefficients by gender in each year are summarized in Appendix B.

[6] Although the standardized average DISCRATE of the elicited discount rates should theoretically satisfy

E (DISCRATE) = 0 and σ (DISCRATE) = 1, neither equality is actually met as seen in the table. This comes

from the fact that the numbers of effective responses differ among the five discount rate questions.

[7] More detailed statistics by gender in each year are summarized in appendix A and C.

immediate future choice (i.e., 2 days or 9 days), is not significantly higher than DR , applied to more

distant future choice (i.e., 90 days or 97 days). Secondly, in all years, the discount rate DR applied for

future receipts is significantly higher than DR , the one used to discount future payments, which implies

that our average respondent displays the sign effect .[8]

To examine the effects of the time discounting biases on the respondents' cigarette consumption, we

construct a binary indicator HYPERBOL for hyperbolic discounting and SIGN for the sign effect, where,

e.g., HYPERBOL=1 if DR >DR and HYPERBOL=0 otherwise. From the mean values of HYPERBOL

and SIGN, shown in Table 5, the proportions of the respondents who display the anomalies are 67.3% for

hyperbolic discounting and 90.3% for the sign effect. Our hypothesis is that, with other things being equal,

the respondents' cigarette consumption is positively related to HYPERBOL and negatively to SIGN.

In Table 5, the correlation coefficient of SIGN with cigarette consumption is significantly positive as

expected above. The coefficient of HYPERBOL is, however, negative, which is inconsistent with our

hypothesis. In section 4, we will discuss whether these results are robust after controlling other factors.

3.2.2. A proxy for procrastination and naïve hyperbolic discounting

To capture the immediacy effect, we also construct a proxy variable PROCR for hyperbolic discounting

and NAÏVE for naïve agent. To measure respondents' degrees of hyperbolic discounting or procrastination,

the JHPS survey asked them to indicate on a 5-point scale from 1 to 5 how they had been likely to

procrastinate doing homework assignments for the vacation in their childhood.[9] Variable PROCR is the

response data to this question averaged over time, where a larger value implies a stronger tendency for

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[8] In addition, although we have not put the results of the t test in the table, DR , the discount rate for JPY

10,000 (around USD 93.32), is significantly higher than DR , which applies for JPY 1 million (around USD

9331.84). This implies that people are more patient for larger amounts than for smaller amounts. This tendency

is called *the magnitude effect* (e.g., Benzion *et al*., 1989; Frederick *et al*., 2002).

[9] In Japanese elementary and high schools, students are usually assigned many pieces of homework during

summer vacations.

procrastination or hyperbolic discounting. The JHPS survey also asked respondents in 2007 and 2008 how they had projected doing homework assignments for the vacation in their childhood with the same point scales as above. We define differences in PROCR from the response to this question and average them over time as NAÏVE, which indicates the degree of default in own planning. It is hypothesized that, with other things being equal, the respondents' cigarette consumption depends positively on PROCR and NAÏVE. Table 5 shows that PROCR and NAÏVE have strongly positive correlation with smoking as predicted.

Figure 2 shows the distributions of PROCR and NAÏVE. As shown in panel A, the proportion of people who had done their homework assignment latterly, whose PROCR is more than 4, is slightly less than half of the respondents. Meanwhile 67.1% of all respondents, shown in panel B, had been unable to do their homework assignment when planned.

Insert Figure 2:

Distributions of PROCR and NAÏVE

3.3. Control variables

We define the following variables for controlling personal attributes: RISKAV, MALE, UNIV, INCOME, AGE, and CHILD.

RISKAV measures the degree of risk aversion, which is constructed by subtracting from 100 the respondents' responses to the question: "When you go out, how high a probability of rainfall makes you bring an umbrella with you?" We hypothesize that more risk-averse respondents are likely to consume less cigarettes.

MALE is a binary indicator which equals 1 if the respondent is male and 0 if female. As shown in Table 2 and Figure1, average cigarette consumption and smoking rates for males are larger than for females in our Japanese data, and therefore we naturally hypothesize that being male has positive effects on smoking.

UNIV is a proxy variable of respondents' education level, which equals 1 if the respondent had

received college education and 0 otherwise. It was hypothesized that persons with a college background smoke less than others.

INCOME takes the value of per capita household income in ten thousand yen. Previous studies empirically verify positive relation between income levels and the smoking status (e.g., Hersch, 2000; Ishii, 2005).[10] According to the literature, we hypothesize that persons earning higher incomes are likely to consume less cigarettes.

AGE takes ages of respondents. Hersch (2000) shows that the effect of age on cigarette consumption displays a nonlinear relation, which is significantly positive for the linear term and negative for the quadratic term. Ishii (2005) reports the same relation for japanese female samples. We hypothesize that the effect of AGE on cigarette consumption is positive in the linear term and negative in the quadratic term.

CHILD is a binary indicator that takes 1 if the respondent has children and 0 otherwise. Hersch (2000) reports that females having a youngest child under 2 years old decrease their cigarette consumption. Our hypothesis is that females with children moderate their smoking behavior.

The correlation coefficients between control variables and SMOKING are shown in table 7.[11]

Insert Table 7:

Correlations between SMOKING and control variables

MALE displays a significantly positive coefficient and RISKAV and UNIV display negative coefficients for all, male, and female samples as expected. The coefficient of INCOME for female samples is significantly negative as hypothesized. On the other hand, for all and male samples, the coefficients of INCOME are insignificant, which is consistent with Ishii (2005).

Coefficients of AGE are negative and strongly significant. These results are seemingly shown as

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[10] Hersch (2000) reports that high-income groups display lower smoking rates than other groups by using US data. Ishii (2005) shows that, by using Japanese data, logarithmic household income displays a significantly negative correlation with the amount of cigarette consumption for female samples and with smoking rates for male and female samples.

[11] More detailed statistics by gender-year are summarized in Appendix D.

contrary evidence for the literature and our hypothesis. As seen in Figure 3, however, which displays graph trends of averaged cigarette consumption of smokers by gender in their 20s to 70s, cigarette consumption looks like following quadratic trends. In the next section, we will use the linear and the quadratic terms of AGE as explanatory variables for capturing the age trend of smoking.

Insert Figure 3:

Age trends of averaged cigarette consumption of smokers

As is pointed out in Hersch (2000), for female samples, CHILD displays a significantly negative coefficient, which implies that the presence of children reduces cigarette consumption.[12]

4. Determinants of smoking behavior

In this section, we estimate the marginal effects on SMOKING using random-effects tobit models to identify determinants of cigarette consumption. The following three models are estimated: model (1) uses as explanatory variables DISCRATE, HYPERBOL, SIGN, and other control variables including TAX; model (2) adopts PROCR, instead of HYPERBOL, to capture the effect of hyperbolic discounting; and model (3) adopts NAÏVE for hyperbolic discounting. All the models are estimated in all, male and female samples. Table 8 shows the estimation results. All coefficients display the marginal effects which are measured around the mean values of smokers.

Insert Table8:

Random-effects tobit estimations for SMOKING

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[12] Unreported tests of the differences of the average of cigarette consumption between females with and without children including nonsmokers' samples suggest that the former significantly smoke less than the latter, but using only smokers' samples suggest that having children is insignificant. This implies that having children leads to quitting, rather than reducing, smoking.

4.1. Tax hikes

The coefficients of TAX are significantly negative for all and male samples, where hiking per cigarette tax by one yen, *ceteris paribus*, decreases per capita cigarette consumption by 0.32 (model (3)) to 0.43 (model (2)) in all samples or by 0.49 (model (3)) to 0.60 (model (2)) in male samples. On the other hand, the insignificant coefficients for the female sample suggest that there would be some female-specific factors that push up their smoking in our sample period. Differences in smoking moderation behavior under tax hikes due to the types of time discounting and/or the degree of the biases will be estimated in the next section.

4.2. Time discounting

In model (1), consistent with our hypothesis, DISCRATE displays positive effects on cigarette consumption, which are, significant for all and female samples. The sign effect SIGN has expected negative coefficients, which are significant for all and male samples. In contrast, the results regarding the coefficients of HYPERBOL are weak. In particular, they are insignificantly negative for all and male samples.

In model (2) and model (3), all of DISCRATE, PROCR and NAÏVE display fairly significant coefficients with the expected sign. Especially, all of them have strongly significant coefficients in the all sample case. Male samples also display significant effects of these variables, and for female samples all coefficients of time discounting variables except for the sign effect of model (2) are significant. All of them are consistent with our expectations.

In sum, cigarette consumption has expected correlations with discount rates, procrastination, naiveness, and the sign effect. Discount rates, for example, that exceed the average by one unit of standard deviation, *ceteris paribus*, increase the amount of cigarette consumption by 0.32 (model (2)) to 0.34 (model (3)) for males and by 0.20 (model (3)) to 0.32 (model (1)) for females. The respondents who had procrastinated about doing their homework until the very end of the vacation (PROCR=5), ceteris paribus, smoke more than respondents who had finished it at the beginning of the vacation (PROCR=1) by 1.096 for males and

by 0.528 for females. The most naïve respondents (NAÏVE=4) smoke more than sophisticated ones (NAÏVE=0) by 0.874 for males and by 0.539 for females. The respondents with the sign effect (SIGN=1) consume less cigarettes than others, around 0.5 for males and 0.3-0.4 for females.

4.3. Control variables

Estimated coefficients of risk aversion variables (RISKAV) display expectedly negative signs , which are strongly significant for all and female samples in all the models. For example, cigarette consumption for female respondents who are risk averse such that their critical precipitation percentage to bring an umbrella is 10% higher than the average is *ceteris paribus* lower than the average female by 0.13 (model (3)) to 0.14 (model (1) and (2)). The coefficients of MALE display significantly positive implying that male respondents smoke more heavily than female ones by 5.21 (model (3)) to 5.71 (model (1)). Coefficients of UNIV are strongly significant consistent with our expectations for all, male, and female in the entire models. Respondents with a college background smoke less than others by 0.91 (model (3)) to 1.41 (model (2)) for males and by 1.43 (model (3)) to 1.48 (model (1)) for females. Smoking depend significantly on AGE in a quadratic form in the entire models, such that cigarette consumption increase with aging at decreasing rates until some critical age, and thereafter it decreases at increasing rates. The critical peaks of smoking are an age of 39.89 (i.e., 0.164/2*0.002) years (model (1)), 41.97 (model (2)) and 39.96(model (3)) for male smokers and 38.32 (model (1)), 38.37 (model (2)) and 40.29 (model (3)) for female smokers (after controlling other personal attributes). The estimated signs are consistent with our hypothesis, and the peak ages for cigarette consumption are more or less the same by gender with other things being equal. The coefficients of per capita household income (INCOME) are significantly negative and those of the income squared (INCOME^2) are significantly positive only for female samples in the entire models. The critical income levels of females at the bottom of cigarette consumption are 7.04 (model (1)), 7.04 (model (2)), and 7.03 million yen (model (3)). The coefficients of CHILD are, as are expected, significantly negative for females suggesting that female respondents with children smoke less than others by 0.91 (model (3)) to 0.94 (model (1)).

5. The effects of tax hikes

In this section, we analyze the effects of time discounting biases on the reduction of cigarette consumption responding to the hiking of cigarette tax. To do so, we sort the sample from the viewpoints of hyperbolic discounting, the procrastinating tendency, and naïveness, and thereby compare the estimated coefficients of TAX among the sorted samples. Our hypothesis is that cigarette consumption of hyperbolic discounting, procrastination, or naïve agents respond more negatively to tax hikes than other samples.

5.1. Responses to tax hikes with/without hyperbolic discounting

To detect the effect of hyperbolic discounting, respondents are classified by using HYPERBOL and PROC as follows:

(i)   Hyperbolic or exponential: Agents are classified as

- *hyperbolic* if HYPERBOL= 1; and

- *exponential* if HYPERBOL= 0

(ii)   The degree of procrastinating tendency is classified as

- *severe procrastination* if PROCR   5;

- *modest procrastination* if 5 > PROCR   3; and

- *weak/ no procrastination if*   PROCR< 3.

Table 9 shows the marginal effects of tax hikes on cigarette consumption for each type of agents by using random-effects tobit models. All models use SMOKING for dependent variables, and are estimated in all, male and female samples by controlling for DISCRATE, SIGN, RISKAV, MALE, UNIV, AGE, AGE^2, INCOME, INCOME^2, and CHILD. The coefficients indicate the marginal effects of TAX.

Panel A of table 9 displays the estimated coefficients of TAX whose samples are sorted by using

HYPERBOL. For all and male samples, the coefficients of hyperbolic agents (HYPERBOL=1) are significantly negative and the coefficients of exponential agents (HYPERBOL=0) are insignificant. The differences of the responses to tax hikes between hyperbolic and exponential agents are -0.186 in all samples and -0.442 in the male samples, which are both negative as expected. These results imply that hyperbolic agents reduced cigarette consumption after the tax hike more than exponential discounting agents. For the female samples, the estimated coefficients are insignificant in both agents, however.

Panel B compares the effect of tax reduction on cigarette consumption among different degrees of procrastinating tendency. In the all sample case, the coefficients are significantly negative for respondents with strong and modest procrastination while the coefficient is insignificantly negative for respondents with weak/ no procrastination. The difference of the coefficients between the respondents with strong procrastination and those with weak/ no procrastination is positive as expected. For males, the coefficients for respondents with strong procrastination and with weak/no procrastination are significantly negative, where the difference between the coefficients is negative, consistent with our expectations. For the female sample, although all the coefficients are insignificant, they have expected signs. In sum, hyperbolic or procrastinative agents reduce their cigarette consumption more than exponential agents after tax hikes, which implies that these agents postpone smoking moderation up to after-tax-hike period even though the tax hike was preannounced several months before..

Insert Table 9:

Comparing the marginal effects of tax hikes for each agent　HYPERBOL and PROCR

5.2. Naïve vs. Sophisticated

We also detect the effect of naiveness by defining the degree of naiveness as follows:

(iii)　The degree of naiveness: Respondents are classified as:

- *sophisticated* if NAÏVE < 1;
- *naïve* if 1　NAÏVE < 4; and

■ *strongly naïve* if NAÏVE = 4.

By sorting the sample by the degree of naiveness, Table 10 compares the marginal effects of tax hikes on the cigarette consumption, which are estimated in the same manner as table 9. The values of the estimated coefficients and their differences are consistent with our expectations. In particular, the coefficients for strongly naïve agents in all and female samples and those for naïve agents in all and male samples are significant, where all of the differences exhibit negative signs as expected. These results imply that naïve agents postpone smoking moderation even when a tax hike is pre-announced. It is only after the actual tax hike when they reduce cigarette consumption.

Insert Table 10:

Comparing the marginal effects of tax hikes for each agent NAÏVE

5.3. Policy implications

Cigarettes are addictive goods which have two important aspects related to policyl decisions: firstly, habitual consumption of them damages health status, and consequently brings about decreases of social welfare and increases of the medical care costs; and secondly the revenues from cigarette taxes are a significant source of public finance. For the governments to decide the cigarette tax level by taking into account both national health care and tax revenues, it is important to estimate the quantitative effects of cigarette tax hikes on smoking behavior and on the resulting tax revenues.

Table 11 shows the estimates of cigarette consumption, the smoking rate, the smoking cessation rate, and the tax revenue after tax hikes, where the three alternative tax hikes are considered: hikes by JPY 10, 20, and 35 (around USD 0.09, 0.19, and 0.33) per cigarette. All results are obtained from the tax elasticity of cigarette demand for smokers, ranging from 0.079 for the heaviest smokers to 1.329 for the lightest smokers.[13]

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[13] The elasticity are calculated from the marginal effects of TAX, -0.416, in model (1) for the all sample, which is measured around the mean values of smokers in 2008. Appendices E and F show the cases of models (2) and

In 2008, when most cigarettes are priced at JPY 300 (around USD 2.80) per pack, the average cigarette consumption for smokers is 20.87, and the smoking rate is 25.1%. In the case of a tax hike by JPY 10 (around USD 0.09) per cigarette, which is equivalent to setting the price at JPY 500 (i.e., 300+ (10*20)) per pack (around USD 4.67 per pack), the predicted average cigarette consumption after the tax hike is 18.9 and the smoking rate becomes 22.4%. Consequently, 10.7% of smokers reduce their cigarette consumption in response to the tax hike, and the resulting increase in the rate of tax revenue is 73.2%. In the case of a tax hike by JPY 20 (around USD 0.19) per cigarette, which corresponds to pricing at JPY 700 (around USD 6.53) per pack, the smoking rate becomes 22.4%, and the resulting increase in the rate of tax revenue is 107.2%. In the case of hiking tax by JPY 35 (around USD 0.33) per cigarette, which is equivalent to pricing at JPY 1000 (around USD 9.33) per pack, the smoking rate becomes 15.6%, and the resulting increase in the rate of tax revenue is 107.9%.

Figure 4 depicts the relationship between the amount of the per-cigarette tax hike and the associated increasing rate of the tax revenue. The government revenue reaches a peak when the per-cigarette tax hike equals JPY 29.92 (around USD 0.28), with the corresponding per-pack cigarette price is JPY 898.4 (around USD 8.38). The break-even tax-hike which keeps the tax revenues unchanged is estimated as JPY 58.85 (around USD 0.55). This implies that even though the government sets the per-pack price of cigarettes at JPY 1,477.09 (around USD 13.78), there is a room to raise tax revenues on one hand, and to decrease the domestic smoking rate, on the other hand.[14]

Insert Table 11:

Tax hikes, smoking moderation, and tax revenue

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model (3).

[14] On March 24th, the Japanese government has passed a bill on hiking the cigarette tax by JPY 3.5 (around USD 0.03) per cigarette in October 1st, 2010. Following the passage, JT (Japan Tobacco, Inc.), the Japan's monopolistic cigarette manufacturer, has announced the decision to increase cigarette prices to around JPY 410 to 440 (around USD 3.83 to 4.11) per 20-cigarette pack. According to our estimation results, it is predicted that, by executing the tax- and price-increasing policy, smokers would decrease by 10.7%, and that government's revenue would increase by about 20.3 to 28.4%.

Insert Figure 4:

Tax hikes and the increasing rates of tax revenue

6. Conclusion

By using our broad panel survey of Japanese adults, we have found that discount rates and its behavioral biases affect smoking behavior. Respondents' discount rates are higher, or their procrastinating tendency or naiveness is stronger, they are likely to smoke more than others. In the response to cigarette tax hikes, hyperbolic, procrastinating or naïve agents postpone smoking moderation up to after-tax-hike period even though the tax hike was preannounced several months before.

We have also clarified that the Japanese government is able to hike cigarette taxes for increasing tax revenue. The government's tax-rising policy, however, does not necessary lead to consumer's welfare improvement. It causes welfare losses to exponential discounters, whereas it works as a commitment devise for hyperbolic discounters and consequently increases their welfare level. As the further research, we would like to incorporate heterogeneity of discounting function to determine precise welfare-changing processes and the quantities induced by tax-changing policies.

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Table1: The number of samples and frequencies of responses

	2005	2006	2007	2008	Total
Num. of samples	2,987	3,763	3,112	4,018	13,880

	Four times	Three times	Twice	Once	Total
Freq. of responses	1,824	1,125	488	2,233	5,670

Note: The data are from the Japan Household Panel Survey on Consumer Preferences and Satisfaction from 2005 to 2008. The row of "Num. of samples" shows the number of respondents each year. The row of "Freq. of respondents" shows the number of frequencies in responses during our sample period.

Table2: Summary statistics of smoking behavior

(Panel A) Cigarette consumption

		2005	2006	2007	2008
	Mean	6.502	6.226	5.873	5.238
All	S.D.	11.971	11.679	11.294	10.724
	Freq.	2,972	3,746	3,084	4,001
	Mean	11.373	10.937	10.218	9.172
Male	S.D.	14.728	14.378	13.703	13.394
	Freq.	1,395	1,763	1,437	1,870
	Mean	2.193	2.038	2.081	1.785
Female	S.D.	6.223	6.054	6.649	5.748
	Freq.	1,577	1,983	1,647	2,131

(Panel B) Cigarette consumption (Smokers)

		2005	2006	2007	2008
	Mean	21.517	21.879	21.820	20.873
All	S.D.	12.296	11.697	11.222	11.488
	Freq.	898	1,066	830	1,004
	Mean	24.483	24.253	23.760	23.368
Male	S.D.	12.077	11.635	10.712	11.193
	Freq.	648	795	618	734
	Mean	13.832	14.916	16.166	14.092
Female	S.D.	9.136	8.734	10.777	9.355
	Freq.	250	271	212	270

(Panel C) Smoking rates

		2005	2006	2007	2008
	Mean	0.264	0.258	0.245	0.224
All	S.D.	0.441	0.437	0.430	0.417
	Freq.	2,972	3,746	3,084	4,001
	Mean	0.424	0.419	0.404	0.367
Male	S.D.	0.494	0.494	0.491	0.482
	Freq.	1,395	1,763	1,437	1,870
	Mean	0.122	0.114	0.106	0.099
Female	S.D.	0.327	0.318	0.308	0.299
	Freq.	1,577	1,983	1,647	2,131

Note: The data are from the Japan Household Panel Survey on Consumer Preferences and Satisfaction from 2005 to 2008. Summary statistics of Panel A include nonsmokers in samples. Panel B shows the statistics only smokers. Panel C shows rates of regular smokers.

Table 3: Question to elicit discount rates: An example (QUESTION 1 for DR$_1$)

Suppose you have two options to receive some money. You may choose Option "A", to receive 10,000 JPY in two days; or Option "B", to receive a different amount in nine days. Compare the amounts and timing in Option "A" with Option "B" and indicate which amount you would prefer to receive for each of all 8 choices.

Option A (Receipt in 2 days)	Option B (Receipt in 9 days)	Interest rate (Annual)	Circle A or B.	
JPY 10,000 (USD 93.32)	JPY 9,981 (USD 93.14)	-10%	A	B
JPY 10,000 (USD 93.32)	JPY 10,000 (USD 93.32)	0%	A	B
JPY 10,000 (USD 93.32)	JPY 10,019 (USD 93.50)	10%	A	B
JPY 10,000 (USD 93.32)	JPY 10,038 (USD 93.67)	20%	A	B
JPY 10,000 (USD 93.32)	JPY 10,096 (USD 94.21)	50%	A	B
JPY 10,000 (USD 93.32)	JPY 10,191 (USD 95.10)	100%	A	B
JPY 10,000 (USD 93.32)	JPY 10,383 (USD 96.89)	200%	A	B
JPY 10,000 (USD 93.32)	JPY 10,574 (USD 98.67)	300%	A	B

Note: This is a question in the Japan Household Panel Survey on Consumer Preferences and Satisfaction from 2005 to 2008. The US dollar amounts are computed by using the average JPY/ USD exchange rate, 107.16, in February, 2008.

Table 4: Elicited discount rates under alternative choice conditions

Choice conditions		DR$_1$			DR$_2$			DR$_3$			DR$_4$			DR$_5$		
	Timings ((A) or (B))	2 days or 9 days			90 days or 97 days			1 month or 13 months			1 month or 13 months			1 month or 13 months		
	Amounts for (A)	JPY 10,000 (USD 93.32)			JPY 10,000 (USD 93.32)			JPY 10,000 (USD 93.32)			JPY 1million (USD 9331.84)			JPY 1million (USD 9331.84)		
	Receipt or payment	receipt			receipt			receipt			receipt			payment		
		Mean	S.D.	Obs.	Mean	S.D.	Obs.	Mean	S.D.	Obs.	Mean	S.D.	Obs.	Mean	S.D.	Obs.
	2005	1.904	2.390	2,737	1.892	2.421	2,768	0.153	0.193	2,790	0.023	0.042	2,771	-0.008	0.044	2,331
	2006	1.798	2.274	3,444	1.843	2.387	3,464	0.147	0.183	3,475	0.024	0.042	3,475	-0.008	0.040	2,912
	2007	1.591	1.968	2,905	1.623	2.059	2,872	0.137	0.166	2,902	0.022	0.036	2,891	-0.001	0.028	2,292
	2008	1.561	1.952	3,761	1.515	1.941	3,765	0.136	0.166	3,765	0.022	0.036	3,756	-0.002	0.027	3,103
	Pooled	1.704	2.148	12,847	1.708	2.206	12,869	0.143	0.177	12,932	0.023	0.039	12,893	-0.005	0.036	10,638
Time discounting biases		hyperbolic discounting: DR1>DR2									sign effect: DR4>DR5					

Note: This is a question in the Japan Household Panel Survey on Consumer Preferences and Satisfaction from 2005 to 2008. The US dollar amounts are computed by using the average JPY/ USD exchange rate, 107.16, in February, 2008.

Table 5: Correlation coefficients of time discounting variables with SMOKING

	SMOKING					
	All		Male		Female	
DISCRATE	0.116	***	0.075	***	0.045	***
	(0.000)		(0.000)		(0.001)	
HYPERBOL	-0.048	***	-0.039	***	-0.015	
	(0.000)		(0.003)		(0.219)	
SIGN	-0.024	**	-0.035	**	-0.024	*
	(0.014)		(0.015)		(0.078)	
PROCR	0.124	***	0.084	***	0.059	***
	(0.000)		(0.000)		(0.000)	
NAÏVE	0.063	***	0.063	***	0.057	***
	(0.000)		(0.000)		(0.000)	

Note: This table shows the correlation coefficients of cigarette consumption
with time discounting variables. Samples include nonsmokers.
P-values are in parentheses.
*, **, *** denote statistical significance at the 10%, 5%, and 10% levels, respectively.

Table 6: Definition, summary statistics, and hypothesized signs of variables

Variables		Definition	Mean	S.D.	Obs.	Hypothesis
Cigarette consumption	SMOKING	The amount of cigarette consumptioon per day.	5.920	11.398	13,803	
Taxation level	TAX	Taxation level per cigarette. 7.892 yen from 2005 to 2006 and 8.744 yen from 2007 to 2008.	8.330	0.426	13,880	–
Time Preferences factors	DISCRATE	Simple mean, defined by equation (1), of the standardized values of the elicited discount rates DR_i ($i = 1, \dots, 5$) as a measure of the degree of impatience.	0.042	0.718	10,125	+
	HYPERBOL	A binary indicator for hyperbolic discounting which equals 1 if $DR_1 > DR_2$, and 0 otherwise.	0.673	0.469	12,639	+
	PROCR	Time averaged response to the question 'When did you do homework for the vacation in your childhood?' on a 5-poit scale, from 1 (Homework was finished at 'the beginning of the vacation') to 5 (it was not done until 'the very end of the vacation'), which is a proxy measure of the degree of procrastination.	3.262	1.184	13,827	+
	NAÏVE	Time averaged difference between respondents' plan and execution to do homework in summer vacation in their high school day.	1.117	1.206	11,638	+
	SIGN	A binary indicator for the sign effect which equals 1 if $DR_4 > DR_5$, and 0 otherwise.	0.903	0.296	10,450	–
Control variables	RISKAV	A variable which measures the degree of risk aversion, constructed by subtracting from 100 the respondents' responses to the question: "When you go out, how high probability of rainfall makes you bring an umbrella with you?"	50.160	20.203	13,654	–
	MALE	A binary indicator for males which equals 1 for male respondents and 0 otherwise.	0.469	0.499	13,880	+
	UNIV	A binary indicator for university graduates which equals 1 for university graduates and 0 otherwise.	0.218	0.413	13,454	–
	INCOME	Per capita household income in ten thousand yen.	223.615	174.910	11,608	–
	AGE	Ages of respondents.	49.686	13.058	13,880	+
	CHILD	A binary indicator for parent of children which equals 1 for respondents with childlen and 0 otherwise.	0.811	0.391	13,639	–

Note: "Hypothesis" shows the theoritically predicted signs of associations with smoking.

Table 7: Correlations between control variables and SMOKING

	SMOKING					
	All		Male		Female	
MALE	0.366	***	NA		NA	
	(0.000)					
UNIV	-0.017	**	-0.130	***	-0.067	***
	(0.050)		(0.000)		(0.000)	
RISKAV	-0.099	***	-0.111	***	-0.062	***
	(0.000)		(0.000)		(0.000)	
INCOME	0.003		0.001		-0.042	***
	(0.719)		(0.927)		(0.001)	
AGE	-0.034	***	-0.056	***	-0.107	***
	(0.000)		(0.000)		(0.000)	
CHILD	-0.032	***	0.003		-0.039	***
	(0.000)		(0.820)		(0.001)	

Notes: This table shows the correlation coefficients of cigarette consumption with control variables. Samples include nonsmokers.

P-values are in parentheses.

*, **, *** denote statistical significance at the 10%, 5%, and 10% levels, respectively.

Table 8. Random-effects tobit estimations for SMOKING

SMOKING	Model (1) All Coef. (P-value)	Model (1) Male Coef. (P-value)	Model (1) Female Coef. (P-value)	Model (2) All Coef. (P-value)	Model (2) Male Coef. (P-value)	Model (2) Female Coef. (P-value)	Model (3) All Coef. (P-value)	Model (3) Male Coef. (P-value)	Model (3) Female Coef. (P-value)
TAX	-0.422 *** (0.003)	-0.536 *** (0.003)	-0.125 (0.431)	-0.430 *** (0.002)	-0.597 *** (0.001)	-0.087 (0.581)	-0.318 ** (0.024)	-0.490 *** (0.009)	-0.041 (0.807)
DISCRATE	0.389 *** (0.000)	0.180 (0.192)	0.323 *** (0.007)	0.373 *** (0.000)	0.316 ** (0.013)	0.245 ** (0.025)	0.353 *** (0.001)	0.338 ** (0.013)	0.204 * (0.085)
HYPERBOL	-0.029 (0.849)	-0.288 (0.131)	0.248 (0.141)						
PROCR				0.355 *** (0.000)	0.274 ** (0.016)	0.132 ** (0.045)			
NAÏVE							0.237 *** (0.002)	0.219 ** (0.049)	0.135 * (0.057)
SIGN	-0.631 *** (0.007)	-0.495 * (0.083)	-0.318 (0.168)	-0.687 *** (0.003)	-0.481 * (0.092)	-0.328 (0.157)	-0.658 *** (0.006)	-0.512 (0.102)	-0.467 * (0.066)
RISKAV	-0.016 *** (0.000)	-0.007 (0.114)	-0.014 *** (0.001)	-0.016 *** (0.000)	-0.007 (0.136)	-0.014 *** (0.001)	-0.014 *** (0.001)	-0.008 * (0.097)	-0.013 *** (0.002)
MALE	5.714 *** (0.000)			5.666 *** (0.000)			5.210 *** (0.000)		
UNIV	-2.057 *** (0.000)	-1.339 *** (0.000)	-1.475 *** (0.000)	-2.027 *** (0.000)	-1.405 *** (0.000)	-1.467 *** (0.000)	-1.528 *** (0.000)	-0.907 *** (0.001)	-1.428 *** (0.000)
AGE	0.339 *** (0.000)	0.164 ** (0.041)	0.238 *** (0.000)	0.354 *** (0.000)	0.211 *** (0.006)	0.233 *** (0.000)	0.280 *** (0.000)	0.160 * (0.067)	0.342 *** (0.000)
AGE^2	-0.004 *** (0.000)	-0.002 *** (0.008)	-0.003 *** (0.000)	-0.004 *** (0.000)	-0.003 *** (0.001)	-0.003 *** (0.000)	-0.004 *** (0.000)	-0.002 ** (0.020)	-0.004 *** (0.000)
INCOME	-0.001 (0.118)	0.001 (0.618)	-0.003 *** (0.002)	-0.001 (0.150)	0.000 (0.676)	-0.003 *** (0.003)	-0.001 (0.133)	0.001 (0.520)	-0.004 *** (0.001)
INCOME^2	0.000 (0.115)	0.000 (0.867)	0.000 ** (0.018)	0.000 * (0.099)	0.000 (0.984)	0.000 ** (0.020)	0.000 (0.126)	0.000 (0.848)	0.000 *** (0.008)
CHILD	-0.416 (0.146)	0.424 (0.252)	-0.942 *** (0.000)	-0.337 (0.234)	0.494 (0.123)	-0.926 *** (0.000)	-0.007 (0.978)	0.514 (0.148)	-0.914 *** (0.001)
Num. of Obs.	8383	4086	4297	8359	4074	4285	7181	3372	3809
Num. of Group	4277	2112	2165	4253	2100	2153	3355	1575	1780
Log likelihood	-12184.501	-8479.015	-3625.779	-12130.185	-8429.206	-3621.708	-9846.033	-6684.307	-3091.643

Notes: This table shows the results of random-effects tobit model. Estimated coefficients are transformed into the marginal effects for the expected cigarette consumption conditional on SMOKING>0.

P-values are in parentheses.

*, **, *** denote statistical significance at the 10%, 5%, and 10% levels, respectively.

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Table 9: Comparing the marginal effects of tax hikes for each agent   HYPERBOL and PROCR

(Panel A) HYPERBOL

	Hyperbolic (HYPERBOL=1)	Exponential (HYPERBOL=0)
All	-0.412 **	-0.226
	(0.023)	(0.415)
Difference	-0.186	
Male	-0.642 ***	-0.199
	(0.007)	(0.497)
Difference	0.442	
Female	-0.154	-0.181
	(0.452)	(0.634)
Difference	0.027	

(Panel B) PROCR

	Strong procrastination (PROCR=5)	Procrastination (5>PROCR 3)	Weak/ No procrastination (PROCR<3)
All	-0.975 **	-0.393 **	-0.451
	(0.047)	(0.043)	(0.174)
Difference	-0.524		
Male	-1.120 *	-0.336	-0.968 ***
	(0.061)	(0.139)	(0.002)
Difference	-0.153		
Female	-0.643	-0.487	0.159
	(0.403)	(0.402)	(0.525)
Difference	-0.802		

Notes: This tables show the coefficients of marginal effects of TAX by estimating random-effects tobit models. Samples are sorted by using NAIVE. SMOKING is used as an explained variable and DRSTD, SIGN, RISKAV, MALE, UNIV, AGE, AGE^2, INCOME, INCOME^2, and CHILD are used as explanatory variables.

P-values are in parentheses.

*, **, *** denote statistical significance at the 10%, 5%, and 10% levels, respectively.

"Difference" shows the differences between marginal effects of Hyperbolic and Exponential in Panel A, and the differences between marginal effeccts of Strong procrastination and Weak/ No Procrastination in Panel B.

Table 10: Comparing the marginal effects of tax hikes for each agent   NAÏVE

	Strong naïve (NAÏVE=4)		Naïve (4>NAÏVE 1)		Sophisticate (NAÏVE<1)
All	-2.106	**	-0.344	***	-0.140
	(0.012)		(0.006)		(0.551)
Difference	-1.966				
Male	-1.512		-1.296	**	-0.407
	(0.180)		(0.030)		(0.202)
Difference	-1.105				
Female	-3.907	***	-2.678		0.193
	(0.001)		(0.623)		(0.507)
Difference	-4.100				

Notes: This table shows the coefficients of marginal effects of TAX by estimating random-effects tobit models. Samples are sorted by using NAIVE. SMOKING is used as an explained variable and DRSTD, SIGN, RISKAV, MALE, UNIV, AGE, AGE^2, INCOME, INCOME^2, and CHILD are used as explanatory variables.

P-values are in parentheses.

*, **, *** denote statistical significance at the 10%, 5%, and 10% levels, respectively.

"Difference" shows the differences between marginal effects of Strong naive and Sophisticate.

Table 11: Tax hikes, smoking moderation, and increasing rates of tax revenue

Model (1): The marginal effect of TAX= -0.416

	before tax hikes	after tax hikes		
Cigarette price per pack	JPY 300 (USD 2.80)	JPY 500 (USD 4.67)	JPY 700 (USD 6.53)	JPY 1000 (USD 9.33)
TAX per cigarette	JPY 0 (USD 0)	JPY 10 (USD 0.09)	JPY 20 (USD 0.19)	JPY 35 (USD 0.33)
Averaged cigarette consumption	20.873	18.880	14.725	13.956
Smoking rates	25.1%	22.4%	22.4%	15.6%
Smoking cessation rates for smokers	0.0%	10.7%	10.7%	37.8%
Increasing rates of revenues	0.0%	73.2%	107.2%	107.9%

Notes: This tabel shows the predicted smoking status and increasing rates of government's revenues responding to tax hikes by JPY 10, 20, and 35 (around USD 0.09, 0.19, and 0.33) per cigarette. The estimated coefficient of TAX in model (1) for full samples is used for the predictions. The marginal effect is measured around mean values of smokers in 2008. The row of "Cigarette price per pack" shows the hypothetical prices per 20-cigarette pack after tax hikes calculated by (20* TAX per cigarette). The row of " TAX per cigarette" shows the increased rates of tax per cigarette. The rows of "Averaged cigarette consumption", "Smoking rates", and "Smoking cessation rates for smokers" show the resulting status of cigarette consumption after tax hikes. The row of "Increasing rates of revenues" shows the net increasing rates of government's revenues by hiking cigarette tax.

Figure 1: Transition graphs of smoking behavior

(Panel A) Cigarette consumption
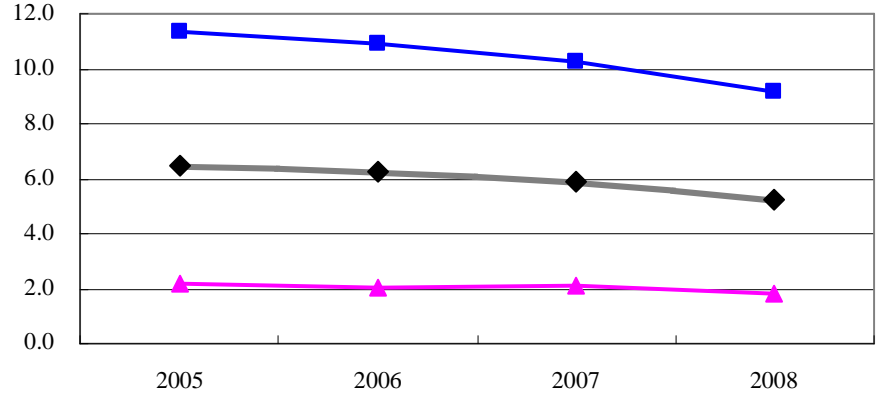
(Panel B) Cigarette consumption (Smokers)
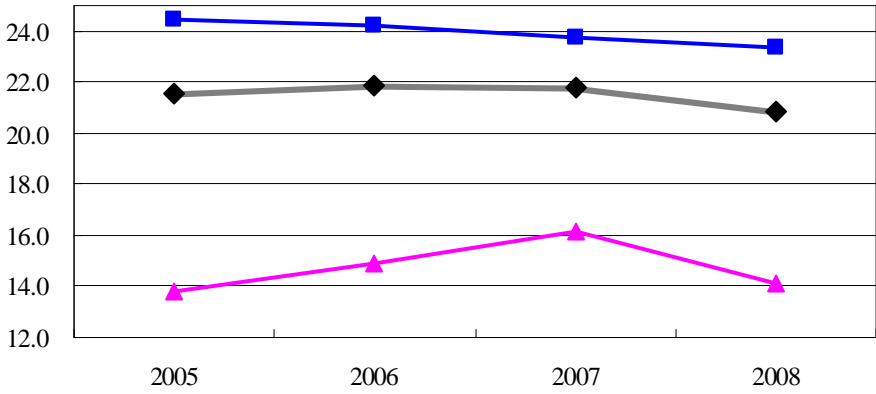
(Panel C) Smoking rates

◆ All   ■ Males   ▲ Females
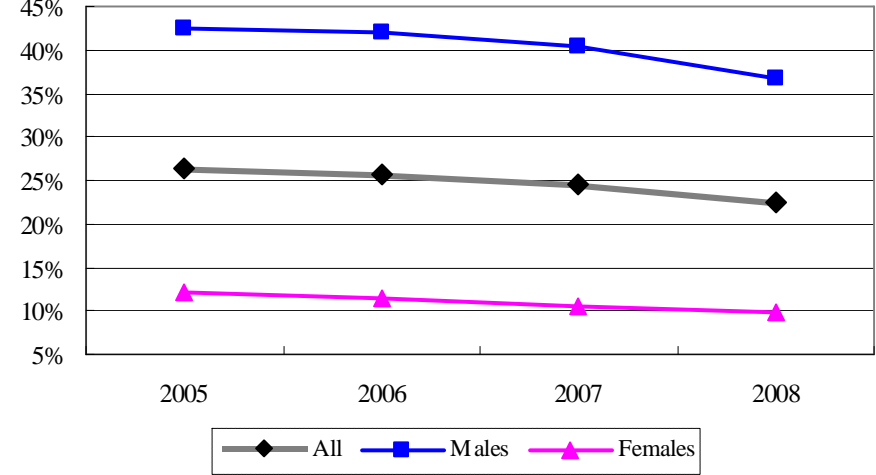
Note: The graphs show trends of smoking behavior. Panel A shows averaged cigarette consumption including nonsmokers in samples. Panel B shows ageraged cigarette consumption among smokers. Panel C shows rates of regular smokers.

Figure 2: Distributions of PROCR and NAÏVE

(Panel A) PROCR
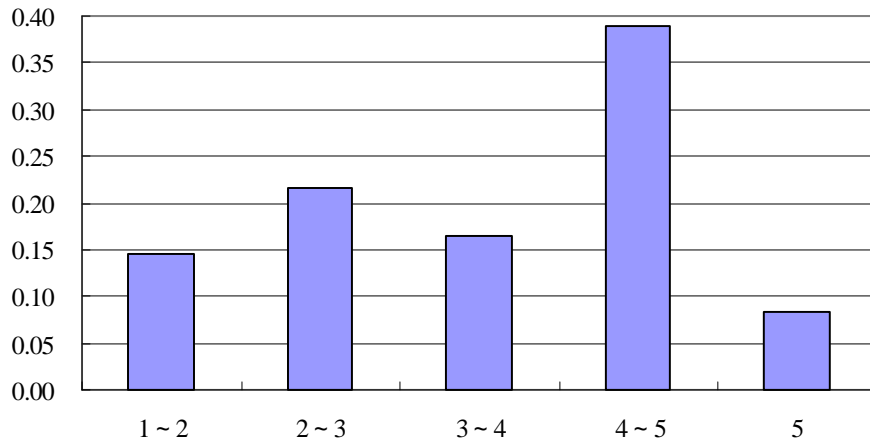
(Panel B) NAÏVE
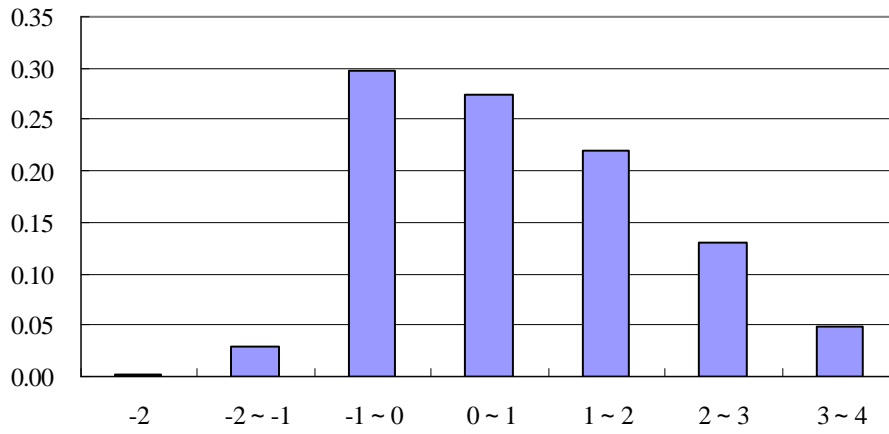
Figure 3: Age trends of averaged cigarette consumption of smokers

(Panel A) All
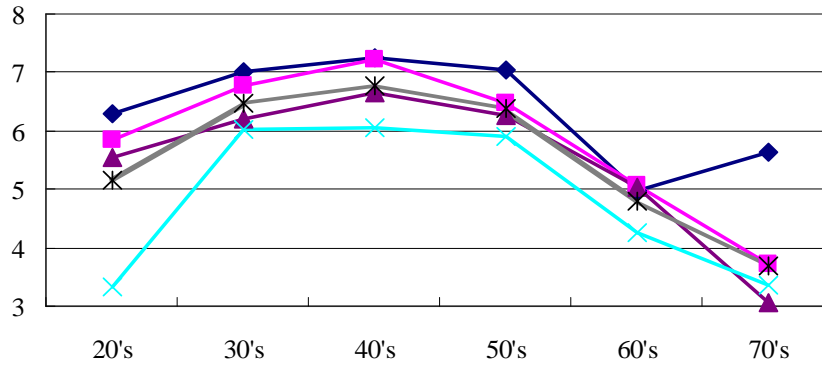
(Panel B) Males
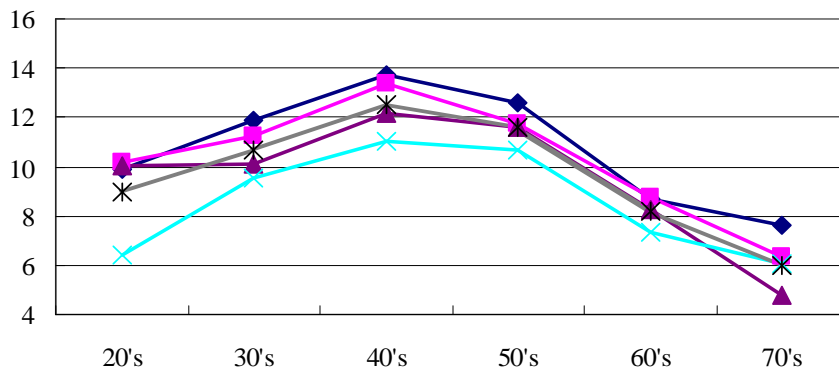
(Panel C) Females
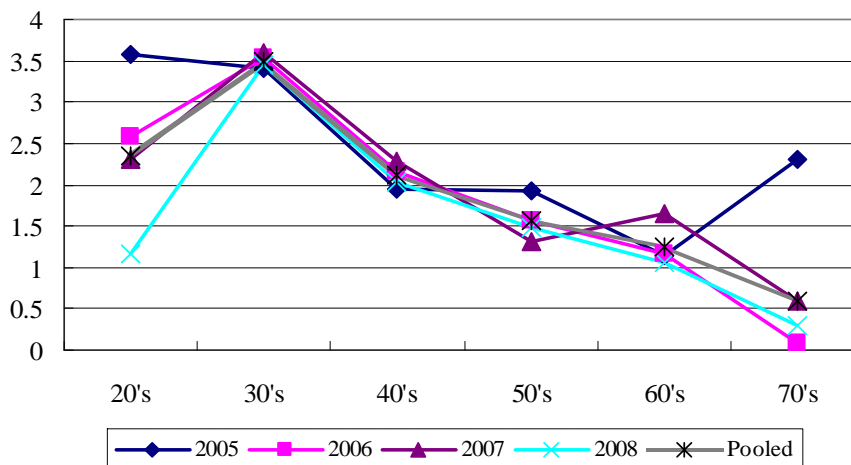
Notes: the graphs show the age trends of averaged cigarette consumption including nonsmokers. The horizonal axes indicate the averaged number of cigarette consumption. The vertical axes indicate age brackets.

Figure 4: Tax hikes and the increasing rates of tax revenue

The marginal effect of TAX= -0.416 (model (1))
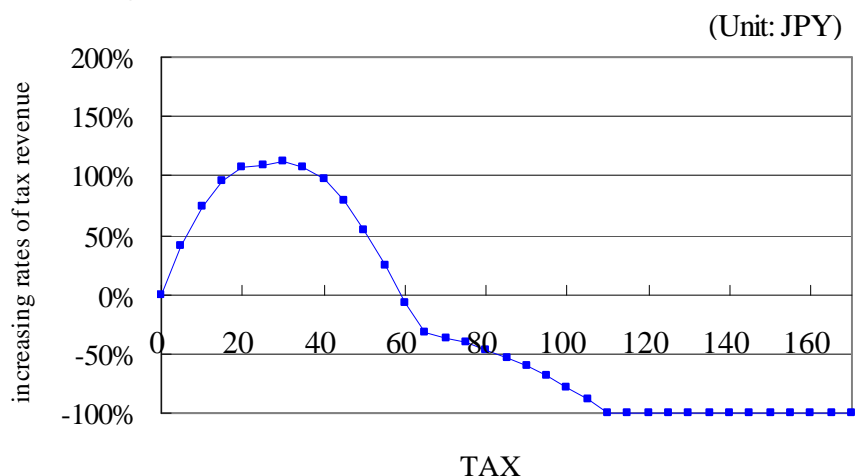
Notes: This figure shows the predicted increasing rates of government's revenues responding to tax hikes. The horizonal axis indicates increased rates of tax per cigarette. The vertical axis indicates net increasing rates of government's revenues by hiking cigarette tax in JPY terms. The estimated coefficient of TAX in model (1) for full samples is used for the predictions. The marginal effect is measured around mean values of smokers in 2008.

Appendix A: Summary statistics of time preferences

All samples

2005

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	2737	1.904	2.390	-0.369	5.724
DR2	2768	1.892	2.421	-0.373	5.742
DR3	2790	0.153	0.193	-0.121	0.512
DR4	2771	0.023	0.042	-0.065	0.118
DR5	2331	-0.008	0.044	-0.073	0.117
DISCRATE	2202	0.042	0.688	-1.376	2.033
HYPERBOL	2694	0.621	0.485	0	1
SIGN	2289	0.885	0.319	0	1
PROCR	2963	3.263	1.195	1	5
NAIVE	1951	1.087	1.196	-2	4

2006

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	3444	1.798	2.274	-0.363	5.537
DR2	3464	1.843	2.387	-0.372	5.675
DR3	3475	0.147	0.183	-0.117	0.503
DR4	3475	0.024	0.042	-0.065	0.118
DR5	2912	-0.008	0.040	-0.070	0.115
DISCRATE	2784	0.033	0.693	-1.396	2.099
HYPERBOL	3412	0.585	0.493	0	1
SIGN	2862	0.902	0.297	0	1
PROCR	3747	3.277	1.171	1	5
NAIVE	2962	1.120	1.201	-2	4

2007

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	2905	1.591	1.968	-0.339	5.074
DR2	2872	1.623	2.059	-0.348	5.188
DR3	2902	0.137	0.166	-0.110	0.487
DR4	2891	0.022	0.036	-0.062	0.114
DR5	2292	-0.001	0.028	-0.061	0.108
DISCRATE	2190	0.048	0.753	-1.580	2.407
HYPERBOL	2844	0.587	0.492	0	1
SIGN	2249	0.914	0.280	0	1
PROCR	3112	3.260	1.162	1	5
NAIVE	2962	1.120	1.201	-2	4

2008

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	3761	1.561	1.952	-0.339	5.041
DR2	3765	1.515	1.941	-0.341	5.017
DR3	3765	0.136	0.166	-0.110	0.487
DR4	3756	0.022	0.036	-0.062	0.114
DR5	3103	-0.002	0.027	-0.061	0.108
DISCRATE	2949	0.045	0.737	-1.576	2.450
HYPERBOL	3689	0.860	0.347	0	1
SIGN	3050	0.910	0.287	0	1
PROCR	4005	3.248	1.205	1	5
NAIVE	3763	1.129	1.219	-2	4

Pooled

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	12847	1.704	2.148	-0.369	5.724
DR2	12869	1.708	2.206	-0.373	5.742
DR3	12932	0.143	0.177	-0.121	0.512
DR4	12893	0.023	0.039	-0.065	0.118
DR5	10638	-0.005	0.036	-0.073	0.117
DISCRATE	10125	0.042	0.718	-1.580	2.450
HYPERBOL	12639	0.673	0.469	0	1
SIGN	10450	0.903	0.296	0	1
PROCR	13827	3.262	1.184	1	5
NAIVE	14156	1.111	1.202	-2	4

Male samples

2005

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	1296	2.088	2.442	-0.369	5.724
DR2	1307	2.075	2.484	-0.373	5.742
DR3	1320	0.172	0.198	-0.121	0.512
DR4	1312	0.028	0.043	-0.065	0.118
DR5	1116	-0.006	0.045	-0.073	0.117
DISCRATE	1051	0.132	0.707	-1.376	2.033
HYPERBOL	1271	0.595	0.491	0	1
SIGN	1096	0.885	0.319	0	1
PROCR	1395	3.485	1.155	1	5
NAIVE	860	1.129	1.217	-2	4

2006

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	1631	2.060	2.361	-0.363	5.537
DR2	1639	2.111	2.489	-0.372	5.675
DR3	1655	0.170	0.191	-0.117	0.503
DR4	1656	0.031	0.042	-0.065	0.118
DR5	1386	-0.005	0.042	-0.070	0.115
DISCRATE	1322	0.158	0.730	-1.396	2.099
HYPERBOL	1611	0.540	0.499	0	1
SIGN	1363	0.903	0.298	0	1
PROCR	1767	3.487	1.135	1	5
NAIVE	1348	1.165	1.204	-2	4

2007

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	1350	1.851	2.059	-0.339	5.074
DR2	1331	1.847	2.136	-0.348	5.188
DR3	1350	0.162	0.176	-0.110	0.487
DR4	1345	0.029	0.038	-0.062	0.114
DR5	1071	0.002	0.031	-0.061	0.108
DISCRATE	1010	0.196	0.795	-1.580	2.407
HYPERBOL	1317	0.547	0.498	0	1
SIGN	1046	0.922	0.269	0	1
PROCR	1449	3.467	1.124	1	5
NAIVE	1348	1.165	1.204	-2	4

2008

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	1761	1.819	2.040	-0.339	5.041
DR2	1762	1.752	2.043	-0.341	5.017
DR3	1760	0.157	0.176	-0.110	0.487
DR4	1757	0.028	0.039	-0.062	0.114
DR5	1481	0.000	0.030	-0.061	0.108
DISCRATE	1416	0.173	0.781	-1.576	2.450
HYPERBOL	1729	0.855	0.352	0	1
SIGN	1456	0.913	0.282	0	1
PROCR	1872	3.450	1.171	1	5
NAIVE	1711	1.148	1.208	-2	4

Pooled

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	6038	1.949	2.227	-0.369	5.724
DR2	6039	1.940	2.294	-0.373	5.742
DR3	6085	0.165	0.185	-0.121	0.512
DR4	6070	0.029	0.041	-0.065	0.118
DR5	5054	-0.002	0.038	-0.073	0.117
DISCRATE	4799	0.165	0.754	-1.580	2.450
HYPERBOL	5928	0.645	0.478	0	1
SIGN	4961	0.905	0.293	0	1
PROCR	6483	3.471	1.147	1	5
NAIVE	6377	1.149	1.208	-2	4

Female samples

2005

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	1441	1.739	2.332	-0.369	5.724
DR2	1461	1.728	2.351	-0.373	5.742
DR3	1470	0.136	0.186	-0.121	0.512
DR4	1459	0.018	0.040	-0.065	0.118
DR5	1215	-0.010	0.043	-0.073	0.117
DISCRATE	1151	-0.040	0.660	-1.376	2.033
HYPERBOL	1423	0.644	0.479	0	1
SIGN	1193	0.884	0.320	0	1
PROCR	1568	3.066	1.196	1	5
NAIVE	1091	1.055	1.179	-2	4

2006

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	1813	1.563	2.168	-0.363	5.537
DR2	1825	1.602	2.265	-0.372	5.675
DR3	1820	0.125	0.173	-0.117	0.503
DR4	1819	0.017	0.039	-0.065	0.118
DR5	1526	-0.010	0.038	-0.070	0.115
DISCRATE	1462	-0.079	0.637	-1.396	2.099
HYPERBOL	1801	0.625	0.484	0	1
SIGN	1499	0.903	0.297	0	1
PROCR	1980	3.090	1.171	1	5
NAIVE	1614	1.083	1.198	-2	4

2007

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	1555	1.365	1.857	-0.339	5.074
DR2	1541	1.430	1.971	-0.348	5.188
DR3	1552	0.116	0.155	-0.110	0.487
DR4	1546	0.016	0.032	-0.062	0.114
DR5	1221	-0.004	0.025	-0.061	0.108
DISCRATE	1180	-0.079	0.691	-1.580	2.407
HYPERBOL	1527	0.622	0.485	0	1
SIGN	1203	0.908	0.290	0	1
PROCR	1663	3.079	1.165	1	5
NAIVE	1614	1.083	1.198	-2	4

2008

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	2000	1.334	1.842	-0.339	5.041
DR2	2003	1.307	1.822	-0.341	5.017
DR3	2005	0.117	0.155	-0.110	0.487
DR4	1999	0.018	0.033	-0.062	0.114
DR5	1622	-0.005	0.024	-0.061	0.108
DISCRATE	1533	-0.074	0.674	-1.576	2.450
HYPERBOL	1960	0.864	0.343	0	1
SIGN	1594	0.907	0.291	0	1
PROCR	2133	3.072	1.208	1	5
NAIVE	2052	1.112	1.228	-2	4

Pooled

Variable	Obs	Mean	Std. Dev.	Min	Max
DR1	6809	1.488	2.052	-0.369	5.724
DR2	6830	1.503	2.104	-0.373	5.742
DR3	6847	0.123	0.167	-0.121	0.512
DR4	6823	0.017	0.036	-0.065	0.118
DR5	5584	-0.007	0.033	-0.073	0.117
DISCRATE	5326	-0.069	0.665	-1.580	2.450
HYPERBOL	6711	0.698	0.459	0	1
SIGN	5489	0.901	0.299	0	1
PROCR	7344	3.077	1.186	1	5
NAIVE	7779	1.080	1.197	-2	4

Appendix B: Correlation coefficients of time discounting variables with SMOKING

2005

	SMOKING		
	All	Male	Female
DISCRATE	0.094 ***	0.053 *	0.056 *
	(0.000)	(0.087)	(0.057)
HYPERBOL	-0.044 **	-0.020	-0.047 *
	(0.024)	(0.474)	(0.078)
SIGN	-0.036 *	-0.043	-0.040
	(0.090)	(0.156)	(0.171)
PROCR	0.140 ***	0.080 ***	0.100 ***
	(0.000)	(0.003)	(0.000)
NAIVE	0.087 ***	0.080 **	0.101 ***
	(0.000)	(0.019)	(0.001)

2006

	SMOKING		
	All	Male	Female
DISCRATE	0.127 ***	0.091 ***	0.029
	(0.000)	(0.001)	(0.271)
HYPERBOL	-0.069 ***	-0.055 **	-0.013
	(0.000)	(0.027)	(0.591)
SIGN	-0.025	-0.033	-0.017
	(0.189)	(0.228)	(0.515)
PROCR	0.135 ***	0.096 ***	0.064 ***
	(0.000)	(0.000)	(0.005)
NAIVE	0.062 ***	0.057 **	0.060 **
	(0.001)	(0.037)	(0.015)

2007

	SMOKING		
	All	Male	Female
DISCRATE	0.140 ***	0.100 ***	0.056 *
	(0.000)	(0.002)	(0.056)
HYPERBOL	-0.074 ***	-0.065 **	-0.028
	(0.000)	(0.018)	(0.282)
SIGN	-0.040 *	-0.070 **	-0.035
	(0.062)	(0.025)	(0.233)
PROCR	0.132 ***	0.103 ***	0.053 **
	(0.000)	(0.000)	(0.033)
NAIVE	0.069 ***	0.073 ***	0.055 **
	(0.000)	(0.008)	(0.029)

2008

	SMOKING		
	All	Male	Female
DISCRATE	0.105 ***	0.062 **	0.040
	(0.000)	(0.021)	(0.120)
HYPERBOL	0.042 **	0.052 **	0.056 **
	(0.012)	(0.033)	(0.014)
SIGN	0.004	0.003	-0.006
	(0.842)	(0.914)	(0.799)
PROCR	0.095 ***	0.059 **	0.027
	(0.000)	(0.011)	(0.221)
NAIVE	0.042 **	0.048 **	0.031
	(0.010)	(0.046)	(0.166)

Pooled

	SMOKING		
	All	Male	Female
DISCRATE	0.116 ***	0.075 ***	0.045 ***
	(0.000)	(0.000)	(0.001)
HYPERBOL	-0.048 ***	-0.039 ***	-0.015
	(0.000)	(0.003)	(0.219)
SIGN	-0.024 **	-0.035 **	-0.024 *
	(0.014)	(0.015)	(0.078)
PROCR	0.124 ***	0.084 ***	0.059 ***
	(0.000)	(0.000)	(0.000)
NAIVE	0.063 ***	0.063 ***	0.057 ***
	(0.000)	(0.000)	(0.000)

Notes: The tables show the correlation coefficients of cigarette consumption with time discounting variables. Samples include nonsmokers. P-values are in parentheses.

*, **, *** denote statistical significance at the 10%, 5%, and 10% levels, respectively.

Appendix C(a): Summary statistics of SMOKING and control variables (All samples)

2005

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	2972	6.502	11.971	0	46.622
SMOKING>0	898	21.517	12.296	2.739	46.622
MALE	2987	0.470	0.499	0	1
UNIV	2893	0.204	0.403	0	1
RISKAV	2941	50.478	20.489	0	100
INCOME	2361	223.208	164.655	11.667	1500
AGE	2987	49.077	12.962	21	71
CHILD	2939	0.806	0.395	0	1

2006

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	3746	6.226	11.679	0	46.286
SMOKING>0	1066	21.879	11.697	2.767	46.286
MALE	3763	0.471	0.499	0	1
UNIV	3632	0.211	0.408	0	1
RISKAV	3690	50.063	20.196	0	100
INCOME	3085	220.669	176.196	11.667	1700
AGE	3763	49.229	13.111	19	72
CHILD	3679	0.809	0.393	0	1

2007

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	3084	5.873	11.294	0	45.619
SMOKING>0	830	21.820	11.222	2.710	45.619
MALE	3112	0.466	0.499	0	1
UNIV	3029	0.212	0.409	0	1
RISKAV	3063	50.250	20.057	0	100
INCOME	2633	224.453	179.273	17.500	3000
AGE	3112	50.441	12.849	20	73
CHILD	3069	0.824	0.381	0	1

2008

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	4001	5.238	10.724	0	45.825
SMOKING>0	1004	20.873	11.488	2.734	45.825
MALE	4018	0.468	0.499	0	1
UNIV	3900	0.239	0.427	0	1
RISKAV	3960	49.944	20.112	0	100
INCOME	3529	225.837	177.167	7.000	1700
AGE	4018	49.981	13.205	20	74
CHILD	3952	0.808	0.394	0	1

Pooled

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	13803	5.920	11.398	0	46.622
SMOKING>0	3798	21.515	11.688	2.710	46.622
MALE	13880	0.469	0.499	0	1
UNIV	13454	0.218	0.413	0	1
RISKAV	13654	50.160	20.203	0	100
INCOME	11608	223.615	174.910	7.000	3000
AGE	13880	49.686	13.058	19	74
CHILD	13639	0.811	0.391	0	1

Appendix C(b): Summary statistics of SMOKING and control variables (male samples)

2005

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	1395	11.373	14.728	0	46.622
SMOKING>0	648	24.483	12.077	2.753	46.622
UNIV	1364	0.297	0.457	0	1
RISKAV	1385	49.558	21.259	0	100
INCOME	1141	231.022	173.059	14	1500
AGE	1403	50.159	12.875	21	71
CHILD	1375	0.774	0.419	0	1

2006

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	1763	10.937	14.378	0	46.286
SMOKING>0	795	24.253	11.635	2.767	46.286
UNIV	1715	0.307	0.461	0	1
RISKAV	1734	49.156	21.141	0	100
INCOME	1500	231.259	187.844	11.667	1700
AGE	1774	50.231	13.045	19	72
CHILD	1729	0.782	0.413	0	1

2007

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	1437	10.218	13.703	0	45.619
SMOKING>0	618	23.760	10.712	2.797	45.619
UNIV	1412	0.311	0.463	0	1
RISKAV	1426	49.471	20.720	0	100
INCOME	1266	232.342	190.234	17.500	3000
AGE	1449	51.602	12.756	21	73
CHILD	1421	0.806	0.395	0	1

2008

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	1870	9.172	13.394	0	45.825
SMOKING>0	734	23.368	11.193	2.774	45.825
UNIV	1825	0.351	0.477	0	1
RISKAV	1849	49.063	20.983	0	100
INCOME	1700	229.309	176.042	7.000	1700
AGE	1879	51.090	13.093	20	74
CHILD	1838	0.782	0.413	0	1

Pooled

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	6465	10.361	14.051	0	46.622
SMOKING>0	2795	23.965	11.430	2.753	46.622
UNIV	6316	0.318	0.466	0	1
RISKAV	6394	49.286	21.024	0	100
INCOME	5607	230.864	181.893	7.000	3000
AGE	6505	50.769	12.969	19	74
CHILD	6363	0.786	0.410	0	1

Appendix C(c): Summary statistics of SMOKING and control variables (female samples)

2005

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	1577	2.193	6.223	0	43.060
SMOKING>0	250	13.832	9.136	2.739	43.060
UNIV	1529	0.122	0.327	0	1
RISKAV	1556	51.298	19.749	0	100
INCOME	1220	215.900	156.104	11.667	1500
AGE	1584	48.119	12.969	21	71
CHILD	1564	0.834	0.372	0	1

2006

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	1983	2.038	6.054	0	42.996
SMOKING>0	271	14.916	8.734	2.777	42.996
UNIV	1917	0.125	0.331	0	1
RISKAV	1956	50.866	19.289	0	100
INCOME	1585	210.647	163.845	11.667	1500
AGE	1989	48.335	13.108	19	72
CHILD	1950	0.833	0.373	0	1

2007

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	1647	2.081	6.649	0	44.248
SMOKING>0	212	16.166	10.777	2.710	44.248
UNIV	1617	0.126	0.332	0	1
RISKAV	1637	50.929	19.442	0	100
INCOME	1367	217.147	168.228	17.500	1700
AGE	1663	49.428	12.848	20	73
CHILD	1648	0.839	0.368	0	1

2008

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	2131	1.785	5.748	0	43.201
SMOKING>0	270	14.092	9.355	2.734	43.201
UNIV	2075	0.142	0.349	0	1
RISKAV	2111	50.715	19.288	0	100
INCOME	1829	222.610	178.193	10.000	1700
AGE	2139	49.006	13.229	20	74
CHILD	2114	0.832	0.374	0	1

Pooled

Variable	Obs	Mean	Std. Dev.	Min	Max
SMOKING	7338	2.008	6.144	0	44.248
SMOKING>0	1003	14.688	9.487	2.710	44.248
UNIV	7138	0.129	0.336	0	1
RISKAV	7260	50.929	19.420	0	100
INCOME	6001	216.842	167.856	10.000	1700
AGE	7375	48.730	13.062	19	74
CHILD	7276	0.834	0.372	0	1

Appendix D: Correlations between SMOKING and control variables

2005

	SMOKING		
	All	Male	Female
MALE	0.383 ***		
	(0.000)		
UNIV	-0.012	-0.127 ***	-0.052 **
	(0.506)	(0.000)	(0.044)
RISKAV	-0.109 ***	-0.137 ***	-0.041
	(0.000)	(0.000)	(0.107)
INCOME	0.041 **	0.060 **	-0.051 *
	(0.047)	(0.043)	(0.078)
AGE	-0.039 **	-0.060 **	-0.124 ***
	(0.033)	(0.025)	(0.000)
CHILD	-(0.055) ***	-(0.023)	-(0.047) *
	(0.003)	(0.393)	(0.067)

2006

	SMOKING		
	All	Male	Female
MALE	0.380 ***		
	(0.000)		
UNIV	-0.021	-0.136 ***	-0.075 ***
	(0.202)	(0.000)	(0.001)
RISKAV	-0.100 ***	-0.112 ***	-0.059 ***
	(0.000)	(0.000)	(0.009)
INCOME	-0.001	-0.016	-0.047 *
	(0.967)	(0.536)	(0.061)
AGE	-0.033 **	-0.052 **	-0.112 ***
	(0.044)	(0.029)	(0.000)
CHILD	-(0.043) ***	-(0.008)	-(0.050) **
	(0.009)	(0.734)	(0.028)

2007

	SMOKING		
	All	Male	Female
MALE	0.360 ***		
	(0.000)		
UNIV	-0.019	-0.130 ***	-0.065 ***
	(0.305)	(0.000)	(0.009)
RISKAV	-0.091 ***	-0.102 ***	-0.059 **
	(0.000)	(0.000)	(0.017)
INCOME	-0.003	-0.010	-0.037
	(0.879)	(0.718)	(0.175)
AGE	-0.037 **	-0.066 **	-0.097 ***
	(0.040)	(0.013)	(0.000)
CHILD	-(0.029)	(0.002)	-(0.047) *
	(0.114)	(0.940)	(0.056)

2008

	SMOKING		
	All	Male	Female
MALE	0.344 ***		
	(0.000)		
UNIV	-0.010	-0.118 ***	-0.072 ***
	(0.528)	(0.000)	(0.001)
RISKAV	-0.099 ***	-0.099 ***	-0.087 ***
	(0.000)	(0.000)	(0.000)
INCOME	-0.013	-0.016	-0.035
	(0.446)	(0.515)	(0.140)
AGE	-0.025	-0.042 *	-0.096 ***
	(0.122)	(0.071)	(0.000)
CHILD	-(0.003)	(0.038)	-(0.017)
	(0.868)	(0.102)	(0.442)

Pooled

	SMOKING		
	All	Male	Female
MALE	0.366 ***		
	(0.000)		
UNIV	-0.017 **	-0.130 ***	-0.067 ***
	(0.050)	(0.000)	(0.000)
RISKAV	-0.099 ***	-0.111 ***	-0.062 ***
	(0.000)	(0.000)	(0.000)
INCOME	0.003	0.001	-0.042 ***
	(0.719)	(0.927)	(0.001)
AGE	-0.034 ***	-0.056 ***	-0.107 ***
	(0.000)	(0.000)	(0.000)
CHILD	-(0.032) ***	(0.003)	-(0.039) ***
	(0.000)	(0.820)	(0.001)

Notes: The tables show the correlation coefficients of cigarette consumption with control variables. Samples include nonsmokers.
P-values are in parentheses.
*, **, *** denote statistical significance at the 10%, 5%, and 10% levels, respectively.

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Appendix E: Tax hikes, smoking moderation, and increasing rates of tax revenue

Model (1): The marginal effect of tax= -0.416

	before tax hikes	after tax hikes		
Cigarette price per pack	JPY 300 (USD 2.80)	JPY 500 (USD 4.67)	JPY 700 (USD 6.53)	JPY 1000 (USD 9.33)
TAX per cigarette	JPY 0 (USD 0)	JPY 10 (USD 0.09)	JPY 20 (USD 0.19)	JPY 35 (USD 0.33)
Averaged cigarette consumption	20.873	18.880	14.725	13.956
Smoking rates	25.1%	22.4%	22.4%	15.6%
Smoking cessation rates for smokers	0.0%	10.7%	10.7%	37.8%
Increasing rates of revenues	0.0%	73.2%	107.2%	107.9%

Model (2): The marginal effect of tax= -0.423

	before tax hikes	after tax hikes		
Cigarette price per pack	JPY 300 (USD 2.80)	JPY 500 (USD 4.67)	JPY 700 (USD 6.53)	JPY 1000 (USD 9.33)
TAX per cigarette	JPY 0 (USD 0)	JPY 10 (USD 0.09)	JPY 20 (USD 0.19)	JPY 35 (USD 0.33)
Averaged cigarette consumption	20.873	18.807	14.579	13.701
Smoking rates	25.1%	22.4%	22.4%	15.6%
Smoking cessation rates for smokers	0.0%	10.7%	10.7%	37.8%
Increasing rates of revenues	0.0%	72.6%	105.1%	104.1%

Model (3): The marginal effect of tax= -0.315

	before tax hikes	after tax hikes		
Cigarette price per pack	JPY 300 (USD 2.80)	JPY 500 (USD 4.67)	JPY 700 (USD 6.53)	JPY 1000 (USD 9.33)
TAX per cigarette	JPY 0 (USD 0)	JPY 10 (USD 0.09)	JPY 20 (USD 0.19)	JPY 35 (USD 0.33)
Averaged cigarette consumption	20.873	19.890	16.745	17.491
Smoking rates	25.1%	22.4%	22.4%	15.6%
Smoking cessation rates for smokers	0.0%	10.7%	10.7%	37.8%
Increasing rates of revenues	0.0%	82.5%	135.6%	160.5%

Notes: This tabels show the predicted smoking status and increasing rates of government's revenues responding to tax hikes by JPY 10, 20, and 35 (around USD 0.09, 0.19, and 0.33) per cigarette. Estimated coefficients of TAX in model (1), (2), and (3) for full samples are used for the predictions, respectively. The marginal effects are measured around mean values of smokers in 2008. The rows of "Cigarette price per pack" show the hypothetical prices per 20-cigarette pack after tax hikes calculated by (20* TAX per cigarette). The rows of " TAX per cigarette" show the increased rates of tax per cigarette. The rows of "Averaged cigarette consumption", "Smoking rates", and "Smoking cessation rates for smokers" show the resulting status of cigarette consumption after tax hikes. The rows of "Increasing rates of revenues" show the net increasing rates of government's revenues by hiking cigarette tax.

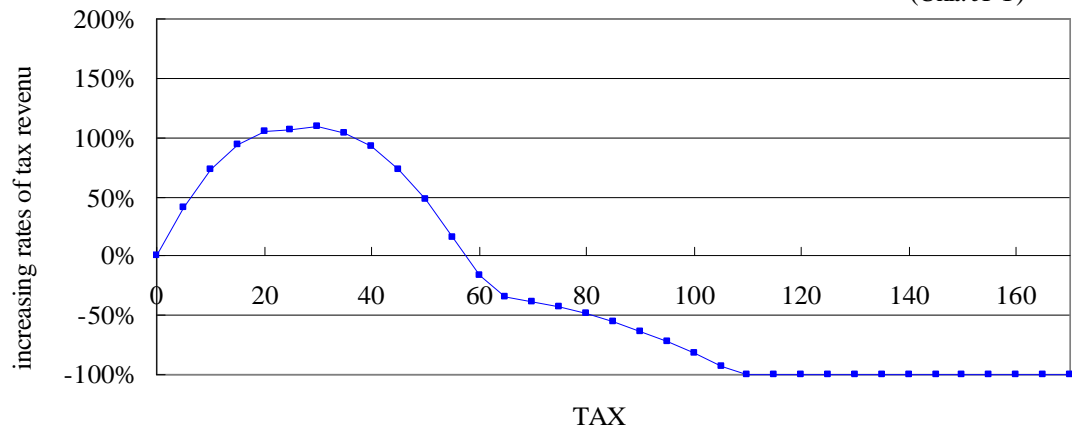**Appendix F: Tax hikes and the increasing rates of tax revenue**

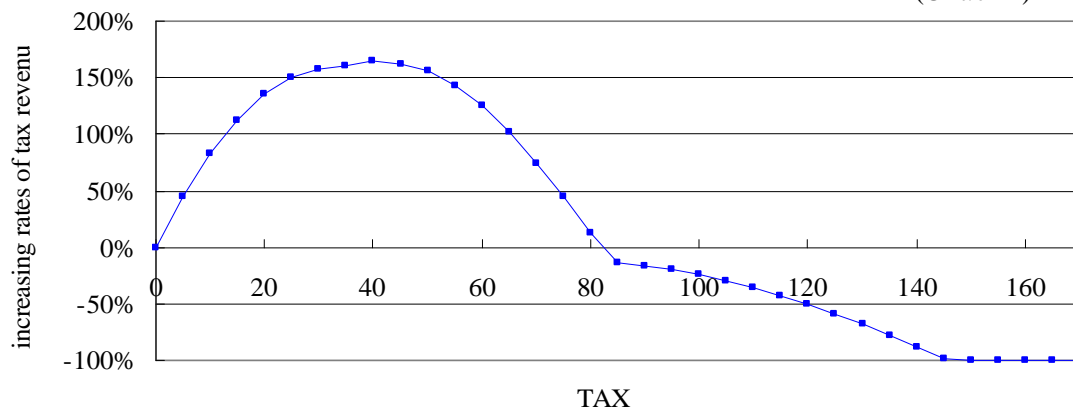**Panel (A): The marginal effect of TAX= -0.416 (Model (1))**

(Unit: JPY)

TAX
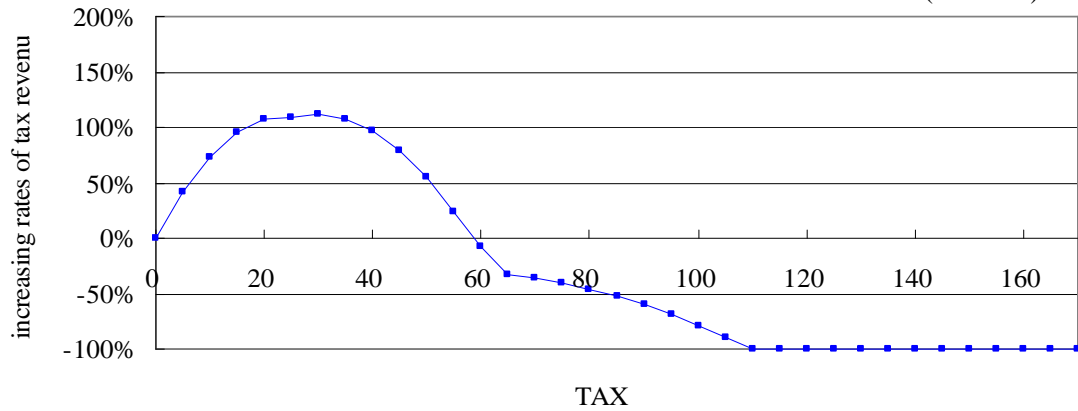
Panel (B): The marginal effect of TAX= -0.423 (Model (2))

(Unit: JPY)

TAX

Panel (C): The marginal effect of TAX= -0.315 (Model (3))

(Unit: JPY)

TAX

Notes: This figures show the predicted increasing rates of government's revenues responding to tax hikes. The horizonal axes indicate the increased rates of tax per cigarette. The vertical axes indicate the net increasing rates of government's revenues by hiking cigarette tax in JPY terms. The estimated coefficients of TAX in model (1), (2), and (3) for full samples are used for the predictions, respectively. The marginal effects are measured around mean values of smokers in 2008.