

**Short-run or Long-run Impacts of Tobacco Tax on  
Teenager's Smoking? A Ten-year Longitudinal  
Study**

by

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February, 2012

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## Short-run or Long-run Impacts of Tobacco Tax on Teenager's Smoking? A Ten-year Longitudinal Study

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**Abstract:** The effects of the tobacco tax and prevention act in reducing smoking behavior have been extensively examined and confirmed, which provides a policy basis for the prevention of smoking. Previous studies in terms of micro data, however, mainly focus on the concurrent impact of a single-wave tax implementation. Little evidence has been known on the persistent effect of single wave shock or dynamic impact of several tax shocks on teenager's smoking behaviors. By using three longitudinal surveys of Taiwanese youths, this study investigate the dynamic impacts of three-wave tobacco taxes implemented in 2002, 2006, and 2009 in Taiwan on teenager's smoking. Our results show that the first-wave tobacco tax performed a largest impact on reducing teenagers' smoking and onset smoking behaviors. With 1% increasing in tobacco price, the probabilities of smoking and onset smoking decreased by 0.021-0.022 and 0.019-0.020 for teenagers born in 1988, 1986 and 1984. The negative impacts of the first-wave tax shock declined gradually with age. Comparing among three waves of tobacco tax shocks, our results depict that the impacts of tax shocks decreased as teenagers aged. The average effects of the first, second, and third tax shocks are -0.02, -0.012, and -0.007, respectively.

**Keywords:** Tobacco taxes, Teenager's smoking, Dynamic impact

JEL Classification: H30, I12, I18

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## **Short-run or Long-run Impacts of Tobacco Tax on Teenager's Smoking? A Ten-year Longitudinal Study**

### **1. Introduction**

The effects of the tobacco tax and prevention act in reducing smoking behavior have been extensively examined and confirmed, and tobacco taxes have emerged as a policy basis for the prevention of smoking (Carpenter and Cook, 2008; Nonnemaker and Farrelly, 2011; DeCicca et al., 2008; Sherry Glied, 2002; Powell et al., 2005; Douglas and Hariharan, 1994; DeCicca et al., 2002). This health policy support mainly comes from the evidences that higher taxes reduce aggregate tobacco sales and adult smoking. The impact of taxes on young smoking, however, is disproportionate. Based on the findings of the Global Youth Tobacco Survey (GYTS) conducted by the World Health Organization (WHO) during 2000s, a large number of teen smokers in developing countries start using tobacco products between the ages of 13-15, becoming long-term tobacco users later in their lives. With the implementation of tobacco tax and prevention act, the teen smoking rates continued rising in numerous developing countries. Taiwan is one of the countries with rising teen smoking rates. During the years of 2002 and 2009, the government of Taiwan levied three-wave tobacco taxes, the male adult smoking rates dropped from 43% in 2004 to 39% in 2007. The smoking rates for teens aged 12-15, however, increased from 8% in 2003 to 10% in 2008. Does tobacco tax play no roles in reducing teens' smoking behaviors? In this study, by tracing three consecutive birth cohorts starting at ages of 12-15 for six to ten years longitudinal data, we investigate the dynamic impacts of repeated tobacco taxes levied in Taiwan during 2000s on teenagers' smoking behaviors.

The rising young smoking rates in U.S. in 1990s received extensive attentions during 2000s. DeCicca, et al.,(2002) started to reexamine whether higher tobacco tax will substantially reduce youth onset smoking. The emphases of recent research on the impacts of tobacco tax includes the impacts on the initiation and/or cessation behaviors of young smoking, and the direct and indirect influences of taxes via peer groups. Previous studies in terms of micro data, however, mainly focus on the concurrent impact of a certain tax implementation, except Glied (2002) in *Journal of Health Economic*. Glied (2002) examine whether the enactment of a certain Tobacco

tax, which reduces youth smoking initiation, will further lessen their lifetime smoking propensities. Her results find that the antismoking policy has significant effect to reduce youth's smoking, but can't sustain for a long time. Accordingly, the important policy questions would then be the following. What would be the dynamic effects of a certain Tobacco tax on teenagers' smoking? How long would the tax effect last? Would the duration of tax impacts depend on the ages of teenagers, and their habituation of smoking? To prevent the teen smokers becoming long-term tobacco users in their later lives, should government impose Tobacco tax in every other years? During the years of 2002 - 2009, the Taiwanese government imposed three waves of tobacco taxes (2002, 2006, and 2009) to lessen nationwide smoking. What would be the dynamic impacts of these Tax implementations on teenagers' smoking behaviors in Taiwan? This study intends to answer these questions.

Since tobacco has a characteristic of addiction which is a state of periodic or chronic intoxication produced by the repeated consumption, the addictive nature of smoking may become a negative force to mitigate the persistent effect of tobacco tax. On the other hand, the risk perception or health risk resulting from lung cancer and tobacco related diseases may enhance the motivation to quit or reduce smoking and further increase the persistent effect of tobacco tax. The persistent impacts of tobacco tax are unclear and become an empirical issue. A single wave shock may only lessen short-term tobacco consumption, but has no long-term effect on lowering the prevalence of smoking if the persistent effect is weak. In contrast, if government repeated imposing tobacco, it may recover the disadvantage of weak persistent effect and make the tobacco control policy more efficiency on youth smoking control. Therefore, to understand the persistent effect for single wave or the dynamic impact for several wave tax shocks is an important topic on understanding youth smoking behavior. The contribution of this study is to examine the dynamic impact of several wave tax shocks on youth smoking behavior, and measure the persistent effect for each single tax shock.

Three identification strategies are carried out in this study. Firstly, to investigate the dynamic effects of a series Tobacco taxes on teenagers' smoking and further

distinguish the concurrent effect from long-run effect of taxes, a rich ten-year longitudinal youth data –Taiwan Youth Project (TYP) Phase I – is used. TYP data is the only data set that contains not only 10 years important life-spans for Taiwanese youths from ages 13-24, but also covers the time periods of major smoking prevention policies in Taiwan. Secondly, three consecutive birth cohorts (1984, 1986 and 1988 birth cohorts) from TYP are compared to identify the impact of tax intervention on teen smoking behavior during different age periods. The 1988 cohort experienced the first, second, and third waves of tobacco price shock when they were in the ages of 15, 19, and 22. While, the 1986 cohort encountered the first, second, and third waves of tobacco price shock when they were 17, 21, and 24 years old. Thirdly, we use a dynamic panel discrete choice model with the difference-in-difference comparisons of the smoking behaviors of 1986 and 1988 birth cohorts before and after the tax to examine the three wave shock of the tobacco tax.

The paper is structured as follows. Section 2 provides a review of tobacco tax effect on smoking behavior. Section 3 describes the Taiwan control policy and data. Section 4 describes our estimation methods. The results are presented in Section 5. Finally, section 6 is the conclusion.

## **2. Recent Literature of Tobacco Tax on Youth Smoking**

Raising the tobacco tax may decrease adult smoking by encouraging current smokers to quit and reduce smoking in teens by preventing the initiation of smoking behaviors. A large number of studies focused on the initiation of young smoking. DeCicca, et al.,(2002) started to reexamine whether higher tobacco tax will substantially reduce youth onset smoking. A number of studies found that the tobacco taxes or price had insignificant influences on youth onset smoking (Douglas and Hariharane, 1994; Hariharan, 1994; Douglas, 1998; DeCicca et al., 2002; DeCicca et al., 2008a; DeCicca et al., 2008b). Furthermore, Glied (2002) showed that higher taxes are positive correlated with delaying smoking initiation. Laux (2000) considered the differences of young and adult initiation behaviors suggested that youth were more reluctant to initiate smoking than adult when they faced higher taxes. By using the survival analysis, Forster and Jones (2001) and Nicolas (2002) found small but

significant the effect of tax and price on reducing smoking initiation. Cawley et al. (2004) focused on gender difference and found that males were more sensitive on price increment than females.

According to conventional wisdom, teens are strongly influenced by the behavior of classmates and close friends. A pioneer work by Powell et al. (2005) used a national representative sample, with a total of 17,287 high school students from 202 senior high schools in the U.S. during 1996, to examine the direct and indirect effects (via peer effect) on smoking behavior. Powell et al. concluded that school-based peer effects have significant impact on youth smoking decision. The cigarette prices and tobacco control policy significantly reduced youth smoking participation directly and indirectly via peer influence. Nonemaker and Farrelly (2011), moreover, jointly examined the influence of cigarette price, tobacco taxes, and peer effect on youth smoking behavior. They found that peer effect has significantly influence on youth initiation smoking. Considering about the gender difference, cigarette prices both significantly reduce the onset smoking of male and female, and tobacco taxes only significantly decreased female initiation smoking and have no impact on male.

The influences of tobacco taxes or price with cessation behavior of youths are also concerned in recent studies. A number of studies found that increasing tobacco taxes or price can encourage cessation behavior of youth (Tworek et al., 2008; DeCicca et al., 2008b). Glied (2002) also provided similar result that tobacco taxes were insignificant correlated with youth quitting smoking behavior.

Limited studies examined the long term effect on tobacco taxes, and suggested that people faced the tobacco tax policy in youth may have no effect after adolescence (Orphanides and Zervos, 1995; Suranovic et al., 1999; Gruber and Koszegi, 2000). Similar topic was extended by Glied (2002), the study provided a new hypothesis and examined whether an enactment of a certain Tobacco tax, which reduced youth smoking initiation, will further lessen their lifetime smoking propensities. Condition on the people who faced taxes increment at age 14, the result showed that higher tax has a significant short-term effect on reducing smoking, but, in the long-term, the tobacco tax effect declined progressively with age increment. Respecting the result,

she concluded that the tax policy may only reduce youth smoking behavior, but no sufficient effect to substantially reduce smoking in adulthood.

### **3. The Development of Taiwan Tobacco Control Policy and Data**

#### ***3.1 Taiwan Tobacco Control Policy***

To prevent tobacco hazards, the government of Taiwan started to implement “Tobacco Hazards Prevention Act” in 1997 to set several restrictions on the advertising of tobacco products and to prohibit vending tobacco products to young under ages of eighteen.<sup>1</sup> The Act was revised several times and made a major milestone in January 2009 to completely prohibit smoking in public area and building.<sup>2</sup> At the same time, during the years of 2002 and 2009, Taiwan’s government imposed three waves of health and welfare surcharge (tobacco tax) to lessen the national-wide smoking. In January 2002, the government of Taiwan officially levied the first tobacco tax, which amounted to NT\$5. The government raised tobacco taxes from NT\$5 to NT\$10 in January 2006, and from NT\$10 to NT\$20 in July 2009. Consequently, the price of tobacco increased substantially in the years of 2002, 2006, and 2009 (Figure 1), with the first wave of tax levied in 2002 implementing a larger tobacco price increase than the other two waves.

Table 1 presents the changes in the smoking rates of teens between the ages of 12 and 15 as well as in adults age 18 and above since the late 1990s. Table 1 reveals that during periods when the price of tobacco increased, the smoking rates of male adults dropped substantially, while the smoking rates of teens aged 12-15 lingered at 4% for females, but increased from 8% to 10% for males. In addition, smoking rates among males were much higher than rates among females. The smoking rates of

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<sup>1</sup> The detailed act is as follow: (1) Tobacco products shall not be sold via Vending machines, mail orders, on-line shopping, or any other methods which cannot be screened the customer’s age by vendors (Article 5); (2) the warning slogan of tobacco hazards was required to print on the tobacco product containers (Article 7); (3) The level of nicotine and tar contained in the tobacco products shall be indicated, in Chinese, on the tobacco product containers (Article 8); (4) no advertise for tobacco products promotion (Article 9); (5) Persons under the age of eighteen shall not smoke, and no person shall provide tobacco products to persons under the age of eighteen (Article 11-12); (6) smoking is prohibited in specific place (Article 13-14); (7) education and publicizing campaign against tobacco hazards (Article 17-19).

<sup>2</sup> The revise of the Act in 2009 specially focused on two aspects: (1) imposed the health and welfare surcharge (tobacco tax) for NT 10 per package of 20 cigarettes (Article 4); (2) smoking is complete prohibited in public place (Article 15-16)

males were 2.0 times higher than females for teens aged 13-15 and almost tenfold higher for adults aged 18 and above.

### **3.2 Data**

To investigate the tobacco tax effect of three consecutive shocks implemented in 2002, 2006, and 2009, three longitudinal surveys of Taiwanese teens are used and compared. The first and second panel survey data used are obtained from a longitudinal survey of “Taiwan Youth Project (TYP)” which comprise 1988 birth cohort (survey year from 2000 to 2009) and 1986 birth cohort (survey year from 2000 to 2008). The 1988 birth cohort were first investigated in the first year of junior high school or 7<sup>th</sup> grades with an average age of 13 years old, and the 1986 birth cohort were first surveyed in the third year of junior high school or 9<sup>th</sup> grades with an average age of 15 years old. The 1988 cohort experienced the first, second, and third waves of tobacco price shock when they were in ages of 14, 18, and 21. The 1986 cohort encountered the first and second waves of tobacco price shock when they were 17 and 21 years old. The 1988 birth cohorts are referred as the experiment cohort. The third panel survey used in this study is “The Etiology of Adolescent’s Substance Abuse: A Social Learning Model (EASA)”, in which the survey year of 1984 birth cohort was from 1996 to 2002 and first interviewed were in 7<sup>th</sup> grades with an average age of 13 years old. The 1984 birth cohort encountered the first waves of tobacco price shock when they were in age 17.<sup>3</sup> Since the teens of 1984 and 1986 birth cohorts have not encountered the first boost of tobacco price before age 17, they were referred as the control cohort for the first tobacco price shock. These three longitudinal surveys were conducted by Research Center for Humanities and Social Sciences of Academia Sinica in Taiwan.

These three longitudinal surveys are all school based sampling and employs a multi-stage stratified sampling design to produce representative data on students aged 13 in the first year of junior high school. The first stage consists of a probabilistic selection of schools, and the urbanization degree and class size of schools in northern Taiwan were taken into account. The second stage consists of a random selection of 2

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<sup>3</sup> The accurate comparison between tobacco price shock and the age of three panel survey data please see Table 1.



to 3 classes from the participating schools. All students in the selected classes are eligible for the survey. These three surveys interviewed teenagers from entire class provides us with complete information regarding the smoking history, individual and family characteristics of teenagers and their entire classmates.

The survey of 1988 and 1986 birth cohort samples 2696 and 2890 students from 81 classes in 40 schools, and the survey of 1984 birth cohort samples 1596 students from 44 classes in 33 schools.

### **3.3 Smoking behaviors and Sample Characteristics**

Table 2 presents the difference-in-difference comparisons of individual's smoking rate before and after tax for 1988, 1986, and 1984 cohorts. Due to the different exposures of tobacco shocks in each age for 1988, 1986, and 1984 cohorts, the 1988 cohort was referred as experiment group, and both 1986 and 1984 cohort was combined to be control groups. The participants in the 1988 cohort (experiment group) practiced the first wave of tobacco tax between age 13-14 and age 14-15 while the cohort of control group did not encountered the first price shock until age 16-17. The second wave of tax shock in the cohort of experiment group was between age 17-18 and age 18-19, while the cohort of control group encountered the second wave of tax shock not until age 19-20. The third wave of tax shock in in the cohort of experiment group was between age 20-21 and age 21-22, but not the cohorts of control group during our sample years. The difference-in-difference comparisons in column 5 show that after the first wave of tax shock, the smoking rate was immediately reduced 4.3% for youth age 14-15. The impacts of the first tax shock, however, diminished since then for youth aged 15-17. The impact of the second and the third tax shocks were respectively equal to 1 % and 0.9% on reducing smoking rate at age 19-20 and at 21-22. Comparing with three waves of tax shock, we found that even though the amount of third wave tax shock was double than previous two waves, the impacts of tax increment were alleviated when the teens became older. During the second and third shock, the effects of tobacco tax policy were weaker on reducing young smoking.

The mean statistics of the characteristics of both youth and their parents are

presented in Table 3. It shows that over ages 12-22, youths living in Taipei city had lower smoking rates and lower onset smoking rates than suburb neighboring countries. Although the tobacco tax levied nation-widely at the same amount, tobacco prices may rise differently among urban and rural areas depending on the local demand and supply. Table 3 shows that tobacco price per pack is about NT\$84, and is slightly lower in Taipei city.

Student characteristics show that the city of Taipei has a slightly higher male population. With more educational resources privately and publicly in Taipei city, academic scores in the last semester of the school year in Taipei city were higher than her neighboring counties. While, academic scores in the last semester of the school year were similar for teens in neighboring counties. The average academic score was around 3.0 on a 5.0 scale, which represents absolute score points in the range of 70-79 on a 100-point base.<sup>4</sup> Variable “health conditions in the last year” includes mental disorder, physical disorder, and sleep disorder.<sup>5</sup> The three measures of “disorder” ascend with the degree of discomfort, and range from no distress (a score of 1) to very serious distress (a score of 5). The higher the score of the “disorder” is the more serious the distress reported by the youth. It showed that in general, youths living in Taipei city were in better health than those living in neighboring counties. Teens in neighboring counties also had better health than teens in the city of Taipei.

In terms of family characteristics, the study’s data showed determined that Minnan, the major tribal group in Taiwan, were more likely to live in Taipei and Yilan counties than in the city of Taipei. Native Taiwanese were also more likely to reside in Taipei and Yilan counties than in the city. In contrast, Hakka and Mainlander tribal groups were more likely to live in the city of Taipei. The education of the father of the family unit and family income were higher for teens living in the city of Taipei and

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<sup>4</sup>The scale of academic score are defined as following: 5= 「100-90 points」, 4= 「89-80 points」, 3= 「79-70 points」, 2= 「69-60 points」, 1= 「59-0 points」.

<sup>5</sup> “Mental disorder” measures the degree of loneliness and depression and is computed as the average of the self-reported measures of “loneliness” and “depression”. “Physical disorder” measures the degree of physical discomfort and is classified and computed as the average of the self-reported measures of “something stuck in your throat”, “weakness in some parts of the body”, “headache”, and “numbness in some parts of the body”. “Sleep disorder” measures the degree of insomnia and is calculated by averaging the self-reported measures of “insomnia”, “awake early in the morning and can’t fall asleep”, and “unstable to sleep or wake up often”.

relatively lower for teens living in Taipei and Yilan counties. Also, teens living in the city of Taipei were more likely to grow up in an intact family; an absent father or mother was more often observed in the families of teens in neighboring counties. In general, teens in the city of Taipei had more economic and social advantages than teens in neighboring counties.

#### **4. Methodology**

Based on the smoking rates shown in Table 1, the nationwide cross-sectional youth data and the longitudinal youth data reveals that smoking rates of youth rise with ages. It implicitly indicates that as young person transit from teen years to young adulthood, their onset smoking behaviors exceeded their cessation smoking which induced a growing smoking rates. Orphanides and Zervos (1995) argued that an inexperienced user, such as a teen, is not fully aware of the potential harm associated with cigarette consumption. The hazardous effects of consuming an addictive substance are not the same for all consumers, and each consumer possesses a subjective understanding of his or her potential to become addicted. The timing of psychological and cognitive development for younger teens has observed age differences. To explicitly examine the impacts of repeated three waves tobacco taxes on the smoking behavior of Taiwanese youths at different ages, we conduct two specification of dynamic tobacco tax effect on smoking participation and initial smoking. First, we use Fixed Coefficient Model to estimate the tobacco tax effect. Second, we release the restriction on constant marginal impact of tobacco tax and take into account the possibility of different responses of youth at different ages on tobacco price change. Thus, the Random Coefficient Model was used in this analysis. The models are represented as follow.

##### ***4.1 Model 1. The Fixed Coefficient Model***

The ordinary logit model and random-effect logit model are used to capture the tobacco tax effect on the smoking participation or initial smoking behavior. Eq.(1) is the logit model, which can be estimated by maximum likelihood estimate method.

$$y_{it} = \alpha + \beta \ln TP_{it} + \sum_{s=12}^{22} AGE_{it} \delta_s + X'_{it} \gamma_2 + \varepsilon_{it}, \quad i=1, \dots, N; \quad t=12, \dots, 22 \quad (1)$$

where  $y_{it}$  is the dummy variable indicating either smoking participation or onset smoking.  $\ln TP_{it}$  is the logarithm tobacco price which a youth  $i$  faced at age  $t$ .  $AGE_{it}$  is the age dummy variable, which equals to 1 if  $t=s$ , and 0 otherwise.  $X_{it}$  is the youth's and family characteristics vector.  $\varepsilon_{it}$  is an error term.

In Eq.(1), the coefficient  $\beta$  measures the elasticity of participation probabilities, which indicates the changes of the probability of smoking participation behavior or onset smoking behavior when tobacco price changes one percentage. The tobacco tax effect is expected to be the negative value of  $\beta$ . Under ordinary logit specification, the marginal impact of tobacco tax  $\beta$  is constant over different ages. The set of  $\delta$ , however, captures the different smoking participation behaviors or onset behaviors at different ages.

To take into account the unobserved individual heterogeneity, we further adopt the random-effect logit model. Equation (1) becomes the following.

$$y_{it} = \alpha + \beta \ln TP_{it} + \sum_{s=12}^{22} AGE_{it} \delta_s + X'_{it} \gamma_2 + u_i + \varepsilon_{it} \quad (2)$$

After controlling for the unobserved individual heterogeneity, the model could provide the more precise tobacco tax effect estimation and the coefficient estimate of  $\beta$  obtained from random-effect logit model is consistent..

#### **4.2 Model 2. The Random Coefficient Model**

In order to capture the different age responses to the tobacco tax when a youth aged, we adopt the Random Coefficient Model to evaluate the tobacco tax effect on the probability of individual smoking. Comparing with the Fixed Coefficient Model, the Random Coefficient could provide multiple coefficient of the logarithm tobacco price,  $\beta_t$ , which the individual faced at his/her different age. This model could provide further analysis of the tobacco tax effect and the individual's response to the tobacco tax when individual is at different ages.

The Random-Coefficient logit model and Random-coefficient random effect logit model are considered to capture the different marginal responses of tobacco on a youth's smoking participation and onset smoking behaviors at different age,  $\beta_t$ . The

Random-coefficient random effect logit model is specified as follows.

$$y_{it} = \alpha + \ln TP_{it} \beta_t + X'_{it} \gamma_2 + u_i + \varepsilon_{it} \quad (3)$$

After controlling for the unobserved individual heterogeneity of a youth, we could obtain the more accurate and consistent estimates of the coefficients from the Random-Effect Random Coefficient logit model. Hence, we know more clearly how the tobacco tax affects the individual's response to smoking or initial smoking at different ages.

## 5. Empirical Result

Since smoking rates of youth rise with ages, it shows that onset smoking behaviors of youths exceeded their cessation smoking as young persons transit from teen years to young adulthood. In this study, we examine the short-run and long-run impacts of three-wave tobacco taxes levied during 2002-2009 in Taiwan on youth participation and onset smoking behaviors.

### 5.1 Smoking Participation

Table 4 presents the results of the ordinary logit and random effect logit estimation for individual's smoking participation behaviors. The result suggests that after controlling for the individual and family characteristics, the smoking rate of a youth was significantly reduced due to the rise in tobacco price. The marginal effect of Logit model shows that 1% increases in tobacco price would significantly reduce the probability of smoking participation by 0.074. The elasticity of smoking participation probability among Taiwanese youth is -0.074. Age dummies in Table 4 capture the smoking preference of different ages, and suggest a significant increment in smoking preference when the age is going up. Columns 3 and 4 in Table 4 present the result of the random effect estimation. After controlling for unobserved individual heterogeneity, the result also suggests a statistically significant reduction in smoking rate when tobacco price is increment. The marginal effect of random effect logit model suggests a slightly lower elasticity of smoking participation of -0.048 after controlling for the unobserved individual heterogeneity. Based on the fixed coefficient model, the average effect of tobacco price is constant for youth at different

ages.

The significant and large positive impact of variable “smoking in last year” reveals the addictive nature of consuming tobacco products among young people. A youth smoking in the last year will have a probability of 0.237~0.465 consuming tobacco product this year. Gender plays a significant role in influencing youth’s smoking behavior. A male has a higher probability of smoking participation than a female counterpart. In contrast, a youth’s academic performance is negatively and significantly associated with smoking participation. Since academic score was available for all 1984, 1986, and 1988 cohorts and reported by teachers, academic score at Grade 9 is used as a proxy variable for youth’s academic ability. The higher the academic score at Grade 9 is, the lower the probability of smoking. Variable “health conditions in the last year” includes mental disorder, physical disorder, and sleep disorder. The three measures of “disorder” ascend with the degree of discomfort. The higher the score of the “disorder” is the more serious the distress reported by the youth. Mental disorder and physical disorder play no roles in influencing youth’s smoking, while sleep disorder in last year are positively and significantly associated with individual’s smoking participation.

Comparing to the intact family, the living in a non-intact family is positively and significantly correlated with youth’s smoking behavior. Higher parental education will lower the probability of their youth’s smoking participation, especially father graduated from college and above. After controlling for age propensity, individual and family characteristics, native Taiwanese has no significant different smoking propensity from other tribal. Results of the estimates in control variables are similar between ordinary logit model and Random effect model.

In Table 5, we present the Random Coefficient estimation of smoking participation to allow for the different age responses to the changes in tobacco price. The results also support that tobacco prices faced by a youth at each age had different, negative and significant impacts on youth’s smoking behavior. Despite the impacts of tobacco price declined with ages, the price effect at each age is still statistically significant on reducing the smoking participation. The random effect estimations in

column 3 and 4 also indicate that after controlling for the observed and unobserved individual's heterogeneity, a youth's smoking participation behavior was significantly reduced due to the rises in tobacco prices at each age. Although the impact of tobacco price diminish with ages, the price effect is significant at each age. After controlling for the unobserved individual heterogeneity, the elasticity of smoking participation probability ranging from -0.56 to -0,042 for youth ages of 12~22.

## **5.2 Onset Smoking**

Raising the tobacco tax may decrease adult smoking by encouraging current smokers to quit and reduce smoking in teens by preventing the initiation of smoking behaviors. The hazard-like onset smoking rate was conducted and examined in this study. The effect of tobacco price on individual onset smoking is reported in Table 6 and Table 7. Table 6 shows that, after controlling for the observed and unobserved individual and family characteristics, the marginal effect of  $\ln$  tobacco price depicted the elasticity of onset probability by -0.066. Age dummies show a significant increment in onset smoking preference when a youth's age is going up.

Comparing to the results of smoking participation in Table 4 with onset smoking behavior in Table 6, the influences of individual and parental characteristics on a youth's smoking participation and onset smoking are similar. For example, variables, including gender, academic preference in the pervious year, sleep disorder in the last year, and parental education, have similar impact on both smoking participation and onset smoking behaviors. Furthermore, serious mental disorder in the last year will induce a higher probability of a youth's onset smoking behavior. Comparing to the intact family, a parent's absent will significantly result in higher probability of their youth's onset smoking.

The random coefficient estimation in Table 7 takes into account different age responses to the changes in tobacco price. Both logit model and the random effect model reveal that tobacco price effect at each age was negatively and significantly associated with a youth's onset smoking behavior. Result for random coefficient model suggests that larger age a youth is, the lower the impact of tobacco price on a youth's onset smoking is.

### 5.3 Price Impacts during Three-wave Tax Shocks

During the years of 2002 - 2009, the Taiwanese government imposed three waves of tobacco taxes (2002, 2006, and 2009) to lessen nationwide smoking. What would be the dynamic impacts of these Tax implementations on teenagers' smoking behaviors in Taiwan? What would be the short-run effects of a certain Tobacco tax on teenagers' smoking? How long would the tax effect last? Would the duration of tax impacts depend on the ages of teenagers, and their habituation of smoking? Table 8-11 calculate the total tax effect on smoking participation and onset smoking rate for 1984, 1986, 1988 cohorts at each age during the period of 2000~2009 by using the coefficient estimates of Fixed Coefficient model and Random Coefficient model. Since the price effects of three-wave tax shocks were substantially different and each cohort was facing tobacco tax shock at different ages, we calculate the total tobacco price impacts of three-wave tax shock for each birth cohort and report the overall tax effect in column 1 to 6. Table 8 and Table 9 present that the total tobacco tax effects on smoking participation calculated by using Fixed Coefficient and Random Coefficient model, respectively. The fixed coefficient results of Table 8 for 1984, 1986, and 1988 cohorts consistently reveal that the first-wave shock of tax increment in year of 2002 significantly reduced the probability of a youth's smoking participation by 0.021-0.022. After controlling for unobserved individual heterogeneity, the effect of first tax shock on three cohorts still remained -0.014. Comparing with three waves of tobacco tax shock for 1988 cohort, the result shows that the tax effect is decreasing with age. In general, the effect of the first shock effect is -0.020, the second shock is -0.012, and the third shock is -0.007. The result of the Random Effect model is less but similar.

After considering the different responses of a youth's smoking behavior to the rises in tobacco prices at different ages, Table 9 shows that the tobacco tax impacts under random coefficient estimation are similar with those from fixed coefficient estimation. Comparing with 1988, 1986 and 1984 birth cohort in Table 9, the effect of first-wave tobacco tax is around -0.021~ -0.020 on reducing smoking rate, and the tax effect declined with age.



Table 10 and Table 11 present the price impacts of three-wave tobacco taxes on a youth's hazard-like onset smoking effect by using the fixed and random coefficient estimations. The first tax impacts on reducing a youth's onset smoking for 1988, 1986 and 1984 cohorts are in the range of 0.019-0.020. Comparing three-wave shocks of tobacco tax increment for 1988 cohort, the results in Table 9 indicate that the first tax impact is largest among all three waves of tax shock. Similarly, the tax effect on a youth's onset smoking behavior declined with the growing of ages. After controlling for the unobserved individual heterogeneity, the random effect model for each cohort reveal similar tobacco tax impacts on a youth's onset smoking. Table 11 shows the tobacco tax impacts on hazard-like onset smoking for Random Coefficient model. Considering the age influence, either logit model or Random Effect logit model reveals the same impact of tobacco tax increment on onset smoking behavior. The dynamic tax effects mitigated when a youth became elder.

## **6. Conclusion**

During the years of 2002 - 2009, the Taiwanese government imposed three waves of tobacco taxes (2002, 2006, and 2009) to lessen nationwide smoking. In this study, we examined the short-run and long-run tobacco price responses on a youth's smoking participation and onset smoking behaviors in Taiwan during the years of 2000 - 2009. Three consecutive birth cohorts (1984, 1986 and 1988 birth cohorts) from TYP are compared to identify the impact of tax intervention on teen smoking behavior during different age periods. To explicitly examine the impacts of repeated three waves tobacco taxes on the smoking behavior of Taiwanese youths at different ages, we conduct two specification of dynamic tobacco tax effect on smoking participation and initial smoking. First, we use fixed coefficient model to estimate the tobacco tax effect. Second, we release the restriction on constant marginal impact of tobacco tax and take into account the possibility of different responses of youth at different ages on tobacco price change by using random coefficient model.

We found that rising tobacco prices due to the implement of tobacco taxes are the significant policy tools on reducing a youth's smoking participation and onset smoking behaviors. The elasticity of smoking participation probability among

Taiwanese youth is -0.074. After controlling for unobserved individual heterogeneity, the marginal effect of random effect logit model suggests a slightly lower elasticity of smoking participation of -0.048. The random coefficient estimation suggests that the elasticity of smoking participation probability ranged from -0.56 to -0.042 for youth ages of 12~22.

By multiplying the percentage changes in tobacco prices confronted by each cohort at each age with the elasticity of smoking participation and onset smoking from fixed coefficient model and random coefficient estimations, the total tax effect on smoking participation and onset smoking rate for 1984, 1986, 1988 cohorts at each age during the period of 2000~2009 were calculated. The first-wave shock of tax increment in year of 2002 significantly reduced the probability of a youth's smoking participation by 0.021-0.022. After controlling for unobserved individual heterogeneity, the effect of first tax shock on three cohorts still remained -0.014. Comparing with three waves of tobacco tax shock, the result shows that the tax effect is decreasing with age. In general, the effect of the first shock effect is -0.020, the second shock is -0.012, and the third shock is -0.007. The first tax impacts on reducing a youth's onset smoking for 1988, 1986 and 1984 cohorts are in the range of 0.019-0.020. Similarly, the tax effect on a youth's onset smoking behavior declined with the growing of ages.

This study contributes to previous studies by addressing the repeated tax impacts on a youth's smoking participation and onset smoking by using a longitudinal youth data in developing countries. We found that a higher tobacco price and tax will decrease both young smoking and onset smoking behaviors in Taiwan. The tobacco price- and tax-effect are significant at each age.

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**Table 1: Smoking Rates of Comprehensive Sex by Difference Dataset In Taiwan**

	Taipei City	Taipei County & Yilan County	Nation -wide
<b>Teenager survey (age 12 to 15)</b>			
<b>Panel Data:</b>			
<b>The Etiology of Adolescent's substance Abuse: A Social Learning Model</b>			
1984 Birth cohort (survey years 1996-1998)			
Male	0.220		
Female	0.135		
<b>Taiwan Youth Project Survey</b>			
1988 Birth cohort (survey years 2000-2002)			
Male	0.166	0.229	
Female	0.100	0.128	
<b>Cross Section Data:</b>			
<b>Global Youth Tobacco Survey</b>			
1992-1994 Birth Cohort (2004 survey)			
Male	0.051	0.100	0.082
Female	0.026	0.051	0.043
1996-1998 Birth Cohort (2008 survey)			
Male	0.053	0.108	0.103
Female	0.022	0.059	0.049
<b>Adults survey (age 18 and above)</b>			
<b>Cross Section Data:</b>			
<b>Adult Smoking Behavior Surveillance System</b>			
2004 survey			
Male			0.428
Female			0.045
2007 survey			
Male			0.390
Female			0.051

Data resource: Both Global Youth Tobacco Survey and Adult Smoking Behavior Surveillance System are conducted by the Bureau of Health Promotion, Department of Health, Taiwan, R.O.C..

**Table 2 Smoking rate of Comprehensive dataset longitudinal youth data**

	<b>Experiment Group</b>		<b>Control Group</b>		<b>Difference in Difference</b>
	1988 birth cohort (Survey year 000-2009)		1984 and 1986 birth cohort (Survey year 1996-2006)		
	mean	Diff. (before tax)	mean	Diff. (before tax)	Diff. (before tax)
Smoking rate of age:					
<b>junior middle school:</b>					
Age 12-13	0.078		0.032		
Age 13-14	0.083		0.108		
	<b>( Tax Shock I )</b>				
Age 14-15	0.098	0.015	0.166	0.058	-0.043
<b>Senior high school:</b>					
Age 15-16	0.053	-0.030	0.068	-0.040	0.010
Age 16-17	0.084	0.001	0.106	-0.002	0.003
	<b>( Tax Shock I )</b>				
Age 17-18	0.135	0.051	0.141	0.033	0.018
	<b>( Tax Shock II )</b>				
<b>College:</b>					
Age 18-19	NA	NA	0.192	0.051	NA
Age 19-20	0.145	0.010	0.161	0.020	-0.01
Age 20-21	---	---	---	---	---
	<b>( Tax Shock III )</b>		<b>( Tax Shock II )</b>		
Age 21-22	0.170	0.025	0.195	0.034	-0.009

Note: Tax Shock I is 2002 Tobacco Tax Increase to NT5. Tax Shock II is 2006 Tobacco Tax Increase to NT10. Tax Shock III is 2009 Tobacco Tax Increase to NT20.

**Table 3 Mean Statistics**

	Taipei city	Taipei county	Yilan county	Overall
Smoking ratio	0.099	0.124	0.114	0.110
Onset smoking ratio	0.038	0.041	0.041	0.040
Tobacco price (CPI/month)	81.167	86.160	86.217	83.711
<b>Student's Characters</b>				
Gender=1 if male	0.513	0.491	0.517	0.507
Academic score in the grade 9	3.209	2.910	3.017	3.099
Health condition				
Mental disorder in the last year	1.645	1.723	1.660	1.672
Physical disorder in the last year	1.386	1.479	1.433	1.423
Sleep disorder in the last year	1.328	1.402	1.379	1.360
<b>Parent's characters</b>				
Father's ancestry				
Minnan	0.689	0.752	0.852	0.738
Hakka	0.181	0.116	0.060	0.139
Mainlander	0.088	0.074	0.029	0.073
Native	0.007	0.012	0.009	0.009
Father's education				
Father junior middle school graduate and below	0.263	0.480	0.506	0.377
Father high school graduate	0.294	0.300	0.287	0.294
Father college graduate and above	0.396	0.174	0.152	0.280
Family Income (unit: NT1000)	70.656	59.835	52.942	63.715
Parental living				
Intact family	0.883	0.873	0.863	0.876
Non-intact families	0.077	0.072	0.076	0.075
Father or mother absent	0.040	0.055	0.062	0.049

Note: Standard error in parentheses. \*\*\*, \*\*, and\* denotes statistical significance at the 1%, 5% and 10% level. Mental disorder combines two health measures: loneliness and depression. Physical disorder includes four health measures: "something stuck in your throat"、"weakness in some parts of the body"、"headache"、and "numbness in some parts of the body". Sleep disorder includes three health measures: "insomnia", "awake early in the morning and can't fall asleep"、and "unstable sleep or wake up often"。Constant term is included.



**Table 4 Empirical Result for Fixed Coefficient Model of Smoking**

	Logit Model		Random Effect Logit Model	
	Coefficient	Marginal effect	Coefficient	Marginal effect
Ln Tobacco Price	-1.453*** (0.532)	-0.074*** (0.027)	-1.506** (0.619)	-0.048** (0.020)
Age 14-15 (dummy)	0.354*** (0.127)	0.020** (0.008)	0.348** (0.141)	0.012** (0.005)
Age 15-16 (dummy)	-0.670*** (0.173)	-0.028*** (0.006)	-0.786*** (0.191)	-0.020*** (0.004)
Age 16-17 (dummy)	0.490*** (0.168)	0.030** (0.012)	0.495*** (0.185)	0.019** (0.008)
Age 17-18 (dummy)	0.722*** (0.174)	0.048*** (0.015)	0.843*** (0.195)	0.037*** (0.012)
Age 19-20 (dummy)	0.898*** (0.241)	0.064*** (0.023)	1.113*** (0.275)	0.056*** (0.020)
Age 21-22 (dummy)	1.053*** (0.275)	0.079*** (0.029)	1.304*** (0.316)	0.070*** (0.026)
<b>Control Variables</b>				
<b>Student's characters</b>				
Smoking in last year	3.146*** (0.075)	0.465*** (0.017)	2.559*** (0.122)	0.237*** (0.033)
Gender, male=1	0.735*** (0.070)	0.038*** (0.004)	0.877*** (0.094)	0.028*** (0.003)
Academic score in the grade 9	-0.402*** (0.030)	-0.020*** (0.001)	-0.536*** (0.045)	-0.017*** (0.001)
<b>Health condition</b>				
Mental disorder in the last year	0.053 (0.041)	0.003 (0.002)	0.073 (0.047)	0.002 (0.001)
Physical disorder in the last year	0.012 (0.059)	0.001 (0.003)	-0.012 (0.068)	0.000 (0.002)
Sleep disorder in the last year	0.222*** (0.048)	0.011*** (0.002)	0.254*** (0.056)	0.008*** (0.002)
<b>Parent's characters</b>				
<b>Father's ancestry:</b>				
Native	0.093 (0.268)	0.005 (0.015)	0.280 (0.374)	0.010 (0.015)
<b>Parental living arrangement</b>				
Non-intact families	0.302*** (0.116)	0.017** (0.007)	0.387*** (0.147)	0.014** (0.006)
Father or mother absent	0.163 (0.138)	0.009 (0.008)	0.264 (0.180)	0.009 (0.007)
<b>Father's education</b>				
Father high school graduate	-0.063 (0.079)	-0.003 (0.004)	-0.110 (0.100)	-0.003 (0.003)
Father college graduate and above	-0.215** (0.092)	-0.010** (0.004)	-0.281** (0.118)	-0.008** (0.003)
Family income	-0.001 (0.001)	0.000 (0.000)	-0.001 (0.001)	0.000 (0.000)
<b>Residential area in junior high school</b>				
Taipei county	-0.034 (0.080)	-0.002 (0.004)	-0.071 (0.108)	-0.002 (0.003)
Yilan county	-0.149 (0.094)	-0.007 (0.004)	-0.226* (0.127)	-0.007* (0.004)
Random Effect			Yes	Yes
<b>Observations</b>	16023	16023	16023	16023

Note: Standard error in parentheses. \*\*\*, \*\*, and\* denotes statistical significance at the 1%, 5% and 10% level.

**Table 5 Empirical Result for Random Coefficient Model of Smoking**

	Logit Model		Random Effect Logit Model	
	Coefficient	Marginal effect	Coefficient	Marginal effect
<b>Random Coefficient Ln Tobacco Price in:</b>				
Ln Tobacco Price *Age 13-14	-1.553*** (0.552)	-0.079*** (0.028)	-1.610** (0.643)	-0.051** (0.021)
Ln Tobacco Price *Age 14-15	-1.468*** (0.532)	-0.075*** (0.027)	-1.526** (0.619)	-0.048** (0.020)
Ln Tobacco Price *Age 15-16	-1.698*** (0.527)	-0.086*** (0.027)	-1.780*** (0.614)	-0.056*** (0.020)
Ln Tobacco Price *Age 16-17	-1.438*** (0.525)	-0.073*** (0.027)	-1.494** (0.613)	-0.047** (0.020)
Ln Tobacco Price *Age 17-18	-1.387*** (0.524)	-0.070*** (0.027)	-1.416** (0.611)	-0.045** (0.020)
Ln Tobacco Price *Age 19-20	-1.351*** (0.506)	-0.069*** (0.026)	-1.361** (0.591)	-0.043** (0.019)
Ln Tobacco Price *Age 21-22	-1.320*** (0.498)	-0.067*** (0.025)	-1.323** (0.581)	-0.042** (0.019)
<b>Control Variables</b>				
<b>Student's characters</b>				
Smoking in last year	3.146*** (0.075)	0.465*** (0.017)	2.559*** (0.122)	0.237*** (0.033)
Gender, male=1	0.735*** (0.070)	0.038*** (0.004)	0.877*** (0.094)	0.028*** (0.003)
Academic score in the grade 9	-0.402*** (0.030)	-0.020*** (0.001)	-0.536*** (0.045)	-0.017*** (0.001)
<b>Health condition</b>				
Mental disorder in the last year	0.053 (0.041)	0.003 (0.002)	0.073 (0.047)	0.002 (0.001)
Physical disorder in the last year	0.012 (0.059)	0.001 (0.003)	-0.012 (0.068)	0.000 (0.002)
Sleep disorder in the last year	0.223*** (0.048)	0.011*** (0.002)	0.254*** (0.056)	0.008*** (0.002)
<b>Parent's characters</b>				
<b>Father's ancestry:</b>				
Native	0.093 (0.268)	0.005 (0.015)	0.280 (0.374)	0.010 (0.015)
<b>Parental living arrangement</b>				
Non-intact families	0.302*** (0.116)	0.017** (0.007)	0.387*** (0.147)	0.014** (0.006)
Father or mother absent	0.163 (0.138)	0.009 (0.008)	0.264 (0.180)	0.009 (0.007)
<b>Father's education</b>				
Father high school graduate	-0.063 (0.079)	-0.003 (0.004)	-0.110 (0.100)	-0.003 (0.003)
Father college graduate and above	-0.215** (0.092)	-0.010** (0.004)	-0.281** (0.118)	-0.008** (0.003)
<b>Family income</b>				
Residential area in junior high school	-0.001 (0.001)	0.000 (0.000)	-0.001 (0.001)	0.000 (0.000)
Taipei county	-0.033 (0.080)	-0.002 (0.004)	-0.069 (0.108)	-0.002 (0.003)
Yilan county	-0.147 (0.094)	-0.007 (0.004)	-0.224* (0.128)	-0.007* (0.004)
Random Effect			Yes	Yes
<b>Observations</b>	16023	16023	16023	16023

Note: Standard error in parentheses. \*\*\*, \*\*, and\* denotes statistical significance at the 1%, 5% and 10% level.

**Table 6 Empirical Result for Fixed Coefficient Model of Hazard-like Onset Smoking**

	Logit Model		Random Effect Logit Model	
	Coefficient	Marginal effect	Coefficient	Marginal effect
Ln Tobacco Price	-2.190*** (0.586)	-0.066*** (0.018)	-2.191*** (0.586)	-0.066*** (0.018)
Age 14-15 (dummy)	0.364** (0.146)	0.012** (0.005)	0.364** (0.146)	0.012** (0.005)
Age 15-16 (dummy)	-0.642*** (0.222)	-0.016*** (0.004)	-0.642*** (0.222)	-0.016*** (0.004)
Age 16-17 (dummy)	0.169 (0.162)	0.005 (0.005)	0.169 (0.162)	0.005 (0.005)
Age 17-18 (dummy)	0.587*** (0.207)	0.022** (0.010)	0.587*** (0.207)	0.022** (0.010)
Age 19-20 (dummy)	0.878*** (0.281)	0.038** (0.017)	0.878*** (0.281)	0.038** (0.017)
Age 21-22 (dummy)	0.578* (0.332)	0.022 (0.016)	0.578* (0.332)	0.022 (0.016)
<b>Control Variables</b>				
<b>Student's characters</b>				
Gender, male=1	0.810*** (0.091)	0.025*** (0.003)	0.810*** (0.091)	0.025*** (0.003)
Academic score in the grade 9	-0.434*** (0.039)	-0.013*** (0.001)	-0.434*** (0.039)	-0.013*** (0.001)
Health condition				
Mental disorder in the last year	0.121** (0.053)	0.004** (0.002)	0.121** (0.053)	0.004** (0.002)
Physical disorder in the last year	0.006 (0.079)	0.000 (0.002)	0.006 (0.079)	0.000 (0.002)
Sleep disorder in the last year	0.272*** (0.062)	0.008*** (0.002)	0.272*** (0.062)	0.008*** (0.002)
<b>Parent's characters</b>				
Father's ancestry:				
Native	-0.255 (0.431)	-0.007 (0.010)	-0.255 (0.431)	-0.007 (0.010)
Parental living arrangement				
Non-intact families	0.348** (0.154)	0.012** (0.006)	0.348** (0.154)	0.012** (0.006)
Father or mother absent	0.412** (0.175)	0.015** (0.008)	0.412** (0.175)	0.015** (0.008)
Father's education				
Father high school graduate	0.051 (0.101)	0.002 (0.003)	0.051 (0.101)	0.002 (0.003)
Father college graduate and above	-0.273** (0.123)	-0.008** (0.003)	-0.273** (0.123)	-0.008** (0.003)
Family income	-0.001 (0.001)	0.000 (0.000)	-0.001 (0.001)	0.000 (0.000)
Residential area in junior high school				
Taipei county	0.018 (0.108)	0.001 (0.003)	0.018 (0.108)	0.001 (0.003)
Yilan county	-0.109 (0.126)	-0.003 (0.004)	-0.109 (0.126)	-0.003 (0.004)
Random Effect			Yes	Yes
<b>Observations</b>	14625	14625	14625	14625

Note: Standard error in parentheses. \*\*\*, \*\*, and\* denotes statistical significance at the 1%, 5% and 10% level.

**Table 7 Empirical Result for Random Coefficient Model of Hazard-like Onset Smoking**

	Random Coefficient Model			
	Logist Model		Random Effect Logist Model	
	Coefficient	Marginal effect	Coefficient	Marginal effect
<b>Random Coefficient Ln Tobacco Price in:</b>				
Ln Tobacco Price *Age 13-14	-2.269*** (0.607)	-0.069*** (0.018)	-2.269*** (0.607)	-0.069*** (0.018)
Ln Tobacco Price *Age 14-15	-2.183*** (0.585)	-0.066*** (0.018)	-2.183*** (0.586)	-0.066*** (0.018)
Ln Tobacco Price *Age 15-16	-2.409*** (0.580)	-0.073*** (0.017)	-2.409*** (0.580)	-0.073*** (0.017)
Ln Tobacco Price *Age 16-17	-2.229*** (0.587)	-0.068*** (0.018)	-2.229*** (0.587)	-0.068*** (0.018)
Ln Tobacco Price *Age 17-18	-2.134*** (0.577)	-0.065*** (0.017)	-2.135*** (0.577)	-0.065*** (0.017)
Ln Tobacco Price *Age 19-20	-2.074*** (0.558)	-0.063*** (0.017)	-2.074*** (0.558)	-0.063*** (0.017)
Ln Tobacco Price *Age 21-22	-2.139*** (0.549)	-0.065*** (0.017)	-2.139*** (0.549)	-0.065*** (0.017)
<b>Control Variables</b>				
<b>Student's characters</b>				
Gender, male=1	0.810*** (0.091)	0.025*** (0.003)	0.810*** (0.091)	0.025*** (0.003)
Academic score in the grade 9	-0.434*** (0.039)	-0.013*** (0.001)	-0.434*** (0.039)	-0.013*** (0.001)
Health condition				
Mental disorder in the last year	0.121** (0.053)	0.004** (0.002)	0.121** (0.053)	0.004** (0.002)
Physical disorder in the last year	0.006 (0.079)	0.000 (0.002)	0.006 (0.079)	0.000 (0.002)
Sleep disorder in the last year	0.272*** (0.062)	0.008*** (0.002)	0.272*** (0.062)	0.008*** (0.002)
<b>Parent's characters</b>				
Father's ancestry:				
Native	-0.255 (0.431)	-0.007 (0.010)	-0.255 (0.431)	-0.007 (0.010)
Parental living arrangement				
Non-intact families	0.348** (0.154)	0.012** (0.006)	0.348** (0.154)	0.012** (0.006)
Father or mother absent	0.412** (0.175)	0.015** (0.008)	0.412** (0.175)	0.015** (0.008)
Father's education				
Father high school graduate	0.051 (0.101)	0.002 (0.003)	0.051 (0.101)	0.002 (0.003)
Father college graduate and above	-0.273** (0.123)	-0.008** (0.003)	-0.273** (0.123)	-0.008** (0.003)
Family income	-0.001 (0.001)	0.000 (0.000)	-0.001 (0.001)	0.000 (0.000)
Residential area in junior high school				
Taipei county	0.019 (0.108)	0.001 (0.003)	0.019 (0.108)	0.001 (0.003)
Yilan county	-0.108 (0.126)	-0.003 (0.004)	-0.108 (0.126)	-0.003 (0.004)
Random Effect			Yes	Yes
<b>Observations</b>	14625	14625	14625	14625

Note: Standard error in parentheses. \*\*\*, \*\*, and\* denotes statistical significance at the 1%, 5% and 10% level.

**Table 8 Three-wave Tobacco Taxes Impacts on Youth's Smoking Participation  
under Fixed Coefficient Model**

	1988 birth cohort (Survey year 2000-2009)		1986 birth cohort (Survey year 2000-2006)		1984 birth cohort (Survey year 1996-2002)	
	Logit Model	Random Effect Logit Model	Logit Model	Random Effect Logit Model	Logit Model	Random Effect Logit Model
<b>junior middle school:</b>						
Age 12-13						
Age 13-14						
	<b>( Tax Shock I )</b>					
Age 14-15	-0.021*** (0.008)	-0.014** (0.006)				
<b>Senior high school:</b>						
Age 15-16	-0.018*** (0.007)	-0.012** (0.005)				
Age 16-17	-0.019*** (0.007)	-0.012** (0.005)				
			<b>( Tax Shock I )</b>		<b>( Tax Shock I )</b>	
Age 17-18			-0.022*** (0.008)	-0.014** (0.006)	-0.021*** (0.008)	-0.014** (0.006)
			<b>( Tax Shock II )</b>			
<b>College:</b>						
Age 18-19						
Age 19-20	-0.012*** (0.004)	-0.008*** (0.003)	-0.019*** (0.007)	-0.012** (0.005)		
Age 20-21						
	<b>( Tax Shock III )</b>		<b>( Tax Shock II )</b>			
Age 21-22	-0.007*** (0.002)	-0.004** (0.002)	-0.008*** (0.003)	-0.005** (0.002)		

**Table 9 Three-wave Tobacco Taxes Impacts on Youth's Smoking Participation  
under Random Coefficient Model**

	1988 birth cohort (Survey year 2000-2009)		1986 birth cohort (Survey year 2000-2006)		1984 birth cohort (Survey year 1996-2002)	
	Logit Model	Random Effect Logit Model	Logit Model	Random Effect Logit Model	Logit Model	Random Effect Logit Model
<b>junior middle school:</b>						
Age 12-13						
Age 13-14						
	<b>( Tax Shock I )</b>					
Age 14-15	-0.021*** (0.008)	-0.014** (0.006)				
<b>Senior high school:</b>						
Age 15-16	-0.022*** (0.007)	-0.014*** (0.005)				
Age 16-17	-0.019*** (0.007)	-0.012** (0.005)				
			<b>( Tax Shock I )</b>		<b>( Tax Shock I )</b>	
Age 17-18			-0.021*** (0.008)	-0.013** (0.006)	-0.020** (0.008)	-0.013** (0.006)
			<b>( Tax Shock II )</b>			
<b>College:</b>						
Age 18-19						
Age 19-20	-0.011*** (0.004)	-0.007** (0.003)	-0.018*** (0.007)	-0.011** (0.005)		
Age 20-21						
	<b>( Tax Shock III )</b>		<b>( Tax Shock II )</b>			
Age 21-22	-0.006*** (0.002)	-0.004** (0.002)	-0.007** (0.003)	-0.004** (0.002)		

**Table 10 Three-wave Tobacco Taxes Impacts on Youth's Onset Smoking under Fixed Coefficient Model**

	1988 birth cohort (Survey year 2000-2009)		1986 birth cohort (Survey year 2000-2006)		1984 birth cohort (Survey year 1996-2002)	
	Logit Model	Random Effect Logit Model	Logit Model	Random Effect Logit Model	Logit Model	Random Effect Logit Model
<b>junior middle school:</b>						
Age 12-13						
Age 13-14						
	<b>( Tax Shock I )</b>					
Age 14-15	-0.019*** (0.005)	-0.019*** (0.005)				
<b>Senior high school:</b>						
Age 15-16	-0.017*** (0.004)	-0.017*** (0.004)				
Age 16-17	-0.017*** (0.005)	-0.017*** (0.005)				
			<b>( Tax Shock I )</b>		<b>( Tax Shock I )</b>	
Age 17-18			-0.020*** (0.005)	-0.020*** (0.005)	-0.019*** (0.005)	-0.019*** (0.005)
	<b>( Tax Shock II )</b>					
<b>College:</b>						
Age 18-19						
Age 19-20	-0.011*** (0.003)	-0.011*** (0.003)	-0.017*** (0.005)	-0.017*** (0.005)		
Age 20-21						
	<b>( Tax Shock III )</b>		<b>( Tax Shock II )</b>			
Age 21-22	-0.006*** (0.002)	-0.006*** (0.002)	-0.007*** (0.002)	-0.007*** (0.002)		

**Table 11 Three-wave Tobacco Taxes Impacts on Youth's Onset Smoking under Random Coefficient Model**

	1988 birth cohort (Survey year 2000-2009)		1986 birth cohort (Survey year 2000-2006)		1984 birth cohort (Survey year 1996-2002)	
	Logit Model	Random Effect Logit Model	Logit Model	Random Effect Logit Model	Logit Model	Random Effect Logit Model
<b>junior middle school:</b>						
Age 12-13						
Age 13-14						
	<b>( Tax Shock I )</b>					
Age 14-15	-0.019*** (0.005)	-0.019*** (0.005)				
<b>Senior high school:</b>						
Age 15-16	-0.018*** (0.004)	-0.018*** (0.004)				
Age 16-17	-0.018*** (0.005)	-0.018*** (0.005)				
			<b>( Tax Shock I )</b>		<b>( Tax Shock I )</b>	
Age 17-18			-0.019*** (0.005)	-0.019*** (0.005)	-0.019*** (0.005)	-0.019*** (0.005)
			<b>( Tax Shock II )</b>			
<b>College:</b>						
Age 18-19						
Age 19-20	-0.010*** (0.003)	-0.010*** (0.003)	-0.016*** (0.004)	-0.016*** (0.004)		
Age 20-21						
	<b>( Tax Shock III )</b>		<b>( Tax Shock II )</b>			
Age 21-22	-0.006*** (0.002)	-0.006*** (0.002)	-0.007*** (0.002)	-0.007*** (0.002)		



### Appendix I. Smoking rate of Comprehensive dataset longitudinal youth data

	1988 birth cohort (Survey year 2000-2009)	1986 birth cohort (Survey year 2000-2006)	1984 birth cohort (Survey year 1996-2002)
	Survey year and month	Survey year and month	Survey year and month
<b>junior middle school:</b>			
Age 12-13	2000.3		1996.9
Age 13-14	2001.3		1997.10
	<b>( Tax Shock I )</b>		
Age 14-15	2002.3	2000.3	1998.10
<b>Senior high school:</b>			
Age 15-16	2002.10	2000.10	1999.11
Age 16-17	2003.10	2001.10	2001.2
		<b>( Tax Shock I )</b>	<b>( Tax Shock I )</b>
Age 17-18	2005.3	2003.3	2002.3
	<b>( Tax Shock II )</b>		
<b>College:</b>			
Age 18-19	2006.3	2004.2	2002.10
Age 19-20	2007.6	2004.10	2004.01(略)
Age 20-21			
	<b>( Tax Shock III )</b>	<b>( Tax Shock II )</b>	
Age 21-22	2009.6	2006.12	

Note: the survey year and month are arranged from the internet of Taiwan Youth Project (TYP):  
<http://www.typ.sinica.edu.tw/newpage/1/researchstructure.htm> .