2019

Tobacco Taxation and Cigarette Consumption: Do Cigarette Tax Hikes Reduce Smoking Participation and Cigarette Consumption?

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By

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A Thesis Submitted to

Department of Economics

Skidmore College

In Partial Fulfillment of the Requirement for the B.A Degree

Thesis Advisor: Qi Ge

April 30, 2019

Abstract

This paper utilizes two waves of data from the Current Population Survey Tobacco Use Supplement as well as data from the *Tax Burden on Tobacco* to analyze the impacts of tobacco tax hikes on both smoking participation and daily cigarette consumption. By implementing a difference-in-differences approach, I find that there is a positive insignificant effect of cigarette excise tax hikes on the probability of smoking, while there is a negative insignificant impact on daily cigarette consumption. My empirical results suggest that the tobacco control strategy of raising cigarette taxes seems to only generate tax revenues but is not an effective tool in reducing either smoking participation rates or cigarette consumption. In this case, some possible explanations for my findings are cigarette demand inelasticity, tax salience effect, substitution effect, or inefficient allocation of tax revenues.

Acknowledgement

I would like to express my appreciation to Professor Qi Ge for his professional guidance, extraordinary support, and useful critiques throughout my thesis writing process. I would also like to thank my peer editor Carol Hu, who provided useful comments and thorough critiques for my paper. In addition, my grateful thanks are extended to Jiebei Luo for her assistance with my data collection. Finally, I would like to offer my thanks to the Skidmore Writing Center's tutors, Jane Barnes, Olivia Mendlinger, and Elianna Mentzer for their insightful comments on my thesis.

1 Introduction

According to the World Health Organization (WHO), cigarette smoking is a leading cause of preventable illness and death in the world by killing more than 7 million people per year, including both smokers and secondhand smokers. Particularly, smoking is responsible for one in five deaths annually in the United States (CDC, 2019). Even though smoking provides instant gratification, it causes serious long-term health effects such as damaged organs, cancers, and cardiovascular diseases, all of which can accelerate mortality (CDC, 2019). In fact, the negative health effects of smoking are now common knowledge thanks to the internet, media, and the packaging of cigarettes. Despite all of the publicity, smoking appears to be a popular behavior and a social phenomenon, which not only harms smokers themselves, but also creates the negative externality of secondhand smoke. Therefore, it is important to study how to control cigarette smoking behavior.

Since tobacco use is a rising public health concern, attention and actions are required to protect and discourage people from smoking. In this case, tobacco taxation is one of the tools to reduce tobacco consumption. There are multiple goals of tobacco taxation. One of them is to generate tax revenues for the purpose of governmental use. Another goal is to reduce tobacco use in order to improve public health. In some cases, the government protects domestic tobacco manufacturers from foreign producers by imposing a high import tax on tobacco products (Chaloupka *et al*., 2012). Altogether, it is worth studying the effectiveness of tobacco taxation in order to design a better tax policy aiming at reducing cigarette smoking and improving health. My research question is whether increasing tobacco taxes reduces cigarette consumption in the United States; particularly, how analyzing this impact across different sociodemographic groups will provide profound insight into effectively regulating tobacco taxation.

This paper examines whether increasing cigarette taxes is an effective tool in reducing cigarette consumption. I utilize two waves of individual survey data, January, 2007 and May, 2010, from the Tobacco Use Supplement to the Current Population Survey (TUS-CPS), which contains information about participants' smoking history, smoking status, and daily cigarette consumption. In addition to the TUS-CPS, I obtain data from the *Tax Burden on Tobacco*, published by Orzechowski and Walker, to determine the treatment group by identifying the states that experience the largest excise tax increase in percentage term. The premise for selecting a control group is that control states must not have any changes in cigarette excise tax during the same time periods used. Then, I conduct two-sample t-test to compare the mean differences in smoking rates between each state and all of the treatment states. As a result of the t-test, the treatment and control group contain eight and six states respectively.

In terms of methodology, I implement a difference-in-differences (DiD) strategy in my empirical analysis. To be specific, I estimate smoking participation and smoking intensity with state fixed effects separately by controlling for participants' demographic information. Smoking participation refers to whether a person decides to become a smoker, which is identified in TUS-CPS, while smoking intensity is expressed by the amount of cigarettes consumed by current smokers. I formulate a probit model to predict the probability of smoking since the response variable is a binary variable of 0 and 1. I expect that the smoking rate will decrease after the enactment of the tax increase. As a result, I find statistically significant results at a 10% significance level that smoking probability rises in the treatment group after the tax hikes, which is contradictory to my expectation. However, this significant effect disappears after I control for all of the demographic variables. Therefore, there is no compelling evidence that suggests raising

cigarette taxes convinces smokers to quit smoking or prevents potential cigarette users from becoming smokers.

Later, I use an Ordinary Least Squares (OLS) regression model to estimate smoking intensity. I expect that the number of daily cigarette consumption will decrease after the tax hikes. My finding suggests that the direction of changes in the number of daily cigarettes is negative, meaning that smokers tend to reduce cigarette consumption given the higher taxes. Nonetheless, this finding is not statistically significant, which indicates that there is no effect of cigarette taxes on daily cigarettes consumed.

Furthermore, I estimate these two models by gender, income level, and educational attainment. In terms of my expectations, after the increased taxes, females are more likely to reduce cigarette consumption, low-income groups tend to reduce consumption due to affordability, and the same goes for smokers with higher education because of their greater awareness and knowledge about the dangers of cigarettes. As a result, the DiD estimator for the female group suggests that females are more likely to be smokers compared to males after the tax hikes at a 10% significance level. The positive direction of the female smoking probability trend matches the direction in the first model of the estimation of the overall smoking probability. Other than the female group, DiD estimators for other subgroups are not statistically significant and thus there is no evidence suggesting a negative impact of increased taxes on different groups of people.

Altogether, my findings are not consistent with the economic theory that higher prices lead to lower demand for goods and services. Why is there no significant negative association between tobacco taxes and cigarette consumption? There are some possible explanations for my results. The most relevant one is the inelastic demand for cigarettes because smokers are addicted to cigarettes. Therefore, there is no change in cigarette consumption after the tax hikes. Another

explanation could be tax salience effect. Even though cigarette taxes are embedded in the cigarette price, the magnitude of the tax increase is too small. In this case, cigarette taxes are not highly visible to smokers, which can result in no impact of raising taxes on reducing smoking behavior. Additionally, substitution effect emphasizes that smokers have incentive to substitute other cheaper or illegal tobacco products for cigarettes. Similarly, smokers can switch brands that sell cheaper cigarettes in a cost of consuming lower quality of cigarettes. Moreover, the government may not utilize the tax revenues efficiently on promoting smoking cessation and assisting smokers who want to quit smoking.

Admittedly, there are a number of limitations in this study. The disadvantage of using an individual survey data is that it only records participants' responses at that certain moment and does not have the information of each individual across multiple years. In this case, I am not able to compare how responses of the same survey participant vary before and after the tax hikes. Regarding to the survey question of how many cigarettes are smoked every day, it is possible that respondents are either not telling the truth or the numbers they provide are not accurate because they do not pay attention to the amount of their daily cigarette smoking. Thus, the survey data used in my study can lead to biased results. More importantly, I only consider the effective date of the increased excise tax in the treatment states, but do not account for the announcement date in my empirical analysis. The announcement date of increasing state cigarette excise tax may affect smokers' behavior before the actual enactment. In other words, the data might not capture the complete effect of cigarette tax hikes.

My study contributes to the existing literature in several ways. First of all, I use a DiD model with state fixed effects to perform the empirical analysis since there is only a limited amount of literature that implements the same methodology to study tobacco usage (Callison and Kaestner,

2014; Lien and Evans, 2005). DiD is a useful tool in assessing the effectiveness of taxation policy because it enables me to classify the treatment and control group by using multiple states. The DiD interaction term allows me to compare the differences in smoking participation rates and smoking intensity between two groups. In particular, my study is similar to Callison and Kaestner (2014) in the way that we both use the DiD strategy with respect to excise tax hikes. However, my study differs from theirs by controlling for sales tax in my model in order to estimate how cigarette consumption depends on the increase in sales tax and by utilizing a different specification for the placebo analysis. Furthermore, I use a negative binomial count data model as a robustness check for the estimation of the number of daily cigarette consumption, which is not used in the field of tobacco taxation research according to the literature that I review.

In terms of policy implications, my findings appear to support one of the tobacco taxation's goal – tax revenues generation. Both cigarette excise tax and sales tax provide a major source of revenue collection for the government. If the government's ultimate goal is to improve public health by discouraging potential tobacco users from smoking and motivating smoking cessation, it should use tobacco tax revenues to fund smoking educational campaigns, tobacco control programs, and policy improvement research. My study requires further research in the investigations of smoking addiction and cigarette substitution in order to thoroughly examine the impact of tobacco taxes on cigarette consumption.

This paper is organized as follows. Section 2 introduces tobacco tax structures and reviews relevant literature on both tobacco taxation and smoking behavior. Section 3 discusses data collection and descriptive statistics of the variables of interest. Section 4 constructs two models to analyze the impact of tobacco taxes on smoking participation and smoking intensity. Section 5 presents the results of the empirical models. Section 6 discusses the limitations of this paper,

possible explanations for the insignificant findings, and policy implications. Section 7 contains the conclusion and future possible research.

2 Literature Review

Since cigarette smoking is a leading cause of health problems these days, this public health concern motivates me to conduct this study to investigate one of the tobacco control strategies, tobacco taxation. The economic theory suggests that there is an inverse relationship between tobacco taxes and cigarette consumption due to the law of demand. As the price of cigarettes increases due to increased tax, quantity demanded for cigarettes will decrease. However, many empirical studies find inconsistent results regarding to this economic theory. Some scholars find that the rise in cigarette taxes indeed reduce cigarette smoking rate (Cebula *et al.*, 2014; Chaloupka *et al*., 2012); while the others find no supportive evidence to prove the law of demand in the context of cigarette (Callison and Kaestner, 2014; Chen *et al.,* 2014). In addition, some researchers investigate the effects of tobacco taxation on different population groups' cigarette consumption (Farrelly *et al.*, 2001; Hersch, 2000; Lien and Evans, 2005; Stehr, 2007; Townsend *et al*., 1994). In order to fully evaluate the effectiveness of tobacco tax policy, it is essential to understand smokers' behavioral changes toward the increase in cigarette taxes (Chen *et al.,* 2014; Chiou and Muehlegger, 2014; Tsai *et al.,* 2005). Particularly, tax salience plays an important role in affecting consumer behaviors in response to taxes (Chetty *et al.*, 2009; Goldin and Homonoff, 2013; Li *et al*., 2014).

2.1 Tobacco Tax Structures

Before delving into my research question of how tobacco taxes affect cigarette consumption, it is necessary to understand the variety of tobacco taxes. Governments all over the

world impose different taxes on tobacco products. In my study, I only focus on the tobacco tax structures in the U.S. An excise tax is a per unit tax that is levied on tobacco manufacturers, but is often transferred to the prices of the tobacco products (WHO, 2011). A sales tax is an ad valorem tax that consumers are charged a fixed amount of tax when they purchase tobacco products (Goldin and Homonoff, 2013).

The U.S. federal government impose excise tax on tobacco products in order to achieve an equal level of excises across all products (Chaloupka *et al*., 2012). On April 1, 2009, the U.S. government raised federal cigarette tax by 62 cents, to $1.01 per pack of cigarette (Orzechowski and Walker, 2014). The U.S. states levy different excises on tobacco products so that the tobacco prices vary across all products (Chaloupka *et al*., 2012). The majority of the states include federal tax, state excise tax, and state sales taxes in their cigarette prices. There is no federal sales tax. However, there are some exceptions for state sales tax. For example, Delaware does not have sales tax; Oklahoma has a sales tax, but it is not applied to cigarettes; Alabama, Georgia, and Missouri do not apply a sales tax to the portion of state excise tax of cigarette retail prices (Campaign for Tobacco-Free Kids, 2018).

2.2 Impact of Tobacco Taxation on Cigarette Consumption

Empirical studies find inconsistent conclusions for the question of whether higher tobacco taxes are able to reduce cigarette consumption. For example, Chaloupka *et al*. (2012) conclude that raising tobacco excise tax is an effective tool to control cigarette smoking and to improve health. Similarly, Cebula *et al.* (2014) find a negative relationship between cigarette consumption and tobacco taxes. On the contrary, Callison and Kaestner (2014) find that cigarette consumption

is unaffected by the rise in tobacco taxes; and Chen *et al.* (2014) do not find that higher cigarette prices will decrease cigarette smoking.

In terms of data and methodology, Chaloupka *et al*. (2012) conduct a meta-study to assess the effectiveness of tobacco taxation policy by reviewing many different literatures on tobacco taxes, instead of collecting their own data to conduct an empirical study. Through reviewing over 100 studies, they find that low- and middle-income countries have higher price elasticity of cigarette demand than high-income countries. Studies from high-income countries suggest that higher cigarette taxes affect smoking prevalence by encouraging smoking cessation. The same impact is found from comparable studies of low- and middle-income countries. As a result, there is a substantial literature find a consistent conclusion that tobacco taxation is an effective tool to control cigarette consumption, to prevent potential smokers from smoking, and to generate government revenues.

Cebula *et al.* (2014) use state-level data of 50 states from 2002 to 2007 to analyze the effect of both federal and state tobacco excise tax on cigarette consumption by implementing a panel least squares model with random effects. They also implement log transformation to the regression model. In the semi-log model, they find that cigarette consumption is reduced by 0.49% to 0.58% on average as the excise tax increases by one cent. In the log-log model, they find a 50% increase in tobacco taxes among all states would decrease cigarette smoking by 30%.

One of the limitations in Cebula *et al.*'s (2014) paper is that their model does not account for smokers' behavior of substituting high nicotine for low nicotine cigarettes when tobacco taxes increase. This substitution may worsen smokers' health conditions. Therefore, they propose a policy recommendation regarding to this problem, which is to impose a selective supplementary

excise tax (SSET) on cigarettes with high nicotine and high tar. Specifically, this policy requires the cooperation across all 50 states by adopting the same SSET at the same time.

On the other hand, Callison and Kaestner (2014) use 15 waves of data from the TUS-CPS from years 1995 to 2007 to estimate the effects of taxes on both smoking rate and smoking intensity through a standard empirical approach of state and year fixed effects, a paired DiD strategy, and a placebo analysis. First, they implement the state and year fixed effect model by using all states that change cigarette taxes as the treatment group, including those change taxes in different time periods, while using all other states that do not change taxes at all as the control group.

Since not all of the control states are good controls for the treatment states, Callison and Kaestner (2014) decide to use the DiD approach. They focus on the states that experience the largest excise tax changes in order to better observe the largest reduction in cigarette consumption. The treatment group contains states with large excise tax increase, while the states in the control group are the ones that do not change cigarette excise tax and have similar smoking rates with the treatment group. Inspired by Callison and Kaestner (2014), I also use the TUS-CPS data at state-level and implement a DiD model to analyze the effect of tobacco taxation. I follow their method of determining the treatment group by identifying all states that have the largest cigarette excise tax hikes and selecting paired control group by using a two-sample t-test. However, Callison and Kaestner (2014) do not mention how they define a large tax increase. In my study, I specifically use tax percentage change (100% or above) to determine whether a state qualifies as the treatment state. Consequently, Callison and Kaestner (2014) conclude that the relationship between cigarette taxes and either smoking participation rate or cigarette consumption is usually small and statistically negative insignificant. As a result, they predict that cigarette taxes must be increased by 100% in order to reduce adult smoking by 5%.

At last, they utilize a placebo analysis to test the validity of their DiD results by using the same treatment and control groups in the time periods when both groups do not change taxes and then randomly assigning 50 cents increase in cigarette tax to one of the states. Later on, they apply a robustness check regarding the issue of purchasing cigarettes in a lower tobacco tax state and find that cross-border cigarette purchases do not affect cigarette tax elasticities. Nevertheless, the limitation of Callison and Kaestner's (2014) paper is that their placebo test cannot rule out the small deviation in tax elasticities even though it validates the DiD results. That is, even if the treatment and control groups are perfect matched, the causal estimates of the impact of taxes on smoking may not be reliable.

Chen *et al.* (2014) construct three different scenarios of decision making to examine smokers' behavioral changes to higher cigarette taxes by using data from Taiwan. They use probit model to test the first scenario where smokers make two independent decisions to reduce cigarette consumption and to switch brands. For the second scenario, smokers sequentially decide whether to reduce consumption; if not, they then decide whether to practice brand switching. This two-stage process is assessed by implementing a probit model with sample-selection bias since smokers with similar characteristics are more likely to behave in a similar way in the second stage decision making. The authors use multinomial logit to investigate the third scenario that smokers make decision of reducing consumption and switching brands simultaneously. As a result, they find that male smokers are more likely to reduce their cigarette consumption compared to females. The overall effect does not suggest an inverse relationship between tobacco taxes and cigarette consumption.

Both findings of Callison and Kaestner (2014) and Chen *et al.* (2014) raise a question of whether tobacco taxes are beneficial to improve health in the society as a whole. The ineffective

tax can create greater tax burden to low-income groups since commodity tax is generally regressive. To be specific, a regressive tax refers to the effective average tax rates that increase when a tax payer's income decreases. On the contrary, a progressive tax is a tax which increases when a tax payer's income increases (Gruber, 2015). In other words, as the tax payer's ability to pay declines, most likely to be the poor, the greater tax burden they have to bear if the tax is a regressive tax. Unfortunately, tobacco taxes are defined as regressive and the concentration of smokers are from the lower socioeconomic groups (Lewit, 1989).

2.3 Different Responses to Tobacco Taxes by Sociodemographic Groups

Other than studying the overall effect of tobacco taxes on cigarette consumption, it is also important to examine how different groups of people respond to tobacco tax policy. However, there are inconsistent study results on the heterogeneity of responses, especially among men and women. For instance, Hersch (2000) find that men are more responsive to higher tobacco taxes than women, while both Stehr (2007) and Farrelly *et al.* (2001) find the opposite results.

Knowing the methodology of each study is the key to identifying why the researchers reach a different conclusion. Hersch (2000), Stehr (2007), and Farrelly *et al.* (2001) all use the two-part procedure of probit and OLS regressions to estimate smoking participation and smoking intensity respectively since it is popularly used in health economics such as medical care, drinking, and smoking. The main reason why these three papers' findings differ is because Hersch (2000) does not apply state-specific fixed effects to his regression models while both Stehr (2007) and Farrelly *et al.* (2001) account for the state-fixed effects model.

Most studies divide the sample data by gender, then implement regressions separately without using state-fixed effects, which find that men are more price responsive than women. For

example, Hersch (2000) uses 1992 to 1993 data from the TUS-CPS to examine gender and income differences in the demand for cigarettes and finds that men are more price responsive than women. One of the limitations of Hersch's (2000) paper is that he does not include the state-fixed effect in his model specifications, which can lead to a biased result due to endogenous taxes (Stehr, 2007). Using state-fixed effects will yield a more accurate result that women are more sensitive to taxes than men. On the other hand, state-fixed effects are irrelevant for non-US studies. For example, Townsend *et al*. (1994) find that women respond more to the cigarette taxes than men by using British data, which is consistent with the result obtained from the US studies with state-fixed effects model.

Farrelly *et al.* (2001) investigate how smokers react to cigarette taxes by sociodemographic characteristics, such as gender, age, income, race, and ethnicity. They use 14 years of data from the National Health Interview Survey (NHIS) as well as the average annual cigarette prices data from the *Tax Burden on Tobacco*. However, there are two limitations of their study. The first one is that NHIS data is at the national level, but not at a state level. Thus, their findings cannot be generalized to each state given that different states have different tobacco tax implementations. The second limitation of Farrelly *et al.*'s (2001) paper is that they use data of cigarette prices instead of cigarette taxes. According to Stehr (2007), using cigarette prices to estimate the demand for cigarettes could lead to biased results. One reason is that prices are determined by the firms, which only reflects to local demand conditions. Another reason is that price data is collected from the survey, which does not take into account cigarette discount coupons.

Stehr (2007) uses data from Behavioral Risk Factor Surveillance System (BRFSS) in 1985 to 2000, which is one of the limitations of his study. Since BRFSS no longer conducts the survey question of how many cigarettes smokers consume on a daily basis after 2000, Stehr (2007) is not

able to include the later time periods in his empirical analysis. Hence, his findings are not generalizable to a more recent time frame. BRFSS samples are not truly random because it uses weights in order to have an unbiased inference at the state level, but not at the nation level due to different population sizes. Thus, Stehr (2007) uses the data without the weights. He codes someday smokers as non-smokers and divides sample into income quartiles. He includes an interaction between education and age since the association between smoking and education varies by age. The data shows that the gender gap is negatively correlated with cigarette taxes. Gender gaps are larger when cigarette taxes are lower (Southeastern states), and are smaller where cigarette taxes are higher (Northeastern and a few Western states). In this case, there is a greater tolerance toward smoking in Southeastern states because they grow tobacco.

Using the state-fixed effects model, Farrelly *et al.* (2001) controls for the time-invariant feature such as tobacco-grown states. They find that states that produce tobacco tend to have lower taxes and higher smoking rates. More importantly, they find that women are more price responsive than men, which makes women become more likely to quit smoking. Likewise, Stehr (2007) finds that cigarette taxation reduces both smoking participation and intensity. In particular, men's smoking participation is twice as responsive to the taxes than women without using state fixed effects, while women are more price responsive than men with state fixed effects. Even though Stehr (2007) applies state-fixed effects with separate regressions by gender, there is a disadvantage of his model in that it cannot estimate whether the results are due to other factors correlated with gender, such as income. Overall, since both Farrelly *et al.* (2001) and Stehr (2007) conclude that women are more likely to quit smoking due to their greater tax responsiveness and women usually show more interests in the programs that offer peer support for quitting smoking. Therefore, it is possible that higher tobacco taxes effectively reduce smoking among women.

In addition to gender differences, heterogeneity in tax responsiveness by other population groups is also worth studying. For instance, Stehr (2007), Farrelly *et al.* (2001), Hersch (2000), and Chen *et al.* (2014) find an identical result on how price and income elasticities differ by income groups. They conclude that higher income groups have lower price elasticities, while price elasticities are the greatest in the lowest income groups since those groups face greater financial burden. Similarly, Gruber and Koszegi (2004) find that higher income groups tend to have lower price elasticities. Specifically, Chen *et al.* (2014) find that low-income smokers are more likely to switch brands that sell cigarettes at a lower price in order to fulfill their cigarette consumption level. Equally important, education level can affect cigarette smoking decision. Hersch (2000) find that individuals who receive higher education are less likely to smoke, especially in the group of high-income earners. Interestingly, Chen *et al.* (2014) find that higher education does not induce reduction in cigarette consumption among current smokers; instead, it encourages them to practice brand switching.

In terms of race and ethnicity, Farrelly *et al.* (2001) find that African-Americans and Hispanics are more price responsive than white. The reason for this may be because of tax regressivity, which emphasizes that low-income groups (African-Americans and Hispanics) suffer a greater financial burden of cigarette taxes than the high-income groups (white). For groups of young and old smokers, Callison and Kaestner (2014) find that there is not enough evidence to support that young smokers are more tax responsive than older smokers. However, Farrelly *et al.* (2001) find the opposite result since they argue that it is harder for long-term smokers to quit or reduce smoking due to tobacco addiction.

Furthermore, Hersch (2000) investigates the smoking behavior in labor force. White-collar workers are less likely to smoke compared to blue-collar workers and unemployed individuals,

perhaps because of workplace restrictions on smoking for white-collar workers. Additionally, he points out that having children could affect smoking decisions as well. However, the presence of children only has a little effect on reducing parents' cigarette consumption. Similarly, Lien and Evans (2005) study the impact of cigarette taxes on both pregnant women's smoking rate and infant birth weight. By using a DiD approach, they find that increasing cigarette taxes is an effective control strategy to reduce maternal smoking as well as to reduce the risk of low infant birth weight. This finding has a significant impact on infant health since it suggests that cigarette tax hikes can improve birth outcomes by reducing the possibility of infant death caused by low birth weight. Nevertheless, their findings should be taken with caution since only a minority of pregnant women are smokers and the majority of them are non-smokers, which indicates that their data sample may not be the representative of the population of pregnant women who smoke and give birth to low-weight babies.

As shown above, it is necessary to examine the impact of tobacco taxation by different population subgroups in order to design an effective policy that can both reduce smoking rate and improve health conditions. Therefore, I will analyze whether the increase in tobacco taxes is effective in reducing cigarette consumption by gender, education, and income levels.

2.4 Smokers' Behavioral Changes

Smokers' behavioral changes are related to my study in a way that they can affect the results of tobacco taxation policy by offsetting the reduction in cigarette consumption. For example, brand loyalty gives power to the firms so that higher taxes do not have large impact on cigarette prices. Consumers can purchase cigarettes in a black market, which leads to less reaction to the increase in cigarette taxes (Callison and Kaestner, 2014). Chen *et al.* (2014) mention that some

researchers believe that smoking behavior can be explained by an external factor of addiction because smokers discount the costs of health. Additionally, Becker *et al.*'s (1994) rational addiction model implies that cigarette consumption decision-making depends on consumers' expectations toward future cigarette prices. Furthermore, an economic theory indicates that smoking is a rational decision since marginal benefits are greater than marginal costs of smoking. Thus, smokers prefer to maximize their utilities through smoking (Chen *et al.*, 2014).

In addition, brand-switching – the outcome of consumers substituting another brand for the one they used to consume – is another reason why smokers are less likely to reduce smoking in response to increased taxes. In this case, smokers choose to purchase cigarettes with lower price and possibly lower quality in order to maintain their cigarette consumption level (Chen *et al.*, 2014). Likewise, Tsai *et al.* (2005) discuss two factors of biological and economic compensations that affect smokers' decisions of switching brands. Biological compensation occurs when smokers choose to purchase cigarettes with higher nicotine in order to offset their reduction in the quantity of cigarette consumption. Economic compensation implies that smokers choose to purchase low-priced cigarettes due to financial burden in order to maintain their utility-maximized smoking level.

Chiou and Muehlegger (2014) explore consumers' response to increased cigarette taxes from the perspectives of stockpiling and substituting between low- and high-quality products. They use weekly data from Universal Product Code (UPC) that contains 85 supermarkets in Chicago from 1989 to 1996. First, they allow consumers to choose either low- or high-quality cigarettes. Then, consumers can stockpile the products they choose in the first stage in terms of the anticipation of the tax hike. Finally, the authors apply adjustment cost in the model when consumers start to change their cigarette consumption. In this case, adjustment cost refers to cigarette addiction cost, which indicates smokers' disutility as they decrease smoking consumption.

The limitation of Chiou and Muehlegger's (2014) study is that their data only covers Chicago metropolitan area and Indiana border, which makes their results may not be generalizable to other regions or different magnitude of tax hikes.

As a result, Chiou and Muehlegger (2014) conclude that consumers substantially stockpile low-priced cigarettes before tax increases. In the short-term, consumers substitute from high-quality to low-quality cigarettes for smoothing their lower level of smoking consumption. However, in the long-term, they find the opposite evidence that consumers substitute from low- to high-quality cigarettes. Even though the short-term result shows a way of consumers mitigating their losses from increased taxes, the longer term result supports the "flight-to-quality" theory, which states that consumers tend to purchase high-quality products when the excise tax rises.

In terms of policy implications as a result of product shifting, the finding of Chiou and Muehlegger (2014) suggests that there are negative health outcomes of smoking in the long run since the consumption of cigarettes with high tar and high nicotine rises as consumers switch brands with higher quality cigarettes. Additionally, they find that consumers bear the greater amount of tax incidence. More importantly, considering the changes in consumer behavior in both short and long terms is essential to accurately evaluate tobacco tax policy.

2.5 Tax Salience Effects

Tax salience theory emphasizes how excise tax and sales tax are displayed and demonstrates that consumers are more likely to change their behavioral responses toward more visible and salient taxes (Chetty *et al*, 2009). In relation to my study, tax salience can explain smokers' behavioral changes toward higher cigarette taxes. There are empirical studies that find conclusive evidence that salience matters since consumers do not take nontransparent tax into

account (Chetty *et al*, 2009; Li *et al*., 2014; Goldin and Homonoff, 2013). All three papers obtain an identical conclusion even though they focus on different fields. Chetty *et al*. (2009) examine the theory of taxation salience through a grocery store experiment and an observational study on alcohol consumption. Li *et al*. (2014) investigate how consumers respond to gasoline taxes based on the changes in gasoline consumption. Goldin and Homonoff (2013) study how tax salience affects the attention gap between both cigarette excise tax and sales tax as well as analyze how the taxes are distributed across consumers. In public economics, the optimization assumption is that individuals fully respond to the tax changes the same way as how they respond to the price changes (Chetty *et al*. 2009; Li *et al*., 2014). Nevertheless, this assumption often fails to predict consumers' behavior since they often respond differently to the change in tax given the fact that they are not attentive to the nontransparent tax system.

In terms of methodology, Li *et al.* (2014) use a linear regression model to estimate how consumers respond to both gasoline tax and gasoline tax-posted price. Chetty *et al*. (2009) use two strategies to show that tax-inclusive prices induce larger effects on product consumption. The first strategy is a field experiment in a grocery store. They implement a DiD model to compare quantity sold and product revenues between the treatment and the control groups. The treatment group contains three products with relatively high prices and high price elasticities, while the control group consists of the products located in the same aisle as the treatment products. The authors include the tax with the price of the product for the treatment group, whereas keep the original price tags without tax for the control products. As a result, they find that tax-inclusive price tags have negative impact on product demand because consumers may either think that the product prices have increased or the products have had additional taxes added. However, the limitation of Chetty *et al*.'s (2009) methodology is that the grocery store field experiment is conducted at only

one supermarket for three weeks, which makes his sample size restricted in a single store in one area. Therefore, the inference that they make based on this data might contain biases and cannot be generalized to other geographic location.

Goldin and Homonoff (2013) use similar methodology as Chetty *et al.* (2009). Regarding to another limitation of Chetty *et al.*'s (2009) paper that they are not able to access tax salience effects across different groups of population due to unavailable disaggregated consumption data, Goldin and Homonoff (2013) account for this problem by using individual survey data to examine heterogeneity in consumers' attention to sales tax. For example, consumers are divided into groups A and B where both of them are aware of the tax-inclusive posted price. However, only group A takes into account the sales tax added at the register. Then, they implement a neutral revenue increase by raising sales tax and reducing posted tax in order to examine how the government chooses to impose taxes can affect welfare of both consumers A and B separately. As a result, shifting posted tax to sales tax always benefits consumers in group A, who pay attention to the less salient tax, while the welfare effect is ambiguous for consumers in group B. Thus, policymakers are able to manipulate tax salience for redistribution in tax burden.

In order to solve the potential concern of the "Hawthorne effect", the change of behavior due to participants' awareness of being observed, Chetty *et al.* (2009) use a second strategy of an observational study of alcohol consumption based on alcohol taxes. Alcohol is subject to two taxes: excise tax, which is included in the prices; and sales tax, which is less salient in a way that it is added at the register only. In this case, the authors find that consumers underreact to sales tax in both short run and long run because it is less salient. As a result, an increase in excise tax has a larger effect on alcohol consumption compared to the increase in sales tax.

Chetty *et al*. (2009) indicate that there are two reasons why consumers underreact to sales tax. One is that consumers do not have knowledge about the sales tax. Another one is that salience matters since consumers do not account for the sales tax. Similarly, Li *et al.* (2014) find consistent results that consumers strongly react to tax-inclusive price tags because those are more salient compared to the added tax at the register. They find that consumers respond more to gasoline taxes than to its tax-exclusive prices. Thus, gasoline consumption reduction is greater in tax changes than in price changes. They discuss that one of the potential explanations is persistence, which indicates that consumers expect gasoline tax to be more persistent in the future. Another explanation is that tax salience affects how consumers react to tax changes because of media coverage of increased gasoline taxes.

Furthermore, it is important to understand how tax burden is distributed across different income level since many of the taxes are regressive, meaning that low-income consumers bear greater tax burden. Goldin and Homonoff (2013) obtain data from BRFSS to investigate whether high- or low-income groups are more aware of the sales tax. Then, they measure the effects on cigarette consumption in states that have sales tax and states that exempt sales tax. As a result, they find that low-income smokers reduce cigarette consumption in response to cigarette excise tax and sales tax, while high-income smokers only respond to excise tax. Therefore, they suggest that policymakers can impose tobacco taxes as sales tax instead of excise tax because this way can ease the tax burden borne by low-income consumers. Nevertheless, the limitation of Goldin and Homonoff's (2013) paper is that their empirical specification does not take into account of whether or not high-income groups' attentiveness toward cigarette sales tax depends on the magnitude of the tax. That is, policymakers should be careful on making decision of imposing a higher cigarette sales tax.

Moreover, Chetty *et al*. (2009) analyze the welfare consequences of taxation when the optimization theory does not hold. The findings are that consumers who bear statutory tax incidence bear more economic incidence, an increase in tax generates efficiency costs, and the increase in demand elasticities decreases deadweight loss and raises incidence on the consumer side.

My paper contributes to the existing literature on tobacco taxation in three ways. First, I use the state-level individual survey data to construct a DiD model to estimate the different outcomes of tobacco taxation on cigarette consumption. Compared to the common use of two-part procedure of probit and OLS regression in the studies of cigarette smoking, DiD model is less popularly used but is suitable for the purpose of evaluating the effectiveness of tobacco taxation. The advantage of using DiD is that it allows me to limit my control states to those who are more appropriate and comparable for the treatment states. Second, I account for the largest change in cigarette excise tax in the treatment states by calculating the tax percentage changes, as well as control for the sales tax in my empirical models to estimate the association between sales tax and cigarette consumption. Lastly, I use a negative binomial count data model to check the robustness of my DiD findings of the daily cigarette consumption.

3 Data

3.1 State Cigarette Taxes

I obtain data on cigarette taxes at the state-level from the *Tax Burden on Tobacco*, published by an economic consulting firm, Orzechowski and Walker[1]. The data contains federal

[1] The data is provided by the Centers for Disease Control and Prevention, which can be assessed through https://chronicdata.cdc.gov/Policy/The-Tax-Burden-on-Tobacco-1970-2017/7nwe-3aj9.

excise tax, state excise tax, average cigarette prices, cigarette consumption measured by pack sales per capita, and cigarette tax revenues from 1970 to 2017. Additionally, the state-level data on cigarette sales tax is obtained from the *Tax Burden on Tobacco* 2014 report.

Table 1 exhibits the date of enactment of the treatment states' excise tax hikes within the time periods of January, 2007 and May, 2010. I use the tax percentage changes to determine the treatment states that are used in my study. The larger the tax hikes, the larger reduction in cigarette consumption (DeCicca and McLeod, 2008). Thus, I define a tax hike is large if the percentage of the excise tax change is more than 100%. To be noted, the determination of the treatment group only accounts for the changes in excise tax but not in the sales tax. As a result, there are eight states that qualify as the treatment group.

In order to select matched control states, they must not implement any changes in cigarette excise tax before, and after, the effective date of the treatment states' tax hikes. Accordingly, there are 21 states that have not changed their taxes within the specified time. Secondly, I follow Callison and Kaestner's (2014) method of two-sample t-test to verify whether those 21 control states are comparable with the treatment states by comparing their differences in mean smoking participation rates prior to the tax hikes. For instance, if Illinois has a similar smoking rate as the average smoking rate of all treatment states, Illinois is considered as a control state. The same process of two-sample t-test is repeated for 21 times since there are 21 potential candidates for the control states, resulting in 10 states validating as control states. Nevertheless, I remove four of them, Maine, Montana, Nevada, and Oregon since they are not comparable with the treatment states in terms of geographic location and the size of the state. Therefore, the remaining six control states are Alabama, Colorado, Illinois, Louisiana, Michigan, and Nebraska.

Table 2 reports the average excise tax and sales tax in both the treatment and control groups. The treatment group's average excise tax increases by $0.69 to $1.19 per pack of cigarette with a larger standard deviation. Its sales tax increases by $0.12 to $0.34 per pack. On the other hand, the control group's average excise tax and sales tax only increase by 1 cent and by 2 cents, respectively. Overall, the treatment states have larger tax increase than the control states.

3.2 State-Level Tobacco Survey

I obtain data from the TUS-CPS, sponsored by the National Cancer Institute (NCI). NCI conducts the TUS-CPS every three to four years since 1992. I use two waves of the TUS-CPS data for my study: January, 2007 and May, 2010. The TUS-CPS questionnaires contain topics such as smoking history, current smoking status, the number of daily cigarettes consumed, workplace smoking restrictions, *etc* (NCI). In detail, the questionnaires ask questions of whether the respondents have smoked at least 100 cigarettes in their lives, when they first started smoking, whether they smoke every day, some days, or not at all, how many cigarettes they smoke if they are every day smokers (20 cigarettes per pack), and whether there is any policy that restricts smoking at workplace. Other than these smoking related questions, the TUS-CPS also provides respondents' demographic information such as age, gender, race, marital status, educational attainment, family income, and employment status.

Table 3 summarizes the descriptive statistics of the full sample divided by the treatment and control groups with total observations of 16,043 and 11,444 questionnaire participants, respectively. Overall, the summary statistics are similar for both groups. For example, the average age of respondents in both groups is 42 years old. Approximately 19% of the survey participants are smokers in both the treatment and control groups. In addition, the average number of daily

cigarettes is similar for both groups as well, 15.68 cigarettes for the control group and 16.73 cigarettes for the treatment group.

3.3 Simple DiD Estimates

Based on the descriptive statistics of the probability of smoking and the number of daily cigarette consumption, I am able to compute the simple DiD estimates of the effect of higher cigarette taxes without doing a regression analysis. Table 4 presents the probability of smoking by the treatment and control groups before and after the tax hikes. The DiD estimate is 0.0183, which indicates that the probability of smoking in the treatment states increases by 1.83% after the increase in taxes. This DiD estimator results in a t-statistic of 1.90 and a corresponding p-value of 0.97. Therefore, there is no evidence suggesting that increased taxes reduce smoking rates in the treatment states.

In addition, Table 5 exhibits the number of daily cigarettes consumed by the treatment and control groups before and after the tax changes. Using the same procedure as Table 4, I obtain a DiD estimator of -0.33, indicating that the treatment states reduce their daily cigarette consumption by 2% (0.33/16 cigarettes) on average compared to the control states. By calculation, the t-statistic is -0.54 with a corresponding p-value of 0.29, which illustrates that there is no evidence supporting that tax hikes reduce everyday smokers' daily cigarette consumption.

In terms of my expectations, I expect that both the probability of smoking and the number of cigarettes smoked would decline after a large increase in taxes. The DiD estimator from the two-sample t-test is positive insignificant for the probability of smoking, while it is negative insignificant for the number of cigarettes consumed. Even though both DiD estimators are not consistent with my expectations, I will continue my empirical analysis through using a DiD

methodology to examine the impact of cigarette tax hikes on smoking participation rate and smoking intensity.

4 Methodology

The DiD methodology is used to estimate the impact of an exogenous event by comparing the change in the outcomes of the matched treatment and control groups. In my study, the DiD strategy allows me to investigate the effect of cigarette tax changes on smoking rate and cigarette consumption by comparing the changes in both outcomes before and after the tax hikes in the treatment group. Among all the tobacco taxation related literature that I am aware of, Callison and Kaestner's (2014), Lien and Evans (2005) are the only two empirical studies that utilize DiD approach to examine the impact of tobacco taxes on cigarette consumption. Given that DiD is rarely used in the field of tobacco taxes, I choose this method for my study since it enables me to testify the assumption of parallel trends before tax changes, while other standard methods cannot.

Based on the literature review, assessing smoking participation and smoking intensity are two different scenarios. This model is called "double-hurdle" (Goldin and Homonoff's, 2013). Smoking participation indicates whether higher cigarette taxes encourage smokers to quit smoking, while smoking intensity implies how taxes affect smokers' decision of how many cigarettes to smoke. This two-part procedure is commonly used in the tobacco taxation literature (Hersch, 2000; Stehr, 2007; Farrelly *et al.*, 2001). Therefore, I implement two models[2] of estimating smoking participation and smoking intensity separately.

[2] I find similar results using different specifications with and without excise tax and sales tax in two of my models. Thus, I only keep the sales tax variable as an independent variable in both models since the DiD estimator essentially includes the changes in excise tax.

By using an individual survey data of before and after the tax hikes from the TUS-CPS, I use probit model with state fixed effects to predict smoking probability based on the effect of increased tax is as follows:

$$(1) \quad Pr(smoke = 1)_{ist} = \Phi(\beta_0 + \beta_1 Post_{it} + \beta_2 Treatment_{is} + \beta_3 Interaction_{ist} + \beta_4 Sales\ Tax_{st} + \beta_5 X_{ist})$$

Then, I use the Ordinary Least Squares (OLS) with state fixed effect to estimate the second model of how increased taxes affect cigarette consumption. The regression model takes the form as follows:

$$(2) \quad y_{ist} = \theta_0 + \theta_1 Post_{it} + \theta_2 Treatment_{is} + \theta_3 Interaction_{ist} + \theta_4 Sales\ Tax_{st} + \theta_5 X_{ist} + \gamma_s + \varepsilon_{ist}$$

where $i = i^{th}$ individual, $s =$ states (treatment and control groups), and t = time. γ_s is the state fixed effect, which is used for controlling the time-invariant unobserved characteristics of each state. In particular, Southeastern states tend to have lower cigarette taxes since they grow a large amount of tobacco (Farrelly *et al.,* 2001; Stehr, 2007). Thus, these states have greater tolerance of smoking, meaning that they are more likely to have higher smoking rates. In this case, the treatment group contains two tobacco-producing states, Kentucky and Tennessee. On the other hand, the control group contains mostly Northeastern states, where tend to have higher cigarette taxes.

In equation (1), the dependent variable *smoke* is a binary variable of 1 for every day and someday smoking status otherwise 0 for non-smokers. In equation (2), the dependent variable *y* is a quantitative variable of the number of cigarettes smoked every day. Regardless of these two different dependent variables, all other independent variables are the same for two equations. *Post* is a dummy variable of 1 if year is 2010 and 0 if year is 2007. *Treatment* is also a dummy variable,

which is equal to 1 if treatment states and 0 if control states. *Interaction* is the multiplication of *Post* and *Treatment*. *Sales Tax* is measured in US dollar. *X* includes demographic variables such as age, age-squared, gender, race, family income level[3], educational attainment, and employment status. Particularly, I use age-squared in my model since I expect that there is a quadratic relationship, meaning an upside-down parabola, between age and both smoking probability and the number of smoking consumption. In other words, as age increases, smoking probability and the number of cigarettes smoked rise until age reaches a certain point, then they start to decline. Altogether, I expect that the tax hikes between 2007 and 2010 decrease both the probability of smoking and cigarette consumption within the treatment states, which implies that both of their interaction terms are expected to be negative values.

5 Results

5.1 Smoking Participation

Table 6 presents the marginal effects of the probability of smoking, which is estimated using the probit model based on the increase in cigarette taxes in eight treatment states. Column 1 is a preliminary estimate of the DiD model. The interaction term, as well as the DiD estimator, is statistically significant at a 5% significance level. That is, the probability of smoking increases by 1.97% given the cigarette excise tax hikes in the treatment states. By adding S*ales tax* into the probit model, the second column shows that the DiD estimator is no longer statistically significant. The coefficient of sales tax indicates that the probability of smoking declines by 5.2% for each additional dollar increase in the sales tax. Nevertheless, this coefficient is not statistically

[3] Family income refers to the combined income of all family members in the past 12 months. Following Goldin and Homonoff (2013)'s method of categorizing income level, I use the 25th, 50th, and 75th percentile to divide family income into low-, middle-, and high-income groups.

significant either. Later, I add more control variables to the model, including gender, age, age-squared, race and employment status to the model, which is shown in column 3. As a result, the magnitude of the DiD estimator slightly decreases and still remains insignificant.

Finally, the fourth column exhibits the aggregate results of the model with all of the independent variables. The DiD estimator suggests that the probability of smoking increases by 1.11% for the treatment states that enact the tax increase. However, it becomes statistically insignificant in the final one where I control for all the demographic information. The sign of the interaction term remains positive throughout four columns and the only significant interaction coefficient is in the preliminary result (column 1). This direction is not consistent with the economic theory that the higher taxes cause a lower smoking participation rate. Therefore, there is no evidence suggesting that the increase in cigarette taxes has impact on the probability of smoking.

Moreover, all control variables are statistically significant at a 1% significance level except *Sales tax*. The direction of *Sales tax* changes to positive in column 4. The change of sign could be due to the fact that all cigarette taxes are included in the price, which hinders smokers to distinguish the changes in price and taxes separately. By controlling gender, I find that the probability of male smoking is 2.7% higher than female. The coefficient of age is positive, while it is negative for age-squared. In this case, it implies that there is indeed a quadratic relationship between age and smoking probability. However, the effect is extremely small that the smoking probability only declines by 0.02% as people get older. This finding may reflect on cigarette addiction since it is more difficult for long-term smokers to quit smoking. Interestingly, white smokers are 6.7% more likely to smoke than smokers in the other racial groups after the tax hikes. Additionally, high-income groups are more likely to not become smokers compared to the low-income groups. As cigarette taxes increase, the probability of smoking increases by 5.6% for low-income groups,

whereas it decreases by 6.0% for high-income groups. Furthermore, both coefficients of high school graduates and bachelor's degree are negative, while the magnitude of the negative impacts are different. To be specific, higher taxes reduce smoking probability by 16.5% for bachelor's degree earners while reducing the probability by 3.3% for high school graduates.

5.1 Smoking Participation by Subgroups

In addition to examine the impact of cigarette tax hikes on smoking participation rate, I expand the empirical analysis to the impact on different subgroups. Table 7 presents the probit regression marginal effects on the probability of smoking by demographic groups including male, female, low-income groups, high-income groups, high school graduates, and people with a bachelor's degree. Among all of the subgroups, the only statistically significant DiD estimator is for the female group, which is shown in column 2. It illustrates that the probability of smoking increases by 3.6% for female at a significance level of 10%, which suggests that the female group may be driving some of the positive results in the full sample model. However, this result contradicts the findings of Farrelly *et al.* (2001) and Stehr (2007), which conclude that women are more likely to quit smoking after using state fixed effects since they are more price responsive than men.

Moreover, *Sales tax* in column 3 is statistically significant at a 10% significance level, which indicates that smoking probability decreases by 1.02 for low-income groups as sales tax increases by $1. This result is consistent with Goldin and Homonoff (2013)'s research, which finds that low-income consumers have greater attentiveness to sales tax. In this case, policymakers may lessen the regressivity of cigarette taxes by levying the taxes at the register instead of embedding them to the posted price.

5.3 Smoking Intensity

Table 8 presents the estimated effect of increase in cigarette excise tax on smoking intensity, which is indicated by daily smokers' decision of how many cigarettes to smoke every day. Similar to the probit model, there are four columns in Table 8 where the first column exhibits the preliminary estimate of the impact. The DiD estimator is an insignificant coefficient of -0.17, which means that the tax hikes of treatment states decrease daily smokers' cigarettes consumption by 1.06%[4]. As I add more control variables to the regression model, the magnitude of the DiD estimator decreases but remains statistically insignificant. By controlling all the demographic variables in column 4, the number of daily cigarettes smoked decreases by 0.72 cigarettes (4.5%). By comparing to the mean number of cigarettes, 4.5% decrease indicates a relatively large reduction in daily cigarette consumption. Nonetheless, this DiD estimator is not statistically significant and neither is the independent variable of *Sales tax*.

On the other hand, the rest of the independent variables display similar direction as the probit model such that white smokers and male smokers are more likely to increase cigarette consumption, and smokers with a bachelor's degree reduce daily cigarette consumption more than high school graduates. As smokers become older, there is only a small effect of cigarette taxes on reducing cigarette consumption. Surprisingly, low-income smokers increase their daily consumption by 0.86 cigarettes on average, which indicates a 5.4% increase in cigarette consumption, while high-income smokers' coefficient exhibits a negative insignificant direction. According to Chen *et al.* (2014), high-income smokers have smaller price elasticities for cigarettes, while price elasticities are larger for low-income smokers. The possible explanation for my result

[4] The percentage is calculated by using the coefficient divided by the average number of daily cigarettes (16 cigarettes). For example, 0.17/16 = 1.06%.

is that low-income smokers might switch brands with lower cigarette price and poorer quality in order to maintain their optimal level of cigarette consumption (Chen *et al.,* 2014).

5.4 Smoking Intensity by Subgroups

Table 9 presents the effect of cigarette taxes on smoking intensity by subgroups. The identical six demographic groups are applied to the OLS regression model of cigarette consumption. Under the effect of cigarette tax hikes, females are more likely to reduce daily consumption by 1.76 cigarettes (11%) compared to males, who increase daily smoking by 1 cigarette (6.3%). Low-income and high-income daily smokers tend to reduce consumption by 0.4 (2.5%) and 2 cigarettes (12.5%) respectively. Additionally, smokers with a bachelor's degree and those with high school diploma both decrease cigarette consumption by 4 cigarettes (25%) and 0.6 cigarettes (3.75%) respectively. Nevertheless, none of these results are statistically significant. In other words, there is no evidence that validates my hypothesis of the negative impact of cigarette taxes on cigarette consumption among any subgroups. As shown above in all of my empirical analyses, the overall conclusion is that the enactment of raising state cigarette excise tax neither encourages smokers to become non-smokers nor reduces daily cigarette consumption. I will discuss my paper's limitations and explore the potential explanations for my insignificant findings in the following section.

6 Robustness Check

I follow Callison and Kaestner's (2014) paper to conduct a placebo analysis as the robustness check for my study. In Callison and Kaestner's (2014) placebo test, they randomly assign a 50 cents tax increase to one of the states when both the same treatment and control groups

do not implement any changes in cigarette taxes. Different from Callison and Kaestner's (2014) placebo test, I account for both changes in excise tax and sales tax[5]. Accordingly, I keep the original control group used in my DiD model, but replace the treatment group with those states that do not experience any changes in excise tax and sales tax. In this case, there are 11 treatment groups: California, Georgia, Maine, Missouri, Montana, North Dakota, Ohio, Oklahoma, Oregon, West Virginia, and Wyoming. I expect to obtain no effect on both the smoking probability and daily cigarette consumption from my placebo test since only the insignificant results can validate my DiD findings.

Table 10 presents the placebo test results of the probability of smoking. It shows that both DiD estimators with and without controlling other demographic characteristics are statistically significant at a 1% level. In other words, the probability of smoking increases in the treatment group even though there is no actual tax increase occurs, which does not verify the results of my DiD estimation of the probability of smoking.

Table 11 reports the placebo test of the number of daily cigarettes. The interaction terms exhibit an insignificant negative direction regardless of controlling for individual characteristics. Since the DiD estimates from this placebo experiment are not significantly different from zero given that there are no actual tax changes in the treatment group, the placebo test validates my DiD results of daily cigarette consumption.

In addition to the placebo analysis, I implement a negative binomial count data model as my second robustness check to estimate the number of daily cigarettes consumed. Originally, there are missing information of how many cigarettes are smoked every day for both someday smokers

[5] In my original DiD model, I do not account for the changes in sales tax in determining the treatment and control groups. However, I do account for the changes in these two types of tax in my placebo analysis.

and non-smokers. In my count model, I replace all of those missing values of the number of daily cigarettes into zero since the negative binomial regression is used for modeling a zero-inflated count variable.

Table 12 presents the results of the negative binomial model. Column 1 is the result from the original treatment and control groups. Thus, it contains the control variable of *Sales tax* because the determination of treatment and control groups only accounts for the change in the excise tax. As a result, the DiD estimator exhibits an insignificant positive direction, which shows that the rise in cigarette excise tax increases the number of daily cigarettes by 11.5%. Column 2 represents the negative binomial model using the placebo's treatment and control groups. The interaction term is statistically significant at a 10% significance level, suggesting that the treatment group increases the number of cigarette consumption by 24.7% even though there are no actual tax changes implemented in the treatment group. Therefore, the placebo analysis (column 2) does not validate the negative binomial model presented in the column 1.

7 Discussion

Even though my empirical results are not statistically significant, my study contributes to the existing literature in three ways. First, I use a DiD model with state fixed effects to perform the empirical analysis since it allows me to compare the differences in smoking participation rates and smoking intensity between the treatment and control groups. Second, I control for sales tax in my model to testify the relationship between cigarette consumption and sales tax. Finally, I use both placebo analysis and negative binomial regression model to check the robustness of my DiD findings. Unfortunately, my robustness check does not validate my DiD findings.

My study is subject to a number of limitations. First, the data that I use for this study is individual survey data. NCI does not keep track of every individual's response in each year. That is, survey participants may not be the same people throughout the years, which means that it is impossible for me to know the change in cigarette consumption for each person with respect to the increased taxes. Second, there might be measurement error in the number of daily cigarettes consumed. Since it is highly likely that those daily smokers do not count the number of cigarettes they smoke every day, the number of cigarettes is not completely reliable due to the inaccurate information. Third, there is a large gap between the pre-tax and post-tax time periods used in my study. Therefore, there may exist some potential factors other than the tax hikes that influence the decision of smoking. At last, there can be an anticipation issue due to the timing of the announcement date of tax hikes in each state. Smokers might react to the announcement of tax implementation earlier than the actual effective date of tax hikes. Under this circumstance, the data time periods might not capture the immediate effect of the increased taxes on cigarette consumption.

Since all taxes, including federal tax, state excise tax, and sales tax, are embedded in the cigarette prices in the majority of the states, cigarette tax is considered a salient tax based on the definition of tax salience stated by Chetty *et al.* (2009). If the tax salience theory holds, smokers should reduce their consumption of cigarettes since cigarette price increases due to the rise in cigarette taxes. On the contrary, increased cigarette taxes seem to be ineffective in reducing smoking behavior based on my findings. There are two possible reasons why my findings confine the tax salience theory. One is inelasticity of cigarette demand, meaning that the demand for cigarettes remains unchanged regardless of the higher prices. In other words, cigarettes are necessities to addicted smokers and thus those smokers do not reduce cigarette consumption even

though taxes increase. Another possible reason is that smokers are uninformed about the tax hikes since the magnitude of the tax increase is too small. For instance, Table 1 shows that the smallest magnitude of the excise tax increase is 30 cents and the largest is $1. Even though the percentage change in the excise tax is more than 100%, the magnitude is too small for the smokers to pay attention to it. Consequently, although my findings do not confirm the tax salience theory, it does not imply that the theory is invalid in the case of cigarette taxes.

Inelastic demand for cigarettes due to an uncontrollable factor of addiction can also explain why my findings are statistically insignificant. Cigarettes contain harmful chemicals such as nicotine and tar, which can cause smokers to become addicted to tobacco products. In this case, smokers with longer smoking histories are more likely to have a stronger dependency toward cigarettes since smoking makes them feel immediate satisfaction and relief (Chen *et al.*, 2014). Additionally, smokers can underestimate the long-term health costs of smoking, resulting in inelastic demand for cigarettes. Also, there is only a small number of manufacturers producing tobacco products, which limits the substitutions for cigarettes and creates an inelastic demand for tobacco products (Chaloupka *et al.*, 2012).

Another possible explanation of why the cigarette tax has no impact on cigarette consumption is the substitution effect or brand switching. The reduction in cigarette consumption in response to the increase in cigarette taxes can be offset by increased consumption of other tobacco products, such as electronic cigarettes, chewing tobacco, and snuff, if their prices are relatively lower than cigarettes (Chaloupka *et al.*, 2012). In order to maintain the same level of cigarette consumption after the tax hikes, smokers might switch brands to cheaper cigarettes even though the cigarette quality is poorer (Chen *et al.*, 2014). The motivation behind the practice of brand switching is financial; for instance, low-income or low-education groups of smokers are

more likely to purchase cheaper or illegal cigarettes after the enactment of increased taxes (Lee *et al.,* 2005).

Moreover, tax revenues generated from tobacco may not have been used efficiently on improving public health by reducing cigarette consumption. As has been noted, there is a dramatic increase, more than 100 percent, in cigarette excise tax in each treatment state. As a result, tax revenues from those treatment states must increase over those time periods. Nevertheless, there are only a limited amount of state governments dedicating their tax revenues to tobacco control programs. Even if they do, those governments typically allocate only a small portion of the tax revenues to tobacco control efforts (Chaloupka *et al*., 2012). From the perspective of public finance, cigarette tax revenues should be used to benefit the tax payers. For instance, there should be more resources to help smokers quit smoking, to prevent potential smokers from using tobacco products, and to provide healthcare programs funded by the tax revenues (Chaloupka *et al*., 2012). Consequently, the lack of proper allocation of tobacco tax revenues reduces social welfare by failing to promote smoking cessation and to lower cigarette intake.

The policy implications vary by the ultimate goals of tobacco taxation. One of the goals of tobacco taxes is to generate tax revenues either for tobacco control or for alternative purposes. Given a such inelastic demand for cigarettes, revenue collection from cigarette taxes is an efficient and reliable source for the government. Based on my findings, neither the increase in excise tax nor sales tax results in reducing cigarette consumption. Hence, cigarette excise tax and sales tax certainly generate a large amount of government revenues, especially the revenues from excise tax that is raised by more than 100%. Since cigarettes taxes are regressive, the more tax revenues the government collects, the greater tax burden the low-income smokers bear. Therefore, the

policymakers should take tax regressivity into consideration in order to equally distribute the tax burden across low- and high-income smokers.

The other goal of tobacco taxes is to improve public health by encouraging a healthy lifestyle without engaging in smoking behavior. The findings of my study seem to support the first goal of tax revenue generation since they result in no impact on reduction of cigarette consumption. If tobacco taxation policy is designed to achieve the second goal, to change smokers' behavior, the government should utilize tax revenues efficiently through funding more tobacco cessation programs and public health educational campaigns (Chaloupka *et al*., 2012). Moreover, the government can increase the salience of tobacco taxes by increasing the amount of media coverage about the tax hikes or listing the original cigarette prices and the cigarette taxes separately on the posted-price. In both ways, smokers will be more attentive to the increased taxes, which may lead to negative responses toward consuming tobacco products. Furthermore, to overcome the substitution effect, policymakers can raise taxes for all tobacco products so that smokers have fewer options to substitute for cigarettes (Chaloupka *et al*., 2012)

8 Conclusion

My study investigates the effect of tobacco taxation on cigarette consumption. Unlike most of the existing literature, which only use the two-part estimation of probit and OLS models, my study incorporates a DiD strategy based on their models. I analyze the effects of higher taxes on the probability of smoking and the number of daily cigarette consumption by using data of January, 2007 as the pre-tax hike period and May, 2010 as the post-tax hike period. Based on my empirical results, I find that smoking probability increases after the tax hikes before I control for all the demographic variables, which contradicts my expectation of lower likelihood of being a smoker.

For my other models, I do not find statistically significant results, including the ones estimated by using subgroups. As a result, there is no conclusive evidence that supports the economic theory of higher prices result in fewer demand for the goods and services.

Further research extension is required for my study in order to thoroughly examine the impact of tobacco taxation on cigarette consumption. One of them is to examine how cigarette addiction offsets the effectiveness of tobacco control taxation. Since I do not find available data that allows me to model addiction, data collection on nicotine and tar intakes would be preferable for future study to analyze smoking addiction. Another possible extension is to collect data on the consumption of cigarette substitutes in order to estimate the substitution effect. Additionally, since my study only focuses cigarette excise tax changes between 2007 and 2010, future study can implement an investigation of smokers' responses to cigarette taxes by looking at the smoking consumption trends form a more recent time frame. Furthermore, administrative panel data would be useful for tracking smokers over time. Finally, future researchers can conduct a field study in a tobacco shop, which is similar to Chetty *et al*'s (2009) grocery experiment, by specifically targeting tobacco products. In this case, researchers can manipulate the magnitude of the tax hike in order to examine the tax salience effect on reducing cigarette consumption by assigning a sizable tax increase to the cigarette price.

Overall, my study highlights that the ineffectiveness of tobacco taxation as a strategy for controlling cigarette consumption may be due to the inelastic demand for cigarettes, substitution effect, brand switching behavior, or inefficient allocation of tax revenues. If the government invests the tax revenues in other purposes instead of focusing on preventing smoking behavior, smokers as well as the tax payers will not be the greatest beneficiaries in this tobacco tax system.

Altogether, it is worth conducting research on policy development in the field of tobacco taxation given that smoking is a growing public health concern.

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Tables

Table 1. Treatment States Used in DiD

STATES	Date of Excise Tax Increase	Pre-Tax	Post-Tax	Tax Change (%)
Iowa	03/15/2007	$0.36	$1.36	277.78
Tennessee	07/01/2007	$0.20	$0.62	210.00
Delaware	07/31/2007	$0.55	$1.15	109.09
Maryland	01/01/2008	$1.00	$2.00	100.00
Wisconsin	01/01/2008	$0.77	$1.77	129.87
Kentucky	04/01/2009	$0.30	$0.60	100.00
Mississippi	05/15/2009	$0.18	$0.68	277.78
Florida	07/01/2009	$0.339	$1.339	294.99

Note: The federal cigarette tax (applied to all 50 states) increased by 62 cents, to $1.01 per pack of cigarette on April 1, 2009 (the *Tax Burden on Tobacco*).

Table 2. Summary Statistics of Excise Tax and Sales Tax

VARIABLES	Pre-Tax Hike	Post-Tax Hike
Excise tax ($)		
Treatment	0.50	1.19
	(0.28)	(0.78)
Control	1.00	1.01
	(0.54)	(0.54)
Sales tax ($)		
Treatment	0.22	0.34
	(0.03)	(0.03)
Control	0.26	0.28
	(0.07)	(0.09)
Observations	12,944	14,543

Note: Standard deviations are reported in the parentheses.

Table 3. Descriptive Statistics – Full Sample

VARIABLES	Control	Treatment
Age (18 – 85)	41.96	42.44
	(13.40)	(13.57)
Gender		
Male	0.5180	0.5101
Female	0.4820	0.4899
Race		
White	0.8506	0.8435
Other	0.1494	0.1565
Marital status		
Married	0.5796	0.5676
Other	0.4204	0.4324
Educational attainment		
Below high school	0.0834	0.0856
Between high school and associate degree	0.5788	0.5953
Bachelor's degree and above	0.3377	0.3190
Family income		
Low-income (< $19,999)	0.1136	0.1087
Middle-income ($20,000 to $74,999)	0.5379	0.5323
High-income (> $75,000)	0.3485	0.3590
Employment status		
Employed	0.9326	0.9397
Unemployed	0.0674	0.0603
All smokers	0.1892	0.1871
Everyday smokers	0.1534	0.1543
Daily cigarettes	15.68	16.73
	(8.28)	(8.86)
Observations	11,444	16,043

Note: All variables are dummy variables (expressed in percentage term) except age and daily cigarettes (expressed in mean value), which are quantitative variables. Standard deviation is reported in the parentheses.

Table 4. Comparisons of the Probability of Smoking

	Pre-Tax Hike	Post-Tax Hike	Difference
Treatment	0.1988	0.1764	-0.0224
	(0.40)	(0.38)	(0.79)
Control	0.2110	0.1703	-0.0407
	(0.41)	(0.38)	(0.79)
Difference	-0.0122	0.0061	0.0183
	(0.83)	(0.77)	(1.60)

Note: Standard deviations are reported in the parentheses. The difference-in-differences estimator is shown at the lower right hand corner.

Table 5. Comparisons of the Number of Daily Cigarette Consumption

	Pre-Tax Hike	Post-Tax Hike	Difference
Treatment	17.42	16.01	-1.41
	(9.30)	(8.31)	(17.62)
Control	16.19	15.11	-1.08
	(8.62)	(7.84)	(16.46)
Difference	1.23	0.90	-0.33
	(18.07)	(16.41)	(34.49)

Note: Standard deviations are reported in the parentheses. The difference-in-differences estimator is shown at the lower right hand corner.

Table 6. Effect of Cigarette Taxes on the Probability of Smoking

VARIABLES	(1)	(2)	(3)	(4)
Treatment	-0.0517***	-0.0445*	0.00199	-0.0664***
	(0.0188)	(0.0236)	(0.0286)	(0.0251)
Time	-0.0416***	-0.0380***	-0.0415***	-0.0393***
	(0.00733)	(0.0119)	(0.0118)	(0.0116)
Interaction	0.0197**	0.0174	0.0152	0.0111
	(0.00978)	(0.0141)	(0.0140)	(0.0136)
Sales tax		-0.0519	-0.0200	0.0277
		(0.160)	(0.159)	(0.155)
Male			0.0292***	0.0271***
			(0.00492)	(0.00481)
Age			0.00687***	0.0116***
			(0.00113)	(0.00110)
Age-squared			-0.000101***	-0.000151***
			(1.32e-05)	(1.29e-05)
White			0.0509***	0.0670***
			(0.00640)	(0.00582)
Employed			-0.150***	-0.0910***
			(0.0122)	(0.0113)
Low-income				0.0557***
				(0.00850)
High-income				-0.0596***
				(0.00532)
High-school				-0.0326***
				(0.00827)
Bachelor's degree				-0.165***
				(0.00714)
State fixed effects	yes	yes	yes	yes
Chi2	190.01	193.16	617.14	1,876.04
Prob > chi2	0.000	0.000	0.000	0.000
Observations	27,487	24,859	24,859	24,859
R-squared	0.0072	0.008	0.0256	0.078

Note: This table reports the marginal effects of the probit regression. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7. Effect of Cigarette Taxes on the Probability of Smoking by Demographic Group

VARIABLES	(1) Male	(2) Female	(3) Low income	(4) High income	(5) High school	(6) Bachelor degree
Treatment	-0.0251	0.0270	-0.0204	0.0131	0.0547	-0.0518
	(0.0365)	(0.0387)	(0.0849)	(0.0395)	(0.0394)	(0.0363)
Time	-0.0458***	-0.0320*	0.0439	-0.0163	-0.0457***	-0.0245
	(0.0171)	(0.0164)	(0.0399)	(0.0172)	(0.0167)	(0.0154)
Interaction	0.000470	0.0359*	0.0421	0.0193	0.0228	-0.0133
	(0.0198)	(0.0202)	(0.0469)	(0.0221)	(0.0198)	(0.0171)
Sales tax	0.151	-0.243	-1.021*	-0.271	-0.0285	0.128
	(0.230)	(0.222)	(0.567)	(0.233)	(0.226)	(0.208)
State fixed effects	yes	yes	yes	yes	yes	yes
Chi2	111.24	104.30	55.38	27.64	122.16	43.24
Prob > chi2	0.000	0.000	0.000	0.024	0.000	0.003
Observations	12,756	12,103	2,832	8,688	14,733	8,057
R-squared	0.0086	0.0094	0.0161	0.0044	0.0076	0.0079

Note: This table reports the marginal effects of the probit regression. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 8. Effect of Cigarette Taxes on the Number of Daily Cigarette Consumption

VARIABLES	(1)	(2)	(3)	(4)
Treatment	-1.656*	-1.554	-1.639	-1.669
	(0.911)	(1.217)	(1.149)	(1.144)
Time	-1.215***	-0.989	-0.931	-0.949
	(0.471)	(0.729)	(0.687)	(0.684)
Interaction	-0.168	-0.514	-0.635	-0.718
	(0.612)	(0.839)	(0.790)	(0.787)
Sales tax		0.456	-1.035	-0.0770
		(9.808)	(9.241)	(9.206)
Male			3.557***	3.560***
			(0.296)	(0.295)
Age			0.443***	0.486***
			(0.0757)	(0.0759)
Age-squared			-0.00357***	-0.00399***
			(0.000896)	(0.000897)
White			4.300***	4.547***
			(0.467)	(0.469)
Employed			-0.257	0.160
			(0.483)	(0.490)
Low-income				0.861**
				(0.405)
High-income				-0.565
				(0.398)
High-school				-0.836*
				(0.451)
Bachelor's degree				-2.727***
				(0.619)
Constant	17.89***	17.72***	0.701	0.622
	(0.731)	(1.598)	(2.269)	(2.297)
State fixed effect	yes	yes	yes	yes
F-statistic	6.27	5.82	23.95	21.66
Prob > F	0.000	0.000	0.000	0.000
Observations	3,260	2,955	2,955	2,955
R-squared	0.028	0.029	0.140	0.151

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 9. Effect of Cigarette Taxes on Cigarette Consumption by Demographic Groups

VARIABLES	(1) Male	(2) Female	(3) Low income	(4) High income	(5) High school	(6) Bachelor degree
Treatment	-0.135	-2.850*	-0.982	-1.673	-2.300*	-7.670*
	(1.795)	(1.559)	(3.193)	(2.889)	(1.375)	(3.914)
Time	-0.195	-2.010**	-0.969	-2.497	-0.997	-4.335*
	(1.080)	(0.935)	(1.753)	(1.801)	(0.827)	(2.232)
Interaction	1.012	-1.756	-0.353	-1.905	-0.600	-4.078
	(1.245)	(1.070)	(1.930)	(2.231)	(0.947)	(2.585)
Sales tax	-21.86	22.17*	4.397	22.16	3.695	52.64*
	(14.57)	(12.50)	(24.53)	(24.86)	(11.09)	(30.99)
Constant	23.03***	12.22***	14.52***	14.77***	17.39***	11.55**
	(2.354)	(2.056)	(3.934)	(3.981)	(1.819)	(4.910)
State fixed effect	yes	yes	yes	yes	yes	yes
F-statistic	3.35	3.79	1.24	1.68	3.99	2.28
Prob > F	0.000	0.000	0.237	0.050	0.000	0.005
Observations	1,522	1,433	556	559	2,230	343
R-squared	0.032	0.039	0.033	0.044	0.026	0.094

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 10. Placebo Test – the Probability of Smoking

VARIABLES	(1)	(2)
Treatment	0.00646	-0.0161
	(0.0164)	(0.0175)
Time	-0.0403***	-0.0369***
	(0.00711)	(0.00687)
Interaction	0.0298***	0.0247***
	(0.00878)	(0.00847)
Male		0.0363***
		(0.00383)
Age		0.0108***
		(0.000894)
Age-squared		-0.000138***
		(1.05e-05)
White		0.0313***
		(0.00518)
Employed		-0.0938***
		(0.00897)
Low-income		0.0618***
		(0.00509)
High-income		-0.0499***
		(0.00459)
High school		-0.0218***
		(0.00629)
Bachelor's degree		-0.139***
		(0.00568)
State fixed effects	yes	yes
Chi2	490.86	2,889.75
Prob > chi2	0.000	0.000
Observations	37,366	37,366
R-squared	0.0139	0.0818

Note: Both changes in excise tax and sales tax are taken into consideration in determining the treatment and control groups. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 11. Placebo Test – Number of Daily Cigarettes

VARIABLES	(1)	(2)
Treatment	-1.851**	-2.036**
	(0.909)	(0.870)
Time	-1.215***	-1.170***
	(0.454)	(0.433)
Interaction	-0.00617	-0.0470
	(0.552)	(0.527)
Male		3.073***
		(0.248)
Age		0.409***
		(0.0634)
Age-squared		-0.00339***
		(0.000749)
White		3.104***
		(0.383)
Employed		0.0552
		(0.387)
Low-income		0.479*
		(0.282)
High-income		0.0841
		(0.359)
High school		-1.188***
		(0.370)
Bachelor's degree		-2.557***
		(0.516)
Constant	17.89***	3.980***
	(0.704)	(1.533)
State fixed effect	yes	yes
F-statistic	10.47	23.50
Prob > F	0.000	0.000
Observations	4,081	4,081
R-squared	0.044	0.135

Note: Both changes in excise tax and sales tax are taken into consideration in determining the treatment and control groups. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 12. Count Data Model of the Number of Daily Cigarette Consumption

VARIABLES	(1) Original	(3) Placebo
Treatment	-0.107	-0.153
	(0.294)	(0.240)
Time	-0.272	-0.380***
	(0.173)	(0.110)
Interaction	0.115	0.247*
	(0.206)	(0.131)
Sales tax	-1.032	-
	(2.364)	
Constant	1.150***	1.027***
	(0.384)	(0.184)
State fixed effects	yes	yes
Chi2	69.96	231.40
Prob > chi2	0.000	0.000
Observations	24,859	37,366
R-squared	0.0016	0.0038

Note: Column 1 represents the original specification, where only excise tax is considered in determining the treatment group. Column 2 represents the placebo analysis of the count model. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1