THREE ESSAYS ON TAXATION ANALYSIS

by

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Abstract

This dissertation investigates the commodity tax and corporate income tax. Chapter 1 provides a general introduction and Chapter 2 consists of a literature review.

Chapters 3 and 4 analyze how state governments determine their commodity tax rate and respond to other state and federal government tax rate changes. We construct and estimate the household utility function and the state government objective function, and compute the slope of the reaction functions to evaluate the tax interactions between state governments and between state and federal governments. We find that horizontal tax interactions are very small and that state governments do not change their tax rate even though the neighboring state governments change their tax rates. On the other hand, vertical tax interactions are positive, and if the federal government increases its tax rate, state governments also raise their tax rates to preserve their tax base.

Chapter 5 discusses how the corporate income tax affects firm location and exit decisions. We compute and compare three kinds of individual firm-level tax rates and examine the effect of these corporate income taxes on firm location and exit behaviour. We find that each tax rate has a different distribution across provinces and that using a different tax provides a different interpretation of tax effects. In most cases, high corporate income tax rates are found to discourage firm location choice and encourage firm exit decisions.
I express my great appreciation for all those who helped me complete this Ph.D thesis.

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Chapter 1

General Introduction

The tax system distorts household and firms behaviour by changing disposable income and after tax prices or by raising the production cost. This tax system is valid as long as the tax rate is optimal and tax revenue is used properly to provide public services. Nevertheless, if the tax rate is not optimal, the distortion caused by the tax system expands, which results in the welfare loss in economy. Therefore, taxation is one of the most important research topics in public finance. A large volume of literature has discussed several issues related to taxation, including the optimal tax rate, the distortionary effect of taxation, harms and benefits of tax competition, the scale of horizontal and vertical tax interactions and fiscal policies to resolve tax externalities. All of these analyses and results crucially depend on three important factors, and we address each in turn.

First, the behaviour of economic, i.e. households and firms that are affected by tax policies, needs to be understood. In short, household and firm responses to tax rates are among the key factors determining tax rates. For instance, in the commodity tax cases, households respond to commodity tax rate changes in two different ways. One way is by changing the amount of consumption, the scale of which is captured by the price elasticity
of demand, and another way involves changing the location for purchasing products, which means cross-border shopping. Governments need to understand the price elasticity of demand and the sensitivity of cross-border shopping to change commodity tax rates whatever the purpose of governments. As for the corporate income tax, firms prefer a low production cost location and choose the location where the corporate income tax system is more generous, other thing equal. Once the corporate income tax rate increases, firms respond to the tax increase by changing the state of their acivity or migrating to a different location. It is necessary for governments to determine their tax rates taking into account the effects of the corporate income tax on firm activity scale and location or exit decisions.

Second, the government objective must be identified. Governments are generally assumed to be either Benevolent or Leviathan. The purpose of Benevolent governments is to maximize the total welfare of people, while Leviathan governments aim to maximize total tax revenue. The optimal tax rate and tax characteristics are different under these objectives. In the Benevolent government case, the optimal commodity tax rate follows the Ramsey rule. If commodity tax revenue is used for financing public goods, the modified Samuelson condition has to be satisfied. On the other hand, if governments are Leviathan, the optimal commodity tax rate is inversely proportional to the elasticity of the tax base and the price elasticity of demand will be less than minus one. Thus, the government objective is another important factor for analyzing the tax issue.

Third, interactions with other governments have to be taken into account. There are two kinds of interdependent relations among governments. One is a horizontal relation, in which governments of the same level interact, and another is a vertical relation, in which different level governments interact. Horizontal tax interaction occurs when the same level governments compete against each other for the same tax resources. For example, in the
commodity tax cases, households determine the place to purchase products considering the price differences and choose cross-border shopping if the benefit from the price differences is larger than the cost of transportation. For the corporate income tax, firms locate in the place where production costs are small, and high corporate tax rates discourage firm entry or encourage firm exit. Governments prefer to have a large tax base and reduce their tax rates to attract these cross-border shoppers or firms from other places, which results in horizontal tax interactions.\footnote{In the case of the commodity tax, governments might increase their tax rate to expand their tax revenue from cross-border shoppers, i.e. tax exporting, if they find that increasing tax rate does not have much effect on the number of cross-border shoppers or that the neighboring governments also increase their tax rate.} Vertical tax interaction describes the situation in which two different levels of government share a common tax base and either or both governments ignore the fact that their tax would shrink the tax base of the other government. For instance, if the federal government increases tax rates without recognizing the effect on the state government tax base, households and firms decrease the amount of consumption or activity scale, and state governments need to change their tax rates to sustain their tax base.

The importance of these horizontal and vertical tax interactions depends on household and firm behaviours. For example, if the cost of transportation is too high for households to choose cross-border shopping, horizontal tax interaction does not occur. If the corporate income tax burden is not an important factor for firm location choice, governments do not need to compete for firms. On the other hand, if the consumer’s price elasticity of demand is zero, consumers do not change the amount of consumption even though governments change commodity tax rates, and vertical tax interaction does not exist. In short, both horizontal and vertical tax interactions are important to analyze how governments determine their tax rate, and households and firms behaviors are key factors to measure the scale of the tax interactions.
Taking into account these three important factors, we analyze three sets of taxation issues in the following chapters. The first issue analyzes how households determine their commodity purchases and cross-border shopping. The second sets of issues concern what the state government objective is, and how state governments determine their commodity taxes and respond to other state and federal government tax rate changes. The third issue concerns how the corporate income tax affects firm location and exit behaviour. Chapter 2 provides a literature review of these topics. Chapters 3 and 4 are complementary: we analyze household commodity consumption and cross-border shopping behaviour and state government commodity tax determinations in these two chapters. Chapter 3 focuses on estimating the household utility function and the state government objective function and computes the slope of the reaction functions. Chapter 4 analyzes the objective of state government and identifies the state government objective function, which is used in Chapter 3. Chapter 5 computes individual firm level tax rates and analyzes how these corporate income taxes affect firm location and exit decisions.

Chapter 3 explicitly estimates the structural parameters of the consumer utility function and the state government objective function and examines the existence of strategic interactions of taxation between state governments and between state and federal governments using the U.S. gasoline and cigarette taxes. The existence of strategic interactions between governments is evaluated by computing the slope of the reaction function using the estimated parameters of the models. We first solve and estimate a model of optimal consumption and cross-border shopping behavior of households. Then we recover the parameters of the state government objective function, which is derived in Chapter 4. After all the key structural parameters are estimated, we compute the slope of the reaction functions and evaluate the strategic interactions between governments.
The estimation results are as follows. First, the slope of the reaction functions between state governments of both gasoline and cigarette taxes, which describes a horizontal tax interaction, is positive and small. This finding indicates that, even though the neighboring state governments change their tax rates, state governments will not respond to the tax change. Second, the slope of the reaction functions between state and federal governments, which describe a vertical tax interaction, is positive, and the value is larger for cigarette tax than for gasoline tax. In short, if the federal government increases its tax rate, state governments also raise their tax rate to preserve their tax revenue, and the scale of response is larger for the cigarette tax than for the gasoline tax. Third, the slope of the reaction function of the tax interactions is positive on average, but its value and sign are very different among states and for some states the sign becomes negative. In other words, the reactions of state governments to the neighboring state and federal government tax changes are different not only in scale but also in direction. Lastly, we replicate a weighted matrix approach using simulated tax rates assuming no cross-border shopping. Since tax rates are simulated under the assumption of no cross-border shopping, tax rates do not include a factor of the horizontal tax externality. Therefore, regression analysis should show no horizontal tax interaction if the estimation method is appropriate. Nevertheless, the replication results show strong horizontal tax interactions, which should not exist. This contradiction between the model and the results implies that the weighted matrix approach might not be suitable to evaluate the slope of the reaction function.

Chapter 4 identifies the state government objective and constructs the state government objective function using the U.S. gasoline tax. First, we build the state government objective function based on Benevolent and Leviathan assumptions, and derive the optimal tax function. Then we examine the consistency between the model and real data to determine
which government assumptions and functional forms are suitable. Lastly, we simulate state
taxes based on the model and compare them with real tax data to verify that our model
reflects real state government behavior correctly.

Our finding from the analysis is as follows: First, a Benevolent government idea is more
suitable as the state government objective. The Leviathan assumption is inconsistent to the
estimated price elasticity of demand and small percentage of cross-border shopping, and
Leviathan assumption is not appropriate. Second, the state government objective function is
better described using quasi-linear function. Third, a simulated tax based on the structural
model shows a strong correlation with real tax data and we have confirmed that our model
describes state government behavior well.

Chapter 5 analyzes how the corporate income tax affects firm location choice and exit
behaviours. We focus on manufacturing sectors and use firm longitudinal data the GIFI-
T2LEAP database, which has been created by Statistics Canada. The first analysis con-
structs individual firm level corporate tax rates. We compute three kinds of tax rates and
examine each tax rate distribution. In addition, we compare these tax rates with aggregate
level tax rates and effective tax rates. Second, we analyze firm entry and exit behaviours
across different firm sizes, industry sectors and provinces. Third, firm tax payment be-
aviour is studied. Lastly, the effects of the corporate income tax on firm location choices
and exit decisions are analyzed.

The results from our analyses are as follows: First, each corporate income tax rate has a
different distribution across provinces, and individual firm level tax rates are different from
aggregate level tax rates and effective tax rates. This means that using a different tax rate
for empirical analysis will result in a different interpretation of tax effects. Second, firm
entry and exit decisions depend on firm sizes, industry sectors and provinces, with firm size
being particularly important. Third, the percentage of firms that do not pay taxes hinges on firm structure, age, firm sizes, industry sectors and provinces, and most small, young, and single firms about to leave the market do not pay taxes. Lastly, high corporate income tax rates are found to discourage firm location choice and encourage firm exit decision.

The remainder of the thesis proceeds as follows: Chapter 2 provides a literature review for all chapters. Chapters 3, 4 and 5 discuss the commodity tax and corporate income tax as we explained above, and Chapter 6 concludes.
Chapter 2

Literature Review

In this chapter, we introduce the prior literature following each chapter’s topics. First, we explain the horizontal and vertical tax interaction literature. Then we move to the literature related to the government objective. Lastly, papers on firm location choice analysis are highlighted.

A large amount of literature has discussed horizontal and vertical tax interactions. Horizontal tax interaction occurs when the same levels of government compete against each other for the same tax resources, which are mobile across locations. The idea of horizontal tax competition is first analyzed in Wilson (1986) and Zodrow and Mieszkowski (1986) using the capital tax. Each local government tries to attract mobile capital stock to enhance local production and reduces its tax rate without recognizing a positive spillover effect on the other regions, which results in lowering capital tax rate in Nash equilibrium. Since these papers, capital tax competition has been well argued in the literature. Not only the capital tax, but other kinds of taxes are investigated.

1Yardstick competition is also another resource for the horizontal tax interaction, but we do not argue this issue in this thesis.
The concept of horizontal tax interaction in the commodity tax case is different from that in the capital tax case, and governments aim to expand tax revenue from consumers in their own regions as well as cross-border shoppers from other regions. The situation in which governments levy a commodity tax on consumers from other regions is called "tax exporting". Governments need to balance the benefits and costs of increasing tax rate: the benefits are the increase of per capita amount of tax revenue and the costs are losing cross-border shoppers. Because of these two opposite factors of increasing the tax rate, commodity tax rate in Nash equilibrium might be higher or lower than the optimal tax rate. Mintz and Tulkens (1986) study horizontal commodity tax interaction taking into account the price differences and the transportation costs across regions. They argue the existence of non-cooperative fiscal equilibrium, characteristics of non cooperative fiscal equilibrium, the reasons for the non-optimality of tax rates in equilibrium and the solutions for them. Kanbur and Keen (1993) analyze horizontal commodity tax interactions focusing particularly on the role of country size, and discuss the effects of a tax harmonization policy, imposing a minimum tax rate, and the increased international mobility of cross-border shoppers. Lockwood (1993) studies the effect of switching from the destination to the origin principle of taxation on non-cooperative commodity tax equilibrium. Haufler (1996) analyzes horizontal commodity tax interactions when people’s preferences over public goods are heterogenous, and discusses the effects of tax coordination and imposing a minimum tax rate. Nielsen (2001) considers a tax coordination policy in a model of commodity taxation and cross-border shopping, and three kinds of policies (marginal reform, rate harmonization and a minimum tax rate) are investigated. Lockwood (2001) provides a general form of commodity tax competition based on both destination and origin principle and evaluates the effect of foreign commodity tax changes on commodity
prices, producer prices and profit from production in the home country, respectively, by changing the assumptions about factor mobility and a market condition. He also discusses welfare improving policies like lowering tax rates or tax harmonization.

Vertical tax interactions are attributed to the situation in which two different level governments share a common tax base and in which either or both governments ignore the fact that their tax would shrink the tax base of the other government. Flowers (1988) considers an economy where two different level governments share a common tax base and maximize their own revenue, and finds that the tax rates in Nash equilibrium lie on the backward bending portion of the Laffer curve. Jonhson (1988) discusses the possibility that sharing the common tax base between state and federal governments will decrease the cost of redistributing income to people because some of the cost is borne by all federal taxpayers. Keen (1998) gives a comprehensive summary of the vertical tax externality. He argues a suitable tax revenue allocation between federal and state governments, state tax response to federal tax rate and a relation with an intergovernmental transfer.

Analyses considering both horizontal and vertical tax externalities have also been conducted. Keen and Kotsogiannis (2002) consider the economy in which both vertical and horizontal capital tax externalities exist, and analyze which externality dominates the other. They find that the relative scale of horizontal and vertical externality depends on the balance between the elasticity of the demand for capital and the supply of savings. Keen and Kotsogiannis (2003) analyze horizontal and vertical capital tax competition under Leviathan governments. In this economy, the vertical tax externality is found to dominate the horizontal tax externality and the tax rate in equilibrium is higher than optimal. Keen and Kotsogiannis (2004) investigate the effect of the intensified tax competition on welfare in the presence of both horizontal and vertical tax externalities. They find that intensified tax
competition always worsens welfare, no matter which externality will dominate.

Literature discussing fiscal policies to solve these externalities also exists, and typically an intergovernmental transfer is used. Boadway and Keen (1996) study horizontal and vertical externalities using a distortionary labour tax and analyze the role of an intergovernmental transfer to internalize these externalities. They find that, opposite to the general idea, a transfer from state governments to federal government helps to achieve the optimal tax rate. Dahlby (1996) discusses vertical tax and expenditure externalities and shows that a matching revenue grant and a matching expenditure grant will solve these externalities. Hoyt (2001) considers the economy in the presence of horizontal and vertical commodity tax externalities and provides a specific grant formula to fix both externalities. Dahlby and Wilson (2003) analyze a model where both federal and state government tax wages and profits and the state government provides a public input which enhances labour productivity. They show that the underprovision of the state public input attributed to vertical tax externality can be corrected by using a matching grant system. Vander (2004) provides an economic model of commodity tax competition, taking into account both vertical and horizontal externalities. He finds that using a suitable matching grant solves these externality problems.

Not only theoretical literature, but also empirical analyses which evaluate both horizontal and vertical tax interactions have been conducted. As for horizontal tax externality, Brett and Pinkse (2000) study business property tax competition using municipal level data in British Columbia. They investigate the determinants of the tax base and tax rate jointly and find no strong evidence to support the existence of tax competition. Jacobs, Ligthart and Vrijburg (2010) discuss consumption tax rates across U.S. states, taking into account
spatial characteristics, and find a positive horizontal tax interaction. With respect to vertical tax interactions, Besley and Rosen (1998) use gasoline and cigarette taxes in the U.S. and find a positive vertical interaction in both cases. Goodspeed (2000) assesses the scale of vertical tax interaction using 13 OECD income tax rates. He finds that higher national income tax rates and lower poverty rates lead to lower local income tax rates. Esteller-More and Sole-Olle (2001) investigate the vertical tax externality using U.S. state personal and general sales taxes and find that if the federal government increases its tax rates, state governments also raise their tax rates.

Empirical analyses including both horizontal and vertical externalities are also presented in the literature. Hayashi and Boadway (2001) evaluate horizontal and vertical tax interactions using Canadian corporate income tax rates. They divide ten provinces into Ontario, Quebec and other states, and assess mutual tax interactions between provincial governments and between provincial and federal governments. The empirical analyses show a negative effect of the federal tax rate on province tax rates, and a positive effect of province tax rates on the federal tax rate. A partial positive horizontal tax interaction across provinces is also admitted. Esteller-More and Sole-Olle (2002) assess both horizontal and vertical tax externalities using Canadian personal income tax rates. They take into account the effect of an intergovernmental transfer and compare the scale of horizontal tax externalities between provinces with and without grants. They find a positive interaction for both horizontal and vertical cases, and that the horizontal tax externality is larger for province without federal transfers. Brulhart and Jametti (2006) examine the relative scale of horizontal and vertical tax interaction using personal income tax in Switzerland and find that the vertical tax externality dominates the horizontal tax externality. Devereux, Lockwood and Redoano (2007) extend the Besley and Rosen (1998) paper by including horizontal tax
interactions. They find a positive horizontal tax interaction and an insignificant vertical tax interaction for the cigarette case and an insignificant horizontal tax interaction and a positive vertical tax interaction for the gasoline case. They explain that these different results are attributed to the transfer cost, the price difference across states and the price elasticity of demand.

In order to analyze both horizontal and vertical tax interactions, the previous literature use a weighted matrix approach to approximate the complex strategic interactions between state governments.\(^3\) That is, they estimate a linear model where the dependent variable is state taxes and independent variables include the weighted average of other states’ taxes, the federal tax and other socio-economic variables. While the above regressions based on the approach with and without the weighted matrix have made us aware of the importance of the strategic interactions in taxation, we argue that there are several difficulties in interpreting the estimation results, especially for the results that include horizontal tax interaction, where a weighted matrix is used. In Chapter 3, we discuss the limitations of this weighted matrix method and provide a new method for evaluating horizontal and vertical tax interactions using the U.S. gasoline and cigarette tax.

Next, we move to the literature on the government objective. In the public finance literature, federal and local governments are regarded as either Benevolent or Leviathan.\(^4\) A benevolent government is considered as maximizing the total welfare of citizens, while a

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\(^3\)This approach uses a weighted matrix which is employed to compute the weighted average of state variables \(x\), i.e. \(\sum_{i \neq j} w_{ij} x_j\) for state \(j\). For example, in the U.S. state case, there are 50 states and the matrix dimension is \(50 \times 50\), and a weight factor \(w_{ij}\) between state \(i\) and \(j\) is chosen to define the level of importance. In previous literature, population, density, distance between states, and income are used as a factor of the weighted matrix.

\(^4\)We admit that some papers also consider the cases where the government’s purpose is rent seeking or connected with some political issues. For example, Besley and Case (1995) show that yardstick competition is attributed to the government maximization problem of its rent or the probability to win elections. We do not refer to these issues in this paper.
Leviathan government is assumed to maximize total tax revenue. Apparently, their purposes are different, and the tax rate and tax characteristics under different governments must differ. For example, Abizadeh and Cyrenne (1997) examine income and excise tax rate characteristics and find that important factors for these taxes’ elasticity of demand for private goods are different between Benevolent and Leviathan governments. Keen (1998) analyzes how state government tax rates respond to federal government tax rate changes. State government tax rates are found to react positively to federal government tax rate change in both Leviathan and Benevolent cases, although a specific demand functional form is required in the Leviathan case. Santolini (2009) analyzes the optimal tax rate under Leviathan-type and welfarist-type politicians. He finds that Leviathan-type politicians are more sensitive than welfarist-type politicians to changes in the average tax rate of their peers, and less sensitive to the change in the central government tax rate. In short, the optimal tax rate and its characteristics are different between Benevolent and Leviathan governments, and identifying the government objective is a very important research topic in public finance.

Some papers examine whether government behaviour is consistent with Leviathan. Oates (1985) considers that, under the assumption of Leviathan, the size of public sectors should vary inversely with the extent of fiscal decentralization, since a decentralized public sector works as a mechanism for limiting growth in the size of governments. He examines the relation between the size of government and the extent of fiscal decentralization, but does not find evidence to support the Leviathan assumption. Nelson (1987), Zax (1989) and Stansel (2006) extend Oates’ (1985) idea by changing the definition of fiscal decentralization or the data set and find supportive results for the Leviathan assumption.
Garrett (2001) focuses on state lottery agencies and examines whether state lottery agencies aim to maximize revenue. He estimates the Laffer curve and derives the optimal lottery tax rate, assuming lottery agents maximize revenue. Comparing simulated tax rates based on the estimated model and real tax data, he concludes that state lottery agencies conduct revenue maximization. On the other hand, there are few papers examining whether government behaviour corresponds to a Benevolent idea. Therefore, investigating the government objective in the view of a Benevolent idea is the theme of Chapter 4.

Lastly, we review the literature on firm location analysis. Many papers have investigated empirically the effects of fiscal variables on firm location choices. The measurement of tax burden depends on the scale of location. For example, if firms locate among municipalities, the property tax is a suitable tax index. On the other hand, if location choice is among states or country levels, the corporate income tax will be appropriate. Erikson and Wasylenko (1980) develop a model of the site choice decision and analyze the effect of social economic and fiscal variables on firm relocation choice using Milwaukee city data. They find that an agglomeration effect and available labour force are important for firm relocation choice but fiscal variables including the property tax do not have a significant effect. Batrik (1985) analyzes how the decision to open a new branch plant is influenced by state characteristics using individual U.S. plant data. Using a conditional logit model with some modification, he finds that high unionization has a very strong negative effect on firm location and that high state taxes also discourage new manufacturing plants. Schmenner, Huber and Cook (1987) take into account the sequential decisions of the firms (first choosing a subset of locations and then choosing one location out of that subset) as well as plant specific characteristics (like labour unionism and wage), and investigate plant location choice using plants data in the U.S. The corporate tax rate effect is found to be insignificant. Papke
(1991) examines the impact of state and local tax differential on the location of industry. She finds that after controlling state and industry effects, high state effective marginal tax rates reduce the number of firm births. Head and Mayer (2004) investigate the effect of market potential on firm location choice using Japanese firms in European countries. They find that market potential matters for firm location choice, although the corporate tax rate does not have a significant effect. Basile, Castellani and Zanfei (2008) assess the role of EU Cohesion policy on firm location choice using data on foreign subsidiary established in the EU. After controlling agglomeration effects and regional characteristics, they find that structural Cohesion funds allocated by the EU contribute to attracting multinational company, although effective average tax rates do not have a significant impact.

Some applications based on firm location choice analysis are also well done. For example, Wasylenko (1980) and Lee and Wasylenko (1987) consider the case when jurisdictions which do not allow firm establishments and entry are excluded from the estimation. Carlton (1983) and Feld and Kirchgassner (2002) investigate the effects of tax burden on both firm location and employment. Devereux and Griffith (1998) examine a firm’s three choice behaviours (not serving a foreign market, exporting, and locating in foreign countries) and evaluate the effect of two kinds of tax burden, effective average tax rate and marginal effective tax rate, on both export and location choices. Gabe and Bell (2004) evaluate the effect of the balance between public good expenditure and tax burden on firm location choice. Beaulieau, McKenzie, Vu and Wen (2006) investigate the correlation between the number of firm establishments and corporate tax rates in Canada. Brulhart, Jametti, and Schmidheiny (2008) assess the combined effect of an agglomeration effect and tax burden on firm births. Not only firm location, but other financial variables are employed to evaluate the tax

Despite a large volume of literature, the effect of taxes on firm location choice is inconclusive. Several reasons are considered for the inconsistent results. First, estimation methods are different. Some papers use a conditional logit model (or nested or mixed logit) for estimation, and some use linear regressions. Poisson estimation is also well-used currently for firm location analysis. Second, the explanatory variables included and the analyzed year or duration are different. In addition, a firm location decision must differ for different purposes, such as settling new subsidiaries, FDI or a main department. Beyond these reasons, we consider that using a different tax rate for empirical analysis is one of the most important reasons for these inconsistent results. Given this background, we compute several kinds of individual firm level tax rates and determine the reasons for the inconsistent results by comparing these tax distributions in Chapter 5.
Chapter 3

A New Approach to Estimating Tax Interactions in Fiscal Federalism

3.1 Introduction

This chapter proposes a structural estimation method to evaluate the tax interactions between governments. In another word, this paper explicitly estimates the structural parameters of the consumer utility function and the state government objective function, and examines the existence of strategic interactions of taxation between state governments and between state and federal governments using the U.S. gasoline and cigarette taxes.

Excise taxes distort household consumption, and using an excise tax system is valid as long as the tax rate is optimal and tax revenue is used properly for providing public goods. Nevertheless, tax interactions between governments prevent them from choosing optimal excise tax rates, which results in welfare loss. The scale and direction of the distortion depends on how and why the tax interactions occur. Tax coordination or an
intergovernmental transfers are proposed to solve this distortion\(^1\) and it is important to identify the mechanism of tax interactions. Analyzing strategic tax interactions between governments is an important policy question for countries under fiscal federalism, where both a federal government and state governments co-exist, and a large amount of literature has discussed this issue.

The existence of strategic interactions between governments is evaluated by computing the slope of the relevant reaction functions given the estimated parameters of the model. If the slopes of the reaction functions between state governments are positive, state governments’ tax policies are strategic complements and a state government raises (reduces) its tax rate if other state governments raise (reduce) their tax rates. On the other hand, if the slopes are negative, tax policies are strategic substitutes and a state government will reduce its tax rate if other state governments raise their tax rates. The intuition behind the strategic complements idea is that if other state governments raise their tax rate, a state government can raise its tax rate to increase its revenue without the fear of losing tax base or if other state governments reduce their tax rate, a state government needs to reduce its tax rate to protect its tax base. On the other hand, the intuition behind the strategic substitutes case is that if other state governments raise their tax rate, a state government reduces its tax rate when a state government judges that reducing tax rate will generate more tax revenue by attracting more tax resources than simply increasing the tax rate. The same idea is applicable to the vertical tax interaction between state and federal governments.

Horizontal commodity tax interaction arises when state governments compete against each other for the same tax resources. In this sense, the mobility of tax resource, i.e. cross-border shopping, is a crucial factor of horizontal commodity tax interaction, and the scale

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of horizontal tax interaction depends on the mobility of these cross-border shoppers. Governments aim to expand tax revenue not only from consumers in their own regions but also cross-border shoppers from other regions, which is called "tax exporting", and they balance the benefits and costs of increasing tax rate: the benefits are the increase in per capita tax revenue and the costs involve losing the cross-border shoppers. Because of these two opposite factors of increasing tax rates, the commodity tax rate in Nash equilibrium might be higher or lower than the optimal tax rate. On the other hand, vertical commodity tax interactions result from the situation in which state and federal governments share a common tax base and in which either or both governments ignore the fact that their tax would shrink the tax base of the other government. In this case, the tax elasticity of the tax base, i.e. consumer’s price elasticity of demand, is a crucial factor influencing the intensity of vertical commodity tax interactions. Tax rates in equilibrium tend to be higher than optimal especially when state and federal government taxes are strategic complements. Consequently, if there is a tax interaction, there is a possibility that both tax rate and the amount of public goods are not optimal, and understanding the mechanism of tax interactions is necessary to solve the distortion.

There is already a large body of literature that discusses vertical and horizontal strategic interactions in taxation, both theoretically and empirically. Besley and Rosen (1998) examine theoretically and empirically the vertical excise tax externality, i.e. strategic interactions between state and federal government using gasoline and cigarette taxes in U.S. They find that the theory of optimal consumer and government behavior does not determine the sign of the slope of the reaction function, and their regression analysis show a positive effect of the federal tax rate on state taxes for both gasoline and cigarettes.

Devereux, Lockwood and Redoano (2007) extend the work of Besley and Rosen (1998)
and include horizontal strategic tax interactions in their model. In order to analyze horizontal tax interaction, they use a weighted matrix approach to approximate the complex strategic interactions between state governments. That is, they estimate a linear model where the dependent variable is state taxes and independent variables include the weighted average of other states taxes, the federal tax and other socio-economic variables.² The coefficient of the weighted average of other state taxes represents the horizontal tax interaction and the coefficient of the federal tax is regarded as the vertical tax interaction. The results show that the coefficient of the weighted average of other state tax rates is estimated to be significantly positive but the coefficient of the federal tax rate is insignificant for cigarette tax. For gasoline tax, the former is insignificant and the latter is positive and significant. The authors argue that the difference in the estimated strategic interactions of gasoline and cigarette taxes could be attributed to the different characteristic of the good, such as the difference in the price elasticity of demand and transportation cost.³

While the above estimation results have made us aware of the importance of the strategic interactions in taxation, we argue that there are several difficulties in interpreting them, especially for the results including horizontal tax interaction where a weighted matrix is used.

First, the theory of state tax policy predicts that the slopes of the reaction functions,

²The weighted average of other state taxes are computed using a weighted matrix, i.e., \( \sum_{i \neq j} w_{ij} x_j \) for state \( j \) where \( w_{ij} \) is a weight factor between state \( i \) and \( j \) and \( x_j \) is a social economic variable in state \( j \). For example, in the U.S., there are 50 states and the matrix dimension is 50 × 50, and a weight factor \( w_{ij} \) is chosen to define the level of importance. In previous literature, population, density, distance between states, and income are used as a factor of the weighted matrix.

³"When individual demand for the good is relatively price-inelastic, and incentives for inter state arbitrage are strong, the tax set in any state is likely to be strongly positively responsive to taxes set in neighboring states, but unresponsive to the federal tax. Conversely, when individual demand for the good is relatively price-elastic, and incentives for inter-state arbitrage are weak, the tax set in any state is likely to be unresponsive to taxes set in neighboring states, and responsive to the federal tax, although this response may be positive or negative. As argued below, the first case describes the market for cigarettes in the US well, and the second case the market for gasoline." extract from Devereux, Lockwood and Redoano (2007) pp.452 lines 16-24.
which measure the response of the own-state taxes to the marginal changes of other state or federal taxes, depend on several variables, which are: the difference between the own-state tax rate and that of all the other states, transportation costs, own and other states’ populations, demand and the price elasticity of demand. However, the conventional weighted matrix approach allows the slope of the reaction function to depend on only one variable used as a weighted matrix factor and assumes the sign of the slope is the same across states. Hence, the variables not included in the weighted matrix cause omitted variable bias in the estimation. The direction and the magnitude of the bias are likely to depend on a variable included in the weighted matrix. We suspect that this is the reason why the results are not robust to the specification of the empirical model, i.e. different studies that use different variables in the construction of the weighted matrix often obtain different parameter estimates of tax interactions.

Second, the weighted matrix approach is too simple an approximation of the Nash equilibrium of state and federal governments’ strategic taxation game. The weighted matrix equation is derived from a linear approximation around a symmetric Nash equilibrium and is only applicable when state governments are symmetric and consumer’s utility functions are quasi-linear. Hence, the estimation results based on the weighted matrix approach are reliable only if the equilibrium is close to being symmetric, i.e. if states are very similar to each other. But the data show a large variation of populations, tax rates, commodity prices and the distances across states. Also, quasi-linear utility functions mean that demand is independent of income and this is a strong assumption considering consumption behavior.

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4Devereux, Lockwood and Redoano (2007) consider three cases. One is a uniform case where all states have equal weight "1/ total number of states". Second is a neighbor case where only the neighborhood states have equal weight "1/ total number of neighborhood states". Last is a density case and population density is used as a factor in the weighting matrix.

5Refer to Madiès, Sonia and Yvon (2004).

6Refer to the Proposition 3 in Devereux, Lockwood and Redoano (2007).
varies across different income levels.\textsuperscript{7}

Lastly, the results of previous papers are not consistent with the conventional theory of the relationship between the price elasticity of demand and the scale of tax interaction. Generally, if tax rates are determined optimally, governments avoid a high tax rate on the good whose price elasticity of demand is high (in an absolute value) to avoid losing tax base. This argument is applicable even in the case where strategic tax interactions exist. Therefore, the slope of the reaction function should be small in the case of good whose price elasticity of demand is large. Nevertheless, both Besley and Rosen (1998) and Devereux, Lockwood and Redoano (2007) report that the value of the slope of the reaction functions between state and federal governments is larger for gasoline than for cigarette, in spite of the fact that the price elasticity of demand of gasoline is greater than that of cigarettes.

We take a structural approach to analyze tax interactions. We first solve and estimate a model of optimal consumption and cross-border shopping behavior of consumers, similar to the one analyzed by Devereux, Lockwood and Redoano (2007). We use the U.S gasoline and cigarette tax rates for the following reasons. First, gasoline and cigarette tax revenues are earmarked for highway and health expenditure, respectively, and it is easier for us to build the state government objective function. Second, Besley and Rosen (1998) and Devereux, Lockwood and Redoano (2007) also use these two tax rates, and we can compare our results with theirs. In this first stage, we recover the parameters of the representative consumer’s utility function. In contrast to the weighted matrix approach, our estimation is based on the full solution of the consumer’s behavior subject to taxes. Hence, we include all the important factors that determine the consumer’s consumption, such as the differences in own-state and other states’ tax rates, transportation costs, population, demand and the price elasticity of demand. These variables also affect state and federal

\textsuperscript{7}This point is confirmed using the data of the U.S. Bureau of Labour Statistics.
taxation via consumer consumption behaviour. We next estimate the parameters of the first order condition of the state government objective function. After all the key structural parameters are estimated, we compute the slopes of the reaction functions and evaluate the strategic interactions between governments. Notice that the slope of the reaction function is derived from state government’s first-order condition, and no additional restrictions are imposed. This method fully captures the effect of other state or federal tax changes on consumers’ cross-border shopping and also takes into account nonlinear functional forms of the reaction function.

The estimation results are as follows: First, the slope of the reaction functions between state governments, which describes the horizontal tax interaction, is positive and small for both gasoline and cigarette taxes. The reasons why this value is small are that the share of gasoline and cigarette consumption to total income is small and that the percentage of cross-border shopping is estimated to be small. Second, the slope of the reaction function between state and federal governments, which describes the vertical tax interaction, is positive, and the value is larger for the cigarette tax than for the gasoline tax. This result is consistent with the idea of a negative relationship between the price elasticity of demand and the tax interaction intensity. Third, the slopes of the reaction function of the tax interaction are estimated to be different across states, and some states take a negative sign. This is in contrast to the results from the weighted matrix estimation, where the slopes are constrained to have the same sign for all states and the value of the slope changes linearly with variables used in the weighted matrix, such as population, distance, or the border population density. Fourth, we find that the slope of the horizontal reaction function depends mainly on the share of commodity consumption to total income and the share of own-state
consumption, while the price elasticity of demand and after tax price are important factors for the slope of the vertical reaction functions. These results cast some doubt on the validity of previous results, which are obtained by assuming that the sign of the slope of the reaction function is the same among states, and that the value of the slopes depends on only one variable. Given these arguments, we replicate a weighted matrix approach using simulated tax rates assuming no cross-border shopping. Since tax rates are simulated under the assumption of no cross-border shopping, tax rates do not include a factor of the horizontal tax externality, and regression analysis should show no horizontal tax interaction if the estimation method is appropriate. Nevertheless, the replication results show strong horizontal tax interactions, which should not exist. This contradiction between the model and the results implies that the weighted matrix approach might not be suitable to evaluate the slopes of the reaction function.

The chapter proceeds as follow. In section 2, we explain how to evaluate tax interactions using a reaction function. In section 3, we introduce the model of household consumption and government taxation and spending. In section 4, we provide details about the estimation strategy, and section 5 explains the data. The 6th section discusses the results of the empirical analysis and section 7 explains the intuitions behind them. Section 8 discusses the relation to previous papers and section 9 concludes.

3.2 General Framework of Tax Interaction

In this section, we briefly review the model of Devereux, Lockwood and Redoano (2007). We use Leviathan government model here for simplicity but we assume benevolent governments in the main arguments.

Suppose there are two state governments, $i$ and $j$, which levy an excise tax on a good $x$. 

Assume that state governments are Leviathan, i.e. maximizing total tax revenue $R$. Total tax revenues in state $i$, $R_i$ are composed of tax rate $t_i$ and tax base $X_i(t_i, t_j, d_{ij}, n_i, n_j)$, where $t_j$ is another state's tax rate, and $d_{ij}$ is the distance between state $i$ and $j$, which corresponds to the transportation cost of cross-border shopping, and $n_i$ and $n_j$ are the populations of state $i$ and $j$, respectively. Tax base $X_i$ is the product of two components; per consumer demand $x_i(t_i)$ and the number of people who purchase the good in state $i$ $s_i(t_i, t_j, d_{ij}, n_i, n_j)$.$^8$ From this expression, it is obvious that the number of consumers $s_i$ depends on tax rates of the two states $t_i, t_j$, the number of population $n_i, n_j$ and the distance between two states $d_{ij}$. Then, the state government $i$'s problem is

$$\max_{t_i} R_i = t_i X_i(t_i, t_j, d_{ij}, n_i, n_j)$$

where $X_i(t_i, t_j, d_{ij}, n_i, n_j) = x_i(t_i) s_i(t_i, t_j, d_{ij}, n_i, n_j)$. The first order condition for maximization is

$$\frac{\partial R_i}{\partial t_i} = x_i(t_i) s_i(t_i, t_j, d_{ij}, n_i, n_j) + t_i \frac{\partial x_i(t_i)}{\partial t_i} s_i(t_i, t_j, d_{ij}, n_i, n_j) = 0$$

From this first order condition, the reaction function of state $i$’s tax in response to changes in state $j$’s tax is derived in the following.

$$\frac{\partial t_i}{\partial t_j} = -\frac{\frac{\partial^2 R_i}{\partial t_i \partial t_j}}{\frac{\partial^2 R_i}{\partial t_i^2}}$$

where

$$\frac{\partial^2 R_i}{\partial t_i \partial t_j} = \left(x_i(t_i) + t_i \frac{\partial x_i(t_i)}{\partial t_i}\right) \frac{\partial s_i(t_i, t_j, d_{ij}, n_i, n_j)}{\partial t_j} + x_i(t_i) \frac{\partial s_i^2(t_i, t_j, d_{ij}, n_i, n_j)}{\partial t_i \partial t_j}$$

The denominator is a second order conditions of revenue maximization, i.e. $\frac{\partial^2 R_i}{\partial t_i^2} < 0$ and the sign of the reaction function depends on the sign of the numerator. It is clear

$^8$In Devereux, Lockwood and Redoano (2007), they assume that utility function is quasi-linear, and the demand function $x_i$ is independent of income. In addition, they omit the price difference across states. The number of shoppers $s_i(t_i, t_j, d_{ij}, n_i, n_j)$ includes cross-border shoppers.

$^9$Second order condition of governments maximizing tax revenue is assumed to be satisfied.
that per consumer demand $x_i$, the price elasticity of per consumer demand and the number of consumers $s_i$ are included in the nominator and that these are important factors to determine the tax interactions. In addition, the number of consumer $s_i$ are influenced by state tax rates $t_i, t_i$, the number of population $n_i, n_j$ and the distance between two states $d_{ij}$, and these variables also have an effect on the slope of the reaction functions. Many of these determinants of the slope of the reaction function are not included in conventional weighted matrix specifications. Moreover, we can see from the numerator that except for a specific model specification and parameter values, the reaction function is a fundamentally nonlinear function of tax rate, and a linear regression might not be appropriate.

To derive a specific expression of the reaction function, we need to give a specific functional form for the household and government problems. In the next section, we will construct a more specific model of cross-border shopping that we will then estimate.

### 3.3 Model

There are $N$ states ($i = 1, 2, \ldots N$), and a federal government. Federal and state governments levy a commodity tax on a private good $x$ (gasoline or cigarette), and state governments use this tax revenue to finance a public good $G$.\(^{10}\) $G$ represents a per capita amount of a public good in this model.\(^{11}\) We consider per capita highway expenditure as a public good for the gasoline consumption and per capita health expenditure as a public good for the cigarette consumption. This is because gasoline and cigarette tax revenues are an

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\(^{10}\)The federal government also uses its tax revenue for providing public goods to people. Assuming that utility from the federal public good is separable from the utility from a private good and state government public good, we do not analyze federal government tax determination behaviour in this paper.

\(^{11}\)In short, we treat a public good as a private good.
earmarked revenues for highway and health expenditures, respectively.\textsuperscript{12} We denote $y$ to be the other composite consumption good. We also define the tax rate for state $i$ as $t_i$ and the federal tax rate $T$. They are both assumed to be per unit taxes. Then, the after-tax commodity price in state $i$ can be expressed as $P_i = p_i + t_i + T$, where $p_i$ is before tax price. State $i$ has population $n_i$, and people can cross-border shop for the good $x$.\textsuperscript{13} State governments only consider the welfare of households in their own state, and the federal government’s purpose is to maximize the total welfare of people in the nation. We assume that state governments are Nash Competitors, and state governments determine their tax rate and a public good with other state and federal government tax policies as given. We do not discuss the federal government’s behavior or consider the case where state government is Leviathan. Next, we describe the household’s problem.

3.3.1 The Household’s Problem

A household in state $i$ has income $I_i$, and gets utility from consumption of a private good $x$, a composite good $y$, and a public good $G$. A household can buy a good $x$ either in her own state or in a neighboring state. We assume that the transportation cost of cross-border shopping is independent of the amount of consumption. The price of the composite good $y$ is assumed to be unity for simplicity. We omit public goods from the federal government in this paper for simplicity because, given the assumption of additive separability of the utility of a private and public good, it will not affect cross-border shopping.

The utility function of a household in state A who chooses to purchase a good $x$ in state...

\textsuperscript{12}More than half of the states earmarked tobacco tax revenues for education, health/welfare and debt service etc, according to a study undertaken by the National Conference of State Legislatures in the fiscal year 2005. This trend has become popular recently based on the Tax Policy Handbook for State Legislators in 2010.

\textsuperscript{13}We assume that cross-border shoppers can go both directions between states.
\( i \) is expressed as follows:\textsuperscript{14}:

\[
U^i_A = \alpha_A \log(x^i_A - \gamma_x) + (1 - \alpha_A) \log y^i_A - \beta d_{Ai} + \phi_A G_A
\]

where \( \gamma_x \) is a subsistence level of the good \( x \), and \( d_{Ai} \) is a distance between state A and state \( i \). The household chooses \( x \) and \( y \) to maximize the above utility subject to the following budget constraint.

\[
(p_i + t_i + T) x^i_A + y^i_A = I_A
\]

The parameter \( \alpha_i \) corresponds to the income share the household spends on the good \( x \) above the minimum consumption level \( \gamma_x \). \( \beta \) is the transportation cost coefficient. \( \phi_i \) is the weight between private good and public good utility. We assume that the value of \( \alpha_i \) and \( \phi_i \) are the same for people in the same state but different across states. We allow heterogeneity for \( \beta \) within-state by assuming \( \beta \) to be distributed randomly across households. In words, we assume a representative consumer, so consumers in the same state have the same preferences. The only heterogeneity is the location of living, and consumers choose difference states in which to purchase a private good, depending on the transportation cost and price differences between states. The minimum consumption level \( \gamma_x \) is assumed to be the same for all states. The solution to the above problem gives us the following demand for good \( x \) and \( y \).

\[
x^i_A = \frac{\alpha_A I_A}{(p_i + t_i + T)} + (1 - \alpha_A) \gamma_x, \quad y^i_A = (1 - \alpha_A) \left( I_A - (p_i + t_i + T) \gamma_x \right)
\]  

\textsuperscript{14}We choose the Stone-Geary utility function in our model for the following two reasons. First, according to previous papers, the price elasticity of demand for gasoline is about -0.8 to 1, and that for cigarette is -0.5. Stone-Geary utility function can generate these values of the price elasticity of demand. Second, this Stone-Geary utility function fits well with per capita consumption data of cigarettes and gasoline. Other utility functions, for example Cobb-Douglas utility function and quasi-linear utility function do not satisfy these two points.
Substituting them into the utility function, we derive the indirect utility function as follows:

\[ V_i^A (P_i, I_A, d_A, G_A) = \alpha_A \log \alpha_A + (1 - \alpha_A) \log (1 - \alpha_A) - \alpha_A \log (p_i + t_i + T) \]
\[ + \log (I_A - (p_i + t_i + T) \gamma_x) - \beta d_A + \phi_A G_A \]  
(3.2)

Next, we derive the proportion of consumers who cross-border shop. Since the utility from the public good is exogenous and does not depend on cross-border shopping, we exclude it from the indirect utility function. Furthermore, we add a random component \( \varepsilon_A \) to the indirect utility function, which is the unobserved utility consumer in state A gets from shopping in state \( i \). Then, the indirect utility function becomes

\[ V_i^A (P_i, I_A, d_A, \varepsilon_A) = -\alpha_A \log (p_i + t_i + T) + \log (I_A - (p_i + t_i + T) \gamma_x) - \beta d_A + \varepsilon_A \]  
(3.3)

We assume that people only cross-border shop in the neighboring states that share the same border with their own state. Suppose that state A is surrounded by states B and C, and that people in state A make a choice among three states A, B and C for shopping. Then a household chooses the state to shop that gives the highest indirect utility. That is, if a household in state A chooses state A for shopping, it means \( V_A^A > V_B^A \) and \( V_A^A > V_C^A \). The share of households in state A that purchase products in their own state A is equal to the probability that state A is chosen for shopping among these three states. If the error term \( \varepsilon_A \) is independent and identically distributed whose distribution function is an extreme value distribution, the probability that state A is chosen by households in state A can be expressed as \(^{15}\)

\[ s_A^A = \frac{\exp \left( \left(-\alpha_A \log (p_A + t_A + T) \right) + \log (I_A - (p_A + t_A + T) \gamma_x - \beta d_{AA}) / h \right)}{\sum_{i=A}^C \exp \left( \left(-\alpha_A \log (p_i + t_i + T) \right) + \log (I_i - (p_i + t_i + T) \gamma_x - \beta d_{Ai}) / h \right)} \]  
(3.4)

\(^{15}\)Refer to Green (2003) page 720. The error term distribution is \( \exp(-e^\varepsilon) \) and the conditional logit function \( s_A^A \) is derived by McFadden (1973) "Conditional Logit Analysis of Qualitative Choice Behaviour.", in P. Zarembka ed. Frontiers in Econometrics, Academic Press, New York.
where $s^A_A$ is the share of households in state $A$ who shop in state $A$, and $h$ is a standard error of the random component $\varepsilon_{Ai}$. Similarly, we denote $s^j_i$ to be the share of households in state $i$ who shop in state $j$. This share function can be calculated given the parameters $\alpha_i$, $\beta$, $\gamma_x$ and $h$ and data on income, after tax price and distance. Remember that households can cross-border shop only in the neighboring states, and if state $i$ does not share the border with state $j$, both $s^j_i$ and $s^i_j$ are zero.

From the demand function, the price elasticity of demand becomes

$$
\epsilon = \frac{\partial x}{\partial P} = \frac{-\alpha_i I_i}{\alpha_i I_i + P_i (1 - \alpha_i) \gamma_x}
$$

From this equation, it is clear that the model restricts the price elasticity of demand to lie between -1 and 0 ($-1 < \epsilon < 0$). Most estimates of the price elasticity of demand in the previous literature satisfy the above restriction. Given the parameters $\alpha_i$, $\gamma_x$ and data on income and after tax price, the price elasticity of demand can be easily derived. In the next section, we explain state government’s problem taking into account this household utility function.

### 3.3.2 State Government’s Problem

We assume that state government (for example state $A$) is benevolent and maximizes the aggregate indirect utility of all households in the state as follows,

$$
W_A = \int V^i_A \star (P_i, I_A, d_{Ai}, \varepsilon_{Ai}) \, d\varepsilon
$$

where $i^*$ is the optimal choice of states in which a household in state $A$ goes to shop. Given that the unobserved utility term $\varepsilon_{ij}$ is assumed to be i.i.d. extreme valued, the above integral

---

16We assume that state governments determine gasoline and cigarette tax rates separately. It is impossible to include both gasoline and cigarette consumption in one utility function because it prevents estimating the share function $s^j_i$ separately for both goods.
can be expressed analytically as follows.\(^\text{17}\)\((N_A\) are neighboring states for state A).\(^\text{17}\)

\[
W_A = \log \left( \sum_{i=A}^{N_A} \exp \left( \alpha_A \log \left( x_A^i - \gamma_x \right) + \left( 1 - \alpha_A \right) y_A^i - \beta d_{Ai} + \phi G_A \right) \right)
\]

The state government’s budget constraint is as follows.\(^\text{18}\)

\[
G_A = TR_{GA} + TR_{OA} + g_A
\]

where \(TR_{GA}\) is per capita revenue from the gasoline tax (for cigarettes, it is per capita revenue from the cigarette tax), \(TR_{OA}\) is per capita tax revenue from other sources and \(g_A\) is a per capita grant from the federal government. Gasoline per capita tax revenue \(TR_{GA}\) is expressed as follows,

\[
TR_{GA} = \frac{1}{n_A} \left( n_A s_A x_A^A + n_B s_B x_A^B + n_C s_C x_A^C \right) t_A
\]

where the term in parenthesis is the tax base, i.e. the amount of gasoline that is purchased in state A. Notice that the tax base consists of not only households in state A, \(n_A\), but also households in neighboring states B and C, \(n_B\) and \(n_C\), that decide to purchase gasoline in state A. It is also important that gasoline tax revenue not only depends on per capita consumption \(x_i^A\), but also on the number of shoppers from state \(i\), \(n_i s_i^A\), and the per unit tax \(t_A\). Next, we derive the first order condition under optimal taxation.

State government A determines the optimal tax rate to maximize \(W_A\) with other state and federal government tax policies taken as given. The first order condition with respect

\(^{17}\)Refer to Rust (1987), pp.1012.\(^{18}\)Some might think that a federal transfer depends on the federal tax rate, and that the amount \(g_A\) is also a function of federal tax rate \(T\) to derive the reaction function, especially for the gasoline tax case. Historically, there are several times when the federal government raised gasoline tax rate but most of the increased tax revenue is used to finance other things, such as war expenditures, fiscal deficit and so on. Therefore, an increase in the federal gasoline tax rate does not necessarily mean an increase in federal grants and we assume for the sake of simplicity that increasing the federal tax rate will not affect the federal grant.
to state tax \( t_A \) is

\[
\frac{\partial W_A}{\partial t_A} = \left( \frac{\alpha_A}{x_A^A - \gamma_x} + \frac{1 - \alpha_A y_A^A}{y_A^A} \right) s^A + \phi_A \frac{\partial TRGA}{\partial t_A}
\]

\[
= -\left( \frac{\alpha_A I_A + (1 - \alpha_A) \gamma_x (p_A + t_A + T)}{(I_A - (p_A + t_A + T) \gamma_x) (p_A + t_A + T)} \right) s^A + \phi_A \frac{\partial TRGA}{\partial t_A} = 0 \quad (3.7)
\]

The reaction function is derived from differentiating the above first order condition with respect to the tax rates. The slope of the reaction function measuring the effect of state B taxes change on state A government’s tax is

\[
\frac{\partial t_A}{\partial t_B} = -\frac{\partial^2 W_A}{\partial t_A \partial t_B} \quad (3.8)
\]

and the slope of the reaction function measuring the effect of federal tax change on the taxes of state A \(^{19}\) is

\[
\frac{\partial t_A}{\partial T} = -\frac{\partial^2 W_A}{\partial t_A \partial T} \quad (3.9)
\]

We would like to explain where the strategic interactions of taxation between governments are represented in the reaction function. In the horizontal tax interaction, state governments compete for cross-border shoppers to increase tax revenue for public goods, and the sensitivity of cross-border shoppers to the tax rate change of other state governments is an important factor. In the model, the term \( \partial s^A / \partial t_B \) represents this sensitivity, which shows up in the terms \( \partial^2 W_A / \partial t_A \partial t_B \)

\(^{20}\) and \( \partial^2 TRGA / \partial t_A \partial t_B \)

\(^{21}\) and the scale of horizontal tax interaction depends on this factor. If this value is small, the scale of horizontal tax interaction is small and vice versa.

\(^{19}\)If state government is Leviathan, \( \frac{\partial t_A}{\partial t_B} = -\frac{\partial^2 TRGA}{\partial t_A \partial t_B} \) and \( \frac{\partial t_A}{\partial T} = -\frac{\partial^2 TRGA}{\partial t_A \partial T} \) for each.

\(^{20}\) \( \frac{\partial^2 W_A}{\partial t_A \partial t_B} = \left( \frac{\partial s^A / \partial t_A}{\partial t_B} + \frac{\partial s^A / \partial t_B}{\partial t_A} \right) x_A + \phi_A \frac{\partial^2 TRGA}{\partial t_A \partial t_B} \)

\(^{21}\) \( \frac{\partial^2 TRGA}{\partial t_A \partial t_B} = n_A \frac{\partial s^A / \partial t_A}{\partial t_B} x_A + n_B \frac{\partial s^A / \partial t_B}{\partial t_A} x_A + n_C \frac{\partial s^C / \partial t_A}{\partial t_B} x_A \)

\( + n_A \left( \frac{\partial s^A / \partial t_A}{\partial t_B} + \frac{\partial^2 s^A / \partial t_A^2}{\partial t_B^2} x_A \right) + n_B \left( \frac{\partial s^B / \partial t_B}{\partial t_A} + \frac{\partial^2 s^B / \partial t_B^2}{\partial t_A^2} x_A \right) + n_C \left( \frac{\partial s^C / \partial t_A}{\partial t_B} + \frac{\partial^2 s^C / \partial t_A^2}{\partial t_B^2} x_A \right) \)
On the other hand, in the vertical tax interaction case, state and federal governments share a common tax base and the sensitivity of this tax base (consumer’s demand) to a tax rate change of the federal government is a crucial factor. In the equation, the term \( \frac{\partial x_A}{\partial T} = x_A \epsilon / P^2 \) represents the tax elasticity of tax base which enters in the terms \( \partial^2 W_A / \partial t_A \partial T \) and \( \partial^2 TR_GA / \partial t_A \partial T \). In short, the price elasticity of demand and after tax price are key factors for vertical tax interaction. We will return to this issue again in section 3.7 and section 3.8.2.

### 3.4 Empirical Analysis

#### 3.4.1 Estimating the Parameters of the Household Utility Function

In this section, we explain the method to estimate the parameters of the representative consumer utility function. We derive demand functions from the utility function and compare the amount of consumption based on this demand function with real consumption data. The parameters are chosen so that the predicted amount of consumption based on the model are close to the real consumption value.

One difficulty in estimating the parameters of demand function is that in the data, we cannot distinguish sales consumed by residents of a state from the sales consumed by cross-border shoppers.\(^{24}\) The only available data are total amount of sales, tax revenue, per

\[
22 \frac{\partial^2 W_A}{\partial t_A \partial T} = \left( \frac{-\alpha_A}{(x_A - \gamma_x)} - \frac{\alpha_A}{y_A} \right) \left( \frac{\partial x_A}{\partial t_A} \right) + \frac{\alpha_A}{x_A - \gamma_x} \frac{\partial^2 x_A}{\partial t_A \partial T} + \frac{\alpha_A}{y_A} \frac{\partial^2 y_A}{\partial t_A \partial T} + \left( \frac{\partial^2 TR_GA}{\partial t_A \partial T} \right) \frac{x_A}{y_A}
\]

\[
23 \frac{\partial^2 TR_GA}{\partial t_A \partial T} = n_A s_A \frac{\partial^2 x_A}{\partial t_A \partial T} t_A + n_B s_B \frac{\partial^2 x_B}{\partial t_A \partial T} t_A + n_C s_C \frac{\partial^2 x_C}{\partial t_A \partial T} t_A + n_A \left( s_A + \frac{\partial s_A}{\partial t_A} + \frac{\partial s_A}{\partial t_A} \right) t_A + n_B \left( s_B + \frac{\partial s_B}{\partial t_A} + \frac{\partial s_B}{\partial T} \right) t_A + n_C \left( s_C + \frac{\partial s_C}{\partial t_A} + \frac{\partial s_C}{\partial T} \right) t_A
\]

\(^{24}\)We confirmed this point with the U.S. Bureau of Labour Statistics.
unit tax rate and population in each state level. In other words, we do not know how much tax revenue comes from in-state consumers or out-of-state consumers. Considering this data restriction, we sum consumption of own-state people and consumption of cross-border shoppers and compare this total amount of consumption with the data of total sales. For example, consider the case where there are only 3 states: state A, B and C, and they are all neighbors to each other. The total amount of consumption in state A consists of consumption of people in state A and consumption of cross-border shoppers from state B and C. The amount of consumption of people in state A is computed by multiplying the number of population in state A $n_A$, the share of people in state A who purchase a good in their own state $s^A_A$ and per capita amount of consumption $x^A_A$. Similarly, the amount of consumption of cross border shoppers from state B and C are $n_B s^A_B x^A_B$ and $n_C s^A_C x^A_C$ for each. Then, the total sales in state A become the following.

$$C_A = n_A s^A_A x^A_A + n_B s^A_B x^A_B + n_C s^A_C x^A_C$$

Similarly, the total amount of sales derived from the model in state B and C become,

$$C_B = n_A s^B_A x^B_A + n_B s^B_B x^B_B + n_C s^B_C x^B_C$$

$$C_C = n_A s^C_A x^C_A + n_B s^C_B x^C_B + n_C s^C_C x^C_C$$

This predicted amount of consumption based on the model must be close to real consumption data. Therefore, the actual total sales $C^d_i$ can be expressed as the sum of the predicted total sales $C_i$ plus an error term $e_{C_i}$. That is,

$$C^d_i = C_i + e_{C_i}, \quad \text{for} \quad i = A, B, C$$

The moment condition is that the instrumental variable $Z_i$ is orthogonal to the error term $e_{C_i}$, which is the difference between total sales in the data $C^d_i$ and the total sales predicted
based on the model $C_i$. That is,

$$E(C_i - C_i^d | Z_i) = E(e_{C_i} | Z_i) = 0$$ (3.10)$$

We use the GMM method to estimate the parameters of the household utility function $\alpha_i, \beta, \gamma_x$ and $h$ which show up in the share function $s_i^j$ in (3.4) and demand function $x_i^j$ in (3.1). The GMM method minimizes the following equation,

$$\hat{\theta} = \text{argmin}_{\theta \in \Theta} \left( \frac{1}{T} \sum_{t=1}^{T} Z_i^t e_{C_i} \right)' \hat{W} \left( \frac{1}{T} \sum_{t=1}^{T} Z_i^t e_{C_i} \right)$$

where $\theta$ represent all the parameters $\alpha_i, \beta, \gamma_x$ and $h$, and $T$ is the total number of observations. We use Newey-West estimator as the weight matrix $\hat{W}$.\textsuperscript{26}

The tax policy of the state government creates a potential endogeneity problem in the above moment condition estimation. Since the state government maximizes welfare taking into account the representative consumer’s behavior, the state tax rate also depends on the demand for a private good. Hence, the error term of the consumption equation and the tax rate will be correlated, resulting in bias in the coefficient estimates. To deal with this issue, we employ the IV method in the GMM formula, and use some instrumental variables which are related to the tax rate but not with private good consumption or the error terms $e_{C_i}$. That is, the instrumental variables have to satisfy the condition $\left( \frac{1}{T} \sum_{t=1}^{T} Z_i^t e_{C_i} \right) = 0$. We choose the following instrumental variables for the gasoline consumption equation: federal grants to the highway departments, population, the ratio of gasoline revenue to highway expenditures, the previous year’s amount of CO2 emissions and the previous year’s number of car registrations. Population is obviously exogenous to gasoline consumption. Federal grants to the highway department and the ratio of gasoline revenue to highway expenditures are

\textsuperscript{25}This idea is similar to the concept that the disturbance $e_t$ is assumed to have zero expected value given the exogenous variables $X$, $E(e_t | X) = 0$

\textsuperscript{26}Refer to Green (2003) page 140.
related with gasoline tax rates, but it is not plausible to think that these variables affect gasoline consumption. The state government may take into account the amount of CO2 and the number of car registrations in determining their tax rates to reflect the pollution and highway congestion issues. It is natural to consider that these variables are also relevant to gasoline consumption and we use previous year data to preserve exogeneity. On the other hand, we use federal grants to the health departments, population, the ratio of cigarette tax revenue to health expenditures, the percentage of smokers and the previous year’s percentage of deaths by lung cancer for the cigarette consumption equation. Similar to gasoline consumption, population is exogenous to cigarette consumption. Federal grants to the health department and the ratio of cigarette tax revenue to health expenditures are related to state tax rates but we assume that the effects of these variables on cigarette consumption are negligible. It is plausible that state governments are concerned with people’s health and determine tax rates taking into account the percentage of smokers and deaths by lung cancer. These variables may also influence cigarette consumption, and we use previous year data.

Next, we discuss in more detail the parameterizations of the empirical model. The parameter $\alpha_i$ describes the share of income that is spent above the minimum consumption of the good $x$. This is likely to depend on the household’s preferences and economic conditions. Gasoline consumption depends on geographic factors, such as a high population density. Cigarette consumption will be affected by demographic factors. According to the reports from the Centers for Disease Controls and Prevention and the National Center of Health Statistics, the percentage of Hispanic smokers is less than that of non-Hispanic, and Hispanic smokers tend to smoke fewer cigarettes than non-Hispanic whites. Needless to
say, income is another important factor to determine the consumption. Given these arguments, we assume that $\alpha_i$ for gasoline consumption is a linear function of log population density and log per capita income, and $\alpha_i$ for cigarette consumption is a linear function of log ratio of Hispanic in population and log per capita income. That is,

\[
\alpha_i = \alpha_0 + \alpha_1 \left( \log (\text{density}) - \log (\text{density}) \right) + \alpha_2 \left( \log (\text{income}) - \log (\text{income}) \right) \quad \text{for gasoline}
\]

\[
\alpha_i = \alpha_0 + \alpha_1 \left( \log (\text{hispanic}) - \log (\text{hispanic}) \right) + \alpha_2 \left( \log (\text{income}) - \log (\text{income}) \right) \quad \text{for cigarette}
\]

It is natural to assume that the cost of cross-border shopping is different between people who live in the center of the state and people who live along the border of the state. In order to fully deal with this issue, one needs to accurately account for the geography of each state and the distribution of consumers over its area, which is beyond the scope of this paper. Instead, we address the issue by applying the idea of the random coefficient model from Bajari and Fox (2007) and Berry, Levinsohn and Pakes (1995). We consider that the transportation cost parameter $\beta$ takes different values for different households in the same state, depending on the location where people live. But the distribution of the cost parameters is assumed to be the same across states even though the scale of the area is different for each other. In other words, the cost parameter is defined as $\beta = \eta \beta^*$ where $\beta^*$ is taken to be chi-squared distributed with ten degree of freedom, and the parameter $\eta$ is estimated. The minimum consumption $\gamma_x$ and a standard error $h$ are assumed to be the same for all states.

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27 We also subtract from the average, which is represented by the bar term.
3.4.2 Estimating the Parameter of State Government Objective Function

In this section, we explain the method to estimate the parameters of the state government objective function $\phi_i$, which determines the weight between utilities from private goods and public goods, given the parameters of the household utility function, $\hat{\alpha}_i, \hat{\eta}, \hat{\gamma}_x$ and $\hat{h}$. State government determines tax rate to maximize the welfare of people. If the state government objective function describes state government behaviour correctly, the first order condition with respect to tax rate must be close to zero as follow:

$$\frac{\partial W_A}{\partial t_A} = - \left( \alpha_A I_A + (1 - \alpha_A) \gamma_x (p_A + t_A + T) \right) \left( I_A - (p_A + t_A + T) \gamma_x (p_A + t_A + T) \right) s_A^A + \phi_A \frac{\partial TR_{GA}}{\partial t_A} = 0 \quad (3.11)$$

The parameter $\phi_i$ is estimated using this first order condition as a moment condition. In short, if the residual of this first order condition is defined as $e_{Gi}$, the equation (3.11) becomes

$$\left( \frac{\alpha_A I_A + (1 - \alpha_A) \gamma_x (p_A + t_A + T)}{(I_A - (p_A + t_A + T) \gamma_x (p_A + t_A + T))} \right) s_A^A = \phi_A \frac{\partial TR_{GA}}{\partial t_A} + e_{Gi}$$

and a moment condition can be expressed as

$$E(e_{Gi} | Z_i) = 0$$

Similar to the moment condition of the consumer’s demand function, the amount of consumption and the state tax rate affect each other, and both factors are included in the state government first order condition.\(^{28}\) We use the GMM method to estimate the parameter $\phi$ in equation (3.11) using instrumental variables. Again, the instruments are supposed to be related with state tax rates, but not with private good consumption, and instrumental

\(^{28}\)Refer to equation (3.7). The first term represents the marginal cost of increasing state tax rate and includes the demand term $x_A^A$ and tax rate $t_A$. Similarly, the second term $TR_{GA}$ consists of the demand term $x_A^A$ and tax rate $t_A$ as equation (3.6).
variables \( Z \) have to satisfy the condition \( \left( \frac{1}{T} \sum_{t=1}^{T} Z_t e_{C_t} \right) = 0 \). We use the previous year’s federal grant to the highway department, the previous year’s highway expenditures, the previous year’s CO2 emissions and the previous year’s number of car registrations, the residual of regression of the federal tax rate on a federal grant and the ratio of highway expenditures to total expenditures for gasoline tax. We already explained the federal grant to the highway department, CO2 emissions, and the number of car registrations in section 3.4.1. Highway expenditures have a relation with the state tax rate, but we assume that it does not have an effect on gasoline consumption. On the other hand, we use the previous year’s federal grant to the health department, the previous year’s health expenditures, the previous year’s percentage of deaths by lung cancer and the previous year’s number of the Medicaid recipients for cigarette tax. Health expenditure is relevant with cigarette tax rate but we consider it will not change smoker’s consumption behaviour. The number of the Medicaid recipients will be related with both cigarette tax and cigarette consumption, and we use previous year data to satisfy exogenous condition.

We specify the parameter \( \phi_i \) to depend on the economic environment of each state. According to Lin, Botsas and Monroe (1985), gasoline consumption depends on gasoline price, fuel efficiency of vehicles, the percentage of people in metropolitan areas, non-automobile transportation methods, income, number of vehicles, non-agriculture employment, demographic factors and climate factors. On the other hand, not all motor fuel tax revenues are used for highway expenditures, and other financial resources are important for financing highway expenditures. We choose income \( (I) \), the number of population \( (n) \), the ratio of the population in a metropolitan area \( (m) \), the share of people who use a vehicle to get to their workplace \( (v) \), the share of motor fuel tax revenues used for highway expenditures \( (s) \) and highway bonds \( (d) \) as variables affecting the weight \( \phi \). In other words, we
specify \( \phi \) as follows.

\[
\phi = \phi_0 + \phi_1 \log I + \phi_2 \log n + \phi_3 d + \phi_4 \log m + \phi_5 \log v + \phi_6 \log s
\]  

(3.12)

We do not take a log of the highway bond variable \( d \) since some states issues zero highway bond. For the specification of \( \phi \) for cigarettes, we include income, the share of smokers to the population, and a regional dummy for the South region area as independent variables since cigarettes are produced primarily in this region.\(^{29}\)

### 3.5 Data

We use data on 48 U.S. states from 1993 to 2004 for gasoline and from 1997 to 2005 for cigarettes.\(^{30}\) We exclude Hawaii and Alaska since neither share a border with other states. We use the data on the unit tax rate of gasoline and gasoline tax revenue from the webpage of the Federal Highway Administration (U.S. Department of Highway). We use gasoline price and consumption data in official Energy Statistics from the U.S. Government, which can be obtained from the website of the Energy Information Administration. For cigarettes, we use the cigarette price, tax rate, tax revenue, and consumption from the Report "The Tax Burden on Tobacco" by Orzechowski and Walker.\(^{31}\) We use the data on population and per capita disposable income data from the Bureau of Economic Analysis, and the data on government expenditure for highway and health from the U.S. Census of Bureau. Data on Federal grants to highway and health departments are each available from the webpage of the Federal Highway Administration and from the Statistical Abstract (National data book from U.S. Census of Bureau). We derive the population density by dividing the population

---

\(^{29}\)We find that including a share of smokers to the population has a better fit than including the population and the number of smokers separately.

\(^{30}\)The percentage of smoker’s data is only available from 1997.

\(^{31}\)This report is available by request. Please refer to Appendix A.1.
Table 3.1: Data Summary

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<thead>
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<th>Data</th>
<th>unit</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Min</th>
<th>Max</th>
</tr>
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<td>0.377</td>
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<td>CPI of gasoline</td>
<td>1999 = 100</td>
<td>114</td>
<td>19.3</td>
<td>92.2</td>
<td>160.4</td>
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<td>CPI of transportation</td>
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<td>9.4</td>
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<td>163.1</td>
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<td>0.047</td>
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<td></td>
<td>0.011</td>
<td>0.009</td>
<td>-0.008</td>
<td>0.062</td>
</tr>
<tr>
<td>GDP</td>
<td>billion</td>
<td>182</td>
<td>209</td>
<td>15</td>
<td>1340</td>
</tr>
<tr>
<td>GDP growth</td>
<td></td>
<td>0.030</td>
<td>0.026</td>
<td>-0.074</td>
<td>0.201</td>
</tr>
<tr>
<td>Per capita income</td>
<td>$</td>
<td>22792</td>
<td>3245</td>
<td>16073</td>
<td>34387</td>
</tr>
<tr>
<td>Density</td>
<td>pop/square miles</td>
<td>61.8</td>
<td>80</td>
<td>1.9</td>
<td>392.9</td>
</tr>
<tr>
<td>Highway expenditure</td>
<td>$ 1000</td>
<td>1400</td>
<td>1147</td>
<td>172</td>
<td>7315</td>
</tr>
<tr>
<td>Highway grant</td>
<td>$ 1000</td>
<td>435</td>
<td>363</td>
<td>55</td>
<td>2310</td>
</tr>
<tr>
<td>Highway outstanding bond</td>
<td>$ 1000</td>
<td>1129</td>
<td>1806</td>
<td>0</td>
<td>9853</td>
</tr>
<tr>
<td>CO2 emission</td>
<td>million metric tons</td>
<td>36.2</td>
<td>38.3</td>
<td>3.2</td>
<td>230.1</td>
</tr>
<tr>
<td>Highway expend/ total expend</td>
<td></td>
<td>0.076</td>
<td>0.026</td>
<td>0.025</td>
<td>0.163</td>
</tr>
<tr>
<td>Vehicle users</td>
<td></td>
<td>0.894</td>
<td>0.047</td>
<td>0.634</td>
<td>0.956</td>
</tr>
<tr>
<td>the share of pop in a metropolitan area</td>
<td></td>
<td>0.681</td>
<td>0.207</td>
<td>0.235</td>
<td>1</td>
</tr>
<tr>
<td>the share of tax revenue used for highway</td>
<td></td>
<td>0.894</td>
<td>0.049</td>
<td>0.701</td>
<td>1</td>
</tr>
<tr>
<td>Cigarette price</td>
<td>$/gallon</td>
<td>2.382</td>
<td>0.433</td>
<td>1.389</td>
<td>3.737</td>
</tr>
<tr>
<td>Cigarette state tax rate</td>
<td>$/gallon</td>
<td>0.456</td>
<td>0.348</td>
<td>0.022</td>
<td>2.098</td>
</tr>
<tr>
<td>Cigarette federal tax rate</td>
<td>$/gallon</td>
<td>0.308</td>
<td>0.046</td>
<td>0.24</td>
<td>0.361</td>
</tr>
<tr>
<td>Cigarette consumption</td>
<td>1000 gallon</td>
<td>431</td>
<td>363</td>
<td>24</td>
<td>1716</td>
</tr>
<tr>
<td>Population</td>
<td>thousands</td>
<td>5880</td>
<td>6276</td>
<td>489</td>
<td>35990</td>
</tr>
<tr>
<td>Smokers</td>
<td>thousands</td>
<td>1308</td>
<td>1261</td>
<td>108</td>
<td>6334</td>
</tr>
<tr>
<td>Smokers/population</td>
<td></td>
<td>0.228</td>
<td>0.032</td>
<td>0.105</td>
<td>0.326</td>
</tr>
<tr>
<td>Per capita income</td>
<td>$</td>
<td>23811</td>
<td>3248</td>
<td>17369</td>
<td>34387</td>
</tr>
<tr>
<td>Hispanic share</td>
<td></td>
<td>0.081</td>
<td>0.092</td>
<td>0.005</td>
<td>0.44</td>
</tr>
<tr>
<td>Health expenditure</td>
<td>$ 1000</td>
<td>842</td>
<td>1234</td>
<td>42</td>
<td>8997</td>
</tr>
<tr>
<td>Health grant</td>
<td>$</td>
<td>3482</td>
<td>4271</td>
<td>170</td>
<td>25076</td>
</tr>
<tr>
<td>Lung death rate</td>
<td>among thousands</td>
<td>0.561</td>
<td>0.095</td>
<td>0.233</td>
<td>0.813</td>
</tr>
<tr>
<td>Medicaid</td>
<td>thousands</td>
<td>899</td>
<td>1250</td>
<td>45</td>
<td>10014</td>
</tr>
<tr>
<td>Distance</td>
<td>miles</td>
<td>1675</td>
<td>993</td>
<td>66</td>
<td>4292</td>
</tr>
<tr>
<td>Federal debt</td>
<td>billion</td>
<td>5593</td>
<td>374</td>
<td>5016</td>
<td>6486</td>
</tr>
<tr>
<td>Unemployment rate</td>
<td></td>
<td>5.3</td>
<td>0.824</td>
<td>4</td>
<td>6.9</td>
</tr>
</tbody>
</table>
by the land area, which is available from the Statistical Abstract. The ratio of Hispanics to
the total population is accessible from the webpage of the Center of Disease Control
and Prevention. CO2 emission is obtained from the webpage of the U.S. Environment
Protection Agency. The number of car registrations is available from the webpage of the
Federal Highway Administration. We use the data on the percentage of smokers and the
percentage of deaths caused by lung cancer from the Statistical Abstract and the webpage
of the State Cancer Profiles for each. The percentage of people living in a metropolitan
area and the percentage of people who use a vehicle to get to their workplace are available
from the Statistical Abstract. The debt and highway outstanding bonds are from the U.S.
Census of Bureau and the webpage of the Federal Highway Administration, respectively.
The federal debt and the unemployment rate in the U.S. are available from the Statistical
Abstract. We also compute the distance between the center of the states from Google map.
For the estimation, we use the real data by regarding the 1999 year data as the index (=100).
The consumption price index data for this realization is available from the webpage of the
Bureau of Labor Statistics. Details about data resources are explained in Appendix A.1.

We examine socio-economic variable distributions across states which influence con-
sumer’s cross-border shopping: after tax price, income, population and the distance be-
tween states. From Table 3.1, it is obvious that there are a large variation of these variables
across states. After tax price of gasoline takes the value between $1.14 and $2.11, and
almost $1 is different between the minimum price and the maximum price. The minimum
value of cigarette’s after tax price is $1.73 and the maximum value is $5.49 and there are
almost $4 difference between them. Average income varies between $16,073 and $34,387
and shows considerable heterogeneity across states. In addition, the population ranges from
473,000 to 35,722,000. The distance between the center of the states is from 66 miles to
4,292 miles, which is a huge difference. It is no exaggeration to say that assuming states to be symmetric is too strong.

3.6 Estimation Results

3.6.1 Gasoline Results

In this section, we explain the estimation results of gasoline consumption. First we show the results of household utility function and move to the state government objective function results. A household represents a person and we assume that everybody consumes gasoline. The minimum amount of consumption $\gamma_x$ means the minimum consumption for one year. All the parameter estimates for the household utility function are shown in Table 3.2. Recall that $\alpha_i$ measures the share of gasoline consumption to total income after excluding the minimum amount of consumption $\gamma_x$. $\eta$ measures the disutility from transportation costs. High transportation costs discourage consumers from purchasing goods in other states. $h$ is a standard error of the random component $\varepsilon_{ij}$ in (3.3).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_0$ constant</td>
<td>0.0287***</td>
<td>0.00666</td>
</tr>
<tr>
<td>$\alpha_1$ density</td>
<td>-0.00254****</td>
<td>0.0012</td>
</tr>
<tr>
<td>$\alpha_2$ income</td>
<td>-0.0331**</td>
<td>0.0112</td>
</tr>
<tr>
<td>$\gamma_x$ minimum consumption</td>
<td>101.7</td>
<td>97.9</td>
</tr>
<tr>
<td>$\eta$ transportation cost</td>
<td>3.38 e-05**</td>
<td>1.43 e-05</td>
</tr>
<tr>
<td>$h$ standard error</td>
<td>0.0147***</td>
<td>0.0025</td>
</tr>
<tr>
<td>price elasticity of demand</td>
<td>-0.789</td>
<td></td>
</tr>
</tbody>
</table>

Notes: *** means 1% significant, ** mean 5% significant and * means 10% significant. A value in the parenthesis is a standard error.

The coefficient of density $\alpha_1$ is estimated to be -0.00254 and this means that people
in states where population densities are high spend a lower share of their income on gasoline, which seems to be reasonable, since high population density states would be more urban. Furthermore, the coefficient of income $\alpha_2$ is estimated to be -0.0331. This means that people in a wealthy states spend a lower share of their income on gasoline, which again seems reasonable. The total share of gasoline consumption to income, including the minimum consumption $\gamma_x$, is calculated to be 0.036 on average.\(^{32}\) This is very close to the value 0.0369 which is computed from the data on gasoline consumption, price, taxes and income. The minimum consumption value $\gamma_x$ is estimated to be 101.7. Per capita demand for gasoline is 488 gallons on average, where the minimum amount is 292 in New York and the maximum amount is 690 in Wyoming. Considering these numbers, we believe the value of $\gamma_x$ to be reasonable. The transportation cost parameter $\eta$ is estimated to be 3.38 $\times$ 0.05. Based on those parameters, we calculate the average share of households that purchase products in their own state to be 94.2%. That is, about 5.8% of people cross-border shop across states, which we believe to be sensible. Using the model and the parameter estimates, we also calculate the price elasticity of demand, which is -0.789 on average. This is close to the values obtained in the literature, which range from -0.8 to -1.

To see how well the model fits the actual data, we compare the actual total sales and total sales predicted by our model. Figure 3.1 and Figure 3.2 compare actual data and the predicted total gasoline consumption. In Figure 3.1, we can see that the predicted value fits very well across 48 states except New York. Figure 3.2 shows the relation between the predicted value and the actual data, whose correlation is 0.986, which is very close to 1, and R-squared of the linear regression line is 0.986. The predicted values fit the actual data almost perfectly. Notice that per capita demand for gasoline is extremely low in New York.

\(^{32}\)Both the share of private good consumption to income and the price elasticity of demand are computed using the estimated parameters and the data on income, price and tax. We did not compute the standard error for them.
On average, per capita gasoline consumption across states is around 500 gallons, but in New York it is less than 300 gallons. Even though a geographic factor like population density is taken into account for household preference, the availability of public transportation in New York is not captured in the model. Otherwise, the model fits very well to the data in other states, in spite of its rather parsimonious parameterizations.

Next, we analyze the estimation results of the state government objective function. The weight parameter $\phi$ between private good and public good utility is estimated using the first order condition of the state government objective function. The results are shown in Table 3.3.

<table>
<thead>
<tr>
<th>$\phi_i$</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi_0$ constant</td>
<td>0.543***</td>
<td>0.0364</td>
</tr>
<tr>
<td>$\phi_1$ income</td>
<td>-1.047***</td>
<td>0.00575</td>
</tr>
<tr>
<td>$\phi_2$ population</td>
<td>-0.0547***</td>
<td>0.0112</td>
</tr>
<tr>
<td>$\phi_3$ bond</td>
<td>-0.00488***</td>
<td>0.00194</td>
</tr>
<tr>
<td>$\phi_4$ metro</td>
<td>0.0234***</td>
<td>0.00315</td>
</tr>
<tr>
<td>$\phi_5$ vehicle</td>
<td>-0.145***</td>
<td>0.0409</td>
</tr>
<tr>
<td>$\phi_6$ share</td>
<td>0.0891***</td>
<td>0.0378</td>
</tr>
</tbody>
</table>

Notes: *** means 1% significant, ** mean 5% significant and * means 10% significant. A value in the parenthesis is a standard error.

The coefficients of income $\phi_1$ are estimated as -1.047. The effect of income turns out to be negative, and this means that governments in high income states weight utility from public goods less than those in lower income states. This result seems natural, since in wealthier states, private sectors offer similar or alternative services in place of public services, resulting in lower weight on benefit from government public services. The coefficient of population $\phi_2$ is estimated as -0.0547. This result suggests a scale effect of a public good. In short, the amount of per capita highway expenditure necessary to satisfy people is smaller for states with high population. The coefficient of highway bond $\phi_3$ is -0.00488 and if the amount of the bond is larger, the weight of a public good becomes lower, which is
Figure 3.1: Total Gasoline Sales

Figure 3.2: Correlation: Total Gasoline Sales
reasonable. The coefficient of the share of people in a metropolitan area $\phi_4 0.0234$ is positive and significant, and this result implies that state with large population in metropolitan area put less weight on gasoline consumption since alternative transportation methods are easily available in such states. The coefficient of the percentage of people who use a vehicle to get to their workplace $\phi_5$ is estimated as -0.145 and is negatively significant. This means that governments put more weight on utility from gasoline consumption since many people use vehicles for going workplace. The share of motor fuel tax revenues used for highway expenditure result $\phi_6 0.0891$ is positive and significant, which makes sense.

To sum up, in our estimated model, households use about 3.6% of their income on gasoline consumption, and 5.8% of households cross the state border to purchase gasoline. State government use demographic and socio-economic variables to weight private good and public good utility, such as income, the number of population, the ratio of the population in a metropolitan area, the share of people who use a vehicle to get to their workplace, the share of motor fuel tax revenues used for highway expenditure and highway bonds. In the next sections, we investigate the results of the cigarette tax.

### 3.6.2 Cigarette Results

In this section, we explain the estimation results of consumer’s utility function and the state government objective function for cigarettes. The representative household is smokers.\textsuperscript{33} The parameter estimates for the household utility function are shown in Table 3.4. The meaning of the parameters are exactly the same as that of gasoline results.

The coefficient on the Hispanic ratio $\alpha_1$ is estimated to be -0.00562. In short, people in states with higher ratio of Hispanic populations consume fewer cigarettes. This result

\textsuperscript{33}Therefore, per capita amount of consumption is derived by dividing total amount of consumption by the number of smokers.

48
Table 3.4: Parameters of Utility Function: Cigarette

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_0$ constant</td>
<td>0.0264***</td>
<td>0.0021</td>
</tr>
<tr>
<td>$\alpha_1$ Hispanic</td>
<td>-0.00562***</td>
<td>0.000768</td>
</tr>
<tr>
<td>$\alpha_2$ income</td>
<td>-0.0252**</td>
<td>0.0011</td>
</tr>
<tr>
<td>$\gamma_x$ minimum consumption</td>
<td>152.1***</td>
<td>16.02</td>
</tr>
<tr>
<td>$\eta$ transportation cost</td>
<td>3.29 e-05</td>
<td>7.14 e-04</td>
</tr>
<tr>
<td>h standard error</td>
<td>0.0147**</td>
<td>0.00066</td>
</tr>
<tr>
<td>price elasticity of demand</td>
<td>-0.566</td>
<td></td>
</tr>
</tbody>
</table>

Notes: *** means 1% significant, ** mean 5% significant and * means 10% significant. A value in the parenthesis is a standard error.

is consistent with the reports from the Centers for Disease Controls and Prevention and the National Center of Health Statistics. The coefficient of income $\alpha_2$ is estimated to be -0.00252, which means that smokers in higher income states spend a lower share of their income on cigarettes. Again this is consistent with the literature on smoking in health economics. The average share of cigarette consumption to income including the minimum consumption $\gamma_x$ is 0.046 on average. This is close to the share of cigarette consumption 0.0465 which is computed from the data.

The minimum consumption value $\gamma_x$ is estimated to be 152.1. The average per capita demand for cigarette is 357 packs per year. The minimum per capita demand is 158 in New York and the maximum is 853 in Delaware. Considering these values, we again believe the estimated value of $\gamma_x$ to be reasonable. The transportation cost parameter $\eta$ is estimated to be 3.29 e-05. As before, we can determine whether this value is reasonable from the value of the share function $s_i^j$ calculated based on the estimated parameters. The estimated average share of within state consumption is 93.8%. That is, about 6.2% of people cross-border shop for cigarettes. Flennor (1998) shows that the percentage of cross-border purchases of cigarettes was approximately 3.6% in 1997. Considering the recent increase in cigarette prices and tax rates from 1997, we believe the value of 6.2% to be consistent with Flennor’s result. We also compute the price elasticity of demand to be
-0.566, which is close to the value -0.5 obtained in the literature.

We again verify our model by comparing the actual total sales and total sales predicted based by our model. Figure 3.3 shows that the predicted values are almost the same as the actual data. Figure 3.4 shows the correlation between the predicted value and the actual data. The correlation between them is 0.945 and R-squared of the regression line is 0.978. These two figures show that the model also fit very well with actual data on cigarettes. We also regress total sales with socio-economic factors which are used for estimating the utility function. The estimation results show that more than 97% of total sales are explained by these socio-economic factors of own states, and confirm that the percentage of cross-border shopping is very small.\textsuperscript{34} From these analyses, we have confirmed that our model captures consumer consumption behavior appropriately.

| Table 3.5: Parameters of State Government Objective Function: Cigarette |
|-----------------------------|-----------------------------|
| \( \phi_0 \) constant | -0.435*** | 0.196 |
| \( \phi_1 \) income | -0.953*** | 0.0242 |
| \( \phi_2 \) smokers / population | -1.046*** | 0.0297 |
| \( \phi_3 \) regional dummy | -0.0352*** | 0.00708 |

Notes: *** means 1% significant, ** mean 5% significant and * means 10% significant. A value in the parenthesis is a standard error.

Next, we provide the estimation results of the state government objective function. The weight parameter \( \phi \) between utility from a private good and utility from a public good is estimated using the first order condition of the state government objective function. The results are shown in Table 3.5. The coefficient of income \( \phi_1 \) is estimated negatively significant, -0.953, similar to the gasoline tax, and governments in a wealthy state weight utility from a public good less than those in lower income states. The coefficient of the share of smokers to people \( \phi_2 \) is estimated as -1.046 and if the share of smokers to population is

\textsuperscript{34}Refer to Appendix A.2.
Figure 3.3: Total Cigarette Sales

Correlation

$y = 0.945x + 28.81$

$R^2 = 0.978$

Figure 3.4: Correlation: Total Cigarette Sales
larger, the weight on the utility from cigarettes is greater. The result of the regional dummy $\phi_3$ for cigarettes is negatively significant and governments put more weight on the utility from cigarette consumption in the regions which produce cigarettes, which is sensible.

In summary, about 4.6% of income is used for cigarette consumption among smokers, and 6.2% of smokers cross the border to buy cigarettes. It is also important to notice that the transportation cost parameter $\eta$ is estimated to be larger for gasoline than for cigarettes, which results greater cross-border shopping for cigarettes than for gasoline among households. We consider the above results to be reasonable since the transportation costs of gasoline should be higher than those of cigarettes. State governments take into account income, the number of smokers and population and regional characteristics to determine the weight between cigarette consumption and health expenditures. In the next section, we derive the reaction function using all the parameters estimated, and examine the tax interaction for both gasoline and cigarette taxes.

### 3.6.3 Reaction Function

Given the model and the estimated parameters, per unit taxes and other variables in the data, we compute the slope of the reaction function following equations (3.8) and (3.9) in this section. Both the horizontal and vertical reaction functions for each of the 48 states are derived. Notice that in our model, households can cross-border shop only in the neighboring states, and the value of the slope of the reaction function between state governments is zero if two states are not neighbors or states do not compete for the same cross border shoppers. The average slope\(^{35}\) of the horizontal reaction function between state governments is 0.00776 for gasoline tax and 0.011 for cigarette tax. Those results imply that there is almost

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\(^{35}\)The average is the average value for states which take non zero value.
no horizontal tax interaction among state governments, and that a state government does not change its tax rate even though neighboring states change their tax rates. One reason for this result is that the share of gasoline or cigarette consumption to income is estimated to be very small; 3.6% for the former and 4.6% for the latter (on average, only 22% of people smoke cigarette). This small share will not give households enough incentive for cross-border shopping. Also, from the data, state sales and state population roughly correspond, and only a very small fraction of households are estimated to cross-border shop (5.8% for gasoline and 6.2% for cigarettes). Since cross-border shopping is the only factor of state governments to respond to other state taxes, the small horizontal reaction seems to be reasonable. It is also important to notice that the value of the slope of the reaction function between non-neighboring states is not always estimated to be zero. This is because tax changes in non-neighboring states can have an effect through cross-border shopping by consumers who live in states between those two. 36

In contrast, the value of the slope of the vertical reaction function between state and federal governments is moderate (for more details, see Appendix A.3). The average value is 0.091 for gasoline tax and 0.145 for cigarette tax. This means that state and federal taxes are strategic complements. An increase in federal tax reduces the tax base of state governments and makes it necessary for them to increase taxes to pay for the spending of public goods. We plot the slope of the reaction function against the change in federal tax for both gasoline and cigarette taxes in Figure 3.5. It is clear that the value of the slope of reaction function is larger for cigarette tax than for gasoline tax. Figures 3.6 and 3.7 of the histogram also show that the distribution of the slopes are different between gasoline and cigarette taxes. Considering that the price elasticity of demand is smaller for cigarettes than for gasoline, this result is consistent with the general idea of the negative relationship

36This is the case where non-neighboring states compete for the same cross-border shoppers.
between the price elasticity of demand and the intensity of tax interaction. Generally, governments are reluctant to levy a heavier tax rate on a good whose price elasticity of demand is high to avoid losing tax base. Hence, the response of state government tax policies to other state or federal tax changes must be greater for a good whose price elasticity of demand is low since state governments do not need to be afraid of losing tax base even though they change their own tax rate following the other government’s tax changes. Also, we can see a high positive correlation between the two slopes. We discuss this correlation more in detail in section 3.8.2.

It is also important to note that even though on average, the slopes of the reaction function are positive, in some states, the slopes are negative. These results underscore our main point that the slopes of the reaction function are highly nonlinear functions of variables such as the share of consumption to income \( \alpha_i \), price elasticity of demand \( \epsilon \), after
the value of the slope of the reaction function

Figure 3.6: Gasoline Histogram

Figure 3.7: Cigarette Histogram

tax price $P_i$, the share function $s^j_i$ and income $I_i$. As these variables show sizeable variation across states, it is natural that the slopes of the reaction function vary across states in ways that cannot be approximated well by a weighted matrix approach, which imposes the same sign and scale on the slope of the vertical reaction function.

### 3.7 Intuition

In this section, we discuss the factors which determine the sign and the scale of the slope of the reaction function based on the model.

In our model, horizontal tax interaction is attributed to consumer’s cross-border shopping since that is the only way that tax changes of other states affect state tax rate. The model indicates that the slope of the reaction function depends crucially on the share of a private good consumption to income $\alpha$ and the share function $s^j_i$. We have seen from the estimation results that the slope of the horizontal reaction function is estimated to be small. We explain this result by showing the sensitivity of cross-border shoppers to the tax rate change $\frac{\partial s^A_i}{\partial t^B}$: how the share of own state consumers of state A ($s^A_i$) change due to changes
in taxes in a neighbor state B \((t_B)\). This sensitivity is derived by differentiating the share function \(s_A^A\) in equation (3.4) with respect to the tax rate \(t_B\) as follows:

\[
\frac{\partial s_A^A}{\partial t_B} = - \left( \frac{\alpha_A x_B^A}{x_A^A} \epsilon + \frac{1 - \alpha_A}{y_A^B} \frac{\partial y_A^B}{\partial t_B} \right) s_A^B s_A^A
\]

We can see that it depends on the parameter \(\alpha_A\) roughly measuring the share of private goods consumption to income, the price elasticity of demand \(\epsilon\) and the share function \(s_A^A\) and \(s_A^B\). First, the share of private good consumption to income \(\alpha_A\) is small. The ratio of gasoline or cigarette consumption to income is 3.6\% and 4.6\% for each, and this small ratio does not give people enough motivation to cross border shop. In addition, only a small percentage of people cross-border shop for both gasoline (5.8\%) and cigarettes (6.2\%) and the share function \(s^B_1\) (in this example case \(s^B_A\)) is very small. Therefore, few people in state A are affected by state government B’s tax rate change. For these two reasons, the value of the slope of the horizontal reaction function is small in both gasoline and cigarette cases.

The sign of the slope of the reaction function depends on the relative scale of "benefits" and "costs" of increasing the tax rate. In the horizontal tax interaction case, "benefits" is the increased tax revenue to finance the public good and "cost" is the disutility from reducing consumption of the private good. If state government B increases its tax rate, some people not only in state A but also in other states shift the location for shopping from state B to A. Then, the tax base of state A expands, and if state government A raises its tax rate, tax revenue increases. On the other hand, if state government A increases its tax rate at this time, not only people who originally purchase their own region’s goods but also people who stop cross border shopping to state B have to reduce consumption of the private good, and utility from the private good decreases. If the benefit is greater than the cost, the sign of the slopes is positive, and the state government increases its tax rate to increase tax revenue for the public good. If the cost is greater than the benefit, the sign of the slopes is negative,
and the state government decreases its tax rate to protect utility from the private good.

Vertical tax interaction results from the fact that federal and state governments share the common tax base and the scale of the slope of the vertical reaction function depends on the utility function, the price elasticity of demand and after tax price. If the federal government increases its tax rate, households reduces their demand for the private good. Tax revenue in state A for example decreases, and utility from both the private good and the public good decline. If state government A increases its tax rate with the increase of the federal government tax rate, utility from the private good and the public good move in the opposite directions. Households must reduce their demand more for the private good, and utility from the private good decreases further. On the other hand, tax revenue from the private good increases, and utility from the public good increases. For simplicity, we assume no cross border shopping and express the utility function as,

\[ W = u(x) + f(G) \]

where \( x \) is a private good and \( G \) is a public good. The numerator of the vertical reaction function is expressed as follow.

\[
\frac{\partial W}{\partial t_A \partial T} = \frac{\partial^2 u}{\partial x^2} \frac{\partial x}{\partial t_A} \frac{\partial x}{\partial T} + \frac{\partial u}{\partial x} \frac{\partial^2 x}{\partial t_A \partial T} + \frac{\partial^2 f}{\partial G^2} \frac{\partial G}{\partial t_A} \frac{\partial G}{\partial T} + \frac{\partial f}{\partial G} \frac{\partial^2 G}{\partial t_A \partial T} \\
= \frac{\partial^2 u}{\partial x^2} \left( \frac{x}{P} \right)^2 + \frac{\partial u}{\partial x} \left( -\frac{2}{P^2} \frac{x}{\epsilon} \right) + \frac{\partial^2 f}{\partial G^2} \left( \frac{x t_A}{P} \epsilon + x \right) \left( \frac{x t_A}{P} \epsilon \right) + \frac{\partial f}{\partial G} \left( -\frac{2 x t_A}{P^2} \epsilon + \frac{x}{P} \epsilon \right)
\]

State government A compares "the extent of change of cost" which is represented by the first and second terms, and "the extent of change of benefit" which is represented by the third and fourth terms, and tries to equalize these two values to maximize the welfare of people. The scale of state government A’s response to the federal government tax rate change hinges on the difference between these two scales in increasing its tax rate. If this difference is large, the state government has to respond considerably to equalize the marginal benefit and cost of increasing the tax rate. Conversely, if this difference is small,
the state government reacts little to the federal government’s tax policy change. It is clear from this equation that this difference is mainly determined by the utility function \(u(x)\) and \(f(G)\), the price elasticity of demand \(\epsilon\) and after tax price \(P\).

The sign of the slope of the reaction function in the vertical tax interaction case also depends on the relative scale of "benefit" and "cost" of increasing the tax rate. The "benefit" is the increase in the utility from a public good and the "cost" is the disutility from additionally reducing private good consumption. If the scale change of benefit (utility from a public good) is greater than the scale change of cost (utility from a private good), the sign of the slopes is positive and the state government increase its tax rate to finance public good. If the scale change of cost is larger than that of benefit, the sign of the slopes is negative and the state government decreases its tax rate to protect utility from the private good.

In summary, the share of private good consumption to total income and the percentage of cross-border shopping are important factors for horizontal tax interaction, while the utility function, the price elasticity of demand and after tax price are important factors for vertical tax interaction.

### 3.8 Discussion: Comparison with Previous Papers

In this section, we emphasize the contribution of this paper from two different aspects. We first compares the results of our structural approach with the results of the previous literature which use the weighted matrix method. Then we discuss the sign of the slope of the reaction function and the relationship between the scale of the slope of the reaction function and the price elasticity of demand or after tax price in the vertical tax interaction. We refer to Besley and Rosen (1998) and Devereux, Lockwood and Redoano (2007) for the first argument and Keen (1998) for the second argument.
3.8.1 Comparison between the Weighted Matrix Method and the Structural Estimation Method

In previous papers, the weighted matrix method is commonly used for estimating horizontal tax interactions. The idea of the weighted matrix method is to calculate a weighted average of other state tax rates and to use the weighted sum as the independent variable of the equation, in addition to the federal tax rate $T$ and other socio-economic factors $X$, i.e. $t_{it} = \mu_{it} + \delta \sum_{i \neq j} w_{ij} t_{jt} + \kappa T_t + \lambda X_t + v_{it}$. In short, this method approximates the complex strategic interactions between state governments. Table 3.6 shows the comparison between previous papers Besely and Rosen (1998) and Devereux, Lockwood and Redoano (2007) and our results.\(^{37}\)

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State tax rate $\kappa$</td>
<td>0.131</td>
<td>0.191</td>
<td>-0.099</td>
</tr>
<tr>
<td>Federal tax rate $\delta$</td>
<td>0.413***</td>
<td>0.033</td>
<td>0.077</td>
</tr>
<tr>
<td>Cigarette</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State tax rate $\kappa$</td>
<td>0.2</td>
<td>0.277***</td>
<td>0.156**</td>
</tr>
<tr>
<td>Federal tax rate $\delta$</td>
<td>0.277***</td>
<td>0.103</td>
<td>0.082</td>
</tr>
</tbody>
</table>

Notes: *** means 1% significant, ** means 5% significant and * means 10% significant. Uniform, Neighbor and Density are the factors of the weighted matrix.

Devereux, Lockwood and Redoano (2007) estimate a positive and significant horizontal tax externality for cigarettes, but not for gasoline. Besley and Rosen (1998) estimate a positive and significant vertical tax externality for both gasoline and cigarettes, while Devereux, Lockwood and Redoano (2007) find a positive vertical externality only for gasoline. The scale of vertical externality is larger for gasoline than for cigarettes. The sign of the

\(^{37}\)Different from Besely and Rosen (1998) and Devereux, Lockwood and Redoano (2007), our results are computed using the estimated parameters and data of price, tax, income and social economic variables in the state government objective function, and we did not compute an standard error.
slope of the reaction function is positive both for horizontal and vertical externality. Our results are quite different from their results. First, there is little horizontal tax externality for both gasoline and cigarettes. Second, there is a positive vertical tax externality for both goods. The scale of the tax externality is larger for cigarettes than gasoline, which is consistent with the general idea that governments are reluctant to levy a higher tax rate on a good whose price elasticity is high. Third, the sign and value of the slope of the reaction function are different across states, and some states take negative values.

There are several reasons why our results are different from previous papers. The time span for the empirical analysis is different. Also, socio-economic variables used as independent variables are different. But we believe that the most important difference is due to the difference in the estimation method; a weighted matrix method or a structural estimation. This weighted matrix method has some limitations. First, in the weighted matrix approach, tax response depends on only one variable, and the sign of the slope of the reaction function is assumed to be the same across states. On the other hand, our approach include all important factors (difference between own state tax and that of other states, transportation costs, own state and other state’s populations, demand and the price elasticity of demand). Because of this difference, the results are very different, depending which variable is used for the weight. Second, the weighted matrix approach is a simple approximation of the Nash equilibrium of state and federal governments’ strategic taxation game and assumes that states are similar to each other and consumer’s demand for a private good is independent of income. The data does not support those strong assumptions.

To numerically demonstrate the consequences of the methodological differences, we

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simulate state tax rates based on our model assuming no cross border shopping, and repli-
cate the weighted matrix method following Devereux, Lockwood and Redoano (2007).³⁹ The horizontal tax interaction is attributed to cross-border shopping, and state governments
do not need to respond to or take into account other state governments’ tax rate changes. Therefore, if the weighted matrix approach is an appropriate way to evaluate the slope of the reaction function, the estimated coefficient of a weighted average of other state tax rates has to be insignificant.

We first simulate state tax rate based on our model under the assumption of no cross-border shopping. The simulated tax rate is close to actual state tax rate (refer to Figures A3 ∼ A6 in Appendix A.4) and this supports that out model describes state government behavior appropriately. Using these simulated tax rates, we replicate a weighted matrix approach following Devereux, Lockwood and Redoano (2007). The estimation results are shown in Table 3.7. The estimated coefficient of horizontal tax interaction $\kappa$ is significant for both gasoline and cigarettes and demonstrates strong significant horizontal externality. These results are surprising, since state tax rates are simulated assuming no cross-border shopping, and state governments determine their tax rates without taking into account other state’s tax rates. From this analysis, it is no exaggeration to say that the coefficients estimated by the weighted matrix approach do not necessarily represent the slope of the reaction function and that the weighted matrix method might not be appropriate for assessing tax externality.

Contrary to these limitations, our method has the following virtues. First, our estimation is based on an optimal behavior of household consumption and state government’s welfare maximization, and fully captures all the important factors for taxation in the model.

³⁹We are grateful to Michael Devereux for allowing us to use his data. We use similar IV variables for the federal tax but different IV variables for state taxes since the included explanatory variables used for structural estimations are different from the variables they use.
Table 3.7: Replication Results of the Weighted Matrix Approach

<table>
<thead>
<tr>
<th></th>
<th>Uniform</th>
<th>Neighbor</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gasoline</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State tax rate $\kappa$</td>
<td>0.221***</td>
<td>0.102*</td>
<td>0.0159</td>
</tr>
<tr>
<td></td>
<td>(0.0745)</td>
<td>(0.0539)</td>
<td>(0.0816)</td>
</tr>
<tr>
<td>Federal tax rate $\delta$</td>
<td>0.0444</td>
<td>0.116</td>
<td>0.176**</td>
</tr>
<tr>
<td></td>
<td>(0.100)</td>
<td>(0.0789)</td>
<td>(0.830)</td>
</tr>
<tr>
<td><strong>Cigarette</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State tax rate $\kappa$</td>
<td>-0.783****</td>
<td>0.112***</td>
<td>0.0841*</td>
</tr>
<tr>
<td></td>
<td>(0.0810)</td>
<td>(0.0384)</td>
<td>(0.0452)</td>
</tr>
<tr>
<td>Federal tax rate $\delta$</td>
<td>-0.237***</td>
<td>-0.829***</td>
<td>-0.836***</td>
</tr>
<tr>
<td></td>
<td>(0.0585)</td>
<td>(0.0781)</td>
<td>(0.079)</td>
</tr>
</tbody>
</table>

Notes: *** means 1% significant, ** mean 5% significant and * means 10% significant. A value in the parenthesis is a standard error.

In addition, the slope of the reaction function is computed directly from the first order condition of the state government objective function, and non linear functional form is taken into account. All of the slopes of the reaction functions of state governments are derived for each state and federal government, and different values and signs are allowed across states. Concretely, our structure estimation method overcomes the limitations of the previous weighted matrix method, and our results are more appropriate.

3.8.2 The Reaction Function in the Vertical Tax Interaction Case

In this section, we discuss the slope of the reaction function of the vertical tax externality. Keen (1998) examines vertical tax interaction and analyzes the sign of the slope of the reaction function. The sign of the slope of the reaction function depends on the demand function for Leviathan government. If the demand function is log convex in after tax price, the sign is negative and, if not, the sign is positive. This is consistent with our paper. Our demand function is log convex in after tax price and if we calculate the slope of the reaction
function for Leviathan governments, it becomes

\[ \frac{\partial t_A}{\partial T} = -\frac{\partial^2 T_{RG, A}}{\partial t_A \partial T} \]

and the value is negative. Also, under the extreme assumption of no cross border shopping, this value becomes close to -1/2, which is calculated in the equation (C’) in Appendix A.5.

On the other hand, Keen explains that the sign of the slope of the reaction function is positive for benevolent governments. He believes that the cost of additional reduction of utility from private goods is less than the benefit of increase in utility from public goods when both federal and state governments increase their tax rates, and that state governments increase their tax rate to finance public goods when the federal government increases its tax rate. As we argued before, these results do not hold in our model. The sign depends on the relative scale of "benefits (utility increase from public goods)" and "cost (utility decrease from private goods)" in increasing state tax rate, which hinges on utility function, the price elasticity of demand and after tax price, and some states take negative values. Our results show that the slope of the reaction function is positive for some states, and these state governments increase their tax rate when the federal government raises its tax rate, while in some states the slope of the reaction function is negative, and these state governments decrease their tax rate when the federal government raises its tax rate.

Next, we clarify the relationship between the scale of the slope of the vertical reaction function and the price elasticity of demand (\( \epsilon \)) or after tax price (\( P \)). First, we derive the slope of the vertical reaction function under the assumption of no cross-border shopping.

\[ \frac{\partial t_A}{\partial T} = -\frac{\partial^2 W_A}{\partial t_A \partial T} \]

This is an extreme assumption but as we discussed earlier, does not deviate much from the estimated model. From the specification of the slope of the reaction function of the equation

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(C) in Appendix A.5, it is clear that the slope depends on the price elasticity of demand and after tax price. The derivative of the equation (C) with respect to price elasticity of demand ($\epsilon$) is negative $^{40}$ and the derivative of equation (C) with respect to after tax price ($P$) is positive.$^{41}$

In short, the slope of the reaction function is negatively related to the price elasticity of demand and positively related to after tax price. If the price elasticity of demand is large, consumers’ response in demand to tax rate change is large, and state government is reluctant to change its tax rate to avoid losing tax base. This is why the relationship between the price elasticity of demand and the scale of tax interaction is negative. Furthermore, if the after tax price is high, the price elasticity of demand becomes small.$^{42}$ If the price elasticity of demand is low, a state government’s response to another state governments’ tax change becomes large, and this is why a relation between after tax price and the scale of tax externality is positive. This idea is consistent with our results, as shown in Figures 3.8, 3.9, 3.10 and 3.11. Figures 3.8 and 3.9 show the correlation between the slope of the reaction function and the price elasticity of demand for gasoline and cigarettes, and the sign of the correlation is negative.$^{43}$ Figures 3.12 and 3.13 show the correlation between the slope of the reaction function and after tax price, and the sign of the correlation is positive in both the gasoline and cigarette cases.

$^{40}$The value of the denominator is positive, and the numerator is expressed as
$$\frac{P}{P+\alpha} \left( 2 - \left( 2 - \frac{xe}{x-\gamma} \right) \frac{e}{P+\alpha} \right) > 0.$$ The increase in the absolute value of the price elasticity of demand means decreasing the value of the price elasticity of demand since $\epsilon < 0$, and we need to multiply “−” for this value. Therefore, the slope of the derivative becomes negative. This value is derived assuming that $x$ and $P$ are constant for simplicity.

$^{41}$The value of the denominator is positive and the numerator is expressed as $$\frac{e^2 t_A}{(P+\alpha)^2} \frac{xe}{x-\gamma} > 0.$$ Therefore, the slope of the derivative is positive. This value is derived assuming that $\epsilon$ and $x$ are constant for simplicity.

$^{42}$Refer to equation (3.5).

$^{43}$In Figure 3.8, the original sign of the coefficient is positive, but once we exclude outlying observations which take small values of the price elasticity of demand, the coefficient of the slope becomes negative as the figure shows.
Gasoline
\[ y = -0.581x + 0.562 \]
\[ R^2 = 0.0305 \]

Cigarette
\[ y = -1.00x + 0.693 \]
\[ R^2 = 0.251 \]

Gasoline
\[ y = 0.142x - 0.148 \]
\[ R^2 = 0.0626 \]

Cigarette
\[ y = 0.309x - 0.825 \]
\[ R^2 = 0.564 \]

Correlation
\[ y = 0.834x + 0.0684 \]
\[ R^2 = 0.132 \]

Correlation
\[ y = 1.48x + 0.652 \]
\[ R^2 = 0.216 \]
Comparing gasoline and cigarette taxes, the price elasticity of demand is larger for gasoline than for cigarette, and the scale of vertical externality is larger for cigarette than for gasoline. We also show a strong correlation of the slope of the reaction function between gasoline and cigarettes in Figure 3.12, and it is due to a high positive correlation between after price tax of gasoline and cigarettes, as Figure 3.13 shows. From this argument, we can conclude that the price elasticity of demand and after tax price are important factors for vertical externality.

3.9 Conclusions

In this chapter, we propose a structural estimation approach to estimate vertical and horizontal tax interactions for gasoline and cigarette taxes in the U.S. We estimate the structural parameters of the household utility function as well as the percentage of cross-border shopping. Given the parameters of the household utility function, we recover the parameters of the objective function of the benevolent state government. Using all the estimated structural parameters, we compute the value of the slope of the reaction function for each state, which represents strategic interaction of taxation between governments.

From this analysis, we obtain the following results. First, the estimated value of the slope of the horizontal reaction function between state governments is small. That is, in contrast to past literature using the weighted matrix approach, we only estimate small tax interactions between state governments, and state government does not respond to its neighboring states’ tax rate change. This is because both gasoline and cigarette consumption shares to total income are small, and the percentage of cross-border shopping is estimated to be low. Second, the value of the slope of the reaction function of state tax on federal tax is positive on average for both gasoline and cigarette taxes. That is, state government tax
reacts positively to a federal government increase in tax rate. The value of the slope of the reaction function is estimated to be greater for cigarette tax than for gasoline tax. This result is consistent with optimal taxation theory. Third, even though on average, the slope of the reaction function is positive for both taxes, these values are very different across states, even negative in some states. We also find that the important factors affecting the slope of the horizontal reaction function are the share of private good consumption to total income and the percentage of cross border shopping, while the price elasticity of demand and after tax price are important for the slope of the vertical reaction function.

The results obtained are in sharp contrast to those of the previous literature, for example, Besley and Rosen (1998) and Devereux, Lockwood and Redoano (2007). They estimate a positive and significant horizontal tax interaction for the cigarette tax and obtain similar estimates for vertical tax interaction for both cigarette and gasoline taxes. The slope of the vertical reaction function is estimated to be larger for the gasoline tax than for the cigarette tax. This result is inconsistent with the idea of the negative relationship between the price elasticity of demand and the scale of tax interaction. Also, we find a high degree of differences across states in the slopes of the vertical reaction function, which is very interesting, considering the assumption adopted in the literature that the degree of vertical tax interaction is the same across states. Given these inconsistent results, we replicate a weighted matrix approach using simulated tax rates assuming no cross-border shopping. Since tax rates are simulated under the assumption of no cross-border shopping, tax rates do not include a factor for the horizontal tax externality, and the regression analysis should show no horizontal tax interaction if the estimation method is appropriate. Nevertheless, the replication results show strong horizontal tax interactions, which should not exist. This contradiction between the model and the results implies that the weighted matrix approach
might not be suitable to evaluate the slope of the reaction function.

Structural estimation in this chapter shows the advantage of solving the limitations which the weighted matrix methods have. In addition, using a specified model, we can understand the mechanism of tax interactions and identify the factors which determine the sign and scales of tax interactions. On the other hand, it is clear that the structural estimation approach adopted here requires strong assumptions. For example, horizontal tax interaction is only attributed to cross-border shopping and state government are assumed to be benevolent. Restrictive functional forms are also used for the utility function of consumers and the objective function of state governments. Nevertheless, with these strong assumptions, we can derive the state government objective function, and compare this equation to find the problems in the weighted matrix method or use this equation to identify socio-economic variables included in reduced form equations. In that sense, we believe that the structural approach works as a useful complement to the conventional weighted matrix approach in pointing out possible directions for improvements in specification of the linear model.

The estimation result has an important policy implication. The different value and sign of the slope of the reaction function tell us that state governments respond to federal government tax policies differently, and that the federal government should not use the same policy for all states to maximize the total welfare of the nation. This also implies that it could be potentially interesting for researchers using nonstructural approaches such as weighted matrix methods to adopt random coefficients estimation techniques or quantile regression techniques to capture heterogeneity in vertical tax interactions. We believe an important topic for future research for both structural and nonstructural analysis is to investigate further the difference in how each state government reacts to federal government
policy. This will help the federal government to better understand the effect of its tax policy at the state level.
Chapter 4

Analysis of State Government Objectives and Tax Setting Behaviour

4.1 Introduction

The purpose of this chapter is two-fold. First, we identify whether state government behaviour is Benevolent or Leviathan. Second, we estimate the state government objective function in order to understand how state governments determine their tax rates. These two issues are analyzed using the U.S. gasoline tax.

In the public finance literature, federal and local governments are typically regarded as either Benevolent or Leviathan.\(^1\) A benevolent government is considered as maximizing the total welfare of the people and a Leviathan government is assumed to maximize total tax revenue. As their purposes are different, tax rates and tax characteristics under these

\(^1\)We admit that some literature also considers the case where the government’s purpose is rent seeking or connected with some political issues. For example, Besley and Case (1995) show that yardstick competition is linked to the government maximization problem of its rent or the probability to win elections. We do not refer to these issues in this chapter.
governments must be different, as explained in Abizadeh and Cyrenne (1997), Keen (1998) and Santolini (2009). In short, the optimal tax rate and its characteristics are different between Benevolent and Leviathan governments. There is a situation where governments are prevented from choosing the optimal tax rates, and the tax rates in Nash Equilibrium deviate from optimal tax rates. Public policies such as tax coordination or an intergovernmental transfer are necessary to solve this distortion. Nevertheless, it is impossible to measure the scale and direction of the tax distortion and to find solution without knowing the objective of governments. Therefore, identifying the government objective is a very important research topic in public finance.

Some literature examines whether government behaviour is consistent with Leviathan, such as Oates (1985), Nelson (1987), Zax (1989), Stansel (2006) and Garrett (2001). On the other hand, there is only small literature to examine whether government is benevolent. To the best of our knowledge, this chapter is the first attempt to analyze whether state government is Benevolent or Leviathan and to explicitly estimate the state government objective function. To do so, we first build the state government objective function based on the Benevolent and Leviathan assumptions, and derive the optimal tax rate function. Then we examine the consistency between the model and real data to determine which government assumption and functional forms are more suitable. Lastly, we simulate state taxes based on the estimated model and compare them with real tax data to verify that our model matches with the data on state government taxes.

We focus on the U.S. gasoline tax for this analysis. Both federal and state governments levy gasoline taxes per unit. In short, after tax price of gasoline is the sum of gasoline price, state gasoline per unit tax and federal gasoline per unit tax. There are two reasons
for choosing the gasoline tax. First, gasoline tax revenue is earmarked for highway expenditure. Highway expenditure is mainly financed from this gasoline tax, motor vehicle and carrier tax, bonds, and a federal grant, and the close connection between tax revenue and a specific public expenditure makes it easier for us to build the state government objective function. Second, rich gasoline and highway data are available from the U.S. Energy Information Administration and the Federal Highway Administration websites.

Not only state government but also consumer behaviour needs to be estimated, since state governments determine their tax rate taking into account consumers’ gasoline and highway consumption. We choose Stone-Geary utility function considering the following two reasons. First, the price elasticity of demand for gasoline is estimated around -0.8 to -1 in the previous literature, and the Stone-Geary utility function allows the price elasticity of demand to have any value between 0 and -1. Second, per capita gasoline consumption data match with the model. In contrast, Cobb-Douglas utility function and quasi-linear utility function neither produce a suitable price elasticity of demand nor match the consumption data. We derive a demand function and estimate the parameters of the model using gasoline consumption data. The estimated amount of consumption based on the model is very close to the real consumption data. Using this consumer utility function, we explore the state governments objective and build their objective function to understand their tax setting behaviours.

Our finding from the analysis is as follows: First, state governments are likely to be benevolent, not Leviathan. When state government is assumed as Leviathan, a conflict between the model and data arises. Second, the state government objective function that fits the data well is quasi-linear. Third, simulated taxes based on the structural model are close to the data on taxes.
The rest of the chapter is organized as follows. Section 2 analyzes whether the state government objective is consistent with Benevolent or Leviathan. Section 3 builds the state government objective function. Section 4 simulates state taxes and compares them with real tax data. Section 5 provides conclusions.

4.2 State Government Objective: Benevolent or Leviathan

In this section, we analyze which assumption, Benevolent or Leviathan, is empirically more suitable as the objective of the state government. We first consider the Leviathan specification following the model by Devereux, Lockwood and Redoano (2007), which also analyze the U.S. state gasoline tax. In their paper, they regard state governments as Leviathan and derive a reaction function to examine how a state government responds to the tax rate changes of other state and federal governments.

Suppose there are one federal and two state governments $i$ and $j$ in the world. $n_i$ and $n_j$ are the number of people who live in each state. Federal excise tax $T$ and state excise taxes $t_i, t_j$ are levied on a private good $x$ whose prices are $p_i$ and $p_j$ in each state. Consumers purchase a good $x$ in only one place and decide whether to purchase a good $x$ in their own state or to do cross-border shopping. The cross-border shopping can go in both direction between states. The key factor affecting cross-border shopping is the price difference between two states, $P_i = p_i + t_i + T$ and $P_j = p_j + t_j + T$ and the cost of cross-border shopping, which can be represented by the distance between two states $d_{ij}$. If the benefits from the price difference are larger than the costs of cross-border shopping, consumers choose cross-border shopping.

State government $i$ aims to maximize total tax revenue $R_i$. Total tax revenue $R_i$ is composed of tax rate $t_i$ and tax base $X_i(P_i, P_j, d_{ij}, n_i, n_j)$. Tax base $X_i$ can be divided into
two components; per consumer demand $x_i(P_i)$ and the number of people who purchase the good in state $i$, $s_i(P_i, P_j, d_{ij}, n_i, n_j)$. Then state government $i$’s problem is

$$\max_{t_i} R_i = t_i X_i(P_i, P_j, d_{ij}, n_i, n_j)$$

where $X_i(P_i, P_j, d_{ij}, n_i, n_j) = x_i(P_i)s_i(P_i, P_j, d_{ij}, n_i, n_j)$. The first order condition with respect to tax rate $t_i$ is

$$\frac{\partial R_i}{\partial t_i} = x_i(P_i) s_i(P_i, P_j, d_{ij}, n_i, n_j) + t_i \frac{\partial x_i(P_i)}{\partial t_i} s_i(P_i, P_j, d_{ij}, n_i, n_j) = 0$$

This first order condition gives the optimal tax rate as follows

$$t_i = \frac{p_i + t_i + T}{\varepsilon_i + \sigma_i}$$

(4.1)

where $\varepsilon_i$ is the price elasticity of demand and $\sigma_i$ is the price elasticity of the number of shoppers. In short, tax rate $t_i$ depends upon price $p_i$, federal tax rate $T$ and the price elasticity of demand and the number of shoppers $\varepsilon_i$ and $\sigma_i$.

To estimate the slope of reaction function, Devereux, Lockwood and Redoano (2007) regress state tax $t_i$ with a weighted average of other state taxes $\sum_{i \neq j} w_{ij} t_j$, the federal tax $T$ and other socio-economic variables $X_i$ in equation (4.2). $w_{ij}$ is a weight term between state $i$ and $j$. $\mu_i$ is a constant term and $v_i$ is an error term.

$$t_i = \mu_i + \delta \sum_{i \neq j} w_{ij} t_j + \kappa T + \lambda X_i + v_i$$

(4.2)

The estimated coefficients $\delta$ and $\kappa$ are considered to represent the slopes of reaction function to other state tax changes (horizontal tax interactions) and to federal tax change (vertical tax interactions), respectively. The estimation results show that the coefficient on

Devereux, Lockwood and Redoano (2007) assume quasi-linear utility function and a demand function is independent of income.

$\varepsilon_i = -\frac{p_i}{x_i} \frac{\partial x_i}{\partial p_i}$, $\sigma_i = -\frac{p_i}{s_i} \frac{\partial s_i}{\partial p_i}$.

Devereux, Lockwood and Redoano (2007) consider three cases. One is a uniform case where all states have equal weight “1/total number of states”. Second is a neighbor case where only the neighborhood states have equal weight “1/total number of neighborhood states”. Last is a density case and population density is used as a factor in the weighting matrix.
horizontal tax interaction \( \delta \) is insignificant, while the coefficient on vertical tax interaction \( \kappa \) is positively significant. From these results, the authors consider that a high transfer cost of gasoline prevents cross-border shopping since these empirical results are consistent with the model in the case of no cross-border shopping.\(^5\)

Nevertheless, there is a contradiction between this Leviathan model and real data. If a state government is Leviathan and if there is no cross-border shopping, the price elasticity of the number of the shoppers is zero (\( \sigma_i = 0 \)) and state tax rate becomes

\[
t_i = \frac{p_i + t_i + T}{\varepsilon_i}
\]  \hspace{1cm} (4.3)

and the price elasticity of demand \( \varepsilon_i \) must be less than -1 for the optimal tax to be positive. From previous literature, the price elasticity of demand for gasoline is estimated around -0.8 to -1. This result implies that either the Leviathan assumption or the no cross border shopping idea is wrong. Devereux, Lockwood and Redoano (2007) mention that "For gasoline, by contrast, there seems to be no evidence that cross-border shopping or smuggling is an issue".\(^6\) In addition, our previous estimation of the consumer utility function shows that there is only around 5% cross-border shopping for gasoline and that the sensitivity of cross border shoppers to the tax rate change is negligible. Most of the gasoline consumption in each state is found to be explained by socio-economic variables of their own state. These results indicate that the number of cross-border shoppers and the price elasticity of the number of shoppers are small. From these arguments, we conclude that the Leviathan assumption is not appropriate and we assume the government to be benevolent.

\(^5\)In the case of no cross-border shopping, the slope of the reaction function become \( \partial t_i / \partial t_j = 0 \) and \( \partial t_i / \partial T = \frac{n_i(x_i^t + tx_i^c)}{-2^{\alpha X_i^t} + \alpha x_i^t} \) in their model.

\(^6\)An extract from Devereux, Lockwood and Redoano (2007) page 454, lines 15-16.
4.3 State Government Objective Function

4.3.1 The Model

In this section, we build the state government objective function, assuming state government to be benevolent. Since the state government objective is to maximize the welfare of its citizens, we need to define consumer utility function. We employ Stone-Geary utility function, as explained in the Introduction. We assume no cross-border shopping for simplicity, following the results by Devereux, Lockwood and Redoano (2007) and ours.

Consumers have income $I$ and get utility from consumption of a private good $x$, composite good $y$ and public good $G$. There is a subsistence level of the good $x$ which is represented by $\gamma_x$. Consumer’s utility function is expressed as follows.

$$
U = \alpha \log (x - \gamma_x) + (1 - \alpha) \log y + \phi f(G)
$$

(4.4)

The parameter $\alpha$ represents the income share the household spends on the good $x$ above the minimum consumption level $\gamma_x$. $\phi$ is a weight parameter between private good utility and public good utility. We leave the functional form of the public good $f(G)$ to be flexible.

Consumer determines a demand for a private good $x$ and the composite good $y$ under the following budget constraint.

$$(p + t + T)x + y = I$$

Demand functions for a private good $x$ and the composite good $y$ become

$$
x = \frac{\alpha I}{p + t + T} + (1 - \alpha) \gamma_x, \quad y = (1 - \alpha) (I - (p + t + T) \gamma_x)
$$

Public good $G$ is financed by private good $x$’s tax revenue $TR_x$, other tax revenue $TR_o$ and a grant from the federal government $g$.

$$
G = TR_x + TR_o + g, \quad TR_x = t \times x
$$
State government determines state per unit tax $t$ to maximize the welfare of its citizens and the first order condition with respect to the state per unit tax is as follows.

$$\frac{\partial W}{\partial t} = \frac{\alpha}{x - \gamma_x} \frac{\partial x}{\partial t} + \frac{1 - \alpha}{y} \frac{\partial y}{\partial t} + \phi f'(G) \frac{\partial G}{\partial t} = 0 \quad (4.5)$$

The issue is that we do not know the functional form for the public good $f(G)$ and the weight function $\phi$. We consider two functional forms for the public good $f(G)$ - Cobb-Douglas and quasi-linear -, and examine which functional form is consistent with the data. In other words, we develop the optimal state tax function from this first order condition assuming a specific functional form for $f(G)$ and determine in which case this tax function matches the data best.

In the case of the Cobb-Douglas function, $f(G)$ is $\log(G)$ and the term $f'(G)$ in the first order condition becomes $1/G$. By entering each term $x$, $y$ and $G$ in equation (4.5), the first order condition becomes

$$\phi(1 - \alpha)\gamma_x^2(p + t + T)^3 - \phi(1 - \alpha)\gamma_x I(p + t + T)^2 + (1 - \alpha)\gamma_x G(p + t + T)^2$$

$$+ \phi\alpha\gamma_x I(p + T)(p + t + T) + \alpha IG(p + t + T) - \phi\alpha pI^2 = 0 \quad (4.6)$$

which is very complicated. Similarly, if we assume a quasi-liner function, $f(G)$ is $G$ and the term $f'(G)$ in the first order condition becomes 1. The first order condition becomes exactly the same as the case of Cobb-Douglas function if we replace $G$ with 1. For simplicity, if we assume $\gamma_x = 0$, the state tax $t$ is

$$t = \frac{\phi I - 1}{G}(p + T) \quad \text{in the Cobb-Douglas function case} \quad (4.7)$$

$$t = (\phi I - 1)(p + T) \quad \text{in the quasi-liner function case} \quad (4.8)$$

Simple comparison of equation (4.1), (4.7) and (4.8) show that the optimal tax rate is different depending on the specification of the state government objective function. The crucial
difference between Cobb-Douglas function and quasi-linear function is whether state per unit tax $t$ depends on the amount of the public good $G$ or not. If the relation between the state per unit tax and the amount of the public good is weak, a quasi-linear utility function is more appropriate.

### 4.3.2 The Correlation Analysis between State Tax and Social Economic Variables

In this section, we investigate the relation between a state per unit tax and the amount of public expenditure to identify a suitable functional form for the public good. We regress the state gasoline per unit tax on several socio-economic variables to assess the correlation between the gasoline tax and highway expenditure. The data period is from 1993 and 2004, and Hawaii and Alaska are excluded from the states. The total number of observations is 576. Considering endogeneity issues, we avoid using gasoline consumption and the federal per unit tax as explanatory variables. We first regress the gasoline tax on several socio-economic and fiscal variables. For prices, we use not only state level gasoline price but also the consumer price index (CPI) of gasoline and transportation to take into account macroeconomic trends. Other variables are the ones which affect household gasoline demand, including income, the population, density, the number of car registrations, GDP and growth of the population and GDP. We also include fiscal variables. We use the amount of highway expenditure, a grant from the federal government, and the outstanding bond amount in the highway department. Lastly, we include regional dummy variables (Northeast, Midwest, South). There is a possibility that the amount of highway expenditure is determined simultaneously with state tax, and we employ the IV estimation. We use the
residual of regression of federal tax rate on a federal grant and the ratio of highway expenditure to total expenditure as instrumental variables. The data resource is listed in Appendix A.1. The regression results are shown in Table 4.1.

Table 4.1: Correlation Analysis I

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>price</td>
<td>0.397****</td>
<td>0.024</td>
</tr>
<tr>
<td>CPI gas</td>
<td>-0.422***</td>
<td>0.036</td>
</tr>
<tr>
<td>CPI transp</td>
<td>0.311***</td>
<td>0.067</td>
</tr>
<tr>
<td>income</td>
<td>0.162*</td>
<td>0.088</td>
</tr>
<tr>
<td>density</td>
<td>-0.697</td>
<td>3.88</td>
</tr>
<tr>
<td>gdp</td>
<td>-0.167</td>
<td>0.091</td>
</tr>
<tr>
<td>pop</td>
<td>0.107***</td>
<td>0.037</td>
</tr>
<tr>
<td>gdp growth</td>
<td>0.170</td>
<td>0.606</td>
</tr>
<tr>
<td>pop growth</td>
<td>-0.375*</td>
<td>0.232</td>
</tr>
<tr>
<td>car register</td>
<td>-0.587</td>
<td>0.615</td>
</tr>
<tr>
<td>highway expend</td>
<td>-0.380</td>
<td>0.227</td>
</tr>
<tr>
<td>highway grant</td>
<td>0.677**</td>
<td>0.282</td>
</tr>
<tr>
<td>highway bond</td>
<td>-0.107</td>
<td>0.251</td>
</tr>
<tr>
<td>Northeast</td>
<td>0.199</td>
<td>0.723</td>
</tr>
<tr>
<td>Midwest</td>
<td>0.187***</td>
<td>0.064</td>
</tr>
<tr>
<td>South</td>
<td>0.148***</td>
<td>0.056</td>
</tr>
<tr>
<td>constant</td>
<td>-0.322***</td>
<td>0.085</td>
</tr>
<tr>
<td>Observation</td>
<td>576</td>
<td></td>
</tr>
<tr>
<td>R squared</td>
<td>0.482</td>
<td></td>
</tr>
</tbody>
</table>

Notes: *** means 1% significant, ** means 5% significant and * means 10% significant

We find a strong effect of price variables on gasoline state tax.\textsuperscript{7} Not only the coefficient on the gasoline price but also the CPI coefficients are significant, and state tax is strongly affected by price data. On the other hand, economic variables considered to affect gasoline demand are weakly related to state tax and only population and income factors are positive and significant. As for fiscal variables, the coefficient of highway expenditure is negative and insignificant and a federal grant’s coefficient is positive and significant. Highway

\textsuperscript{7}These results are consistent with previous literature. Several literature investigate the factors which affect gasoline price and tax. For example, gasoline content regulation, domestic refinery utilization rate, demand factors (income, vehicle characteristics and consumer characteristics) and industry characteristics (concentration of industry, market power) and government polices are considered as important factors for gasoline price movement. On the other hand, gasoline price, consumption, inflation rate, highway cost, government debt, tolls and political lobby factors seem to have a significant effect on gasoline tax rate.
bond coefficient is insignificant. Some of the regional dummy variables are significant and Midwest and South regions tend to have higher tax rates compared with other regions.

To verify which functional form is suitable using the first order conditions derived in equation (4.7) and (4.8), we also regress state gasoline tax by a limited set of explanatory variables. We consider two sets of variables. The first set includes either the total amount or per capita amount of highway expenditure linearly. The second case includes one over the total amount or per capita amount of highway expenditure. We also add a population variable considering a congestion effect. The results are listed in Table 4.2.

Table 4.2: Correlation Analysis II

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>per capita</th>
<th>1 / Total</th>
<th>1 / per capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>price</td>
<td>0.355*** 0.018</td>
<td>0.352** 0.017</td>
<td>0.412*** 0.025</td>
<td>0.355*** 0.017</td>
</tr>
<tr>
<td>CPI gas</td>
<td>-0.374*** 0.025</td>
<td>-0.374*** 0.025</td>
<td>-0.431*** 0.032</td>
<td>-0.378*** 0.025</td>
</tr>
<tr>
<td>CPI transp</td>
<td>0.262*** 0.041</td>
<td>0.293*** 0.041</td>
<td>0.311*** 0.048</td>
<td>0.300*** 0.043</td>
</tr>
<tr>
<td>income</td>
<td>-0.684 0.543</td>
<td>-0.800 0.532</td>
<td>-0.797 0.612</td>
<td>-0.848 0.545</td>
</tr>
<tr>
<td>pop</td>
<td>-0.323* 0.176</td>
<td>-0.130*** 0.030</td>
<td>-0.337*** 0.068</td>
<td>-0.147*** 0.035</td>
</tr>
<tr>
<td>Highway expend</td>
<td>0.136 0.099</td>
<td>-0.614*** 0.223</td>
<td>-0.245*** 0.060</td>
<td>0.618** 0.244</td>
</tr>
<tr>
<td>constant</td>
<td>-0.205*** 0.045</td>
<td>-0.215*** 0.044</td>
<td>-0.229*** 0.052</td>
<td>-0.264*** 0.050</td>
</tr>
<tr>
<td>Observation</td>
<td>576</td>
<td>576</td>
<td>576</td>
<td>576</td>
</tr>
<tr>
<td>R squared</td>
<td>0.483</td>
<td>0.501</td>
<td>0.325</td>
<td>0.487</td>
</tr>
</tbody>
</table>

Notes: *** means 1% significant, ** means 5% significant and * means 10% significant.

We find that the coefficients of price, income and population are stable across specifications, although the coefficients of public expenditure are not. The coefficient of gasoline price is positive and significant. The CPI coefficient is negative and significant and the coefficient of transportation CPI is positive and significant. The coefficient of income is insignificant and the population result is negative and significant, which are different from the previous results. The coefficients on highway expenditure are different for four cases. If the total amount of highway expenditure is used, the coefficient is positive and insignificant. If the per capita amount and the inverse of the total amount of expenditure are used,
the coefficients are negative and significant. The coefficient of the inverse of per capita amount of expenditure is positive and significant. If the subsistence term of a private good $\gamma_x$ does not have an effect on tax and if Cobb-Douglas function is suitable, the coefficient of the inverse of the public good has to be positive like equation (4.7). The first regression result listed in Table 4.1 shows the coefficients to be insignificant, and the second results listed in Table 4.2 depend on the functional form and using total or per capita amount of expenditure. The results of two estimations do not give a clear evidence to determine the functional form. This ambiguous result might be attributed to non linear functional form of the first order condition in equation (4.6). In order to solve this problem, we estimate the first order condition directly in the next subsection.

4.3.3 Estimation of State Government First Order Condition

The regression analyses in the previous subsection do not determine the functional form of the state government objective function. In this subsection, we directly identify the state government functional form by using the state government first order condition. The state government first order condition is expressed in equation (4.5) and if all the terms $x, y, G$ are substituted using price, tax, income and parameters, the first order condition becomes

$$\frac{\partial W}{\partial t} = \frac{-\left(\alpha I + (1 - \alpha)\gamma_x(p + t + T)\right)}{(I - (p + t + T)\gamma_x)(p + t + T)}$$

$$+ \phi f'(G) \frac{\alpha(p + T)I + (1 - \alpha)(p + t + T)^2\gamma_x}{(p + t + T)^2} = 0$$

(4.9)

The first term "private" represents a product of marginal utility of the private good and the decreased private good consumption caused by state tax increase. Since the demand of
a private good decreases with the increase of state tax, this term is negative. The second
term excluding the term $\phi f'(G)$, "public" is the product of marginal utility from a public
good and an increase in private good tax revenue raised by state tax increase. Tax revenue
increase with state tax increase, and this term is positive. Both "private" and "public" terms
can be computed from data on price, tax, income and the estimated parameters $\alpha$ and $\gamma_x$.
After computing both terms and taking logs, the first order condition becomes as follows.

$$\log \text{private} = \log \phi + \log f'(G) + \log \text{public}$$  \hspace{1cm} (4.10)

We do not know the functional form of $f'(G)$ and the factor components of the weight
parameter $\phi$. If the state government objective function is Cobb-Douglas function, $f'(G)$
is $1/G$ and the coefficient of a public good has to be close to -1. If the state government
objective function is quasi-linear, $f'(G)$ is just 1, and a public good term does not enter in
the equation. The coefficient of log public has to be 1, and we subtract this term from log
private. Then the difference between log private and log public is expressed by log $\phi$ and
log $f'(G)$, and we regress this difference with highway expenditures and social economic
variables using the IV method. Two variables are used for a public good: total amount and
per capita amount of highway expenditure. Income and population are chosen as the factor
components of the weight parameter $\phi$ as expressed in equation (4.11).

$$\log \text{private} - \log \text{public} = \varphi_0 + \varphi_1 \log \text{highway} + \varphi_2 \log \text{income} + \varphi_3 \log \text{population}$$  \hspace{1cm} (4.11)

The estimation results are listed in Table 4.3.

The coefficient of highway expenditure is insignificant, and the public good term does
not contribute to explaining the dependent variable. In short, a functional form $f'(G)$
does not include a public good term $G$ and quasi-linear functional form is appropriate. In
addition, the coefficients on income and population are negative and significant, and these
### Table 4.3: First Order Condition Estimation I

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>log highway</td>
<td>0.336</td>
<td>5.868</td>
<td>0.336</td>
<td>5.868</td>
</tr>
<tr>
<td>log inc</td>
<td>-1.038***</td>
<td>0.006</td>
<td>-1.038***</td>
<td>0.006</td>
</tr>
<tr>
<td>log pop</td>
<td>-0.343</td>
<td>0.470</td>
<td>-0.310**</td>
<td>0.151</td>
</tr>
<tr>
<td>constant</td>
<td>0.510***</td>
<td>0.071</td>
<td>0.510***</td>
<td>0.071</td>
</tr>
<tr>
<td>Observations</td>
<td>576</td>
<td></td>
<td>576</td>
<td></td>
</tr>
<tr>
<td>R squared</td>
<td>0.983</td>
<td></td>
<td>0.983</td>
<td></td>
</tr>
</tbody>
</table>

Notes: *** means 1% significant, ** means 5% significant and * means 10% significant.

Economic variables work as the factor of the weight parameter $\phi$. This negative coefficient of income means that if the amount of income is large, state governments will put a lower weight on public goods. This result is plausible since in wealthy states, private sectors will offer services which are substitutable with public goods, and the role of government might decrease. The negative coefficient of population reflects an economic scale of a public good. From this analysis, we conclude that quasi-linear function is appropriate for the state government objective function, and social economic variables like income and population can be used as the weight factors $\phi$ between the utility from private and public goods.

### 4.4 Simulation Analysis

From the previous analysis, we conclude that the state government objective is more likely to be benevolent and quasi-linear functional form is suitable. In this section, we estimate the state government objective function and simulate state tax to verify that the simulated state tax matches the actual taxes closely.

In section 4.3.3’s analysis, we find that socio-economic variables such as income ($I$) and population ($n$) play an important role in representing the weight function $\phi$. We also
include other socio-economic variables which reflect the importance of gasoline consumption and highway expenditure. According to Lin, Botsas and Monroe (1985), gasoline consumption depends on gasoline price, fuel efficiency of vehicles, percentage of people in metropolitan areas, non-automobile transportation methods, income, number of vehicles, non-agriculture employment, demographic factors and climate factors. On the other hand, not all motor fuel tax revenues are used for highway expenditures, and other financial resources are also important for financing highway expenditures. We choose the ratio of the population in a metropolitan area \((m)\), the share of people who use a vehicle to get to their workplace \((v)\), the share of motor fuel tax revenues used for highway expenditure \((s)\) and highway bond \((d)\) as factors of weight function \(\phi\). In other words, we estimate equation (4.12) as follows.

\[
\log \text{private} - \log \text{public} = \varphi_0 + \varphi_1 \log I + \varphi_2 \log n + \varphi_3 d + \varphi_4 \log m + \varphi_5 \log v + \varphi_6 \log s
\]

We do not take a log for a highway bond variable \((d)\) since some states issue zero bonds. Since we exclude highway expenditures this time, we estimate equation (4.12) by a simple linear regression. The estimated results are listed in Table 4.4.

Both coefficients of income and population variables are negative and significant, which is similar to the estimation results of Table 4.3. The coefficient of the ratio of the population in a metropolitan area is positive and significant, 0.024. This result implies that states with large populations in metropolitan areas put less weight on gasoline consumption since alternative transportation methods are easily available in such states. The vehicle coefficient -0.145 is negative and significant, and this reflects the fact that governments put weight more

---

8"not all motor fuel tax revenues are earmarked for highways. For instance, some states have recently diverted as much as one quarter of their motor revenues to finance general fund expenditures." A quote from Goel and Nelson(1999) page 48, lines 3-6.
Table 4.4: First Order Condition Estimation II

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>log inc</td>
<td>-1.038***</td>
</tr>
<tr>
<td>log pop</td>
<td>-0.317***</td>
</tr>
<tr>
<td>bond</td>
<td>-0.498***</td>
</tr>
<tr>
<td>log metro</td>
<td>0.024***</td>
</tr>
<tr>
<td>log vehicle</td>
<td>-0.145***</td>
</tr>
<tr>
<td>log share</td>
<td>0.089***</td>
</tr>
<tr>
<td>constant</td>
<td>0.543***</td>
</tr>
</tbody>
</table>

Notes: *** means 1% significant, ** means 5% significant and * means 10% significant.

on gasoline consumption since many people use vehicles for going to workplace. The share of motor fuel tax revenues used for highway expenditure result has a positive and significant effect, and if the amount of the bond is larger, the weight of a public good becomes lower, which is reasonable. From this first order condition, the state government objective function is recovered as follows;

\[
W = \alpha \log (x - \gamma x) + (1 - \alpha) \log y + e^{(\varphi_0 + \varphi_3 x)} I^{\varphi_1} n^{\varphi_2} m^{\varphi_4} v^{\varphi_5} s^{\varphi_6} G \] (4.13)

where \( e \) is the base of natural log. We simulate state gasoline tax based on this estimated model to compare it with real state tax data. This comparison will show us how much this model reflects state government behavior.

Figure 4.1 compares the simulated tax rate and real state rates averaged over 1993 ~ 2004. The simulated tax tracks the real state tax closely. The variance of real tax is larger than the variance of simulated tax. Part of the reason for the discrepancy is that simulated tax cannot capture complete characteristics of state taxes which have extreme values, as Connecticut, Georgia, New Jersey and Wyoming. This lower variance can be recognized from a slope value 0.454 which is lower than 1. Figure 4.2 plots the simulated taxes and real taxes, and the correlation between simulated taxes and real taxes is 0.556. In addition,
Relation between real tax and simulated tax

Figure 4.1: Gasoline Tax I

Relation between real tax and simulated tax

\[ y = 0.4542x + 0.1102 \]

\[ R^2 = 0.5557 \]

Figure 4.2: Gasoline Tax II

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R squared value in the estimation result of Table 4.4 is 0.987, which is almost 1. From these results, we are convinced that our state government objective function reflects real state tax movement well, and this model is suitable to analyze how state governments determine their tax rate.

4.5 Conclusions

In this chapter, we estimate the state government objective function to identify how state governments determine their taxes. We focus on the U.S. gasoline tax for the analysis and obtain the following results.

First, state government behaviour is more likely to be benevolent than Leviathan. The Leviathan assumption is inconsistent to the estimated price elasticity of demand and small cross-border shopping. Second, quasi-linear functional form is appropriate to describe the objective function of benevolent state government. We examine two functional forms for the state government objective function; Cobb-Douglas function and quasi-linear function. The critical difference between Cobb-Douglas function and quasi-linear function is that state tax is a function of public expenditures in the former case although it is not in the latter case. When the first order condition of the state government objective function is estimated directly, we find the public expenditure term is insignificant, and we conclude that quasi-linear function is more appropriate. Third, simulation analysis supports that our model fits real tax data. When we simulate tax rates based on the estimated objective function and compare them with real tax data, the simulated tax rate matches closely to the real tax rates in the data despite parsimonious model specification. From this, we conclude that our state government objective function represents real state government behaviour well, and this model is useful to analyze how state governments determine their tax rate.
Our contribution in this paper is to propose a methodology to determine the state government objective function, rather than to empirically estimate comprehensive objective functions of the governments. We admit that we have considered only two extreme specifications in this chapter: Leviathan and Benevolent ones. Previous literature has considered other kinds of government objective functions. One is yardstick competition. Many papers, including Besley and Case (1995), find the evidence for the existence of yardstick competition. In the yardstick competition model, local governments determine their tax rate taking into account their neighboring local government tax rates to win elections. Here, we do not consider yardstick competition in the state government objective function, but we could extend our model to include it as well. A second issue is the use of excise taxes to correct an externality. Consuming gasoline results in the exhaust fumes emission, which causes air pollution. On the other hand, cigarette consumption (discussed in Chapter 3) increases the risk of heart disease, cancer, emphysema, and other disease not only for smokers but also non-smokers through second-hand smoke. Governments may determine their tax rate considering these externality problems. It is important to take into account these externalities in the government objective. In addition, governments discourage cigarette consumption using several kinds of policies such as a medicaid system, tobacco prevention spending, and smoking bans. Analyzing the relation between these policies and tax policy is also a meaningful research topic for the future.
Chapter 5

Corporate Tax Rates and the Entry and Exit Decisions of Canadian Firms

5.1 Introduction

The purpose of this project is to analyze firm entry and exit behaviours and the effect of the corporate income tax system on firm location choices and exit decisions in Canada.\footnote{The chapter is supported by a Tom Symons Research Fellowship at Statistics Canada. We are grateful for this support and this chapter does not represent the view of Statistics Canada.} Given a firm’s objective is to maximize its profit, firms will locate in the place where market demand is large and production costs are low. Tax burden is believed to be one of the important cost factors for firms, and it is natural that firms prefer a low tax burden area. The establishment of new firms stimulates the regional economy through expanding employment and production outcomes, and governments have an incentive to strategically determine their tax system to attract firms. Analyzing the effect of the corporate income tax system on firm behaviors is an important research topic in public finance to encourage
economic growth.

The linkage between the business tax system and firm location choice is well discussed in previous literature. Among recent papers, Devereux and Griffith (1998) analyze whether the corporate tax burden is an important factor for firm export and location decisions using U.S. firms in the European market. Head and Mayer (2004) examine the Japanese firm location choice problem in a European country, taking into account both the corporate tax system and potential market demand. Beaulieu, McKenzie, Vu and Wen (2006) investigate the relationship between the number of firm establishments and corporate tax rates in Canada. In spite of the volume of literature, the results are inconsistent, and the effect of the corporate income tax system on firm location choices remains a controversial issue.

In this project, we focus on the manufacture sector and make several contributions in this research area, using the GIFI-T2LEAP database which has been created by Statistics Canada. T2LEAP is the combined data set of LEAP (The Longitudinal Employment Analysis Program) and T2SUF (Corporate Tax Statistical Universal File), and covers close to 14.5 million enterprise-year observations from 1984 to 2007. LEAP provides longitudinal data on the behaviour of employment levels of Canadian businesses and contains annual employment, payroll and industry for every employer in Canada. T2SUF data is based on T2 corporate income tax return files from the Canadian Revenue Agency, and provides data on sales, gross profits, assets and tax data for all incorporated firms in Canada. GIFI (Generalized Index of Financial Information) consists of extensive financial statements collected by the Canadian Revenue Agency in conjunction with T2 corporate income tax returns. With these detailed data sets, the GIFI-T2LEAP file allows researchers to study business dynamics in Canada.

Using the GIFI-T2LEAP file has several benefits. First, individual firm data sets allow
us to analyze heterogeneous aspects across firm sizes, industry sectors, firm types and financial status which aggregated data cannot provide. In addition, it is possible to compare policy effects on firms with different characteristics. Second, the data set covers most Canadian firms, and includes rich information about individual firms. For example, age, size, employees, financial information, sector, location, and tax data are available. From the T2 file, detailed relationships among firms can also be identified. For instance, we are able to find whether several firms belong to the same enterprise or whether firms have a parent or subsidiary firm. Third, the longitudinal data sets help us to trace firm behaviour over time. In addition to location choice, firm dynamic decisions, such as entry and exit decisions and working duration, can be examined.

The first task is to construct different corporate tax rates. Boadway and Kitchen (1999) document the complexity of the Canadian tax system and the need to consider all possible corporate taxes. In the literature, there are five kinds of corporate tax rates: the statutory tax rate, average tax rate, marginal effective tax rate, effective average tax rate and effective tax rate on marginal production cost. All tax rates have different interpretations and usage; therefore, using an inappropriate tax rate may lead to an incorrect conclusion. We compute individual firm level tax rates for these taxes, and examine each tax rate distribution. In addition, we compare these tax rates with aggregate level tax rates and effective tax rates. These detailed comparisons of tax rates using individual firm level data will explain how much aggregate level tax rates reflect individual firm level tax rates and why the previous literature has generated inconsistent results.

Second, we analyze firm entry and exit behaviours and survival rates. Firm entry and exit behaviours may be different among firms with different characteristics. For example, most of new firms are small-size firms. Firm entry rate is high in prospering industry
sectors and firm exit rate is more frequent in declining industry sectors. Provinces with a large GDP and low production costs are more attractive for firms than other provinces. Given these arguments, firm entry and exit rates are compared across firm sizes, industry sectors and provinces. In addition, firm survival rates and firm size shifts (changes) are examined. These arguments indicate which factors are important for firm entry and exit analysis.

Third, firm tax payment behaviour is investigated. The corporate income tax is levied on firm profits and firms with negative or zero profit do not need to pay corporate taxes. If the percentages of firms which do not pay taxes are high, corporate income tax rates do not have much of an effect on firm behaviours, and the analysis assuming that all firms pay taxes may yield inaccurate results. This issue has not been investigated to date because of the inaccessibility of individual firm level tax data. It is important to investigate what percentages of firms do not pay taxes, and what types of firms have a higher percentage of no tax payment. Examining the relation between tax rate and tax payment behaviour also gives us a suggestion for tax policy reform. We examine these percentages across age, firm size, structure, industry sectors and provinces. In addition, the tax rates change over the firm age is analyzed for different firm sizes, industry sectors and provinces.

Fourth, the effects of corporate income tax rates on firm location choices and exit decisions are analyzed. To the best of our knowledge, this is the first study that uses individual firm-level tax data for firm location choice and firm exit decision analysis. The corporate tax burden is considered to be one of the important cost factors for firms and it is argued that Canadian governments, including both federal and provincial governments, should reduce their corporate tax rates to a greater degree to compete in a competitive international
market and to attract more firms to Canada.\textsuperscript{2} It is important to analyze whether a high corporate income tax rate discourages firm entry and prompts firms to exit the market. We focus on the firms which do not have any relation with other firms to measure the precise effect of tax rate, and investigate the effect of corporate income tax rates on firm location choices and exit decisions, taking into account firm characteristics, an agglomeration effect, demand and cost factors and other social economic factors. In addition, firm financial status data are included for firm exit decision analysis.

The results from our analysis are as follows: First, each corporate income tax rate has a different distribution across provinces, and individual firm level tax rates are different from aggregate level tax rates and effective tax rates. This means that using a different tax rate for empirical analysis will bring us a different interpretation of tax effects. Second, firm entry and exit decisions depend on firm sizes, industry sectors and provinces, with firm size being particularly important. Most new firms are small size, and unsuccessful firms reduce their size until the time of exiting the market approaches. Almost half of new firms exit the market within six years and firm size is changeable within a few years. Third, the percentage of firms which do not pay taxes hinges on firm structure, age, firm size, industry sector and province, and most small size, young, and single firms about to leave the market do not pay taxes. Corporate income tax rates are also different among firms with different characteristics, but the values are stable over the age of the firm regardless of firm characteristics. Lastly, high corporate income tax rates are found to discourage firm location choice and encourage firm exit decisions. In addition to corporate tax rates, other socio-economic factors and firm financial status are important for firm location choices and exit decisions. Large demand factors like population, income and an agglomeration factor are

attractive for firm location choice, and high cost factors such as wages and gasoline prices hamper firm entry and prompt firm exit decisions. Firms with a relatively large amount of assets and capital are less likely to exit the markets, while greater liability increases the probability of exiting the market.

This chapter is organized as follows: Section 2 reviews the previous literature. Section 3 shows how to compute tax rates, and Section 4 explains the Canadian tax system and firm structure. Section 5 describes the data resources used, and Section 6 illustrates three tax rate distributions. Section 7 examines firm entry and exit behaviours and Section 8 investigates firm tax payment behaviour. Section 9 analyzes the effect of the corporate income tax on firm location choices and exit decisions, and Section 11 concludes.

5.2 Literature Review

In this chapter, we introduce several kinds of corporate tax rates and the results of previous research. In the literature, five kinds of corporate tax rates are used: (1) statutory tax rate, (2) average tax rate, (3) marginal effective tax rate (4) effective average tax rate and (5) effective tax rate on marginal production cost. All tax rates have different interpretations and usage, and using an inappropriate tax rate may lead to an incorrect conclusion. In order to evaluate a precise effect of the corporate income tax system on firm behaviours, researchers need to understand each tax rate’s characteristics and use a suitable corporate tax rate.

A statutory tax rate is the most commonly used tax rate because of the easy accessibility of the data. Nevertheless, using a statutory tax rate means to overlook a tax base and tax
deduction systems, which are also important to firms.\(^3\) Average tax rate is also commonly used, and this is the ratio of a firm’s tax payment to the firm’s profit (or taxable income). This tax measure is backward looking, and is based on past tax payments and past earnings, which introduces endogeneity bias into regressions. Marginal effective tax rate measures the marginal cost of tax by increasing additional production factors, and usually marginal effective tax rates on capital or labour are analyzed. This is a forward looking measure, and is based on the expected impact on future earnings.\(^4\) Marginal effective tax rate on capital has been analyzed in previous literature, including King (1974), King and Fullerton (1984), Boadway, Bruce and Mintz (1984), Jung (1989), McKenzie, Mansour and Brule (1998), and Egger, Loretz, Pfaffermayr and Winner (2009). Similarly, marginal effective tax rate on labour is discussed in Lin, Picot and Beach (1996) and Lin (2000) using Canadian data.\(^5\)

Effective average tax rate measures the average impact of corporate tax on total profits and is derived in Devereux and Griffith (2003) as the difference between the pre tax profit and post tax profit. This is also a forward looking measure tax. Devereux and Griffith (2002) argue that when a firm faces a location choice, the firm will choose the location which generates the highest post tax profit, and the relevant measure of tax in this case is effective average tax rate since this captures the impact of tax on total profits. On the other hand, conditional on having chosen location, the decision of how much to invest will be determined by the cost of capital (marginal effective tax rate).\(^6\) Effective tax rate on marginal production is developed in McKenzie, Mintz and Scharf (1997), and extended in Beaulieu, McKenzie, Vu, and Wen (2004) and Beaulieu, McKenzie, and Wen (2006). The

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\(^3\)Important factors for the tax base are investment tax credit, capital depreciation rate, capital cost allowance, inflation and the tax deduction of interest payment for the debt financing and several other reduction systems. Including only a statutory tax rate means to omit these important factors.

\(^4\)These explanations about tax rate characteristics are referred to Devereux and Griffith (2002).


\(^6\)This is an extract from Devereux and Griffith (2002), page 89, lines 19-24.
idea of effective tax rate of marginal production is aggregating the marginal effective tax rate on business inputs, and combines the cost of labour input and capital input into one formula.

These tax rates are well used in previous literature. For example, Head and Mayer (2004) use statutory tax rate to estimate the tax effect on Japanese firm location choice in EU, and find a significant negative effect of the tax rate. Carlton (1983), Batrik (1985) and Feld and Kirchgasner (2002) use average tax rate for analyzing a firm location choice. Carlton (1983) does not find a significant effect although Batrik (1985) and Feld and Kirchgasner (2002) report a negative effect of tax rate on location choices. Papke (1991) use marginal effective tax rate and find a significant negative effect of tax rate on the firm location choice. Devereux and Griffith (1998) use effective average tax rate and marginal effective tax rate to study U.S. firm export and location choice in Europe. They find that effective average tax rate have a significant negative effect on a firm location choice but not on the export decision. Marginal effective tax rate is found to have no significant effect on both choices. Basile, Castellani and Zanfei (2008) use effective average tax rate for examining location choice of subsidiaries in EU, and find no significant effect. Beaulieu, McKenzie, Vu, and Wen (2004) and Beaulieu, McKenzie, Wen (2006) investigate the relation between effective tax rate on marginal production and the number of establishments in Canada, and find a negative correlation between them.

Several reasons are considered for the inconsistent results. First, estimation methods are different. Some papers use conditional logit model (or nested or mixed logit) for estimation, and some use linear regressions. Poisson estimation is also well used currently for firm location analysis. Second, included explanatory variables and the analyzed year are...
or duration are different. In addition, a firm location decision must differ for different purposes, such as settling new subsidiaries, FDI or a main department. Beyond these reasons, we consider that using a different tax rate for empirical analysis is one of the most important reasons for these inconsistent results, and we determine these problems by comparing several kinds of tax rates.

We choose to compute average tax rate, marginal effective tax rate on capital and effective average tax rate on capital among five corporate tax rates. We do not argue marginal effective tax rate on labour since there is no specific theoretical formula to compute. Usually, marginal effective tax rate on labour is computed by dividing the total amount of payroll tax by an average wage. In addition, the tax incidence of labour tax is ambiguous and a controversial issue. On the other hand, effective tax rate on marginal production cost is based on a specific production function (like Cobb-Douglas function), production factors and tax incidence, and using an inappropriate production function or the extent of tax incidence results in imprecise tax rates. Considering these risk, we choose these three tax rates. The theoretical formula to compute these tax rates are available from previous literature. For example, marginal effective tax rate on capital is computed in Broadway, Bruce and Mintz (1984), and effective average tax rate on capital is derived in Devereux and Griffith (2003). In the next chapter, we briefly explain how to compute each tax rate.

5.3 Compute Tax Rate

In this section, we explain how to compute three tax rates: average tax rate (ATR), marginal effective tax rate on capital (METR) and effective average tax rate on capital (EATR). Average tax rate is the ratio of total tax payment to profit (or tax base), and is easily calculated by dividing the total amount of tax payment by profit or taxable income.
We employ the method of Boadway, Bruce and Mintz (1984) to compute marginal effective tax rate on capital. Marginal effective tax rate is defined as the difference between the gross marginal rate of return to capital at the margin in the private sector $r_g$ and the rate of market return $r$. Even though the rates of market return are the same for all capitals, the gross marginal rates of return to capital are different among different capitals since the tax systems including investment tax credit rate ($\phi$), capital cost allowance rate ($\alpha$), and economic depreciation rate ($\delta$) are different. In the paper by Boadway, Bruce and Mintz (1984), four kinds of capitals are used: machinery, buildings, land, and inventories. We have followed a similar plan. Marginal effective tax rate is computed using the following definition for each capital:

$$METR = r_g - r$$

A. Machinery and Structures

$$r_g = (r_f + \delta - \dot{q}/q) \left(1 - \frac{\phi}{1-u}\right) \left(1 - \frac{u\alpha}{r_f + \pi + \alpha}\right) - \delta + \dot{q}/q$$

B. Land

$$r_g = \frac{(r_f - \dot{q}/q)}{(1-u)} + \dot{q}/q$$

C. Inventories

$$r_g = \frac{(r_f - \epsilon + u\gamma e^{-\gamma T})}{(1-u)} + \epsilon$$

---

8Jung (1989) and McKenzie, Mansour and Brule (1998) divide capital in greater detail, but data availability prevents us from using the same method. In T2 corporate income tax return files, the capital of machinery and structure is decomposed into 51 classes, and we compute the gross marginal rate of return for all 51 of these classes.

9The definition of METR is not deterministic. McKenzie, Mansour and Brule (1998) use the definition $\frac{r_g-r}{r}$ to compute marginal effective tax rate.
where \( r_f = \beta (1-u)i + (1-\beta)\rho - \pi \) is the cost of finance to the firm and the rate of market return \( r \) is computed as \( r = \beta i + (1-\beta)\rho - \pi \). \( \beta \) is debt asset ratio, \( \rho \) is nominal return on equity and \( i \) is nominal interest rate on Canadian asset. \( \pi \) is expected inflation rate and \( \dot{q}/q \) is expected rate of change in relative price of capital. \( u \) is corporate income tax rate and \( \epsilon \) is the rate of change in the real price of inventories. \( \gamma (= \epsilon + \pi) \) is the rate of change in the nominal price of inventories, and \( T \) is the average holding period for inventories. We compute the gross marginal rate of return for each capital, and aggregate them using the share of each capital.

Similarly, we refer to Devereux and Griffith (2003) to compute effective average tax rate on capital. Effective average tax rate is defined as the difference between post tax net present value (profit) and pre tax net present value (profit). The post and pre tax net present values are computed by increasing investment in one period and reducing it in the next period, leaving the capital stock in all other periods unchanged. The pre tax net present value is the net profit change of this marginal change of investment in one period, and the post tax net present value is computed by deducting the cost of corporate and personal income tax from this net profit. Both are computed using the following definitions:

\[
EATR = \frac{R^* - R}{p/1 + \bar{r}}
\]

where \( R^* \) is net present value (NPV) in the absence of the tax system, and \( R \) is net present value (NPV) with the tax system. \( R \) is composed of two factors: \( R^{RE} \) (the NPV attributable to investment financed by retained earnings) and \( F \) (the additional cost of raising external finance). All factors are defined as follows:

\[
R^* = -1 + \frac{1}{1+\bar{r}} ((1 + \pi)(p + \delta) + (1 + \pi)(1 - \delta)) = \frac{p - \bar{p}}{1 + \bar{r}}
\]
\[ R^{RE} = -\gamma(1 - A) + \frac{\gamma}{1 + \varrho} ((1 + \pi)(p + \delta)(1 - u) + (1 + \pi)(1 - \delta)(1 - A)) \]

\[ F = \gamma dB_t \left( 1 - \frac{1 + i(1 - u)}{1 + \varrho} \right) - (1 - \gamma) dN_t \left( 1 - \frac{1}{1 + \varrho} \right) \]

\( p \) is real financial return and is defined as \( \beta i + (1 - \beta)\varrho - \pi \). \( \bar{r} \) is real interest rate and is defined as \( (i - \pi)/(1 + \pi) \). \( \gamma = \frac{1 - m_i}{(1 - c)(1 - z)} \) is measuring the tax discrimination between new equity and distribution and \( \varrho = \frac{(1 - m_d)i}{(1 - z)} \) is the shareholder’s nominal discount rate. \( m_i \) is personal tax rate on interest income and \( m_d \) is personal tax rate on dividend income. \( c \) is the rate of tax credit available on dividend paid and \( z \) is accruals equivalent capital gain tax rate. \( A = \frac{m_o}{\varrho + \alpha} \) is the net present value of allowance. \( dB_t \) and \( dN_t \) are the debt asset ratio and the share of new equity issue, respectively.\footnote{According to Devereux and Griffith (2003), we multiply \((1 - \phi u)\) for this share.} All other definitions \( \beta, \delta, u, i, \phi, \alpha \) and \( \pi \) are the same as the METR case. Different from METR, capital composition does not matter for computing EATR, except for computing aggregate level depreciation rate \( \delta \) and capital cost allowance rate \( \alpha \). We use average tax rate as \( u \) to compute marginal effective tax rate and effective average tax rate, and a certain relation is implied among all three taxes.

## 5.4 Canadian Tax System and Firm Structure

In this chapter, we give a brief explanation of the corporate income tax system and firm structures in Canada. Among the several kinds of industry sector, we focus on manufacturer sectors, and the data represent only manufacturer sectors. In addition, GIFI is available
from 2000, and the tables and figures are based on the data between 2000-2007 from GIFI-T2LEAP.\textsuperscript{11}

In Canada, both federal and provincial governments impose corporate income tax on the firms. Each provincial government sets its own corporate tax system including tax rate and some credit systems, but the federal government collects provincial corporate income tax on behalf of provincial governments except Quebec and Alberta. Quebec and Alberta administer and collect their own provincial income taxes, although their tax bases are almost the same as the federal tax bases. Ontario did collect its corporate income taxes until 2008, after which time the federal government began collecting Ontario’s corporate income taxes.

\begin{table}[h]
\centering
\caption{The Amount of Tax Payment}
\begin{tabular}{cccccc}
\hline
 & Total & Federal tax & Provincial tax & Share of Federal & Share of Province \\
\hline
2000 & 10,410 & 7,710 & 3,700 & 0.68 & 0.32 \\
2001 & 10,040 & 6,790 & 3,250 & 0.68 & 0.32 \\
2002 & 9,290 & 6,390 & 2,900 & 0.69 & 0.31 \\
2003 & 7,570 & 5,180 & 2,390 & 0.68 & 0.32 \\
2004 & 8,600 & 6,790 & 2,810 & 0.67 & 0.33 \\
2005 & 9,030 & 6,430 & 2,600 & 0.71 & 0.29 \\
2006 & 10,940 & 7,440 & 3,500 & 0.68 & 0.32 \\
2007 & 8,870 & 5,780 & 3,090 & 0.65 & 0.35 \\
\hline
\end{tabular}
\end{table}

Notes: unit is $1000,000

Table 5.1 shows the total tax payment for both federal and provincial governments. We find that 68\% of total tax revenue comes from federal tax payment and provincial tax payments share the 32\% of total tax revenue. Federal tax payment is composed of ten kinds of tax: Part I tax payable (main corporate income tax), Part I.3 tax payable (tax on capital for large corporations)\textsuperscript{12}, Part II surtax payable (tax on tobacco manufacturing

\textsuperscript{11}We only include firms which can be matched between T2 SUF and LEAP files. The total amount of tax payment is different from aggregate level data, but the trend is the same.

\textsuperscript{12}This was eliminated effective January 1, 2006.
profits), Part III.1 tax payable (tax on excessive eligible dividend designation), Part IV tax payable (tax on dividend for private corporation), Part IV.1 tax payable (tax on dividend for public corporation), Part VI tax payable (tax on capital for financial institution), Part VI.1 tax payable (tax on dividend allowance), Part XIII.1 tax payable (tax on interest expense for foreign bank), Part XIV tax payable (tax on non resident corporation). More than 95% of total federal tax is financed by Part I tax payable. The total provincial tax payment is the sum of each provincial tax payment (which is similar to federal Part I tax payable) and provincial tax on large corporations. Among all provinces, Ontario’s tax payment is the largest and its share of total provincial tax payment is about 50%. The sum of shares from Ontario, Quebec and Alberta amounts to almost 90%. This means that most of the provincial corporate income taxes are paid in these three provinces.

Federal corporate income tax rate (statutory tax rate) has been 38% since 1986 and a firm can receive several kinds of deduction. For example, corporations that are Canadian controlled private corporations with total taxable capital less than $15 million can deduct 16% of the first $400,000 of active business income (Small business deduction). Also, corporations that derive at least 10% of their gross revenue for the year from manufacturing or processing goods in Canada for sale or lease can claim 7% of manufacturing and processing income earned in Canada (Manufacturing and processing profits deduction). Federal tax abatement deduction (10% of taxable income) is another important tax deduction. Most

13 Only Nova Scotia and New Brunswick levy this tax.
14 Although the statutory tax rate was fixed at 38% during 2000 – 2007, the Canadian government has proposed a corporate income tax rate deduction and introduces a new tax reduction category ”General tax reduction” since 2000. Using this new deduction system, effective general income tax rate, which is defined as statutory tax rate minus the sum of tax rates from deduction systems (for example, federal tax abatement is 10%, and effective tax rate is $28 = 38 – 10 if there is no other tax deduction system) is targeted to be around 21%.
15 This tax rate and business limit amount represent the 2007 year system, and both are different for different years.
amounts of tax deduction can be explained by these three tax deduction systems.\(^{16}\) These amounts are deducted from Part I tax payable amount which is calculated by multiplying statutory tax rate 38% by tax base.\(^{17}\) Because of these deduction systems, the tax rate which firms face on their tax base is different among large corporations, small corporations and manufacturing corporations. In addition, firms can receive several kinds of tax refunds, and the total amount of the refund is about 4% of total tax payment. Investment tax credit refund, dividend refund and provincial and territorial refundable tax credit share the greatest amounts among these refunds.

<table>
<thead>
<tr>
<th>Year</th>
<th>All</th>
<th>Single</th>
<th>Complex</th>
<th>Share of Single</th>
<th>Share of Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>62,286</td>
<td>60,643</td>
<td>1,643</td>
<td>0.97</td>
<td>0.03</td>
</tr>
<tr>
<td>2001</td>
<td>63,317</td>
<td>61,685</td>
<td>1,632</td>
<td>0.97</td>
<td>0.03</td>
</tr>
<tr>
<td>2002</td>
<td>64,319</td>
<td>62,649</td>
<td>1,670</td>
<td>0.97</td>
<td>0.03</td>
</tr>
<tr>
<td>2003</td>
<td>64,887</td>
<td>63,219</td>
<td>1,668</td>
<td>0.97</td>
<td>0.03</td>
</tr>
<tr>
<td>2004</td>
<td>65,018</td>
<td>63,340</td>
<td>1,678</td>
<td>0.97</td>
<td>0.03</td>
</tr>
<tr>
<td>2005</td>
<td>63,586</td>
<td>61,892</td>
<td>1,694</td>
<td>0.97</td>
<td>0.03</td>
</tr>
<tr>
<td>2006</td>
<td>62,803</td>
<td>61,106</td>
<td>1,697</td>
<td>0.97</td>
<td>0.03</td>
</tr>
<tr>
<td>2007</td>
<td>62,182</td>
<td>60,533</td>
<td>1,649</td>
<td>0.97</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Notes: unit is $1000,000

\(^{16}\)Another important deduction system is investment tax credit system.

\(^{17}\)Tax base is computed by subtracting many factors, including capital cost allowance, SR&ED expenditures, charitable donations and gifts and non capital or net capital loss of previous tax years, from net income/loss before taxes and extraordinary items.
Next, we explain a firm structure. A corporation is composed of three hierarchies: enterprise, firm and establishment. An enterprise has a unique statistical enterprise number (SEN) and consists of one or several firms. There might be a relation among firms within the same enterprise. Firms have a unique business number (BN) and submit T2 corporate income tax returns. Some firms have more than one establishment. The last rank of corporation is establishment. We can divide firms into two groups: single firms and complex firms. There are two views for each definition. First, from one view, if a firm belongs to an enterprise which has more than one firm, it is categorized as a complex firm. If a firm belongs to an enterprise which consists of only one firm, it is identified as a single firm. On the other hand, from another view, if a firm has establishments in more than one province, it is called a complex firm. If a firm has establishments in only one province, it is regarded as a single firm. In this paper, we use the terms "bn complex firms" and "bn single firms" for a former view and "complex firms" and "single firms" for a latter view.

We compare single firms and complex firms in Tables 5.2 and 5.3. Table 5.2 shows the number and share of single and complex firms, and this table indicates that most of the firms in Canada are single firms. Table 5.3 shows the amount and percentage of tax payment.
payment of single and complex firms. It is surprising that about three-quarters of tax revenue comes from complex firms in spite of the small percentage of complex firms in existence. Another comparison between single and complex firms is available using firm size. We classify all firms into 7 firm sizes using the number of employees. Size 0 firm means 0 employees, size 1 firm indicates a firm with $0 < \text{employees} < 5$, size 2 firm is a firm with $5 \leq \text{employees} < 10$, size 3 firm has $10 \leq \text{employees} < 20$, size 4 firm means a firm with $20 \leq \text{employees} < 50$, size 5 firm is a firm with $50 \leq \text{employees} < 100$, size 6 firm has $100 \leq \text{employees}$. Figure 5.1 and Figure 5.2 show the ratio of each size firm and the share of tax payment of each size of firm for single and complex firms, respectively. More than 50% of single firms are size 0 or 1 firms and about 60% of complex firms are size 5 or 6 firms. About half of the tax payments of single firms and most of the tax payments of complex firms are attributed to size 6 firms. These numbers and figures imply that complex firms are generally large scale, profitable companies that pay large amounts of taxes. In short, complex firms seem to face a higher tax rate than single firms. Given this fact, we conclude that the tax rate and response to a tax policy must be different between single and complex firms, and we should distinguish between both firms. The next section explains the data resource to compute individual firm level tax rates.

5.5 Data

We explain the data resources to compute three kinds of individual enterprise firm level tax rates in this section. We use an experimental version of GIFI-T2LEAP data for this analysis. T2LEAP is the combined data set of LEAP (The Longitudinal Employment Analysis

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18 The total amount of tax payment might be different from Table 5.1 because of rounding error.
Program) and T2SUF (Corporate Tax Statistical Universal File). LEAP provides longitudinal data on the behaviour of employment levels of Canadian businesses and contains annual employment, payroll and industry for every employer in Canada. T2SUF data are based on T2 corporate income tax return file from the Canadian Revenue Agency, and provide data on sales, gross profits, assets and tax data for all incorporated firms in Canada. We only use data between 2000-2007 for which detailed financial data from GIFI (Generalized Index of Financial Information) are available. GIFI provides users of T2LEAP with a broader view of financial positions, capital stock and taxes paid by a firm.

Some cautions have to be made for using T2LEAP. LEAP is enterprise level data and contains only the enterprise with employee. On the other hand, T2SUF is firm level data and includes only incorporated firms. Therefore, there are firms which cannot be matched between LEAP and T2SUF files. Moreover, LEAP and T2SUF’s entity level are different, and we need to combine several firms into an enterprise level to match LEAP and T2SUF. In short, firms with the same statistical enterprise number are gathered into one enterprise, which means that these firms are a complex firms. If only one firm has a unique statistical enterprise number, it is a single firm and not combined with other firms. The LEAP file allows us to trace enterprise longitudinal behavior, but we cannot analyze entry and exit behaviour for firm or establishment level. Enterprise level data show up in the LEAP file once an employee is hired. We define entry when enterprises enter the market and begin hiring employees. We do not consider that enterprises enter the market, even though they exist in the market and pay taxes, as long as the enterprises do not start hiring employees. Exit is defined when enterprise is extinct from the market. We also exclude merge or amalgamation cases from enterprise entry and exit decisions. The arguments in later sections

\textsuperscript{19} Once enterprises show up in LEAP file, they keep existing until they exit the market even though they stop hiring employees.
are all based on enterprise level, even though we might use the term "firm".

Average tax rate is the ratio of total tax payment to taxable income, and this total tax payment is composed of federal tax payment and provincial tax payment. We use the taxable income value of line Z from T2 Corporate Income Tax Return Schedule 200 as taxable income. Federal tax payment is computed by summing all federal tax payments: Part I tax payable (line 700), Part I.3 tax payable (line 704), Part II surtax payable (line 708), Part III.1 tax payable (line 710), Part IV tax payable (line 712), Part IV.1 tax payable (line 716), Part VI tax payable (line 720), Part VI.1 tax payable (line 724), Part XIII.1 tax payable (line 727), Part XIV tax payable (line 728) from T2 Corporate Income Tax Return Schedule 200. Provincial tax payment is calculated by summing the tax payment of all provinces from T2 Corporate Income Tax Return Schedule 5 and provincial tax on large corporations (line 765) from T2 Corporate Income Tax Return Schedule 200. As explained previously, the federal government does not collect provincial tax from Ontario, Quebec and Alberta, and provincial tax payment data from these provinces do not exist in the original T2 Corporate Income Tax Return. Nevertheless, Statistics Canada estimates the provincial tax payments for these three provinces, and we use these estimated provincial tax payments for our calculations.\(^{20}\)

To compute net total tax payment, the amount of refunds has to be subtracted from total tax payment. There are eight kinds of refund systems: investment tax credit refund (line 780), dividend refund (line 784), federal capital gains refund (line 788), federal qualifying environmental trust tax credit refund (line 792), Canadian film or video production tax credit refund (line 796), film or video production services tax credit refund (line 797), provincial and territorial capital gains refund (line 808), and provincial and territorial refundable tax credits (line 812) from T2 Corporate Income Tax Return Schedule 200. We

\(^{20}\)Statistics Canada computes corporate tax payments by multiplying 10% to the tax base.
calculate net total tax payment by subtracting all these refunds from the total tax payment. Some of the calculated tax payments do not take economically meaningful values. Some values are missed, while others take zero or negative values.\textsuperscript{21} In addition, except for Part I tax payable, other federal tax payments are based on other tax bases, and there is a case that average tax rate becomes greater than one. Given these issues, we do not use the data if they take missing values and we compute average tax rate as long as the tax rate is less than one.\textsuperscript{22} If the tax payment amount is negative, we consider that the firms do not pay taxes and that average tax rate is zero.

Several financial and capital data are necessary for computing marginal effective tax rate. For example, debt asset ratio is calculated by dividing total liabilities (GIFI 3499) by total liabilities and shareholder equity (GIFI 3640). The retained earning share is computed by dividing retained earnings (GIFI 3600) by total liabilities and shareholder equity (GIFI 3640). Nominal return on equity is the ratio of net income loss before taxes and extraordinary items (GIFI 9970) to total shareholder equity (GIFI 3620). The corporate bond interest rate is computed by dividing interest and bank charges (GIFI 8710) by total liabilities (GIFI 3499). Capital cost allowance rates and investment tax credit rates are available from the T2 Corporation Income Tax Guide, and the economic depreciation rates are referred in McKenzie, Mansour and Brule (1998) and the Statistics Canada Report (2007). Inflation rates and capital prices are available from CANSIM, and expected price changes

\textsuperscript{21}The reason that some values for the calculated tax payments are missing is because a category may not apply to a firm. Thus, the firm does not need to complete this category, which results in a missing value. In addition, if a firm’s total tax amount is negative or zero, it means the firm does not need to pay taxes.

\textsuperscript{22}We use this average tax rate for computing marginal effective tax rate and effective average tax rate. If the value of average tax rate is bigger than 1, we cannot compute these two tax rates.
are computed using the ARIMA model. Inventory holding year is computed from dividing cost of sales (GIFI 8518) with the amount of inventory (GIFI 1120). The amount of capital stock and investment are from lines 203 and 220 of T2 Corporate Income Tax Return Schedule 8. The land value is from GIFI 1600.

Effective average tax rate is computed by adding personal income tax system data. The after tax dividend \((1 - m_d)/(1 - c)\) is computed using sample Income Statistics data from the Canadian Revenue Agency website. The accruals equivalent capital gain tax rate \(z\) is computed following Boadway, Bruce and Mintz (1984). Necessary data for computing the accruals equivalent capital gain tax rate are nominal capital gain tax rate, the holding period of equity, price increase rate of equity, and shareholder’s discount rate. Nominal capital gain tax rate is computed from sample Income Statistics data from the Canadian Revenue Agency website. S&P/TSX Composite Index data from the Bank of Canada are used to compute price increase rates of equity. Shareholder’s discount rate is available from CANSIM 180-0003. The holding period of equity is computed from data on the website of the World Federation of Exchanges. The share of new issues is computed by subtracting debt asset share and retained earning share from one.

Using these variables, we compute average tax rate, marginal effective tax rate on capital and effective average tax rate on capital. One caution has to be made regarding the data. GIFI requires firms to describe their financial statements in accordance with a list of codes provided by the Canadian Revenue Agency. It is mandatory to report certain items (assets, liabilities, equity, revenue, expenses and net income) but the remainder is left to the discretion of the firms. Therefore, not all items are completed by firms and some items are missed. The original data set consists of about 658,000 manufacturing firms between

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23 This method follows Boadway, Bruce and Mintz (1984). Inflation data are available from CANSIM 326-0021 and prices of capital and inventory are from CANSIM 383-0025 and CANSIM 329-0039 for each.

24 This implies turn over rate of inventory.
2000 - 2007, but some tax payment values are missing or take negative values. Once we drop the unusable data and unmatched data between LEAP and T2SUF, the total amount of data includes approximately 493,000 enterprise. In addition, about half of the enterprise do not pay taxes, and we can compute average tax rates only for about 250,000 enterprise. Similarly, several financial status data are missed, which are necessary to compute marginal effective tax rate and effective average tax rate. We do not compute tax rates for these enterprises, and compute marginal effective tax rate and effective average tax rate for around 162,000 and 144,000 enterprise, respectively.

For complex enterprise firms, we compute tax rates for each province to compare the tax rates of single enterprise firms. Complex enterprise firms have several establishments in more than one province, and pay provincial taxes for each province based on the estimated tax base. Total amounts of tax base across provinces are divided into each province using the share of revenue and salaries or wages of each province. Using this estimated tax base, the tax amount for each province is calculated following each province’s tax system. We compute three tax rates: average tax rate, marginal effective tax rate and effective average tax rate for each province using this estimated tax base. For example, consider the firm which has a $100 tax base, and its calculated tax bases for Ontario, Quebec and Alberta are $50, $25, and $25, respectively. Assume that this firm pays $20 for federal and $10, $5, and $5 for Ontario, Quebec and Alberta. In this case, the average tax rate for Ontario is calculated as \( \frac{\$20 + \$10 \times (\$100 \div \$50)}{\$100} = 4/10 \). This tax rate might not be accurate, but will provide a rough idea of the tax rate distribution across provinces for complex enterprise firms. Using these tax rates, marginal effective tax rates and effective average tax rates are also computed for each province, assuming financial status is the same for the same enterprise firms across provinces.
We analyze these three tax rates from five dimensions: provincial level, industry sectors i.e. NAICS (North American Industry Classification System), firm structure (single or complex enterprise firms), firm size, and age. There are two resources to identify the province of the firms. One is the location data of the firm’s main department from GIFI, and another is the specific provincial name for which the firms pay taxes, from line 750 of T2 Corporate Income Tax Return Schedule 200. We primarily rely on the provincial name of line 750 from T2. With regard to the industry sector, we use the NAICS code from GIFI. Two methods are used to distinguish single firms from complex firms. First, if the firms pay taxes for more than one province, which is identified from Schedule 5, we consider them complex firms. Second, even though the companies pay taxes for one or no provinces, if they submit Schedule 5 and have revenue or wage payment for more than one province, we regard them as complex firms. This case happens if their taxable income is small and the firms do not need to pay taxes even though they have revenue and pay wages for employees. Otherwise, we treat them as single firms. Firm size is based on a measure of imputed employment (ALU) from the LEAP file. A firm’s age is calculated using the firm’s entering year from the LEAP file.

Several social economic variables are used for analyzing firm location choices and exit decisions. The social economic variables used are the following: population, per capita after tax income, population growth rate, average wage, gasoline price, interest rate, unemployment rate, the ratio of people with university degree, the number of firms in the same industry, per capita amount of public transportation expenditure, and per capital amount of public educational expenditure. All data is available from CANSIM data. Population data are from CANSIM 051-0001 and per capita income data are from CANSIM 202-0602. Wage data are accessible from CANSIM 281-0027 and gasoline prices are from CANSIM.

NAICS 311 ~ 339 are manufacturing sectors.
Interest rate and unemployment rate are obtained from CANSIM 176-0043 and 282-0055, respectively. The ratio of the people with university degree and public expenditures are from CANSIM 282-0004 and 385-0001 for each. All values are realized using the CPI from CANSIM 326-0021. Population, income and population growth rates reflect demand side factors, and wages, gasoline price, interest rate variables represent cost factors. Unemployment rates and the ratio of people with university degree explain labour market conditions and the number of the firms in the same industry sectors captures an agglomeration effect. The per capita amount of public expenditures means generosity of public services or high tax rates in a province.

After computing three tax rates, we compare three tax rates and analyze the relation between these tax rates and firm behaviours. First, we investigate each individual firm’s level tax rate distribution and compare it with aggregate level tax rates and effective tax rates. Big difference in tax distribution across provinces will explain why the previous literature have inconsistent results of corporate income tax effect on firm location choices. Second, we examine the percentage of firms which do not pay taxes and whether this percentage depends upon firm characteristics, such as structure, age, size, industry and locations. We also examine the corporate tax rates change over the ages. These analyses tell us whether tax burden is important for firm entry and exit decisions, and whether the tax rate grows higher or lower if firms keep remaining the market. Third, we empirically measure the effects of corporate income taxes on firm location choices and exit decisions.

5.6 Results: Tax Rate Distributions

In this section, we examine corporate income tax rate distribution of three tax rates. First, we compare aggregate level average tax rates and individual firm level average tax rates.
In previous literature, this aggregate level average tax rate is well used because of the inability to access individual firm level data. This comparison indicates how much aggregate level tax rates capture heterogenous aspects of individual firm level tax rates. Second, we compare average tax rates of single firms and complex firms. The large gap in tax rate distribution between single and complex firms implies the problems of combining these firms. Third, we compare the distributions of average tax rate, marginal effective tax rate and effective average tax rate. Lastly, we compare these computed tax rates with effective tax rates. These comparisons provide an indication for the inconsistent results in previous literature.

5.6.1 Comparison between Aggregate Level Average Tax Rate and Individual Firm Level Average Tax Rate

![Figure 5.3: Aggregate Level Tax vs Individual Firm Level Tax](image)

In previous literature, aggregate level average tax rate is used primarily for analysis, since individual firm level tax data are usually inaccessible, and this tax rate only requires tax payment and firm profit (taxable income) data. This aggregate level average tax rate is
computed by dividing total tax payment of all firms by total taxable income of all firms. We compute this aggregate level average tax rate and compare it with the mean of individual single firm average tax rates. Since complex firms have several establishments in more than one province, we exclude complex firms to compute aggregate level tax rate. Figure 5.3 demonstrates that the aggregate level average tax rate is larger than the mean of individual firm level average tax rates. For both tax rates, high tax rate provinces are Quebec and Ontario, but the order of other provinces is different. This result implies that using aggregate level tax rates ignores firm-level heterogeneity and aggregate level tax rates do not reflect individual firm level tax rates very well.

5.6.2 Comparison between Single Firm Average Tax Rate and Complex Firm Average Tax Rate

In section 5.4, we showed that the share of each size of firm and tax payment share of each size of firm are different between single and complex firms, and generally complex firms are large scale and profitable companies. We compare the mean of single firm average
tax rates and the mean of complex firm average tax rates across provinces. Figure 5.4 shows that, as we expected, average tax rates of complex firms are larger than those of single firms. The difference in tax distribution between single and complex firms is small for large tax payment provinces, like Ontario, Quebec and Alberta, while the difference is big for small tax payment provinces. In addition, tax rate order across provinces is different. This means that pooling single and complex firms tax rates might produce misleading results.

### 5.6.3 Comparison of Three Tax Rates: ATR, METR and EATR

Figures 5.5, 5.6, and 5.7 provide the histograms of each tax rate: average tax rate (ATR), marginal effective tax rate (METR) and effective average tax rate (EATR).²⁶ From

²⁶ We set marginal effective tax rate and effective average tax rate 0 if average tax rate is 0 and firms do not
Table 5.4: The Distribution of Tax Rates

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>q 1%</th>
<th>q 5%</th>
<th>q 10%</th>
<th>q 25%</th>
<th>q 50%</th>
<th>q 75%</th>
<th>q 90%</th>
<th>q 95%</th>
<th>q 99%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATR</td>
<td>0.191</td>
<td>0</td>
<td>0</td>
<td>0.017</td>
<td>0.163</td>
<td>0.188</td>
<td>0.229</td>
<td>0.300</td>
<td>0.338</td>
<td>0.427</td>
</tr>
<tr>
<td>METR</td>
<td>0.030</td>
<td>-0.006</td>
<td>0</td>
<td>0</td>
<td>0.004</td>
<td>0.018</td>
<td>0.042</td>
<td>0.076</td>
<td>0.104</td>
<td>0.177</td>
</tr>
<tr>
<td>EATR</td>
<td>0.561</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.359</td>
<td>0.668</td>
<td>0.810</td>
<td>0.878</td>
<td>0.906</td>
<td>0.940</td>
</tr>
</tbody>
</table>

q means quantile %

these figures, it is clear that each tax rate has a different distribution. Table 5.4 shows the distribution range of each tax rate. Average tax rates range between 0 and 0.5, and 5% of the firms do not pay taxes even though they have a positive tax base. The mean of average tax rate is 0.191 and the median is 0.188. Marginal effective tax rate takes values between -0.01 and 0.2. The mean is 0.030 and the median is 0.018. Different from average tax rate and effective average tax rate, marginal effective tax rate can take negative values with generous tax deduction and credit systems. Effective average tax rates range between 0 to 1 and the mean and median are 0.561 and 0.668, respectively.

The variance of average tax rate is attributed to enterprise profits and the availability of tax deduction systems. Marginal effective tax rate is composed of several financial status and capital variables. We examine which factors have a great effect on the gross marginal return to investment $r_g$ by decomposing into several factors. First term $r_f + \delta - q/q$ depends on financing cost $r_f$, depreciation rate $\delta$ and price change of capital $q/q$. Financing cost $r_f$ depends on financial factors, like corporate bond interest rate $i$, corporate tax rate $u$, debt asset ratio $\beta$ and return on equity $\rho$. Financing cost is small if corporate bond interest rate and return on equity are small. On the other hand, financing cost is large if debt asset ratio is small and return on equity is large, which implies profitable firms. The value of financing cost term varies among firms, and this is one of the key factor of the marginal have capital data.
return to investment. The value of investment tax credit $\phi$ and capital cost allowance rate $\alpha$ take different values for different capitals but when all capitals are aggregated, the terms $1 - \phi$ and $\frac{\alpha}{\lambda + \pi + \alpha}$ have less variance across firms. The depreciation rate $\delta$ and inflation rate $\pi$ are the same across firms, and the factors which contribute to the variance of marginal return to investment are financing cost $r_f$ and corporate tax rate $u$. In another word, the marginal return to investment is large if financing cost is large and if the term $1/1 - u$ is large, and vice versa. Concretely, marginal effective tax rate crucially depends on the value of corporate bond interest rate, debt asset ratio, return on equity and corporate tax rate.

Effective average tax rate is also made of several factors. Net present value in the absence of tax system $R^*$ depends on the real financial return $p$ and real interest rate $\bar{r}$. Net present value with the tax system is made of the net present value attributable to investment financed by retained earnings $R^{RE}$ and the additional cost of raising external finances $F$. We first decompose the net present value attributable to investment financed by retained earnings. The first term is $-\gamma(1 - A)$. Net capital allowance value $A$ do not have much variance across firms, and the discrimination between new equity and distributions $\gamma$ is crucial which is common to all the firms. The second term $\gamma/(1 + \varrho)$ depends on the discrimination between new equity and distributions $\gamma$ and shareholder’s discount rate $\varrho$, and the difference across firms is attributed to shareholder’s discount rate. The third term $(1 + \pi)(p + \delta)(1 - u)$ crucially depends on the value of financial return $p$, which in turn depends on debt asset ratio, corporate bond interest rate and return on equity. The last term $(1 + \pi)(1 - \delta)(1 - A)$ do not vary across firms. When we divide the additional cost of raising external finance, the first term $\gamma dB_t \left(1 - \frac{1 + i(1 - u)}{1 + \varrho}\right)$ depends on debt asset ratio $dB_t$, corporate bond interest rate $i$, shareholder’s discount rate $\varrho$ and the cooperate income tax rate $u$. The variance of this first term largely comes from the shareholder’s discount rate.
The second term \((1 - \gamma) dN_t \left( 1 - \frac{1}{1 + \rho} \right)\) is very small and do not have much variance across firms. On the whole, the variance of EATR comes from the difference of shareholder’s discount rate and financial return, which depends on corporate bond interest rate, debt asset ratio and return on equity.

In summary, marginal effective tax rate largely depends on financing cost and the corporate tax rate, and effective average tax rate is affected by shareholder’s discount rate and financial status, like financial return, return on equity, corporate bond interest rate and debt asset ratio. Therefore, computing individual firm level tax rates assuming these important variables are constant will not produce precise tax rates. We use average tax rate for computing marginal effective tax rate and effective average tax rate, and there must exist some correlation among them.\(^{27}\) There is a positive correlation among three tax rates, and each value is 0.520 between ATR and METR, 0.603 between ATR and EATR and 0.592 between METR and EATR. We can see that the distributions of three tax rates are different, and it is natural that using a different tax rate for empirical analysis brings us a different interpretation of tax effect on firm behaviours.

### 5.6.4 Comparison between Effective Tax Rate and Computed Tax Rates

We compare these computed tax rates of single firms with effective tax rates from Finances of the Nation. The effective tax rate is a combined tax rate of federal and provincial statutory tax rates which takes into account several deduction systems. For example, the federal government statutory tax rate was 38% in 2000, and a manufacturing sector firm can receive a federal tax abatement of 10% and a manufacturing and processing profit deduction of 7%. In Newfoundland, the provincial tax rate for the manufacturing sector firms is 5%\(^{27}\)

\(^{27}\) The same method is used in Boadway, Bruce and Mintz (1984) and McKenzie, Mansour and Brule (1998).
and the effective tax rate in Newfoundland becomes $38 - 10 - 7 + 5 = 26\%$. We compare these three tax rates in 2000 and 2007. Figures 5.8 and 5.9 show that the effective average tax rate is the highest, followed by effective tax rate and average tax rate, respectively. The values of marginal effective tax rate are relatively small compared with other three tax rates, and right vertical line represents the value of marginal effective tax rates.

A comparison of the two graphs shows the tax rate changes over seven years. For the effective average tax rate, tax rates of some provinces, including Quebec and Ontario, decreased while other provinces’ tax rates, including Alberta, British Columbia and Saskatchewan, increased over the seven year period. Effective tax rates also changed over seven years, but the changes were different from those of the effective average tax rate in that tax rates of Alberta, British Columbia and Saskatchewan decreased and the tax rate of Prince Edward Island increased. Marginal effective tax rate also changed differently, and the tax rates of Prince Edward Island, Quebec, Ontario and Alberta decreased while the tax rates of Nova Scotia, Saskatchewan and British Columbia increased. Average tax rates decreased in most of the provinces over this seven years. Among the all taxes, effective average tax rates had a similar distribution to average tax rates in 2000, but the four tax
rates had different distributions across provinces on the whole, and using a different tax rate produces a different interpretation of tax effects.

From the analysis from section 5.6.1 to section 5.6.4, we find that each individual firm level tax rate has different distribution across provinces, and its distribution also differs from aggregate level tax rate and effective tax rate distribution, in spite that all the tax rates are computed from the same data set. This result explains inconsistent results in previous literature. Nevertheless, these analyses do not tell whether tax burden affect firm entry and exit decisions. Therefore, we examine firm entry and exit behaviour, and the relation between these firm behaviour and tax burden in the following sections.

5.7 Results: Firm Entry and Exit Behaviours

In this section, we examine firm entry and exit rate behaviours. The entry rate is the ratio of the number of enterprises which enter the market to the total number of enterprises. The exit rate is the ratio of the number of enterprises exiting the market to the total number of enterprises. We analyze the entry and exit rates from three dimensions across years: firm sizes, industry sectors and provinces. In contrast to the previous section, we divide the provinces into six provinces so that lines in figures are easy to identify: Atlantic provinces (Newfoundland, Prince Edward Island, Nova Scotia and New Brunswick), Quebec, Ontario, Prairie provinces (Manitoba and Saskatchewan), Alberta and British Columbia. As for the province case, we only use single firms. We also investigate firm survival rates and firm size changes after entering the market. These analyses indicate which firm characteristics are important for analyzing firm entry and exit decisions.
5.7.1 Firm Entry and Exit Rate

Figure 5.10: Entry Rate across Firm Sizes

Figure 5.11: Exit Rate across Firm Sizes

Figure 5.10 shows the entry rates between 2000 and 2007 for different firm sizes. Right vertical line represents the entry rates of size 1 firms, and left vertical line shows the entry rates of the rest of size firms. From this figure, it is clear that entry rates are different for each size firm and that small size firms have high entry rates. The entry rates of size 1 firms are particularly high because most new enterprises are small size firms. For example, about 85% of new enterprises are size 1 firms, and about 10% of new enterprises are size 2 firms. Entry rates have declined sharply since 2000, and became stable after 2004. On the other hand, Figure 5.11 shows that exit rates do not vary much across different firm sizes and that the order does not necessarily depend on firm size, although small size firms still take a large exit rate. Exit rates declined gradually between 2000 and 2003, and began increasing after 2004. This increase is sharper for large size firms, such as size 5 and 6 firms. We add GDP growth rate in Figure 5.11, whose values are listed in right hand side of the vertical line, to see the effect of GDP on firm entry and exit rates. The sharp decline of entry rate from 2000 seems to be attributed to the GDP growth rate decline. The exit rates do not have a direct correlation with the GDP growth rate, but macroeconomic shocks might affect firm
financial status and behaviour in the later stages. There is a positive correlation between entry and exit rates, meaning that firm entries and exits are more frequent for small size firms.

Next, we compare entry and exit rates across three different industry sectors in Figures 5.12 and 5.13. We divide the manufacture sectors’ enterprises by NAICS 2 digit levels: NAICS 31, NAICS 32, NAICS 33, and compare their entry and exit rates. The values of entry rates are slightly different among the three sectors, but all have the same trend across years. NAICS 33 industry’s entry rate is largest, and the order changes across years. We found a sharp decline in entry rates between 2000 and 2003, and entry rates became stable after 2004. On the other hand, exit rates were stable between 2000 and 2003, and there was a sharp increase in 2004. This result is different from the result of the firm size case, since the latter case does not include the enterprises which stop hiring employees, i.e. size 0 firms. The share and exit rates of these non employee enterprises (size 0 firms) are high and this is why the exit rate movement is different from the firm size case. Exit rate is the largest for NAICS 31 sectors. There is a strong negative correlation between entry and exit rates, indicating the structure change in the manufacture sectors.
Lastly, we show entry and exit rates across six provinces in Figures 5.14 and 5.15. Entry rates varied across provinces, but the trend was a sharp decline between 2000 and 2003. After 2004, only Alberta and British Columbia’s entry rates rose, while the rates of other provinces were stable. The order of entry rates across provinces depended on years, but Alberta and British Columbia had relatively higher entry rates and Ontario and the Prairie provinces had lower entry rates. Exit rates also varied across provinces, and there was a sharp increase of exit rates in 2004, similar to the result in the industry sector. The order varied across years, but generally, the Atlantic provinces and Alberta had higher exit rates and Ontario and Quebec had lower exit rates. If we compute the net entry rate, which is the ratio of net entry number of firms to the total number of enterprises, Ontario, Quebec, and Alberta had high net entry rates, which is consistent with the fact that all three provinces had a large number of enterprises. It is interesting that the correlation between entry rate and exit rate is negative across provinces. This means that some provinces have higher entry and lower exit rates and that others have lower entry rates and higher exit rates.

From these arguments, it is clear that firm entry and exit behaviours are different across firm sizes, industries and locations. The negative correlation between entry and exit rates
across industry sectors shows the structural change in manufacture sectors and the negative correlation across provinces implies the concentration of enterprises in specific regions. Most new enterprises are explained by size 1 firms and size 0 firm take a large share of exiting firms. All the firms enter the market with employee, and it is interesting to see how firm sizes change over the ages and why they need to change. In the next section, we analyze firm survival rate and firm size shift to answer these questions.

5.7.2 Firm Survival Rates and Firm Size Shifts

We compute the survival rates of firms after entering the market conditional on the initial size over six years in Figure 5.16. Since the number of new large enterprises is small, we combine size 4 firms, size 5 firms and size 6 firms together in this section. We only focus on single firms since the share of single firm is large and the behaviour of single and complex firms might be different. It is interesting that the survival rates are almost the same across different firm sizes in spite of the expectation that large scale firms operations would be stable and their survival rate would be higher than small size firms’. From Figure 5.16, we can see that about one quarter of the enterprises exit the market within three years.
years. In addition, more than half of the enterprises exit the market within six years. These numbers show the high rate of construction and destruction of enterprises, regardless of the firm sizes.

<table>
<thead>
<tr>
<th>firm size</th>
<th>Smaller size</th>
<th>Same size</th>
<th>Larger size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.31</td>
<td>0.48</td>
<td>0.21</td>
</tr>
<tr>
<td>2</td>
<td>0.35</td>
<td>0.41</td>
<td>0.24</td>
</tr>
<tr>
<td>3</td>
<td>0.36</td>
<td>0.32</td>
<td>0.32</td>
</tr>
<tr>
<td>4</td>
<td>0.29</td>
<td>0.71</td>
<td></td>
</tr>
</tbody>
</table>

We also compute the ratios of firm size changes after six years and these results are shown in Table 5.5. The ratio represents the firms which survive six years. We find that except size 4 firms, less than half of the firms keep initial size, with about 30% of the firms shifting to a smaller scale firm and about 20-30% of the firms shifting to a larger scale firm. Large size firms are much more stable, and about 70% of the firms keep their initial size. We examine this firm size shift more in detail, focusing on size 1 and 2 firms since most of new enterprises are explained by these two size firms. We also show the percentage of these size firms which do not pay taxes to understand the reason for changing the size. From Figure 5.17, the share of size 1 firms keeping the same size declines to around 60%, while the shares of size 0 and 2 firms are about 20% and 15% after three years. After six years, the share of size 1 firms decreases to 50% and the shares of size 0 and 2 firms become around 30% and 20%, respectively. Most of larger size firms is explained by size 2 firms. When we plot the percentage of the firms which do not pay taxes in Figure 5.18, it is obvious that the size 0 firms’ percentage is larger than that of size 1 and 2 firms and that the former percentage is stable although the latter percentages keep declining over the ages. This figure indicates that unsuccessful firms, which cannot earn profit enough to pay taxes,
Figure 5.17: Size 1 Firm Shift

Figure 5.18: Size 1 Firm No Tax Percentage

Figure 5.19: Size 2 Firm Shift

Figure 5.20: Size 2 Firm No Tax Percentage
shift to smaller size firms and successful firms become larger size firms. Similar argument is applicable for size 2 firms. From Figure 5.19, the share of size 2 firms is about 50%, and the shares of size 0, 1 and 3 firms are about 10%, 10% and 20% for each after three years. After six years, the share of size 2 firms is about 40%, and the shares of size 0, 1 and 3 firms become around 20%, 15% and 20%, respectively. According to Figure 5.20, the percentages of size 0 and 1 firms with no tax are larger than that of size 2 firms, and unpromising firms shift to smaller size firms.

We already see that more than half of the firms exit the market after six years. Combining these results, we can say that only one quarter of the firms can keep their initial size after six years and that firm size is changeable within a few years. In addition, firms which are not successful enough to pay taxes shift to smaller size, and if an unsuccessful period is too long, firms have no choice but to exit the market. From these results, we consider the following questions are important to examine: how much percentage of the firms do not pay taxes, what types of the firms do not pay taxes, and whether the tax rate of successful firms changes over the ages. All questions are investigated in the next section.

5.8 Results: Firm Tax Payment Behaviour

In this section, we analyze firm tax payment behaviour. Corporate income tax is levied on firm profits, and firms do not need to pay taxes if their profit is negative or zero. If the percentage of no tax firms is large, the corporate income tax rate will not have much influence on firm behaviour. We also see that unsuccessful firms which do not pay taxes tend to exit the market in a previous section. It is significant to investigate how much percentage of the firms do not pay taxes or what types of firms do not pay taxes, and we analyze from five dimensions: firm structure, age, firm sizes, industry sectors and provinces. We also
examine the movement of the corporate income tax rates over the firm age.

5.8.1 The Percentage of Firms Which Do Not Pay Taxes

We compute the percentage of firms which do not pay taxes, depending on their status. In other words, we classify firms by when the firms enter or exit the market. If the firms have just entered the market, they are classified as entry. If firms entered in the previous year, the firms are classified as entry +1. Similarly, if the firms have just exited the market, the firms are categorized as exit. If the firms exit the market next year, the firms are defined as exit -1. The firms whose statuses do not change are categorized as no status change. Since the LEAP file gives us the year when firms enter, we can identify the firms’ situation correctly except the cases when firms exit in 2007. We also divide the firms into single firms and complex firms since their entry and exit behavior must be different. Table 5.6 shows the percentage of firms which do not pay taxes depending on their status.

<table>
<thead>
<tr>
<th></th>
<th>Single</th>
<th>Complex</th>
<th></th>
<th>Single</th>
<th>Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>no status change</td>
<td>0.50</td>
<td>0.19</td>
<td>no status change</td>
<td>0.50</td>
<td>0.20</td>
</tr>
<tr>
<td>entry</td>
<td>0.62</td>
<td>0.38</td>
<td>exit</td>
<td>0.74</td>
<td>0.28</td>
</tr>
<tr>
<td>entry +1</td>
<td>0.62</td>
<td>0.35</td>
<td>exit -1</td>
<td>0.72</td>
<td>0.27</td>
</tr>
<tr>
<td>entry +2</td>
<td>0.62</td>
<td>0.38</td>
<td>exit -2</td>
<td>0.71</td>
<td>0.26</td>
</tr>
<tr>
<td>entry +3</td>
<td>0.61</td>
<td>0.33</td>
<td>exit -3</td>
<td>0.69</td>
<td>0.20</td>
</tr>
<tr>
<td>entry +4</td>
<td>0.61</td>
<td>0.35</td>
<td>exit -4</td>
<td>0.67</td>
<td>0.23</td>
</tr>
<tr>
<td>entry +5</td>
<td>0.60</td>
<td>0.37</td>
<td>exit -5</td>
<td>0.63</td>
<td>0.18</td>
</tr>
<tr>
<td>entry +6</td>
<td>0.60</td>
<td>0.34</td>
<td>exit -6</td>
<td>0.58</td>
<td>0.19</td>
</tr>
</tbody>
</table>

It is surprising that almost half of single firms and about 20% of complex firms do not pay taxes. Focusing on the entry situation, the percentage of firms which just enter the market and do not pay taxes is around 60% for single firms and 40% for complex firms. These percentages gradually decrease as time goes on, but we can still observe a gap
between young firms and the firms whose status does not change. On the other hand, the percentage of firms which exit the market and do not pay taxes is more than 70% for single firms and about 30% for complex firms. These percentages will gradually increase as the year of exiting comes close. These numbers imply that most single firms which will exit the market do not pay taxes. This result is consistent with the argument in section 5.7.2. On the other hand, for complex firms, the inability to pay taxes does not seem to be a crucial reason to exit the market.

Figures 5.21, 5.22 and 5.23 illustrate the percentage of single firms which do not pay taxes over the ages, depending on the firm characteristics. The horizontal line shows firms’ status and the vertical line number are the percentage. From Figure 5.21, we find that the
percentages are different across firm sizes, and that small size firms take larger values. For example, the percentage of firms without employees (size 0 firms) is around 80%, and the percentage of size 1 firms is around 60%. The percentage gradually decreases as the age of the firms increases. It is interesting that the percentage of firms without employees (size 0 firms) gradually increases for the first several years, which is opposite to other size firms’ trends. When these percentages are compared across industry sectors, the differences are minimal compared with the firm size case and the percentage order is NAICS 31, 32 and 33, respectively. The percentage gradually decreases as age increases. The percentages of no tax firms vary across provinces, and there is almost a 15% difference between the highest province and the lowest province. Order of the percentages depends on age, but generally British Columbia, the Atlantic provinces and Ontario have higher percentages and Quebec, Alberta and the Prairie provinces have lower percentages. Similar to other two cases, the percentage gradually decreases as age increases.

From these analyses, we find that the percentages of no tax firms vary among different firm structures, firm age, firm sizes, industry and location, and that firm structure and size are particularly important factors. Generally, the percentage decreases as age goes up regardless of the firm characteristic, except the case of size 0 firms. The reason that the movement of the percentage of size 0 firms is different from others will be attributed to the fact that unsuccessful firms which is not able to pay taxes shift to smaller size firms. In another word, firms which survive in the market comes to pay taxes. Nevertheless it is not clear whether firms’ tax rates get decreasing so that tax burden become lower or not, and this is the question argued in the next section.

\[28\] Notice that all the firms entry the market with at least one employee, and there is no value of size 0 firm at the entry point.
5.8.2 Tax Rate Distribution across the Ages

We examine corporate income tax rate changes over the ages from three dimensions: firm sizes, industry sectors and provinces to see whether successful firms can have lower or higher tax rate if they stay longer in the market. We choose average tax rate and effective average tax rate of single firms since these tax rates are mainly used for firm location choice analysis. Figures 5.24 and 5.25 shows average tax rate and effective average tax rate for different firm sizes. The horizontal line shows firm’s status and the vertical line number is tax rate. Obviously, the tax rate is high for large size firms, although the ranking is not consistent with the firm size. There is a jump between entry and entry +1 for both average tax rate and effective average tax rate, but normally tax rate are stable over the ages. Therefore, tax rates do not necessarily decrease even though firms stay longer in the market. Figures 5.26 and 5.27 show the two tax rates across industry sectors. It is interesting that the ranking is different between average tax rate and effective average tax rate. The tax rate order is NAICS 31, 32 and 33 for average tax rate and NAICS 32, 33 and 31 for effective average tax rate. The differences are very small across different industry. We also find a jump between entry and entry+1 for both tax rates, although tax rates are stable after entry+1. Figures 5.28 and 5.29 draw average tax rate and effective average tax rate across provinces, and the tax rate order are different between them again. Quebec, Ontario and British Columbia have relatively higher average tax rate and Alberta, Prairie provinces and British Columbia have relatively higher effective average tax rate. As a whole, corporate income tax rates are stable over the age except a gap between first and second year, regardless of firm’s characteristic.

Given the argument in section 5.8.1 and 5.8.2, we find that the percentage of no tax firms declines as firm ages go up, except size 0 firms. Unsuccessful firms, which are unable
Figure 5.24: ATR across Firm Sizes

Figure 5.25: EATR across Firm Sizes

Figure 5.26: ATR across Industry Sectors

Figure 5.27: EATR across Industry Sectors

Figure 5.28: ATR across Provinces

Figure 5.29: EATR across Provinces
to pay taxes, change to smaller size firms, and finally exit the market with no employee. On the other hand, the corporate tax rates are stable over the ages as long as firms keep the same sizes. These results provide a big picture of the relation between tax burden and firm behaviours, but they are not detail enough to identify a precise effect of the corporate income tax system on firm entry and exit decisions. In the next section, we analyze this issue empirically.

5.9 Firm Location Choices and Exit Decisions

In this section, we examine the effect of corporate income tax rates on firm location choices and exit decisions.29 We focus on single firms which do not have a specific relationship with other firms. It is difficult to measure the effect of corporate income taxes on the behavior of complex firms since they have several establishments across provinces, and all factors in all provinces need to be taken into account. If a firm has a relation with other firms, it will affect the firm’s location choice and exit decision, and we cannot measure a precise effect of the corporate tax rate. Therefore, we choose single and bn single firms for the analysis. In addition, we exclude a firm if it is either a parent or a subsidiary of other firms. We only use Canadian controlled private corporations since public corporations and corporations owned by foreigners may be different. Firms either entered during 2000 - 2007 or exited during 2000 - 2006. We use only new entry firms for location analysis.

For firm location choices, we use the following tax rates: effective tax rate, average tax rate, effective average tax rate and marginal effective tax rate. Effective tax rate seems obvious for firms in whichever province they settle, which is not true. Effective tax rate

29We cannot analyze firm’s entry decision since the data of all firms which consider to enter the markets are not available.
is computed from statutory tax rate and tax deduction systems, such as small business tax deduction, manufacturing and processing profit deduction and federal abatement system. Effective tax rate is different between large and small corporations, and we need to know whether an enterprise is eligible to receive small business deduction or not. Nevertheless, as we discuss in section 5.8.1, about 62% of new single enterprises do not pay taxes, and we cannot identify whether these enterprises are able to receive small business deduction or not. About 95% of enterprises receive small business deductions among new enterprises which pay taxes, and most of the enterprises which pay taxes are small corporations. With this data limit, we compute two kinds of effective tax rate. In the first case, we regard the enterprises which do not pay taxes as a large corporation and use general effective tax rate. In another case, we consider the enterprises which do not pay taxes as small corporations and they face lower effective tax rate with small business deduction system. We regard the enterprises which pay taxes and do not receive small business deduction as large corporations. Considering the high percentage of the enterprises which receive small business tax deduction, the latter effective tax rate might be appropriate.

It is not clear how much average tax rate, effective average tax rate and marginal effective tax rates are when firms locate in new provinces. In section 5.8.2, we found that tax rates depend on firm sizes, industry sectors and provinces. Given this idea, we consider two ways of computing the tax rates. First method is using a mean of the tax rates of the firms which already exist in the market as an expected tax rate for each province. Concretely, tax rate \( t_{yjn} \) of a new firm who enters the market in year \( y \) in province \( j \) and whose firm size is \( n \) is computed as a mean of the tax rates of the firms in the market which have the same property.\(^{30}\) 7 years, 10 provinces and 4 firm sizes are taken into account, and 280 tax rates are computed for each tax rate. The second method is computing average tax rates \( 30\) We prefer more variation of tax rate using industry sector, but the data variation limits our choice.
rate from the estimated tax base taking into account several tax deduction systems, such as small business deduction, manufacture and processing profit deduction and federal abatement system. The tax base is estimated by regressing tax base on industry dummy (NAICS 3 digit level), provincial dummy, firm size dummy, firm age, year dummy and GDP variables. From these methods, we compute two kinds of effective tax rate and average tax rate and one type of effective average tax rate and marginal effective tax rate. We also use aggregate level average tax rate for location choices.

For firm exit decisions, we consider three cases: no tax case, effective tax rate case and average tax rate case. Since most of the firms exiting the market do not pay taxes, as shown in section 5.8.1, we take a look at the case where there is no tax variable. In addition, to measure the effect of tax rates, effective tax rate and average tax rate are used. Similar to location choice analysis, we cannot identify whether firms are large or small corporations if the firms do not pay taxes, and two kinds of effective tax rate are computed as we did in the location choice analysis. Different from the location choice analysis, we use real average tax rate of each individual firm, and we cannot compute this tax rate for the firms which do not pay taxes. Therefore, the number of observations is different between the average tax rate case and the other two cases. Since this average tax rate might have endogenous problem, we also compute two other kinds of average tax rate. First one is computed by regressing real average tax rate on several exogenous variables, such as industry dummy (NAICS 3 digit level), provincial dummy, firm size dummy, year dummy, firm age and GDP variables and the predicted average tax rates are used. Second one is computed from the estimated tax base using the same method in the location choice analysis. We also use aggregate level average tax rate.

All tax rates have different interpretations and usage, as we discussed in the section
5.2. Effective tax rates are computed from statutory tax rates, and regarded as relevant measurement for profit shifting across provinces. Average tax rates are the ratio of tax payment to the profit, and represent the cost of running business. The Marginal effective tax rate on capital is the marginal cost of tax incurred by increasing capital stock, and this tax is used to measure the cost of new investment. The effective average tax rate measures the average impact of corporate tax on total profits, and is used for firm location choice analysis as the relevant measurement of tax. Given these meanings, the average tax rate and the effective average tax rate are important for firm location choices, while firm exit decisions are affected by the average tax rate.

5.9.1 Firm Location Choice Analysis

We use mixed logit model to analyze firm location choices. Mixed logit model is a flexible model and allows parameters to take a random variable. It obviates the three limitations of standard logit model by allowing for random taste variation, unrestricted substitution patterns and correlation in unobserved factors over time.\(^{31}\) We estimate the following mixed logit model,

\[
\text{Prob}(Y_i = j|z_{i1}z_{i2}z_{i3}...z_{iJ}) = \int \left( \frac{\exp^{\beta z_{ij}}}{\sum_{j=1}^{J} \exp^{\beta z_{ij}}} \right) f(\beta) d\beta
\]

where Prob\((Y_i = j|z_{i1}z_{i2}z_{i3}...z_{iJ})\) is a probability of a firm \(i\) choosing to locate in province \(j\) conditional on explanatory variables \(z_{iJ}\).\(^{32}\) \(\beta\) is a parameter to be estimated and \(f()\) is a distribution function of the parameter \(\beta\) for which we use a normally distributed function.

For social economic variables, we use the following variables: population, per capita income, population growth rate, wage, gasoline price, unemployment rate, the ratio of people

\(^{31}\)This is a quote from Train (2003), page 138, lines 2-6.

\(^{32}\)Not only the tax rate in a specific province, but also the tax rates of all the other provinces are implicitly included in this equation to compare the after tax profit across all provinces.
with university degree, the number of firms in the same industry sectors, per capita amount of public transportation expenditure and per capita amount of public education expenditure. Population, income and population growth rate reflect demand side factors, and wage and gasoline prices represent cost factors. Unemployment rates and the ratio of people with university degree explain labour market conditions and the number of firms in the same industry sector captures an agglomeration effect. Per capita amount of public expenditure means generosity of public services or high tax rates in provinces. We also include provincial dummy and industry dummy (NAICS 2 digit level) variables in the regression. We choose four economic variables to have a random parameter; population, income, wage and the number of firms.\(^{33}\) All results are listed in Tables 5.7 and 5.8.

### Table 5.7: Firm Location Choice Results I

<table>
<thead>
<tr>
<th></th>
<th>ETR1</th>
<th></th>
<th>ETR2</th>
<th></th>
<th>Agg ATR</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tax</td>
<td>3.583***</td>
<td>0.485</td>
<td>-1.103</td>
<td>1.414</td>
<td>0.183</td>
<td>0.397</td>
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<tr>
<td>log pop</td>
<td>2.800***</td>
<td>0.825</td>
<td>2.073***</td>
<td>0.860</td>
<td>2.287***</td>
<td>0.832</td>
</tr>
<tr>
<td>log inc</td>
<td>2.924***</td>
<td>0.885</td>
<td>2.540***</td>
<td>0.875</td>
<td>2.440***</td>
<td>0.865</td>
</tr>
<tr>
<td>log wage</td>
<td>-4.906***</td>
<td>1.128</td>
<td>-4.869***</td>
<td>1.107</td>
<td>-4.609***</td>
<td>1.101</td>
</tr>
<tr>
<td>log n firms</td>
<td>1.057***</td>
<td>0.045</td>
<td>1.062***</td>
<td>0.047</td>
<td>1.059***</td>
<td>0.047</td>
</tr>
<tr>
<td>pop growth</td>
<td>4.319</td>
<td>5.508</td>
<td>4.745</td>
<td>5.477</td>
<td>5.204</td>
<td>5.533</td>
</tr>
<tr>
<td>log gas</td>
<td>0.540</td>
<td>0.662</td>
<td>0.080</td>
<td>0.657</td>
<td>0.062</td>
<td>0.659</td>
</tr>
<tr>
<td>unemp</td>
<td>0.008</td>
<td>0.030</td>
<td>0.006</td>
<td>0.030</td>
<td>0.007</td>
<td>0.030</td>
</tr>
<tr>
<td>univ</td>
<td>2.732</td>
<td>2.913</td>
<td>2.666</td>
<td>2.923</td>
<td>2.217</td>
<td>2.934</td>
</tr>
<tr>
<td>log pop transp</td>
<td>-0.061</td>
<td>0.123</td>
<td>-0.021</td>
<td>0.122</td>
<td>-0.014</td>
<td>0.124</td>
</tr>
<tr>
<td>log pop edu</td>
<td>-0.160</td>
<td>0.273</td>
<td>-0.143</td>
<td>0.266</td>
<td>-0.168</td>
<td>0.269</td>
</tr>
</tbody>
</table>

|               |                  |                  |                  |                  |                  |
|---------------|------------------|------------------|------------------|------------------|
| Standard Deviation |               |                  |                  |                  |                  |
| log pop       | 0.920*** | 0.198 | 0.908*** | 0.201 | 0.893*** | 0.205 |
| log inc       | 1.954      | 1.212 | 1.639 | 1.151 | 1.530 | 1.141 |
| log wage      | 5.460*** | 1.621 | 5.659*** | 1.820 | 5.413*** | 1.821 |
| log n firms   | 0.507*** | 0.131 | 0.584*** | 0.130 | 0.578*** | 0.131 |

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations</td>
<td>153,982</td>
<td>153,982</td>
<td>153,982</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-24682</td>
<td>-24712</td>
<td>-24712</td>
</tr>
</tbody>
</table>

Notes: *** means 1% significant, ** mean 5% significant and * means 10% significant.

All tax rate results are different. The coefficient of effective tax rate (ETR1), which

\(^{33}\)We choose these four variables because when we estimate a conditional logit model, only these variable parameters are significant.
Table 5.8: Firm Location Choice Results II

<table>
<thead>
<tr>
<th></th>
<th>ATR1 Coef.</th>
<th>ATR1 Std Err.</th>
<th>ATR2 Coef.</th>
<th>ATR2 Std Err.</th>
<th>EATR Coef.</th>
<th>EATR Std Err.</th>
<th>METR Coef.</th>
<th>METR Std Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tax</td>
<td>-3.815**</td>
<td>1.571</td>
<td>-0.259</td>
<td>2.500</td>
<td>-1.270**</td>
<td>0.533</td>
<td>2.557</td>
<td>4.592</td>
</tr>
<tr>
<td>log pop</td>
<td>0.817</td>
<td>1.018</td>
<td>2.206**</td>
<td>0.929</td>
<td>2.005**</td>
<td>0.844</td>
<td>2.428***</td>
<td>0.889</td>
</tr>
<tr>
<td>log inc</td>
<td>2.694***</td>
<td>0.878</td>
<td>2.482***</td>
<td>0.897</td>
<td>2.891***</td>
<td>0.890</td>
<td>2.359***</td>
<td>0.884</td>
</tr>
<tr>
<td>log n firms</td>
<td>1.063***</td>
<td>0.048</td>
<td>1.061***</td>
<td>0.048</td>
<td>1.062***</td>
<td>0.048</td>
<td>1.059***</td>
<td>0.047</td>
</tr>
<tr>
<td>pop growth</td>
<td>4.402</td>
<td>5.486</td>
<td>4.791</td>
<td>5.491</td>
<td>5.645</td>
<td>5.504</td>
<td>4.858</td>
<td>5.473</td>
</tr>
<tr>
<td>log gas</td>
<td>0.411</td>
<td>0.671</td>
<td>0.092</td>
<td>0.658</td>
<td>0.412</td>
<td>0.671</td>
<td>0.011</td>
<td>0.673</td>
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<tr>
<td>unemp</td>
<td>-0.005</td>
<td>0.031</td>
<td>0.007</td>
<td>0.030</td>
<td>-0.009</td>
<td>0.031</td>
<td>0.010</td>
<td>0.031</td>
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<tr>
<td>univ</td>
<td>2.517</td>
<td>2.900</td>
<td>2.461</td>
<td>2.955</td>
<td>3.293</td>
<td>2.935</td>
<td>2.097</td>
<td>2.959</td>
</tr>
<tr>
<td>log pop transp</td>
<td>-0.197</td>
<td>0.141</td>
<td>-0.025</td>
<td>0.122</td>
<td>-0.040</td>
<td>0.122</td>
<td>0.001</td>
<td>0.131</td>
</tr>
<tr>
<td>log pop edu</td>
<td>-0.097</td>
<td>0.268</td>
<td>-0.148</td>
<td>0.267</td>
<td>-0.050</td>
<td>0.267</td>
<td>-0.149</td>
<td>0.266</td>
</tr>
</tbody>
</table>

Standard Deviation

<table>
<thead>
<tr>
<th></th>
<th>ATR1 Coef.</th>
<th>ATR1 Std Err.</th>
<th>ATR2 Coef.</th>
<th>ATR2 Std Err.</th>
<th>EATR Coef.</th>
<th>EATR Std Err.</th>
<th>METR Coef.</th>
<th>METR Std Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td>log pop</td>
<td>0.901***</td>
<td>0.204</td>
<td>0.909***</td>
<td>0.202</td>
<td>0.902***</td>
<td>0.204</td>
<td>0.899***</td>
<td>0.203</td>
</tr>
<tr>
<td>log inc</td>
<td>1.673</td>
<td>1.168</td>
<td>1.519</td>
<td>1.166</td>
<td>1.531</td>
<td>1.171</td>
<td>1.448</td>
<td>1.120</td>
</tr>
<tr>
<td>log wage</td>
<td>5.616***</td>
<td>1.844</td>
<td>5.474***</td>
<td>1.863</td>
<td>5.502***</td>
<td>1.840</td>
<td>5.329***</td>
<td>1.800</td>
</tr>
<tr>
<td>log n firms</td>
<td>0.585***</td>
<td>0.130</td>
<td>0.583***</td>
<td>0.131</td>
<td>0.580***</td>
<td>0.131</td>
<td>0.579***</td>
<td>0.131</td>
</tr>
</tbody>
</table>

Observations 153,982 153,982 153,982 153,982
Log likelihood -24709 -24712 -24709 -24712

Notes: *** means 1% significant, ** mean 5% significant and * means 10% significant.

is computed assuming that the firms with no tax are large corporations, is positively significant and it means that high effective tax rates encourage firm location choice, which is counter intuitive. On the other hand, the coefficient of effective tax rate (ETR2) which assumes that the firms with no tax are small corporations is negatively insignificant, and the tax rate has no effect on firm location choice. The latter effective tax rate (ETR2) result is more reasonable, and the counter intuitive result of the former effective tax rate (ETR1) might be attributed to misidentifying small corporations as large corporations. The aggregate average tax rate result (Agg ATR) is positively insignificant. The coefficient of average tax rate (ATR1), which is computed as a mean of the existing firm tax rates, is negatively significant and another average tax rate result (ATR2) which is computed from the estimated tax base is negatively insignificant. Average tax rate (ATR2) shows a high correlation with the effective tax rate (ETR2), which explain the insignificant result. The
Table 5.9: Covariance Matrix of the Random Coefficients

<table>
<thead>
<tr>
<th></th>
<th>log pop</th>
<th>log inc</th>
<th>log wage</th>
<th>log n firms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ETR2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log pop</td>
<td>0.847**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log inc</td>
<td>1.081</td>
<td>3.818</td>
<td></td>
<td></td>
</tr>
<tr>
<td>log wage</td>
<td>-4.560*</td>
<td>-9.355</td>
<td>29.81</td>
<td></td>
</tr>
<tr>
<td>log n firms</td>
<td>-0.323*</td>
<td>0.030</td>
<td>1.140</td>
<td>0.257**</td>
</tr>
</tbody>
</table>

| **ETR1** |         |         |          |             |
| log pop | 0.824** |         |          |             |
| log inc | 0.603   | 2.688   |          |             |
| log wage| -3.782* | -8.480  | 32.02    |             |
| log n firms | -0.363* | 0.320   | 0.110    | 0.341**     |

| **Agg ATR** |         |         |          |             |
| log pop | 0.797** |         |          |             |
| log inc | 0.529   | 2.342   |          |             |
| log wage| -3.552* | -7.511  | 29.30    |             |
| log n firms | -0.355* | 0.304   | 0.126    | 0.334**     |

| **ATR1** |         |         |          |             |
| log pop | 0.813** |         |          |             |
| log inc | 0.507   | 2.798   |          |             |
| log wage| -3.591* | -8.452  | 31.5     |             |
| log n firms | -0.357* | 0.398   | -0.036   | 0.342**     |

| **ATR2** |         |         |          |             |
| log pop | 0.826** |         |          |             |
| log inc | 0.518   | 2.307   |          |             |
| log wage| -3.675* | -7.471  | 29.96    |             |
| log n firms | -0.363* | 0.214   | 0.122    | 0.340**     |

| **EATR** |         |         |          |             |
| log pop | 0.814** |         |          |             |
| log inc | 0.533   | 2.344   |          |             |
| log wage| -3.671* | -7.608  | 30.28    |             |
| log n firms | -0.358* | 0.308   | 0.134    | 0.336**     |

| **METR** |         |         |          |             |
| log pop | 0.808** |         |          |             |
| log inc | 0.475   | 2.096   |          |             |
| log wage| -3.551* | -6.884  | 28.40    |             |
| log n firms | -0.358* | 0.305   | 0.145    | 0.335**     |

Notes: *** means 1% significant, ** mean 5% significant and * means 10% significant.
coefficient of effective average tax rate (EATR) is negatively significant and marginal effective tax rate (METR) coefficient is positively insignificant. In short, individual firm level average tax rate and effective average tax rate results show a negative effect on firm’s location choice although other tax rates do not have significant effects. We have already explained the reasons for the different results in section 5.6.4 by showing their different distributions across provinces.

The interpretation of the coefficients are different between random coefficients and constant coefficients. For example in the first effective tax rate (ETR1) case, a mean and a standard deviation of the coefficient of population are 2.800 and 0.920 respectively, and both are significant. In short, the coefficient has a normal distribution with mean 2.800 and standard deviation 0.920. The ratio of a mean and a standard deviation is $\frac{2.800}{0.920} = 3.043$, and it means that almost all of the firms have a positive coefficient in population variable and prefer to locate in the province with large population. A mean and a standard deviation for income variable is 2.924 and 1.954, and only the mean coefficient variable is significant. It seems that firms’ preference on income does not vary across different firms and provinces with large income seem attractive for firm location. A mean and a standard deviation of wage variable is -4.906 and 5.460 respectively, and both are significant. The ratio of a mean and a standard deviation is $\frac{-4.906}{5.460} = -0.899$, and about 81% of the firms have a negative coefficient. In another word, high wage cost prevents firms from locating. Lastly, a mean and a standard deviation of the number of firms variable are 1.057 and 0.507, and both are significant. The ratio of a mean and a standard deviation is $\frac{1.057}{0.507} = 2.085$, and about 2% of the firms have a negative coefficient of the number of firms variable. It seems that an agglomeration effect is significant and firms prefer to locate in the place where the
same industry firms gather. From the covariance matrix results in Table 5.9, we find a negative correlation between population and wage and between population and the number of firms. These results imply that firms prefer provinces with large population and low wage (or smaller number of the same industry firms). These variables results are almost the same in other tax rate cases.

When we move to the constant variable results, the population growth rate coefficient is positively insignificant for all cases and does not have a significant effect. The gasoline price result is positively insignificant and the unemployment rate coefficient is mostly positively insignificant. The share of people with university degree result is positively insignificant. Gasoline price and labour market conditions do not have much explanatory power on firm entry decisions. Public expenditure results are insignificant and public service is not very effective for firm location choice. Most of the provincial dummy variables and some of the industry dummy variables are significant.\textsuperscript{34} Remember that the coefficient results do not represent marginal effects. Nevertheless, for alternative specific variables,\textsuperscript{35} the sign of coefficients has to be the same as the sign of marginal effects and significance levels also do not differ much. We also try the case where several tax rates are included in the same regression, but the multicollinearity among tax rate causes unreasonable results. In summary, the estimation results of tax effect are different among all cases, and using different tax rates produce different interpretation of tax effects. If firms consider average tax rate or effective average tax rate as a relevant measurement of a cost factor, high tax rates hamper firm location choice. Demand side factors like population, income, and an agglomeration effect encourage firm entry, although a high cost factor like wage discourages firms location choice.

\textsuperscript{34}For confidential reasons, we cannot list the results of dummy variables.
\textsuperscript{35}Alternative specific variables are variables which depend on choice variables (in this case, province) and all explanatory variables used here are alternative specific variables.
5.9.2 Firm Exit Decision Analysis

In this section, we analyze firm exit decisions using a logit model. Three cases are considered: no tax case, effective tax rate case and average tax rate case. The following logit model is estimated for firm exit decisions,

\[
\text{Prob}(Y_i = 1|x) = \frac{\exp^{\beta x}}{1 + \exp^{\beta x}}
\]

where \(\text{Prob}(Y_i = 1|x)\) is a probability of a firm \(i\) choosing to exit the market conditional on explanatory variables \(x\). \(\beta\) is a parameter. We include some financial variables in this \(x\) to reflect firm financial standing: the share of cash to assets, assets, liabilities, capital stock and a dummy variable to indicate whether firms pay taxes or not (d not pay). Unfortunately, about half of the firms do not have capital stock data. We also try a dummy variable (d capital) which indicates whether a firm has capital stock or not to reserve many observations. A dummy variable for tax payment is excluded in the real average tax rate case since all firms pay taxes. In addition, several socio-economic variables are also included: population, per capital income, the number of firms in the same industry, wage, gasoline price. More than half of the firms do not have employee when they exit the market, and the product of wage and dummy variable of having employee or not is added. In addition, one year lagged interest rate and two year lagged unemployment rate of Canada are also included to reflect macroeconomic trends. We also include provincial, industry (NAICS 3 digit level) and firm size dummies. The results of capital stock and a capital dummy variable case have the same sign and significance and we list only a capital dummy case result. The results are listed in Tables 5.10 and 5.11.
### Table 5.10: Firm Exit Decision Results I

<table>
<thead>
<tr>
<th></th>
<th>No tax Coef.</th>
<th>ETR1 Coef.</th>
<th>ETR2 Coef.</th>
<th>Agg ATR Coef.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tax</td>
<td>0.760**</td>
<td>0.303</td>
<td>2.110***</td>
<td>0.402</td>
</tr>
<tr>
<td>share cash</td>
<td>-0.068</td>
<td>0.052</td>
<td>-0.067</td>
<td>0.052</td>
</tr>
<tr>
<td>log asset</td>
<td>-0.091***</td>
<td>0.007</td>
<td>-0.091***</td>
<td>0.007</td>
</tr>
<tr>
<td>log liability</td>
<td>0.053***</td>
<td>0.008</td>
<td>0.053***</td>
<td>0.008</td>
</tr>
<tr>
<td>log pop</td>
<td>-3.769***</td>
<td>0.902</td>
<td>-3.724***</td>
<td>0.902</td>
</tr>
<tr>
<td>log inc</td>
<td>0.028</td>
<td>0.677</td>
<td>0.160</td>
<td>0.678</td>
</tr>
<tr>
<td>log n firm</td>
<td>-0.077**</td>
<td>0.034</td>
<td>-0.075**</td>
<td>0.034</td>
</tr>
<tr>
<td>log wage</td>
<td>0.102</td>
<td>0.776</td>
<td>0.025</td>
<td>0.775</td>
</tr>
<tr>
<td>log wage*dummy</td>
<td>0.454*</td>
<td>0.260</td>
<td>0.480*</td>
<td>0.261</td>
</tr>
<tr>
<td>log gas</td>
<td>1.248***</td>
<td>0.298</td>
<td>1.247***</td>
<td>0.298</td>
</tr>
<tr>
<td>interest rate</td>
<td>0.042**</td>
<td>0.050</td>
<td>0.041**</td>
<td>0.050</td>
</tr>
<tr>
<td>unemployment</td>
<td>0.043</td>
<td>0.021</td>
<td>0.043</td>
<td>0.021</td>
</tr>
<tr>
<td>d not pay</td>
<td>0.183***</td>
<td>0.025</td>
<td>0.092**</td>
<td>0.026</td>
</tr>
<tr>
<td>d capital</td>
<td>-0.054**</td>
<td>0.021</td>
<td>-0.054**</td>
<td>-0.054**</td>
</tr>
</tbody>
</table>

### Notes:
- *** means 1% significant, ** means 5% significant and * means 10% significant.

Similar to the mixed logit model, the coefficients do not mean marginal effects. Nevertheless, since logistic cumulative distribution function is a monotonically increasing function, the sign and significance of the coefficients are the same as those of marginal effects. The coefficients of effective tax rate are positive and significant, either we assume firms with no taxes are large corporations (ETR1) or small corporation (ETR2). The coefficient of aggregate level average tax rate (Agg ATR) is positively insignificant. The coefficients of real average tax rate (ATR) and two other average tax rates are positive and significant. The scale is bigger for average tax rate computed from the estimated tax base (ATR2) than for average tax rate estimated from regressing (ATR1). This means high tax rates prompt firms to exit the market. The coefficient of share of cash is negatively insignificant. The coefficient of asset is negatively significant and the coefficient of liability is positively significant. A firm with a large amount of asset and a low amount of liability seems less likely...
Table 5.11: Firm Exit Decision Results II

<table>
<thead>
<tr>
<th></th>
<th>ATR</th>
<th>ATR1</th>
<th>ATR2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tax</td>
<td>1.086***</td>
<td>0.223</td>
<td>1.709***</td>
</tr>
<tr>
<td>share cash</td>
<td>-0.042</td>
<td>0.113</td>
<td>-0.070</td>
</tr>
<tr>
<td>share cash</td>
<td>1.709***</td>
<td>0.433</td>
<td>4.078***</td>
</tr>
<tr>
<td>log asset</td>
<td>-0.107***</td>
<td>0.020</td>
<td>-0.093***</td>
</tr>
<tr>
<td>log liability</td>
<td>0.164***</td>
<td>0.020</td>
<td>0.054***</td>
</tr>
<tr>
<td>log pop</td>
<td>-4.445***</td>
<td>1.478</td>
<td>-3.755***</td>
</tr>
<tr>
<td>log inc</td>
<td>-2.768**</td>
<td>1.124</td>
<td>0.121</td>
</tr>
<tr>
<td>log n firm</td>
<td>-0.027</td>
<td>0.059</td>
<td>-0.076**</td>
</tr>
<tr>
<td>log wage</td>
<td>0.698</td>
<td>1.316</td>
<td>-0.101</td>
</tr>
<tr>
<td>log wage*dummy</td>
<td>0.601</td>
<td>0.458</td>
<td>0.465*</td>
</tr>
<tr>
<td>log gas</td>
<td>2.944***</td>
<td>0.475</td>
<td>1.288***</td>
</tr>
<tr>
<td>interest rate</td>
<td>0.069***</td>
<td>0.027</td>
<td>0.027</td>
</tr>
<tr>
<td>unemployment</td>
<td>-0.113</td>
<td>0.080</td>
<td>0.013</td>
</tr>
<tr>
<td>d not pay</td>
<td>-0.050</td>
<td>0.037</td>
<td>-0.055***</td>
</tr>
<tr>
<td>d capital</td>
<td>-0.050</td>
<td>0.037</td>
<td>-0.055***</td>
</tr>
<tr>
<td>Observations</td>
<td>153,696</td>
<td>298,472</td>
<td>298,472</td>
</tr>
<tr>
<td>Likelihood</td>
<td>-13999</td>
<td>-38194</td>
<td>-38191</td>
</tr>
<tr>
<td>Pseudo R squared</td>
<td>0.114</td>
<td>0.137</td>
<td>0.137</td>
</tr>
</tbody>
</table>

Notes: *** means 1% significant, ** mean 5% significant and * means 10% significant.

The coefficient of population is negatively significant and the coefficient of income is positively or negatively insignificant. This result is different from that of firm location choice, and firms prefer not to exit the market from provinces with large population. The coefficients of the number of firms is negatively significant and firms are reluctant to leave the market if the same industry firms concentrate in the province. The coefficient of wages is positively insignificant although the coefficient of the product of wage and dummy variable of having employee is positively significant, and high wage cost prompt firms to exit the market. The gasoline price coefficient is positively significant and high energy costs increase the possibility of firm exit. The coefficient of interest rate is positively significant although the coefficient of unemployment rate is positively insignificant. The coefficient of the dummy variable for not paying taxes is positively significant, and it implies that if a firm does not earn enough profit to pay taxes, the probability of exit will increase. The
coefficients of capital (both dummy and capital stock variable) are negatively significant, and a firm with a large amount of capital has less probability to exit the market. Most firm size and provincial dummies and some of the industry dummies are significant.

We also include several tax rates in one equation, but multicollinearity happens again. For robustness check, we exclude the firms which remain the market in 2007 and have zero sales during 2005 to 2007. These firms are suspected to being inactive. The estimation results are almost the same except that the coefficient on the product of wage and labour dummy become insignificant, and the coefficient of tax rates are mostly positive and significant. In summary, a firm with large amounts of assets and capital and a low amount of liability is less likely to exit the market. High tax rates and other cost factors like, wage, gasoline prices and interest rate prompt firms to exit the market, and large demand factors like population and an agglomeration factor make firms reluctant to exit the market.

5.10 Conclusions

In this chapter, we analyze firm entry and exit behaviours and the effect of the corporate income tax on firm location choices and exit decisions in Canada. First, three kinds of corporate income tax rates are computed for individual enterprise firm levels: the average tax rate, the marginal effective tax rate on capital and the effective average tax rate on capital. We examine each tax rate distribution and compare them with aggregate level tax rates and effective tax rates. We then examine firm entry and exit behaviours, taking into account firm sizes, industry sectors and provinces. In addition, firm survival rates and firm size changes are investigated. Third, firm tax payments and corporate tax rate movements are examined. We investigate the types of firms that do not pay taxes, and how firm corporate income tax rates change with firm age. Lastly, the effects of the corporate
income tax on firm location choices and entry decisions are analyzed.

Our results are as follows: First, the aggregate level average tax rate is greater than the individual firm level average tax rate, and the distribution across provinces is also different. This result indicates that aggregate level tax rates ignore firm-level heterogeneity, and that aggregate level tax rates do not reflect individual firm level tax rates very well. Second, average tax rates of complex firms are higher than those of single firms, and the distribution across provinces is also different. This finding implies that pooling single and complex firms to measure the effect of tax rates might lead to misleading results. Third, each computed individual firm level tax rate has a unique distribution, and the distribution is different from that of effective tax rates. The results indicate that using a different tax rate produces a different interpretation of tax effects. Fourth, firm entry and exit behaviours depend on firm size, industry sectors and provinces, and it is important to take into account these factors when analyzing firm entry and exit decisions. Firm size is especially important, and most new firms are small size. Unsuccessful firms reduce their size until the time of exiting the market comes close. In addition, about half of the firms exit the market after six years, and firms tend to change their size within a few years. Fifth, the percentage of firms which do not pay taxes hinges on firm structure, firm age, firm sizes, industry sectors and provinces, and most of the small size, young and single firms about to leave the market do not pay taxes. Corporate income tax rates are different among firms with different characteristics, but the values do not change much over time. Lastly, high corporate income tax rates discourage firm entry and encourage firm exit decisions. In addition to tax rates, other socio-economic factors and firm financial status are important for firm location choices and exit decisions. Factors like population, income and an agglomeration effect are attractive for firm location choice, and high cost factors like wage and gasoline prices.
hamper firm entry and prompt firm exit decisions. A firm with a relatively large amount of assets and capital is less likely to exit the market and a large amount of liability increases the probability of exiting the market.
Chapter 6

Summary and Conclusions

In this thesis, we have discussed the commodity tax and corporate income tax, considering three important factors for tax determination: household and firm responses to tax rates, the government objective, and the horizontal and vertical tax interactions. From Chapters 3 and 4, we determine household gasoline and cigarette consumption and cross-border shopping behaviours. In addition, the state government objective and responses to other government tax rate changes are identified. Chapter 5 shows that the corporate income tax has a significant effect on firm location and exit decisions.

Chapter 3 explicitly estimates the structural parameters of the consumer utility function and the state government objective function and examines the existence of strategic interactions in taxation between state governments and between state and federal governments using gasoline and cigarette taxation in the U.S. The existence of strategic interactions between governments is evaluated by computing the slope of the reaction function given the estimated parameters. The estimation gives us the following results: First, the slope of the reaction functions between state governments for both gasoline and cigarette taxes, which describes the horizontal tax interactions, is positive and small. This result means that even
though the neighboring state governments change their tax rates, state governments will not respond to the tax change. Second, the slope of the reaction function between state and federal governments, which describes the vertical tax interaction, is positive, and the value is larger for cigarette tax than for gasoline tax. In short, if the federal government increases its tax rate, state governments also raise their tax rate to sustain their tax revenue, and the scale of response is larger for cigarettes than for gasoline. Third, the value of the slope of the reaction function of the tax interaction is positive on average, but its value and sign are very different among states and for some states the sign becomes negative. In other words, the reactions of state governments to the neighboring state and federal government tax changes are different not only in scale but also in direction. Lastly, we replicate a weighted matrix approach using simulated tax rates assuming no cross-border shopping. Since tax rates are simulated under the assumption of no cross-border shopping, tax rates do not include a factor of the horizontal tax externality. Therefore, regression analysis should show no horizontal tax interaction if the estimation method is appropriate. Nevertheless, the replication results show strong horizontal tax interactions, which should not exist. This contradiction between the model and the results implies that the weighted matrix approach might not be suitable to evaluate the slope of the reaction function.

Chapter 4 tries to identify the state government objective and to construct the state government objective function using the U.S. gasoline tax. Our findings from the analysis are as follows: First, a Benevolent government idea is suitable for the state government objective. The assumption of Leviathan is not consistent with the estimated price elasticity of demand and small percentage of cross border shopping, and we conclude that the Leviathan assumption is not appropriate. Second, the state government objective function is better described using quasi-linear function rather than Cobb-Douglas function. Third,
simulated tax based on the structural model shows a strong correlation with real tax data and we have confirmed that our model describes state government behaviour well.

Chapter 5 aims to compute individual firm level corporate income taxes and to analyze the effects of these corporate income taxes on firm location choice and exit behaviours. We focus on manufacturing sectors and use firm longitudinal data, the GIFI-T2LEAP database which has been created by Statistics Canada. The results from our analysis are as follows: First, each corporate income tax rate has a different distribution across provinces, and individual firm level tax rates are different from aggregate level tax rates and effective tax rates. This means that using a different tax rate for empirical analysis will bring us a different interpretation of tax effects. Second, firm entry and exit decisions depend on firm sizes, industry sectors and provinces, with firm size being particularly important. Third, the percentage of firms which do not pay taxes hinges on firm structure, age, firm sizes, industry sectors and provinces, and most small size, young, and single firms about to leave the market do not pay taxes. Lastly, high corporate income tax rates are found to discourage firm location choice and encourage firm exit decision.

There are a number of interesting questions that can be extended from this thesis. We do not address the yardstick competition issue in this paper. Yardstick competition is attributed to the situation in which the purpose of governments is to be elected and in which there is asymmetric information between governments and voters on fiscal policies and situations. Because of this asymmetric information, voters use the neighboring government fiscal polices to judge their incumbent governments. This causes another source of horizontal tax interaction among governments. It might be interesting to include this yardstick competition issue for analyzing government behaviours. Moreover, we could apply this
commodity tax analysis method to investigate how Canadian governments determine corporate income tax and whether corporate tax competition across provinces exists or not. We intend to address these issues in our future research.
Bibliography


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Appendix A

Appendix for Chapter 3 and 4

A.1 Data Resource
<table>
<thead>
<tr>
<th>Data</th>
<th>resource</th>
<th>webpage</th>
</tr>
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<td>Gasoline price</td>
<td>Energy Information Administration</td>
<td><a href="http://www.eia.doe.gov/emeu/states/">http://www.eia.doe.gov/emeu/states/</a></td>
</tr>
<tr>
<td>Gasoline consumption</td>
<td>Energy Information Administration</td>
<td><a href="http://www.eia.doe.gov/emeu/states/">http://www.eia.doe.gov/emeu/states/</a></td>
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<tr>
<td>Cigarette unit tax rate</td>
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<td>Cigarette consumption</td>
<td>Report:Tax Burden on Tobacco</td>
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</tr>
<tr>
<td>Federal grant to Highway department</td>
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<tr>
<td>Federal grant to Health department</td>
<td>Statistics of Abstract</td>
<td></td>
</tr>
<tr>
<td>Debt</td>
<td>U.S Census of Bureau</td>
<td></td>
</tr>
<tr>
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<td>Bureau of Economic Analysis</td>
<td></td>
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<tr>
<td>Per capita disposal income</td>
<td>Bureau of Economic Analysis</td>
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</tr>
<tr>
<td>Land area</td>
<td>Statistics of Abstract</td>
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<tr>
<td>Ratio of Hispanics</td>
<td>Center of Disease Control and Prevention</td>
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</tr>
<tr>
<td>CO2 emission</td>
<td>U.S. Environment Protection Agency</td>
<td><a href="http://www.epa.gov/climatechange/emissions/">http://www.epa.gov/climatechange/emissions/</a></td>
</tr>
<tr>
<td>the number of car registration</td>
<td>Federal Highway Administration</td>
<td></td>
</tr>
<tr>
<td>the percentage of people in a metropolitan area</td>
<td>Statistics of Abstract</td>
<td></td>
</tr>
<tr>
<td>Vehicle users</td>
<td>Statistics of Abstract</td>
<td></td>
</tr>
<tr>
<td>the percentage of smoker</td>
<td>Statistics of Abstract</td>
<td></td>
</tr>
<tr>
<td>the percentage of deaths by lung cancer</td>
<td>State Cancer Profiles</td>
<td><a href="http://statecancerprofiles.cancer.gov/">http://statecancerprofiles.cancer.gov/</a></td>
</tr>
<tr>
<td>the number of medicaid</td>
<td>Statistics of Abstract</td>
<td></td>
</tr>
<tr>
<td>Federal debt</td>
<td>Statistics of Abstract</td>
<td></td>
</tr>
<tr>
<td>Unemployment rate</td>
<td>Statistics of Abstract</td>
<td></td>
</tr>
<tr>
<td>Distance between the center of the states</td>
<td>Google map</td>
<td></td>
</tr>
</tbody>
</table>
A.2 Total Sales Estimation

We regress total state gasoline or cigarette sales with socio-economic factors of their own state to see how much these socio-economic factors contributes to explaining household consumption behaviors. All variables are taken log, and the factors of $\alpha$ are used as being formulated. The estimation results and the following two figures show that most of total sales are explained by these socio-economic factors of their own state, and the percentage of cross border shopping is small.

<table>
<thead>
<tr>
<th>Table A.2: Total Sales Estimation Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Gasoline</strong></td>
</tr>
<tr>
<td>constant</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>population</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>income</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>price</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>log income</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>number of observation</td>
</tr>
<tr>
<td>R-squared</td>
</tr>
</tbody>
</table>

Notes: *** means 1% significant, ** means 5% significant and * means 10% significant. A value in the parenthesis is a standard error.

Figure A.1: Total Gasoline Sales

Figure A.2: Total Cigarette Sales
### A.3 Vertical Externality

#### Table A.3: The Slope of the Reaction Function

<table>
<thead>
<tr>
<th>Data</th>
<th>Gasoline</th>
<th>Cigarette</th>
<th>Gasoline</th>
<th>Cigarette</th>
<th>Gasoline</th>
<th>Cigarette</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>0.091</td>
<td>0.040</td>
<td>0.114</td>
<td>0.314</td>
<td>0.155</td>
<td>0.108</td>
</tr>
<tr>
<td>Arizona</td>
<td>0.093</td>
<td>0.452</td>
<td>0.077</td>
<td>0.196</td>
<td>0.111</td>
<td>0.142</td>
</tr>
<tr>
<td>Arkansas</td>
<td>0.122</td>
<td>0.195</td>
<td>0.066</td>
<td>0.239</td>
<td>0.129</td>
<td>0.320</td>
</tr>
<tr>
<td>California</td>
<td>0.098</td>
<td>0.270</td>
<td>0.107</td>
<td>0.571</td>
<td>0.163</td>
<td>0.202</td>
</tr>
<tr>
<td>Colorado</td>
<td>0.152</td>
<td>0.048</td>
<td>0.113</td>
<td>0.208</td>
<td>-0.005</td>
<td>0.160</td>
</tr>
<tr>
<td>Connecticut</td>
<td>0.066</td>
<td>0.104</td>
<td>0.092</td>
<td>0.026</td>
<td>0.076</td>
<td>-0.028</td>
</tr>
<tr>
<td>Delaware</td>
<td>-0.041</td>
<td>-0.059</td>
<td>0.065</td>
<td>-0.002</td>
<td>0.115</td>
<td>0.143</td>
</tr>
<tr>
<td>Florida</td>
<td>0.072</td>
<td>0.148</td>
<td>0.181</td>
<td>0.195</td>
<td>0.137</td>
<td>0.027</td>
</tr>
<tr>
<td>Georgia</td>
<td>-0.019</td>
<td>0.020</td>
<td>0.158</td>
<td>0.119</td>
<td>0.153</td>
<td>0.211</td>
</tr>
<tr>
<td>Idaho</td>
<td>0.157</td>
<td>0.118</td>
<td>0.020</td>
<td>0.001</td>
<td>0.138</td>
<td>0.194</td>
</tr>
<tr>
<td>Illinois</td>
<td>0.119</td>
<td>0.284</td>
<td>-0.011</td>
<td>0.005</td>
<td>-0.040</td>
<td>0.055</td>
</tr>
<tr>
<td>Indiana</td>
<td>0.047</td>
<td>0.042</td>
<td>-0.023</td>
<td>0.319</td>
<td>0.082</td>
<td>-0.054</td>
</tr>
<tr>
<td>Iowa</td>
<td>0.109</td>
<td>0.101</td>
<td>0.101</td>
<td>0.111</td>
<td>0.150</td>
<td>0.511</td>
</tr>
<tr>
<td>Kansas</td>
<td>0.121</td>
<td>0.114</td>
<td>0.150</td>
<td>0.308</td>
<td>0.106</td>
<td>0.046</td>
</tr>
<tr>
<td>Kentucky</td>
<td>0.044</td>
<td>-0.049</td>
<td>0.159</td>
<td>-0.039</td>
<td>0.179</td>
<td>0.278</td>
</tr>
<tr>
<td>Louisiana</td>
<td>0.127</td>
<td>0.090</td>
<td>0.102</td>
<td>0.182</td>
<td>-0.084</td>
<td>-0.042</td>
</tr>
</tbody>
</table>
A.4 Tax Rate Simulation

The following figures compare the real state tax rate and simulated tax rate based on the model under the assumption of no cross border shopping, and show that our model describes state government behavior very well.

Figure A.3: Gasoline Tax Rate

Figure A.4: Correlation: Gasoline Tax

Figure A.5: Cigarette Tax Rate

Figure A.6: Correlation: Cigarette Tax
A.5 The Slope of the Reaction Function in the Vertical Externality Case

Here, we would like to express the slope of the reaction function in the vertical externality case. For simplicity, we assume there is no cross border shopping; that is $s_i^1 = 1$ and $s_i^j = 0$. This is an extreme example, but it gives a clear idea of the important factors for vertical tax externality. We estimated that the percentage of cross border shopping is around 5.8% for gasoline and 6.2% for cigarette, and this extreme assumption is not inappropriate. The numerator and denominator of the reaction function are expressed as follows.

\[
\frac{\partial^2 W_A}{\partial t_A^2} = \pi_2^2 A - \pi_1^1 \frac{\partial s_A^A}{\partial t_A} + \phi \frac{\partial^2 TR_A}{\partial t_A^2}
\]

(A)

\[
\frac{\partial^2 W_A}{\partial t_A \partial T} = \pi_2^2 A + \pi_1^1 \frac{\partial s_A^A}{t_A} + \phi \frac{\partial^2 TR_A}{\partial t_A \partial T}
\]

(B)

where

\[
\pi_2^2 = \left( \frac{\alpha_A}{x_A^A - \gamma_x} \frac{\partial^2 x_A^A}{\partial t_A^2} - \frac{\alpha_A}{(x_A^A - \gamma_x)^2} \left( \frac{\partial x_A^A}{\partial t_A} \right)^2 + \frac{1 - \alpha_A}{y_A^A} \frac{\partial^2 y_A^A}{\partial t_A^2} - \frac{1 - \alpha_A}{y_A^A} \left( \frac{\partial y_A^A}{\partial t_A} \right)^2 \right)
\]

\[
= -2 \frac{\alpha_A}{x_A^A - \gamma_x} \frac{x_A^A}{P_A^A} \varepsilon - \frac{\alpha_A}{(x_A^A - \gamma_x)^2} \frac{x_A^A}{P_A^A} \varepsilon^2 - \frac{1 - \alpha_A}{y_A^A} \left( \frac{\partial y_A^A}{\partial t_A} \right)^2
\]

\[
\pi_1^1 = \left( \frac{\alpha_A}{x_A^A - \gamma_x} \frac{\partial x_A^A}{\partial t_A} + \frac{1 - \alpha_A}{y_A^A} \frac{\partial y_A^A}{\partial t_A} \right)
\]

\[
= \frac{\alpha_A}{x_A^A - \gamma_x} \frac{x_A^A}{P_A^\varepsilon} + \frac{1 - \alpha_A}{y_A^A} \frac{\partial y_A^A}{\partial t_A}
\]

\[
\frac{\partial^2 TR_A}{\partial t_A^2} = \frac{\partial^2 x_A^A}{\partial t_A^2} t_A + 2 \frac{\partial x_A^A}{\partial t_A}
\]

\[
= -2 \frac{x_A^A}{P_A^A} \varepsilon t_A + 2 \frac{x_A^A}{P_A^\varepsilon}
\]

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\[
\frac{\partial^2 TR_A}{\partial t_A \partial T} = \frac{\partial^2 x_A^A}{\partial t_A^2} t_A + \frac{\partial x_A^A}{\partial t_A} \\
= -2 \frac{x_A^A}{P_A} \varepsilon t_A + \frac{x_A^A}{P_A} \varepsilon
\]

From the first order condition,

\[
\frac{\partial W_A}{\partial t_A} = \pi_A s_A^A + \phi \frac{\partial TR_A}{\partial t_A} = 0
\]

\[
\phi = \frac{\pi_1 A}{x_A^A (\varepsilon t_A/P_A + 1)}
\]

If we omit the part of \(y_A^A\) term and assume \(\frac{\partial s_A^A}{\partial t_A} = \frac{\partial s_A^A}{\partial T} = 0\) for simplicity,

\[
\frac{\partial^2 W_A}{\partial t_A^2} = \frac{\alpha_A}{x_A^A - \gamma_x} \frac{x_A^A}{P_A^2} \left( -2 \varepsilon - \frac{x_A^A}{x_A^A - \gamma_x} \varepsilon^2 - 2 \left( \frac{P_A - t_A}{P_A + t_A \varepsilon} \right) \varepsilon^2 \right) \quad (A')
\]

\[
\frac{\partial^2 W_A}{\partial t_A \partial T} = \frac{\alpha_A}{x_A^A - \gamma_x} \frac{x_A^A}{P_A^2} \left( -2 \varepsilon - \frac{x_A^A}{x_A^A - \gamma_x} \varepsilon^2 - \left( \frac{P_A - 2t_A}{P_A + t_A \varepsilon} \right) \varepsilon^2 \right) \quad (B')
\]

Then, the value of the slope of the reaction function becomes,

\[
\frac{\partial^2 W_A}{\partial t_A \partial T} = -2 - \frac{x_A^A}{x_A^A - \gamma_x} \varepsilon - \left( \frac{P_A - 2t_A}{P_A + t_A \varepsilon} \right) \varepsilon
\]

\[
\frac{\partial^2 W_A}{\partial t_A^2} = -2 - \frac{x_A^A}{x_A^A - \gamma_x} \varepsilon - 2 \left( \frac{P_A - t_A}{P_A + t_A \varepsilon} \right) \varepsilon
\]

\[
\frac{\partial^2 W_A}{\partial t_A \partial T} = -2 - \frac{x_A^A}{x_A^A - \gamma_x} \varepsilon - 2 \left( \frac{P_A - t_A}{P_A + t_A \varepsilon} \right) \varepsilon \quad (C)
\]

It is also interesting to see the value of the slope of the reaction function in vertical tax competition for the Leviathan case.

\[
\frac{\partial^2 TR_{GA}}{\partial t_A \partial T} = \frac{P_A - 2t_A}{-2(P_A - t_A)} \approx -\frac{1}{2} \quad (C')
\]