Three Essays on Fiscal Federalism and Market Structure

Agustin Redonda

Faculty of Economics

Università della Svizzera italiana, Switzerland

A thesis submitted for the degree of

Doctor of Philosophy in Economics

Lugano, June 2015

Doctoral committee:

Prof. Mario Jametti, Università della Svizzera italiana, Supervisor

Prof. Raphaël Parchet, Università della Svizzera italiana, Internal member

Prof. Marius Brülhart, Université de Lausanne, External member

Prof. Patrick Lenain, OECD, Université de Paris-Est Créteil, External member

A Marce y a Tomi que son mi cable a tierra y a mis viejos que, a pesar de la distancia, me apoyaron en todo...desde el principio y desde antes también.

Acknowledgements

I am grateful to my supervisor, Prof. Mario Jametti, for the patient guidance, encouragement and advice he has provided throughout my time as his student. I would also like to thank the other members of the thesis committee: Prof. Raphaël Parchet, Prof. Marius Brülhart and Prof. Patrick Lenain for having spent part of their time in providing precious suggestions on my research. Finally, a big thank to all my colleagues at IdEP for the great time we spent together during these years. Completing my thesis would have been all the more difficult without their support and friendship.

Introduction

This thesis assesses two different sub-fields inside public economics in general and taxation in particular: tax incidence and tax competition. The thesis is composed of three chapters. While the first chapter analyzes the incidence of taxes in the Canadian retail gasoline market, the second one focuses on the tax competition among Swiss cantons by assessing the impact of introducing a flat tax reform on profits on corporate location decisions. Finally, the third chapter aims at setting a comprehensive model merging these two strands of literature. Let me now give you a brief description of the three chapters.

In the first chapter, "The Power to Pass on Taxes - A Test for Tax Shifting Based on Observables" (with Mario Jametti and Anindya Sen), we devise a novel empirical test, based on observables, to assess whether taxes are under- or overshifted in an oligopolistic market. We apply our test to the Canadian retail gasoline market using a panel data set of 10 cities for the 1991 – 1997 period. Since gasoline has a relatively inelastic demand, raising government revenue via gasoline taxes could appear appropriate as it entails a relatively small deadweight loss. However, the Canadian gasoline retail is a highly concentrated market and, hence, the assumption of perfect competition when considering tax incidence might be misleading. Theoretically, in oligopolistic markets taxes can be shifted forward less (more) than proportionally to retail prices; a possibility usually denoted by undershifting (overshifting). Generally, this depends on unobservable parameters of the demand and cost functions. Our test suggests that the under-/overshifting of taxes can be empirically determined by the sign of an interaction term between tax rates and market structure. When taking our test to data, our results suggest that, in Canada, gasoline taxes are undershifted.

The second chapter, "*Corporate Flat Tax Reforms and Firms' Location Choices. Evidence from Switzerland*" (with Sergio Galletta), empirically assesses corporate tax competition by analyzing the impact of a flat-tax reform on profit taxation on firms' location decisions in Switzerland. Our identification strategy is based on the observed trend in the Confederation where, since 1990, several cantons have been switching from a graduated rate tax (GRT) scheme on profits to a flat rate tax (FRT) system. We thus exploit the different timing of the introduction of these reforms by Swiss cantons to estimate the impact on the stock of firms in Swiss municipalities (and cantons) by applying a panel-based differences-in-differences approach. Our results show that the introduction of a flat-tax reform on corporate taxes has a negative (rather small) impact on the number of firms in a given jurisdiction. Interestingly, this effect is considerably larger for small firms. The latter result confirms the existence of an insurance effect suggesting that the progressivity of the tax system has a positive effect on the number of firms because it acts as an insurance for risk-averse entrepreneurs.

As suggested by the title, the third chapter, "*Market structure and the functional form of demand, the missing links between tax incidence and tax competition*", merges tax incidence and tax competition frameworks and, hence, links the two first chapters of this thesis. These two strands of literature have largely been studied separately. Tax incidence settings do not consider any strategic interactions (neither horizontal nor vertical) and exclusively assess the pass-through of taxes to prices. These models focus on imperfectly competitive markets where prices can react more (less) than proportionally to a variation in tax rates. On the other hand, tax competition settings focus on the strategic interactions arising because of a shared tax base but assume producer prices to be constant. Thus, the pass-through of taxes is restricted to be fully on consumers. This chapter sets a theoretical framework where the tax setting is endogenized and local governments internalize the possibility that taxes are overshifted (undershifted). The contribution of the chapter is twofold. First it formalizes the correspondence between the over-/under shifting condition from tax incidence models and the strategic complementarity/substitutability result from tax competition settings. Second, by relaxing the standard assumption in tax competition models that producer prices are constant, the model explicitly allows the pass-through of taxes to play a key role in the tax setting process. In particular, by accounting for the impact of market structure on the sensitivity of the vertical reaction function that was previously ruled out in previous tax competition studies.

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Chapter 1

The Power to Pass on Taxes - A Test for Tax Shifting based on Observables

1.1 Introduction

Most countries tax gasoline, although to varying degrees. Since gasoline has a relatively inelastic demand, raising government revenue via gasoline taxes could appear appropriate as it entails a relatively small deadweight loss. However, gasoline retail is generally a highly concentrated market leading to prices that are significantly above marginal cost. Hence, tax incidence analysis based on the assumption of perfectly competitive markets might be misleading. Whereas in long-run equilibrium, under perfect competition, taxes are passed on fully to consumers (are fully shifted), the situation in oligopolistic markets is different. Taxes can either be shifted forward less or more than proportionally to retail prices, i.e. they can be *under-* or *overshifted*.

The condition whether taxes are under- or overshifted depends theoretically on parameters of the demand and cost functions. These are often unobservable to the econometrician or inherently difficult to estimate. In this paper we devise a novel empirical test, based on observables, to identify whether a market presents under-, full or overshifting. We show that whether a particular market displays under- or overshifting can be assessed by the sign of an interaction term between tax rates and market structure. We then take our test to data. We use a dataset on the Canadian retail gasoline market comprising monthly observations from 10 Canadian cities over the $1991-1997$ period. In Canada gasoline is taxed both at the federal and provincial levels. The market is dominated by a few vertically integrated national (global) players implying a significant level of market concentration. This also holds at the local level possibly due to cost advantages from vertical integration or other barriers to entry. Both variation across time (including several provincial tax changes) and across locations help us identify our coefficients of interest.

Our results suggest that the direct effect of taxes is not statistically different from 1 indicating, in line with theory, that, under perfect competition, gasoline taxes in the Canadian retail market are fully shifted to consumers. Similarly, as expected, an increase in market concentration - measured through changes to city specific Herfindahl-Hirschman Indices - raises prices. Our main coefficient of interest, the interaction term between the Herfindahl-Hirschman Index and excise tax rates, is negative and, in most specifications, statistically significant. This implies that taxes in the Canadian retail gasoline market are undershifted. We apply a series of robustness checks including alternative specifications for inference and controlling for the potential endogeneity of taxes and market structure. Our results are robust.

Assessing tax incidence in the gasoline market is of particular concern for policy analysis. First, gasoline is an important input. Moreover, in recent years, gasoline taxation has been one of the main tools to encourage rolling back CO2 emissions.[1] Finally, the financial crisis of 2008 has considerably increased pressure on governments all around the world to reduce budget deficits. From this point of view, gasoline taxes might play an important role as a source of revenues for both local and central governments.[2]

Further, we would argue that our results point to a potentially important omission in earlier analyses of tax incidence in oligopolistic markets. First, most empirical applications either implicitly or explicitly assume perfectly competitive markets, or they cursorie control for market structure (via a main effect). We show that not accounting for the interdependence of market structure and taxes by not including an interaction term might result in a misspecified model. In our study, not accounting for the differential effect of taxes depending on market structure results in an underestimation of tax incidence (evaluated at the mean of HHI) of around 20%. Similarly, in our sample, tax incidence varies from not significantly different from full absorption by producers in the most concentrated markets, to not significantly different from full shifting in the least concentrated ones. Thus, policy conclusions might need to be adapted depending on the degree of (local) market concentration. Finally, a point estimate of tax incidence without appropriately controlling for market structure might produce a coefficient larger than but not statistically different from one. Such an estimate might lead authors to conclude that taxes are fully shifted, when indeed they are overshifted. We would argue that our test is a more precise instrument to assess tax incidence leading to potentially improved policy conclusions.

The rest of the paper is structured as follows. In Section 1.2 we present the existing literature in the field. Section 1.3 gives a brief description of the gasoline industry and taxes in Canada.

[1] See, for example, Palazzi (2011).

[2] As mentioned in the OECD Tax Database, currently around 4% of total tax revenue in Canada comes from environmentally related taxes.

In Section 1.4 we describe our dataset and the empirical framework. In Section 1.5, we discuss our main results and illustrate the potential of inadequate policy conclusions. Finally, Section 1.6, provides some concluding remarks.

1.2 Literature background

Krzyzaniak and Musgrave (1963) were among the first to suggest that in oligopolistic and monopolistic markets taxes could be overshifted to final prices. Subsequently, a number of theoretical papers have taken up this point.[3] Katz and Rosen (1985) showed that the Krzyzaniak-Musgrave result can be rationalized in a standard neoclassical model. They find that assuming competitive or monopolistic markets when indeed a sector is imperfectly competitive can lead to bias in the estimation of tax incidence. Further, they illustrate that tax incidence depends on market structure. Similarly, Seade (1985) introduces a cost-side shifter in the equilibrium solution of an oligopolistic market. Under oligopoly (and assuming linear costs), price overshifting turns out to be a likely scenario. Overshifting will occur "if and only if the elasticity of the slope of inverse demand (E) is greater than 1".[4] Note that this is always the case for an isoelastic demand. Besley (1989) extends Seade's paper by allowing for entry in the market. He finds that there is undershifting if the demand function is concave and there is overshifting if it is convex. Also, overshifting is more likely under free entry. Delipalla and Keen (1992) compare the incidence of excise and *ad valorem* taxes in two oligopoly models, with and without free entry finding that that specific taxes are more likely to be overshifted than *ad valorem* ones. Finally, Anderson et al. (2001) extend Delipalla and Keen (1992) by studying the incidence of *ad valorem* and excise taxes in an oligopolistic industry allowing for product differentiation and price-setting firms *à la* Bertrand. Interestingly, their results are very close to those of a Cournot model with homogeneous products.

Summarizing these contributions, the pass-through of taxes or the presence of under- or overshifting generally depends on the functional form of the demand and the cost functions, i.e parameters that are not directly observable to the econometrician. Based on the theoretical literature above, we derive a test to detect whether a particular market displays under- or overshifting which depends on observables, namely on the interaction between taxes and market structure.[5]

Tax incidence and market structure have also been studied empirically. An early contribution is Harris (1987). The author studies the 1983 federal cigarette tax increase in the United States.

[3] A more detailed review can be found in Fullerton and Metcalf (2002).

[4] Seade (1985), p.28.

[5] In Subsection 1.4.2 we give the intuition of the theoretical background behind our test that is formally derived in the Appendix.

He finds that the 36% increase in the real price of a pack of cigarettes (adjusted for general inflation) was mainly explained by the raise in prices charged by the major U.S. manufacturers and not by the increase in the federal excise tax. Besley and Rosen (1999) examine the incidence of sales taxes for 12 commodities in 155 U.S. cities over the $1982-1990$ period and examine the extent to which differences in tax rates and bases are reflected in prices. They find variation in the shifting patterns. For some commodities they cannot reject full shifting but for others they find overshifting. Delipalla and O'Donnell (2001) analyze the incidence of *ad valorem* and specific taxes in the European cigarette market. Basing their analysis on data from the 12 members of the E.U., prior to its expansion in 1995, they find that commodity taxes are not always fully shifted to consumers. Indeed, they show that taxes are overshifted in southern European countries, but there is undershifting in the north of Europe where the pressure of the health lobby is stronger. Moreover, their results reject both extremes, i.e. perfect competition and collusive behavior.

Two papers among the large literature on gasoline tax incidence are of particular interest for our study. Chouinard and Perloff (2007) study price differences across U.S. states. They find that most of the increase in national gasoline prices over the 1990s is explained by a rise in the price of crude oil. Other factors such as taxes and market power did not have a significant impact on the price increase observed during that decade. On the other hand, differences among states in retail gasoline prices are largely explained by variations in taxes and market power. More recently, Marion and Muehlegger (2011) analyze the pass-through rate of federal and state gasoline and diesel taxes to retail prices, focusing on the dependence of the shifting on factors constraining the gasoline and diesel supply chains. They find full pass-through of both state and federal taxes for both gasoline and diesel in most of their specifications. In addition, the authors find that the observed pass-through is immediately translated into final prices. Contrary to our study, none of these papers consider the interplay between the effect of taxes and market structure explicitly and most of them do not even control for market structure. Indeed, some papers implicitly (or explicitly) make the assumption of perfectly competitive markets.

The closest study to ours is Sen (2001). The paper investigates the presence of overshifting in cigarette retail prices using data for 10 Canadian provinces from 1982 to 2002. He focuses on whether the presence of overshifting can be attributed to signs of collusion in the industry. The author finds overshifting of provincial taxes but not of federal ones. Moreover, he cannot attribute the overreaction of prices to provincial taxes directly to collusion. We abstract from the collusion hypothesis, but focus instead on the interdependence of market structure and tax incidence which is, once again, absent in Sen's paper.

1.3 The gasoline industry and taxes in Canada

The retail gasoline market in Canada is composed of three different categories of firms: major vertically-integrated, regional and independent firms.[6] Vertically-integrated firms such as Petro-Canada, Shell and Esso conduct crude exploration, production and development operations as well as downstream refining and retailing, operating at a national level. Regional firms also conduct integrated upstream and downstream activities but are geographically limited. For instance, Irving Oil and Ultramar operate in eastern Canada, whereas Husky is located in the Prairies and the West. Together, majors and regionals account for roughly 80% of all retail sales. Finally, independent firms (e.g. Cango in Ottawa and Domo in Vancouver) and super store retailers (Canadian Tire, Real Canadian Superstore, Save on Foods and Costco) do not own refineries and exclusively conduct downstream retailing.

Retailers considerably decreased during the 1990s from $22,000$ in 1989 to $13,250$ in 2000, i.e. a reduction of around 40%. Although majors have led the rationalization in terms of retail outlets and independents increased their proportion of retail sites, the market share of the latter ones decreased from 23% in 1990 to 18% in 1999 suggesting an increase in the degree of market concentration.[7] These stylized facts are consistent with the following observation noted by the Board's report "the gasoline industry in Canada has a limited number of key players who, through their vertical integration and sheer size, are often expected to have power in the marketplace [and] differences in gasoline prices between cities are generally influenced by the different competitive conditions found at the street level."[8]

Finally, as mentioned in the same report, besides the barriers to entry that are usually present in the gasoline industry (such as economies of scale and capital requirements), costs to both entering and exiting the retail business considerably increased during the 1990s. New environmental regulations were implemented increasing the cost of opening a retail outlet and entry was discouraged by decreasing retail margins throughout most of the decade.

Taxes are the largest component of the pump price in Canada. In 2000, retail gasoline prices consisted of three major components: taxes, crude oil and a refining/marketing component with taxes representing, on average, around 42% of the price. Gasoline taxes in Canada can be divided as follows: federal and provincial excise taxes; the Goods and Services Tax (GST); as well as the Provincial Sales Taxes (PST), where applicable. The federal excise tax is imposed across Canada and added on to the other price components of gasoline (crude oil, refining margin and retail margin). In addition, a similar (excise) tax on gasoline is also levied by provincial governments.

[6] This section is based on the comprehensive review conducted by The Conference Board of Canada. The report gives an overview of the industry during the 1980s and 1990s covering the sample period of our analysis.

[7] See also Sen and Townley (2010).

[8] The Conference Board of Canada (2001), piii.

Moreover, the GST is levied on all components of the price of gasoline. All Canadian provinces pay the GST, although for New Brunswick, Nova Scotia and Newfoundland it is part of the Harmonized Sales Tax (HST). Quebec is the only province in Canada to explicitly charge a Provincial Sales Tax (PST). The PST is an *ad valorem* tax and is calculated on the total cost of gasoline. Finally, some Canadian cities apply their own transit (flat) taxes on retail gasoline.

To sum up, although roughly 80% of sales belong to national and regional retailers, concentration varies across cities and time likely due to differences in market shares of independent and super store retailers. Moreover, gasoline is taxed both at the federal and provincial levels. Provinces are completely free to set their taxes, implying significant variation across cities. Hence, Canada presents an almost ideal setting to test our theory.

To illustrate the variation in our raw data we have divided Canada in four geographical regions: Eastern Canada, Quebec, Ontario and Western Canada. Figure 1.1 illustrates the evolution of (final) retail prices for the four regions. All of them show decreasing retail prices

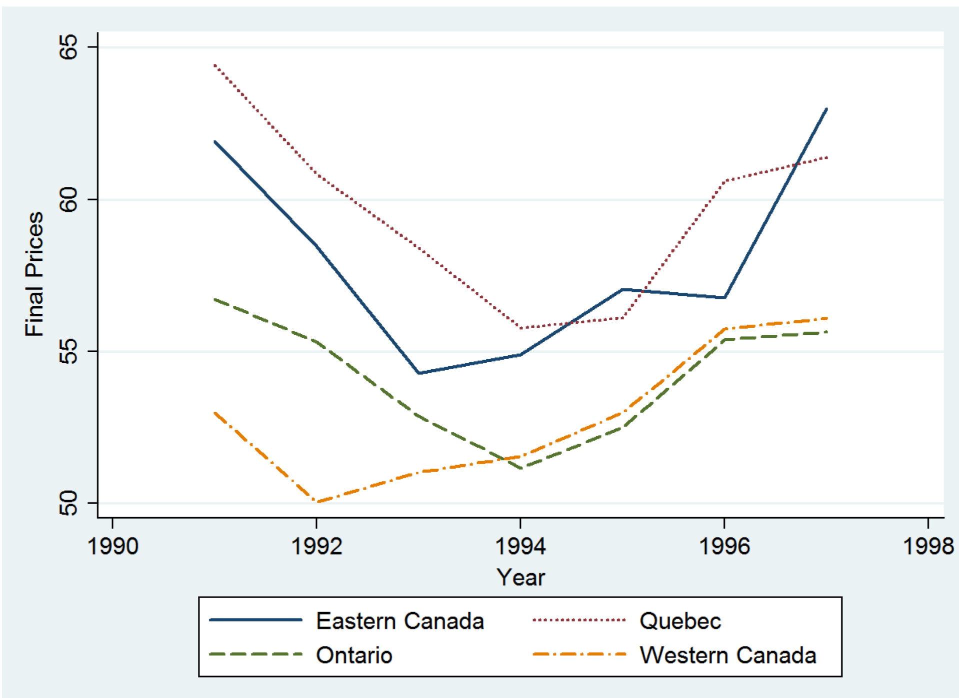

Figure 1.1: Time evolution of prices

Source: The Kent Group

at the beginning of the period and an increasing trend afterwards. Though the inflection year varies for the different regions, i.e. while final prices in Western Canada started increasing in 1992; in Quebec they started augmenting only in 1995. Moreover, taking the two extremes of the time line covered by our sample (1991 and 1997), we observe that final prices in both

Eastern Canada and Ontario remained almost constant while they increased in Western Canada and diminished in Quebec. In the left panel of Figure 1.2 we display the evolution of market concentration (measured by the Hirschmann-Herfindahl Index, HHI) across the period covered in our dataset.[9] Interestingly, we observe different patterns. The highest concentration is found in

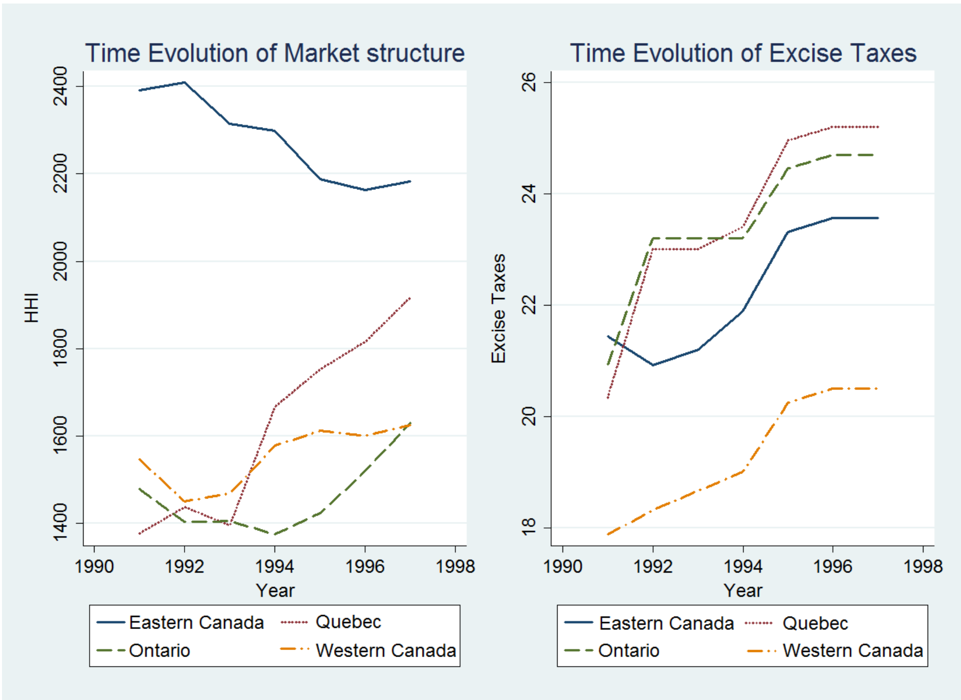

Figure 1.2: Time evolution of market concentration and excise taxes

Source: The Kent Group and own calculations

Eastern Canada with HHI values above 2,000, although with a slight decrease of concentration over time. All other regions have witnessed rationalisation over the period, implying increasing concentration levels. The steepest wave of concentration belongs to Quebec, holding the lowest levels of market concentration (HHI below 1,400) at the beginning of the 1990s, but ending up with an HHI close to 2,000 by 1997. Both Ontario and Western Canada experienced market concentration but at lesser rates than Quebec. On the right panel of Figure 1.2 we plot the evolution of excise taxes (in cents per litre) for the four regions. Taxes have generally increased

[9] The Hirschmann-Herfindahl Indeces are computed as the sum squared of firm specific market shares and are a common measure of market concentration used by antitrust agencies such as the Federal Trade Commission and the Department of Justice, especially with respect to merger analysis. Hence, a monopoly would result in an HHI of 10,000. As detailed in the U.S. Department of Justice's website (http://www.justice.gov/atr/public/guidelines/hhi.html), antitrust agencies generally consider markets in which the HHI is between 1,500 and 2,500 points to be moderately concentrated, and markets in which the HHI is in excess of 2,500 points to be highly concentrated.

over the period but at differing rates across regions. While Eastern Canada taxed gasoline at the highest levels in 1991, they were overtaken by Quebec and Ontario subsequently. Also noteworthy is that the spread of excise taxes has slightly increased over time by roughly one cent per litre. Figure 1.3 illustrates the relation between final prices and market concentration (left panel) and excise taxes (right panel). Both variables display a positive effect on prices, as

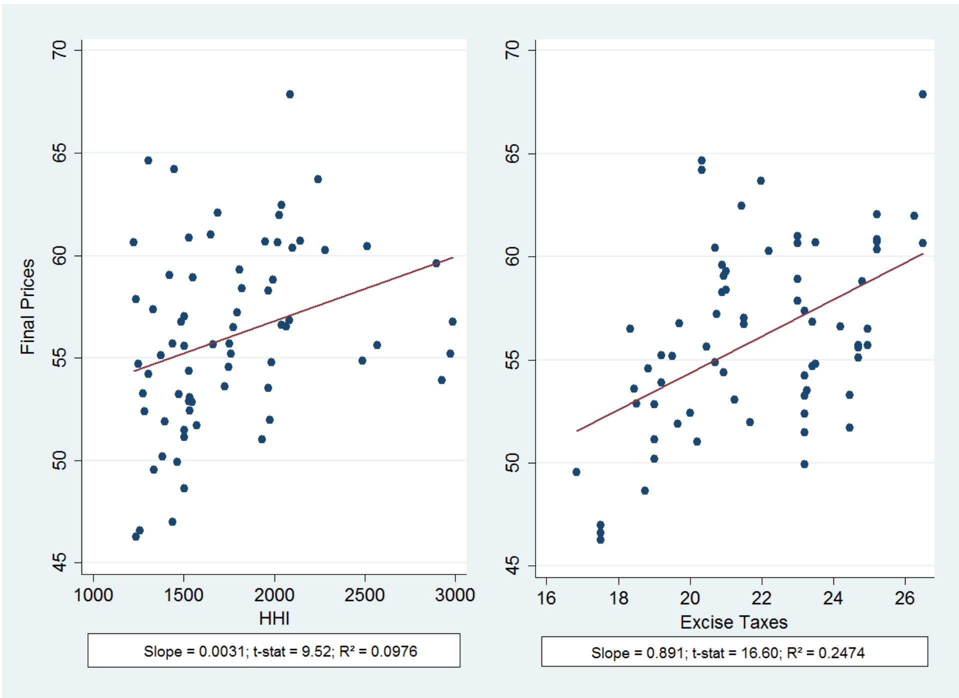

Figure 1.3: Prices, excise taxes and market concentration

Source: The Kent Group and own calculations

expected. The raw correlation coefficients are 0.27 for market concentration and 0.43 for taxes.

Table 1.1 offers more illustration in the variation on firm specific market shares resulting in corresponding changes in city specific HHIs. The table explores the impact of rationalization by documenting firms operating in each city at the sample period end points (1991 and 1007) and their respective market shares calculated from sales volume and the number of outlets. To preserve confidentiality, market shares are stated by firm type (major, regional and independent). Broadly speaking, the table supports the widely held view that rationalization of outlets was mainly conducted by vertically integrated firms. Specifically, the share of outlets owned by major vertically integrated firms declined between 1991 and 1997 in many cities, while the market shares of these firms (measured by sales volumes) actually increased.

Table 1.1: Distribution of industry market shares

City Year	Firms; Market share (Sales volume, Branches) Major	Regional	Independents
Calgary	Esso, Petro-Canada, Shell	Co-op (west), Husky	Canadian Tire, Superstore, Mohawk, Domo
1991	53%, 56%	28%, 28%	19%, 16%
1997	60%, 60%	20%, 16%	20%, 24%
Halifax	Esso, Petro-Canada, Shell	Ultramar, Irving	Wilsons
1991	54%, 47%	43%, 49%	3%, 4%
1997	60%, 44%	36%, 48%	4%, 8%
Montreal	Esso, Petro-Canada, Shell	Ultramar, Sunoco	Sergaz, Olco, Canadian Tire, Super Gaz, Perrette Gaz, U/B, Couche Tard, Crevier
1991	55%, 42%	19%, 11%	26%, 37%
1997	57%, 46%	27%, 10%	16%, 44%
Ottawa	Esso, Petro-Canada, Shell	Ultramar, Sunoco	Sunnys, Sunoco, U/B, Canadian Tire, Top Valu, Mr. Gas, Ultramar, Pioneer, Macewen
1991	57%, 52%	9%, 11%	35%, 37%
1997	62%, 46%	9%, 10%	29%, 44%
Quebec	Esso, Petro-Canada, Shell	Irving, Ultramar, Sunoco	Canadian Tire, Olco, Perrette Gaz, Eko, I.G.S., U/B, Sonic, Couche Tard
1991	54%, 55%	27%, 21%	19%, 24%
1997	74%, 59%	13%	13%
Saint John	Esso, Petro-Canada, Shell	Irving, Ultramar	Canadian Tire, Co-op (East), Metro
1991	32%	54%	14%
1997	27%	50%	23%
St. John's	Esso, Petro-Canada, Shell	Ultramar, Irving	G.E.O, Co-op (East)
1991	38%, 33%	50%, 53%	12%, 14%
1997	37%, 36%	47%, 54%	16%, 10%
Toronto	Esso, Petro-Canada, Shell	Sunoco	Canadian Tire, U/B, Sunys, Cango, V Plus, Olco, Penny Fuels
1991	64%, 68%	10%, 10%	26%, 22%
1997	69%, 60%	9%, 8%	22%, 32%
Vancouver	Esso, Petro-Canada, Shell	Chevron, Turbo	Supersave, Mohawk, Domo, U/B
1991	60%, 58%	25%, 24%	15%, 16%
1997	57%, 54%	27%, 23%	16%, 23%
Winnipeg	Esso, Petro-Canada, Shell	Turbo, Co-op (west), Husky	Domo, Tempo, Canadian Tire, Supersave
1991	58%, 54%	11%, 11%	31%, 35%
1997	59%, 54%	10%, 9%	31%, 33%

Finally, Figure 1.4 illustrates graphically our test. We plot again the relation between taxes and prices dividing the sample into low and high concentrated markets.[10] Further, we fit a simple regression line through the scatter plot for each type of market. In the graph, our test corresponds to comparing the slope coefficients of the fitted lines between low and high concentrated markets (indicated in the figure). We observe that the pass-through of taxes to final prices is slightly lower for high concentrated markets (0.76) than for low concentrated ones (0.81). Thus, the effect of taxes on prices decreases with market concentration, suggesting that the Canadian retail gasoline market undershifts taxes. In the following sections, we intend

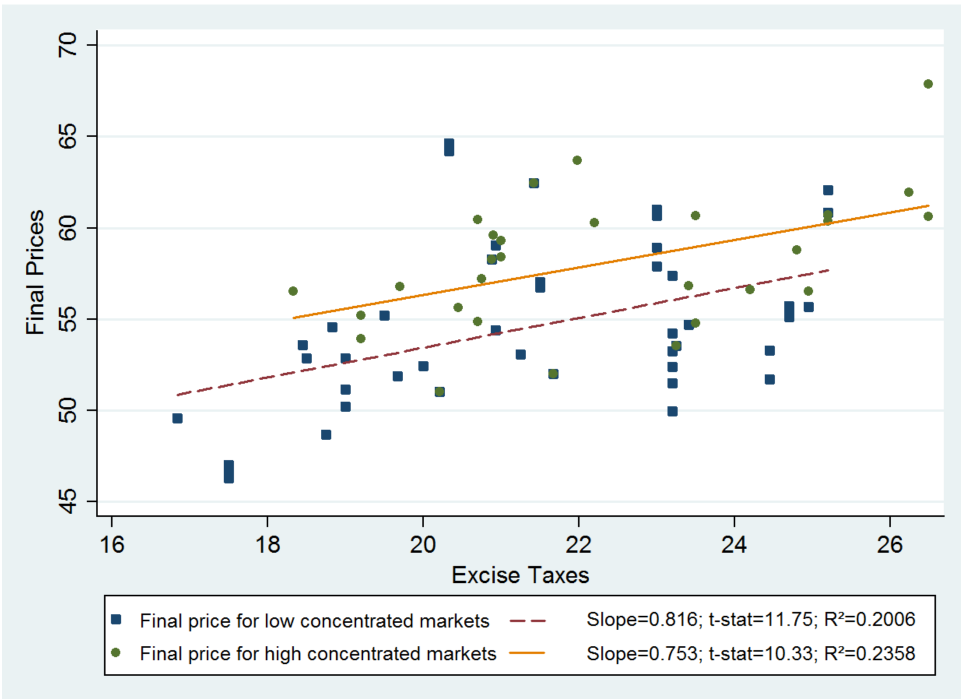

Figure 1.4: Prices and taxes for low and highly concentrated markets

Source: The Kent Group and own calculations

to study the relationship between prices, excise taxes and market concentration using formal econometric models.

[10]The sample is divided along the median.

1.4 Data and empirical framework

1.4.1 Data

Our dataset consists of monthly observations for the period $1991 - 1997$ of ten of the main cities in Canada.[11] The three main variables are those concerning gasoline prices, taxes and the gasoline retail market structure. We obtained retail prices (the dependent variable) from the Weekly Pump Price Survey (WPPS) of MJ Ervin & Associates.[12] This is a survey of Tuesday morning prices for retail gasoline in more than 50 Canadian cities. We use city-level monthly averages and prices are final pump prices including all taxes.[13]

Our main tax variable, *excise*, accounts for federal and provincial excise taxes.[14] We use the standard Hirschmann-Herfindahl Index (HHI) as our market concentration measure and hence, as an index of competition.[15] There are obvious concerns about using a market wide measure of competition, as opposed to more local constructs, as is the case with some recent U.S. studies.[16] However, there are differences between Canada an the United States. First, a significant portion of Canada's population (roughly 80%) lives in urban areas. Second, studies have found a good

[11]The cities in our database are: Calgary, Halifax, Montreal, Ottawa, Quebec, Saint John, St. Johns, Toronto, Vancouver and Winnipeg.

[12]MJ Ervin & Associates is a division of the Kent Group. MJ Ervin & Associates collected data on retail and wholesale prices from a weekly 38 Canadian City survey reaching over 400 outlets.These data are routinely used by government as well as industry. For further details, please consult *http://www.kentmarketingservices.com/*. It is our understanding that their sample has remained more or less constant over time. Thus, we expect their computed average price to be an unbiased estimate of the true overall city average price at each point in time.

[13]Such taxes include the Goods and Services Tax (GST). Since the GST is also applied to excise taxes, one could argue that using final prices biases our results towards finding overshifting of taxes as any (excise) tax increase would be multiplied by one plus the GST into final prices. We are not particularly worried about this issue, mainly because the GST is a level effect and it is not clear that it should affect our coefficient of interest, namely the interaction of taxes and market structure. We would, indeed, argue that this could be seen as an advantage of our test.

[14]We restrict our analysis to variation of provincial and federal excise taxes as the *ad valorem* sales tax component, whether in terms of GST, PST or HST is a relatively small portion of final per litre retail prices. Indeed, our summary statistics show that excise taxes constitute 62% of final retail prices. Nevertheless, as a robustness check, we also carried out the estimations using two additional tax variables: *state* that only accounts for excise taxes at the provincial level and *both*, a broader tax variable including federal and excise taxes and the goods and services tax (GST) converted into dollar equivalents. Results do not significantly differ and are available upon request.

[15]Again, information on market concentration and the number of stations was obtained from The Kent Group that provides this information from all outlets in the markets it surveys. There might be valid concerns if the number of outlets surveyed is limited, which would result in a biased estimate of firm specific market shares. However, ober our sample period, The Kent Group collected data from over $8,000$ retail outlets. Our understanding is that almost all outlets are regularly surveyed for each of the cities in our sample.

[16]See, for example, Lewis (2008).

deal of uniformity of gasoline prices within Canadian cities, which is consistent with the presence of a large commuter population.[17] In other words, while rational drivers should not be willing to drive large distances to search for slightly lower gasoline prices, the marginal cost of such a search is low if they happen to drive between home and work and are able to observe differences in gasoline prices during their journey. Third, informal conversations with operators of outlets affiliated with vertically integrated firms, suggest that local affiliates have in most cases, very little or no discretion at all in setting retail prices, which are set by the regional office of the firm. Further, the consensus was that retail prices are uniform within cities.

We include a number of control variables as well. Gasoline wholesale prices and the number of gasoline stations control for supply-side characteristics. The wholesale price is also reported in the WPPS and is highly correlated with crude oil price suggesting that it captures both the effects from the Canadian wholesale and the international crude oil markets. Thus, we decided not to include crude oil price as a regressor. Finally, we also control for demand side aspects by including per capita gasoline consumption, average income at the provincial level and demographic controls (provincial unemployment rates, *population*, percentage of youths between 15 and 24 years old). Table 1.2 presents summary statistics.

Table 1.2: Summary statistics

Variable	Units	N	Mean	Std. Dev.	Min.	Max.
Final retail price including taxes	¢/litre	840	56.05	5.13	38.67	72.93
State excise tax	¢/litre	840	12.78	2.30	7	16.5
Federal and State excise taxes	¢/litre	840	21.89	2.52	15.5	26.5
Herfindahl Hirschiman Index	0-10.000	840	1766.7	440.5	1196.1	3051.4
Wholesale price of gasoline	¢/litre	840	23.29	2.88	15.24	37.9
Per capita consumption of gasoline	litres (in 1.000)	840	0.20	0.07	0.07	0.50
Total number of stations	1.000	840	0.34	0.35	0.05	1.42
Population	100.000	840	13.22	13.37	1.28	44.99
Prop. population aged 15-24	%	840	14.00	1.74	9.30	19.27
Unemployment rate	%	840	11.39	3.28	5.4	21.5
Average annual income	C$ (in 1.000)	840	44.71	6.69	33.8	55.8
Share of seats pol. party in power	%	840	65.71	9.46	52	87.27
Both lib. in power	Dummy	840	0.32	0.47	0	1
Both conserv. in power	Dummy	840	0.60	0.24	0	1

[17] See The Conference Board of Canada (2001).

1.4.2 Empirical framework

We estimate the following model:

$$Price_{it} = \beta_0 + \beta_1 Excise_{it} + \beta_2 HHI_{it} + \beta_3 Excise_{it} * HHI_{it} + \mathbf{X}'_{it}\beta + \epsilon_{it}, \qquad (1.1)$$

where $Price_{it}$ denotes retail prices including taxes in city i at year t. $Excise_{it}$ accounts for both federal and provincial excise taxes, HHI_{it} is the Hirschman-Herfindahl Index and $\mathbf{X}_{it}$ is the set of control variables described above.[18]

Let us now briefly give the flavor of the theoretical background behind our model.[19] We base the the introduction of the interaction term between tax rates and market structure on a simple Cournot oligopoly model such as the one developed in Besley (1989). The standard tax incidence condition derived in previous tax incidence models shows that the effect of taxes on prices, in general, depends on market structure (proxied by the number of firms in the industry, N) as follows:

$$\frac{\partial p}{\partial \tau} = \frac{N}{N + (\eta + k)} \begin{cases} < 1 & \Rightarrow \textit{undershifting} \\ = 1 & \Rightarrow \textit{full shifting} \\ > 1 & \Rightarrow \textit{overshifting} \end{cases} \qquad (1.2)$$

where, following Seade (1980), we define $\eta = \frac{Qp''}{p'}$ as the elasticity of the slope of the inverse demand and $k = 1 - \frac{c''}{p'}$ represents the relative slopes of the demand and marginal cost curves.[20] As we can observe from equation (), while N affects the degree of the shifting, the sign of $(\eta + k)$ tells us whether we are in presence of under- or overshifting. Moreover, by taking the derivative of the tax incidence condition with respect to N (for given values of η and k), we get:

$$\frac{\partial \left(\frac{\partial p}{\partial \tau}\right)}{\partial N} = \frac{(\eta + k)}{(\eta + N + k)^2} \qquad (1.3)$$

The sign of equation (1.3) equals the sign of $(\eta + k)$ which, at the same time, determines the under- overshifting condition. Interestingly, the empirical counterpart of this cross-derivative is an interaction term of tax rates and market structure in a regression equation.

Now, as is usual in an empirical context, market structure is often characterized by a concentration measure, such as the Herfindahl-Hirschmann Index (HHI), which is an inverse function of N. Therefore, the interaction term of taxes with a concentration measure indicates the *opposite*

[18]In order to simplify the interpretation of the estimates, we re-scale HHI between 0 and 1.

[19]The theoretical background is formally derived in the Appendix.

[20]Standard tax incidence notation is used. Thus, p is the consumer price, q is the output of a given symmetric firm and $Q \equiv Nq$ denotes the total output of the industry. Finally, τ is an excise tax on q and $c(q)$ is the cost function.

sign of $(\eta + k)$ which, in turn, determines whether taxes are under- or overshifted to consumer prices.

This is, in a few lines, the theoretical background behind our test. The main feature of this empirical test is that it will allow the econometrician to assess whether taxes are under- or overshifted in a particular market based on observables. Indeed, in a price-regression framework the sign of the coefficient of the interaction term between taxes and market concentration will inform about tax incidence. If the interaction term has a negative coefficient taxes are under-shifted, while if its sign is positive taxes are overshifted. An empirical application of our test is straightforward and requires variation in taxes and market structure in the relevant product market.

This is relevant, because, to our knowledge, no study of tax incidence in oligopolistic markets has included this specific interaction term (β_3); not even those that do control for market structure. To say it differently, previous studies on tax incidence measure the effect of taxes on *prices* through the coefficient β_1. Similarly, in these models, β_2 measures the effect of market concentration on retail prices. In our case, β_1 measures the direct pass-through effect of taxes under perfect competition, i.e. when $HHI = 0$ and β_2 accounts for the direct effect of market structure on *prices* when no tax is applied. We thus expect β_1 to be equal to 1 and β_2 to be positive. Finally, our main coefficient of interest is β_3, the coefficient of the interaction term that measures the effect of market concentration on the degree of tax shifting. Its empirical sign indicates whether we are in presence of under- or overshifting.

Inference

Our basic specifications present robust standard errors. However, it could be warranted to allow for other standard errors structures. A typical issue when working with time series (or panel data) is the presence of serial correlation. Newey-West standard errors allow the error structure to be heteroskedastic and possibly autocorrelated up to some lag. Another strategy in the same direction is to fit the model using Feasible Generalized Least Squares (FGLS). This strategy allows for the presence of AR(1) autocorrelation within panels and cross-sectional correlation and heteroskedasticity across panels.

Another possibility is to allow the error terms to be correlated within clusters. Clustering at the city level and computing cluster-robust standard errors seems straight forward in our model. Indeed, as it has been shown by Moulton (1990), the estimation of the covariance matrix without controlling for clustering can lead to understated standard errors and overstated statistical significance.[21] Under the usual assumptions, the OLS estimator is unbiased in small samples and normally distributed or consistent and approximately normally distributed when

[21] See also Moulton (1986), Wooldridge (2003) and Stock and Watson (2008) among others.

we work with a large number of clusters. In other words, the cluster-robust covariance matrix is consistent when the number of clusters tends to infinity. However, we are working with only 10 clusters. Thus the standard procedures for clustering might not be valid. An alternative is the application of the wild bootstrap method applied in Cameron et al. (2008).

Endogeneity

One could argue that two potential issues of endogeneity exist in our analysis. First, higher prices could encourage entry and thus impact market structure. Therefore, market concentration may be endogenous to *prices*. Second, coefficient estimates of the effects of taxes may be confounded because of simultaneity bias between taxes and *prices*. In other words, tax setting authorities might adjust tax rates given current prices. As such, we perform instrumental variables regression.

First, concerning market structure, we can expect P_{it} and HHI_{it} to be correlated but it is less likely that $Price_{it}$ and HHI_{it-1} or HHI_{it-2} are. Thus, we use the one- and two-periods lagged value of HHI_{it} as an instrument for market structure. Similarly, following the strategy implemented by Besley and Case (2000), we instrument taxes with the political party in power at the provincial level. Specifically, we use data on the share of seats of the political party in power in each province and an indicator whether the political party in power is the same at both the federal and provincial levels. The idea behind our strategy is that political parties may influence the set of policies to be implemented (including taxation) without having any direct relationship with retail prices.

1.5 Estimation and results

1.5.1 Preliminary results

We start in Table 1.3 repeating, with our sample, what has currently been done in the literature, i.e. we estimate equation (1.1) without the interaction term.

In column (1) we include city-specific fixed effects, while in column (2) we add quarterly dummies to capture seasonality. In column (3) we also include an overall time trend. Finally, in column (4) we omit the city level fixed effects and the overall time trend but allow for city-specific time trends. The overall fit of our model is good with R^2 of around 0.75.

Regarding the control variables, we observe that wholesale prices are an important determinant of retail prices. An increase of the wholesale price of 10 cents raises final prices by roughly 7 cents. Also, the impact of *wholesale* is rather persistent. The lagged value is still positive and highly significant, while the coefficient of the second lag is negative. The socio-economic controls reveal the expected signs. The unemployment rate, an indicator of the economic situation of the

Table 1.3: No interaction term - OLS and fixed effects estimates

	(1)	(2)	(3)	(4)
Excise	0.180*	0.188**	0.256**	0.182*
	[0.0954]	[0.0955]	[0.124]	[0.0957]
HHI	-5.199	-5.205	-5.798	-5.107
	[7.802]	[7.745]	[7.661]	[7.743]
Wholesale	0.669***	0.640***	0.644***	0.639***
	[0.0734]	[0.0785]	[0.0791]	[0.0785]
Wholesale_lag1	0.562***	0.540***	0.541***	0.540***
	[0.111]	[0.113]	[0.113]	[0.113]
Wholesale_lag2	-0.241***	-0.225***	-0.229***	-0.225***
	[0.0847]	[0.0833]	[0.0833]	[0.0833]
Unemployment rate	-0.311***	-0.326***	-0.356***	-0.324***
	[0.116]	[0.114]	[0.120]	[0.114]
Population	0.488**	0.542***	0.571***	0.555***
	[0.192]	[0.193]	[0.192]	[0.195]
Prop. aged 15 to 24	-0.221*	-0.218*	-0.264*	-0.214*
	[0.131]	[0.130]	[0.136]	[0.130]
Stations	9.856***	10.54***	9.698***	10.40***
	[3.170]	[3.250]	[3.413]	[3.192]
Gasoline cons. pp	-0.602	-1.785	-1.493	-1.866
	[3.062]	[3.009]	[3.034]	[3.009]
Average income	0.226**	0.235***	0.236***	0.236***
	[0.0888]	[0.0866]	[0.0866]	[0.0866]
City FE	YES	YES	YES	NO
Quarter FE	NO	YES	YES	YES
Time trend	NO	NO	YES	NO
City Specific Time trend	NO	NO	NO	YES
Observations	820	820	820	820
R^2	0.7433	0.7468	0.7471	0.7467

Notes: Intercept included in all regressions. The dependent variable is *final retail gasoline price*. Standard errors based on robust covariance matrices in brackets. R^2 overall where applicable.
* p<0.10, ** p<0.05, *** p<0.01

city, reduces *prices*, as does a higher share of young. *Population* instead increases *prices*, likely due to increased driving distances and levels of congestion in larger cities. Similarly, *average income* has a positive and significant effect on *prices*.

Of the supply side variables, only the number of stations has a significant effect on *prices*. Slightly contrary to expectations, a higher number of stations raises gas prices. We presume that this result is driven by the fact that larger cities have more stations but also higher demand.

Regarding our main coefficients of interest it is interesting to note that market concentration does not seem to affect retail prices as expected. The coefficient of HHI is negative but not statistically significant, suggesting that these specifications might be biased.

More importantly, *excise* exerts a positive and significant (at least at the 10%-level) effect on *prices* across all specifications. The magnitude of the coefficient is rather small. Taking the coefficient of column (3), an increase in *excise* of ten cents raises the final price by roughly 2.5 cents. Evaluated at the mean this implies an elasticity of *prices* with respect to *excise* of 0.07. These results suggest that we are in presence of undershifting and that retail prices react actually quite little to changes in taxes. However, these results do not take into account the possibility that the degree of tax shifting might vary with market concentration, to which we now turn.

1.5.2 Main results

Table 1.4 shows our main results. The specifications in column (1) to (4) are the same as in Table 1.3.

All the control variables have the identical signs and similar magnitudes. Again, only gasoline consumption is not statistically significant. Hence we will not discuss controls again and concentrate on our main coefficients.

The direct effect of excise taxes on final prices is, statistically significant and positive in all the specifications. Further, the magnitude of the coefficient varies very little across specifications and is around 1.3. This implies, taking the coefficient values of column (3), that under perfect competition ($HHI = 0$) a 10 cent increase in *excise* is associated with a 13.5 cent raise in *prices*. Thus, the results suggest overshifting of taxes even in competitive markets, which is contrary to theory. However, in none of the specifications we can reject that the main effect of *excise* is actually equal to one, i.e. that taxes are fully shifted when $HHI = 0$, as indicated in the last row of Table 1.4, where we test for $\beta_1 = 1$.[22]

Similarly, the direct effect of market structure on *prices* is statistically significant and positive, as expected. Again, the magnitude of the coefficient is robust across specifications and is

[22] An interpretation of $\beta_1 > 1$ could come from the fact that we are estimating out of sample, since we do not observe values of HHI close to 0 in our sample (see Table 1.2).

Table 1.4: Main results - OLS and fixed effects estimates

	(1)	(2)	(3)	(4)	(5)	(6)
Excise	1.361***	1.304***	1.348***	1.311***	1.772***	2.752**
	[0.343]	[0.340]	[0.357]	[0.340]	[0.384]	[1.297]
HHI	127.6***	120.4***	118.5***	121.9***	134.1***	228.0*
	[39.18]	[38.96]	[38.69]	[38.93]	[41.34]	[122.2]
Excise__HHI	-6.264***	-5.924***	-5.859***	-5.993***	-6.934***	-10.21*
	[1.793]	[1.793]	[1.782]	[1.793]	[1.908]	[5.806]
Wholesale	0.691***	0.663***	0.666***	0.663***	0.504***	1.484
	[0.0732]	[0.0784]	[0.0790]	[0.0783]	[0.0943]	[0.937]
Wholesale__lag1	0.547***	0.527***	0.527***	0.527***	0.552***	-0.355
	[0.111]	[0.113]	[0.113]	[0.113]	[0.126]	[0.727]
Wholesale__lag2	-0.204**	-0.191**	-0.194**	-0.190**	-0.320***	
	[0.0875]	[0.0858]	[0.0856]	[0.0858]	[0.0891]	
Unemployment rate	-0.241**	-0.259**	-0.284**	-0.256**	-0.432***	0.0987
	[0.120]	[0.118]	[0.123]	[0.118]	[0.153]	[0.809]
Population	0.462**	0.516***	0.540***	0.529***	0.477**	-2.197
	[0.198]	[0.199]	[0.197]	[0.201]	[0.204]	[4.996]
Prop. aged 15 to 24	-0.271**	-0.265**	-0.302**	-0.261**	-0.323**	-1.014
	[0.134]	[0.133]	[0.139]	[0.133]	[0.147]	[0.743]
Stations	11.17***	11.76***	11.05***	11.63***	9.068***	7.000
	[3.270]	[3.324]	[3.463]	[3.264]	[3.252]	[9.637]
Gasoline cons. pp	-1.028	-2.124	-1.880	-2.200	-1.594	54.81
	[3.012]	[2.969]	[2.992]	[2.968]	[3.284]	[179.1]
Average income	0.274***	0.281***	0.281***	0.282***	0.216**	-0.132
	[0.0872]	[0.0856]	[0.0855]	[0.0856]	[0.100]	[0.371]
City FE	YES	YES	YES	NO	NO	YES
Quarter FE	NO	YES	YES	YES	NO	NO
Year FE	NO	NO	NO	NO	YES	YES
City-Month FE	NO	NO	NO	NO	YES	NO
Time trend	NO	NO	YES	NO	NO	NO
City Specific Time trend	NO	NO	NO	YES	NO	NO
Observations	820	820	820	820	820	60
R^2	0.7474	0.7505	0.7507	0.7505	0.7923	0.8976
Test full shifting	1.10	0.80	0.95	0.83	4.04	1.83
	0.2933	0.3717	0.3297	0.3613	0.0444	0.1765

Notes: Intercept included in all regressions. The dependent variable is *final retail gasoline price*. Standard errors based on robust covariance matrices in brackets. R^2 overall where applicable.
Columns 1 to 5, based on monthly data. Column 6, based on yearly data.
Test for full shifting under perfect competition (excise = 1): χ^2 statistic above and P values below.
* p<0.10, ** p<0.05, *** p<0.01.

around 120. Thus, an increase in HHI of 0.1 implies a raise in *prices* of roughly 12 cents.[23]

Most importantly, the degree of tax shifting depends largely on market structure. Indeed, the coefficient of the interaction term between *excise* and HHI is negative and highly statistically significant. Again, its magnitude is robust across specifications and fluctuates around -6. This is quite an important effect. Evaluated at the mean of HHI ($= 0.18$) our results imply that a 10 cent increase in taxes is associated with a raise of 3.0 cents in final prices, a tremendous difference from the degree of tax shifting under perfect competition (13.5). Incidentally, the average effect of *excise* is slightly higher than the one estimated in the model without the interaction term ($= 0.25$). We return to the interpretation of the results in Section 1.5.4.

Based on our test, the negative sign of the interaction term between taxes and market concentration lets us conclude that excise taxes are undershifted in the Canadian retail gasoline market.

Finally, one could argue that our results are driven by the unit of observation, which is the city-month. This corresponds to the variation we observe for the HHI. Thus, we aggregated the weekly prices we avail of. It could be suspected that both market concentration and excise taxes vary little from month to month and that our coefficients are essentially identified on the cross-section dimension. Columns (5) and (6) of Table 1.3 show that this is not the case. In column (5) we included year fixed effects and a full subset of city-month fixed effects. Our results, do not change qualitatively. However, this is not our preferred specification, as we reject the null hypothesis of $\beta_1 = 1$.[24]

Finally, in column (6) we go in the other direction and estimate our model using yearly instead of monthly averages. Again, results do not change qualitatively although we, quite obviously, loose statistical precision.[25]

1.5.3 Robustness checks

We performed a battery of robustness checks of our main results. Table 1.5 presents alternative specifications of the error structure.

Column (1) repeats the results from column (3) in Table 1.4, which we take as our base specification for the robustness checks. In column (2) we use a random effects model. The next two columns address potential issues of autocorrelation. In column (3) we allow for Newey-West

[23] Recall that HHI in the estimation is re-scaled between 0 and 1. Hence, an increase in HHI of 0.1 represents a $1,000$ point increase in the usual scale.

[24] Furthermore, the magnitude of the coefficients of column (5) is larger for all main coefficients. By preferring the specification in column (3) we also take a somewhat conservative approach for discussion of results.

[25] Further, inspection of Figure 1.1, with the u-shaped evolution of prices could call for a break in the time trend. We estimated our model with a break in 1994, allowing for differential trends in these two periods. Results do not change and are available upon request.

Table 1.5: Robustness checks - Inference

	(1)	(2)	(3)	(4)	(5)	(6)
Excise	1.348***	1.187***	1.209**	1.469***	1.348	1.187*
	[0.357]	[0.218]	[0.475]	[0.324]	[0.847]	[0.676]
HHI	118.5***	93.04***	106.2**	131.5***	118.5	93.04
	[38.69]	[24.37]	[53.81]	[37.37]	[83.40]	[72.66]
Excise_HHI	-5.859***	-3.871***	-5.224**	-6.422***	-5.859	-3.871
	[1.782]	[1.229]	[2.471]	[1.702]	[4.608]	[3.934]
Covariates	YES	YES	YES	YES	YES	YES
Cluster (City)	NO	NO	NO	NO	YES	YES
City FE	YES	NO	YES	YES	YES	NO
Quarter FE	YES	YES	YES	YES	YES	YES
Time trend	YES	YES	YES	YES	YES	YES
Observations	820	820	840	820	820	820
R^2	0.7507	0.7025			0.497	
Test full shifting	0.95	0.74	0.19	2.10	0.17	0.08
	0.3297	0.3904	0.6594	0.1474	0.6906	0.7822

Notes: Intercept included in all regressions. The dependent variable is *final retail gasoline price*. Standard errors in brackets. R^2 overall where applicable.

Column 1 reproduces column 3 in Table 3, our main specification.

Column 2, based on robust covariance matrices.

Column 3, based on Newey-West standard errors. The lagged values of Wholesale (Wholesale_lag1 and Wholesale_lag2) are excluded because the Newey-West specification has already been computed considering 2 lags in the autocorrelation structure.

Column 4, feasible GLS.

Columns 5, FE, clustered standard errors at the city level.

Columns 6, RE, clustered standard errors at the city level.

Test for full shifting under perfect competition (excise = 1): χ^2 (for columns 1, 2, 4 and 6) and F-statistics (for columns 3 and 5) above and P values below.

* p<0.10, ** p<0.05, *** p<0.01

standard errors. Note that in this specification we did not include the lagged values of the wholesale price. Next, in column (4) we estimate a feasible GLS model.

Our results are robust to these alternative specifications and confirm our result that taxes are undershifted. In all of them excise taxes and market concentration exert a positive and significant impact on gasoline prices, while the interaction between these two variables is negative and highly statistically significant. Further, one can note that the magnitude of the effects is also fairly stable across specifications. The lowest magnitudes are obtained in the random effects model. Finally, in none of the specifications we reject the test of full tax shifting under perfect competition (last row of the table).

In columns (5) and (6) we cluster standard errors at the city-level. As mentioned before, this strategy seems straightforward. In column (5) we use city fixed effects, while in column (6) we use a random effects model.

Note that, when clustering standard errors, we loose statistical significance, except for *excise* in the random effects model.[26] However, as discussed above, given that we work with a very small number of clusters (10), clustering techniques might not be adequate in our situation. Hence, we prefer our main results from Table 1.4.

In Table 1.6 we turn to the possible endogeneity issues as described in Subsection 1.4.2.

We instrument *excise* with the share of seats of the political party in power in each province and a dummy indicating whether the political party in power is the same at both the federal and provincial levels. Market structure is instrumented with two lags of HHI. The first three columns are based on FE-2SLS whereas columns (4) to (6) replicate the same specifications under a RE-2SLS approach.

In columns (1) and (4), we only instrument HHI, while in columns (2) and (5) we only instrument the tax variable, *excise*. Finally, in columns (3) and (6), we tackle both endogeneity issues at the same time instrumenting both *excise* and HHI.

Our set of instruments performs quite well in terms of weak instruments. We compute a Weak Identification Test following Stock and Yogo (2002).[27] For columns (1), (2), (4) and (5); where only one endogenous variable is considered at the time, we provide the 1st-stage F-statistic. In all the four specifications the F-statistic is larger than 10 suggesting that we are not in presence of weak instruments. In columns (3) and (6), where we consider two endogenous variables silmutaneously, we provide the Cragg-Donald Wald F-statistic to be compared with the values given by Stock and Yogo (2002). In column (3), we reject the null that the set of

[26]Using the wild-cluster *bootstrap-t* procedure to improve inference while working with few clusters, we find the following p-values: Under the FE approach; $0.25375, 0.26873$ and 0.34466 for *excise*, HHI and the interaction term respectively. Under the RE approach the values are the following ones: $0.32068, 0.44555$ and 0.69630 for *excise*, HHI and the interaction term respectively.

[27]See also Hausman et al. (2005) and Baum et al. (2003).

Table 1.6: Robustness checks - IV-2SLS

	(1)	(2)	(3)	(4)	(5)	(6)
Excise	1.797***	8.830***	9.088***	1.319***	3.249***	3.345***
	[0.589]	[1.893]	[1.960]	[0.316]	[1.013]	[1.016]
HHI	171.7**	867.6***	897.7***	108.5***	314.2***	324.5***
	[66.28]	[195.6]	[204.2]	[36.18]	[108.9]	[109.2]
Excise_HHI	-8.281***	-41.32***	-42.70***	-4.635**	-14.78***	-15.28***
	[3.018]	[9.119]	[9.499]	[1.805]	[5.376]	[5.392]
Covariates	YES	YES	YES	YES	YES	YES
City FE	YES	YES	YES	NO	NO	NO
Quarter FE	YES	YES	YES	YES	YES	YES
Time trend	YES	YES	YES	YES	YES	YES
Observations	820	820	820	820	820	820
R^2	0.742	0.589	0.579	0.696	0.670	0.668
Test full shifting	1.83	17.12	17.03	1.02	4.93	5.33
	0.1759	0.0000	0.0000	0.3137	0.0265	0.0209
Sargan Test	3.157	6.935	8.036	2.395	7.718	9.590
	0.0756	0.0312	0.0453	0.1217	0.0211	0.0224
Weak identif.test	160.77	13.24	7.93	380.62	18.82	11.34

Notes: Intercept included in all regressions. The dependent variable is *final retail gasoline price*. Standard errors in brackets in brackets. R^2 overall where applicable.

Columns 1, 2 and 3, with FE-2SLS. Columns 4, 5 and 6, with RE-2SLS.

Columns 1 and 4: HHI instrumented using all exogenous regressors plus lagged values of HHI (HHI_{t-1} and HHI_{t-2}).

Columns 2 and 5: Excise instrumented using all exogenous regressors plus the share of seats of the political party in power in each province and a dummy indicating whether the political party in power is the same at both the federal and state levels.

Columns 3 and 6: Both excise and HHI instrumented using the instruments mentioned above.

Test for fully shifting under perfect competition (excise = 1): χ^2 above and P values below.

Sargan test of overidentifying restrictions: χ^2 above and P values below.

Weak identification test: 1st-stage F-statistic except for columns 3 and 6 where we provide the Cragg-Donald Wald F-statistic to be compared with the values given by Stock and Yogo (2002).

* p<0.10, ** p<0.05, *** p<0.01

instruments is weak at a 20% maximal IV relative bias.[28] In column (6), we can reject the null that the set of instruments is weak at a 10% maximal IV relative bias.

Things are slightly more problematic in terms of the exogeneity condition. As it can be observed from Table 1.6, the Sargan test is passed when we only instrument for market structure. But, the exogeneity test is not passed once we instrument *excise*. We attribute this result to the fact that we have fairly little variation in our instruments for taxes. Not only is the political situation in the different provinces fairly stable over time but, additionally, political variables do not change over the electoral cycle (usually four years in Canada). Thus, the short time period we avail of implies we are not able to identify the coefficients with sufficient precision.

Nevertheless, turning to our main coefficients, we can observe that across all instrumented specifications our main coefficients remain statistically significant and with the expected signs. Hence, instrumenting confirms the result of our test that excise taxes are undershifted in the market under study.[29] Nevertheless, as it is often the case, the FE-2SLS estimates are bigger than the FE-OLS ones. This is particularly the case when we instrument for *excise*. Indeed, when instrumenting for taxes in a fixed effect framework (columns (2) and (3)), our coefficients literally explode while remaining with the expected signs.

1.5.4 Discussion of results

What do our results imply? In this subsection we briefly discuss four points we consider particularly relevant: i) model specification; ii) policy conclusions; iii) generality of our test; and iv) welfare implications.[30]

We first illustrate our results graphically. Figure 1.5 plots the level of tax shifting depending on market structure. It can be noted that for a large part of concentration values contained in our sample, tax incidence is statistically significantly less than one.[31] Also, one can infer from the graph that full shifting cannot be rejected for perfectly competitive markets (as we

[28]It is worth mentioning that, although we do not have other values than the one provided by Stock and Yogo (2002), we would probably also reject the null at a 15% maximal IV relative bias given that the Cragg-Donald Wald F-statistic of 7.93 has to be compared with the following values: 10% maximal IV relative bias, 8.78 and 20% maximal IV relative bias, 5.91.

[29]Following the procedure in Baltagi (2009), we perform two Hausman tests based on the contrast between the fixed effects and random effects estimators; one before and other after controlling for endogeneity. The idea is that the result could have changed when applying the 2SLS framework. Nevertheless, in our case, we reject the null that the RE estimator is consistent in both cases, before and after controlling for endogeneity. Hence, the FE specification is preferred to the RE one in both Table 1.4 and Table 1.6. We show both the FE and RE estimations as an additional robustness check.

[30]Note that the discussion in this section is based on our preferred specification i.e. column (3) in Tables 1.3 and 1.4.

[31]This is the case for $HHI > 1,450$.

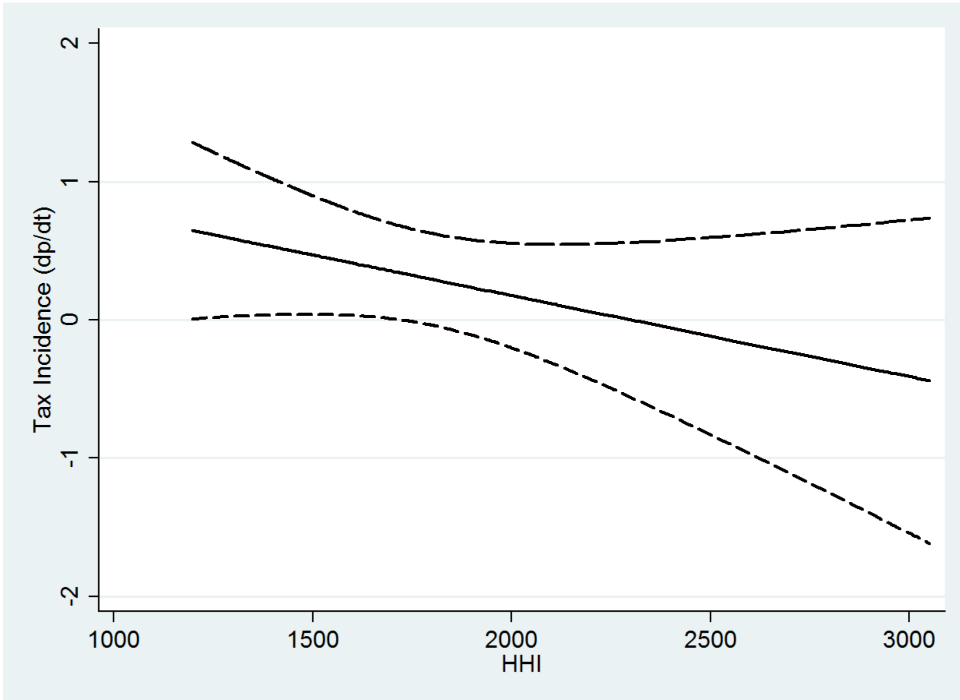

Figure 1.5: Interdependence of tax incidence and market structure

have tested statistically above). Further, the graph nicely illustrates the strong effect market structure has on tax incidence. Indeed, the estimated effect for concentrated markets turns even negative at around $HHI = 2,300$, although this is never statistically significant.

Let us now turn to our first discussion point. As mentioned above, most empirical applications of tax incidence in oligopolistic markets did not include the interaction term between taxes and market structure, although warranted by theory. These models might be inadequately specified as our results suggest. In our sample, not controlling for the interaction term underestimates tax incidence. In column (3) of Table 1.3 the tax coefficient was estimated at around 0.25 while, in our preferred specification, tax incidence at the mean of market concentration is 0.30, i.e. an increase of around 20%.

However, not only tax incidence could be incorrectly estimated, also wrong policy conclusions could be taken. This takes us to the next discussion point. Taking the model of Table 1.3 one would conclude that only about 25% of an increase in taxes is passed on to consumers, and would apply this policy result to all the markets. However, the effective tax incidence varies greatly across different markets (and hence regions). This is again nicely illustrated in Figure 1.5 above. In our sample, tax incidence varies from 0.65 to (an admittedly implausible) -0.44 between the least and most concentrated markets. More importantly, looking at the inference of our coefficients, our results suggest that in the least concentrated markets (Ottawa, Montreal, Calgary, Winnipeg and Toronto) taxes might actually be fully passed on to consumers, while they might be fully absorbed by producers in the most concentrated markets (Vancouver, Quebec, Halifax, St. Johns and Saint John). Obviously, policy conclusions might be quite different under these two scenarios.

Further, some caution should be applied when interpreting a model that does not include the interaction term.[32] Suppose that estimating a model without the differential effect of taxes depending on market structure produces a coefficient on *excise* that is not statistically different from one. Then, one would conclude that taxes are fully shifted to consumers, confirming the implicit assumption of a perfectly competitive market.

For example, we think that our findings are relevant to the conclusions drawn by Marion and Muehlegger (2011), in a recent and important contribution to the sparse literature on tax incidence. While the main focus of their paper is not on imperfectly competitive markets, but rather on the effect of capacity constraints on tax incidence, they do estimate price regressions similar to ours for the U.S. gasoline and diesel markets. In the paper, they estimate a total of 40 pass-through rates. In most cases (in 31 out of 40 regressions) they find coefficient estimates greater than 1, but not statistically significantly different from 1. They conclude that "... gasoline and diesel fuel taxes are on average fully... passed on to consumers".[33] However, the authors do not control for market structure. Given this, our findings raise the possibility that taxes may be *overshifted* in the U.S. gasoline and diesel markets. In other words, if one were to estimate a model controlling for market structure and the interaction term between taxes and market structure, one were likely to find a positive interaction term. The model by Marion and Muehlegger (2011) estimates tax incidence essentially at the mean of market structure across States. The confidence interval of this estimation does not allow them to reject full shifting leading to the confirmation of a perfectly competitive market. In Figure 1.6 we illustrate this alternative scenario. Let's assume taxes are overshifted, hence tax incidence increases with market concentration. However, the confidence interval of the pass-through rates estimated at the mean of market concentration might contain one, leading to the potentially incorrect conclusion of full shifting. It should be finally noted that the policy conclusions might be different under overshifting. For instance, consumer surplus reduction is larger (even in case of inelastic demand) and producer profits can increase when taxes are overshifted.

Of course, the above is a possibility which can only be confirmed if access to market structure data in the U.S. markets are available. However, at the very least, we would argue that our test complements Marion and Muehlegger (2011) quite nicely, in terms of being a useful instrument to assess the degree of tax shifting across industries. Indeed, we think that our test can, with

[32]Although it should be noted that this is not the case in our sample.

[33]Marion and Muehlegger (2011), p. 1202.

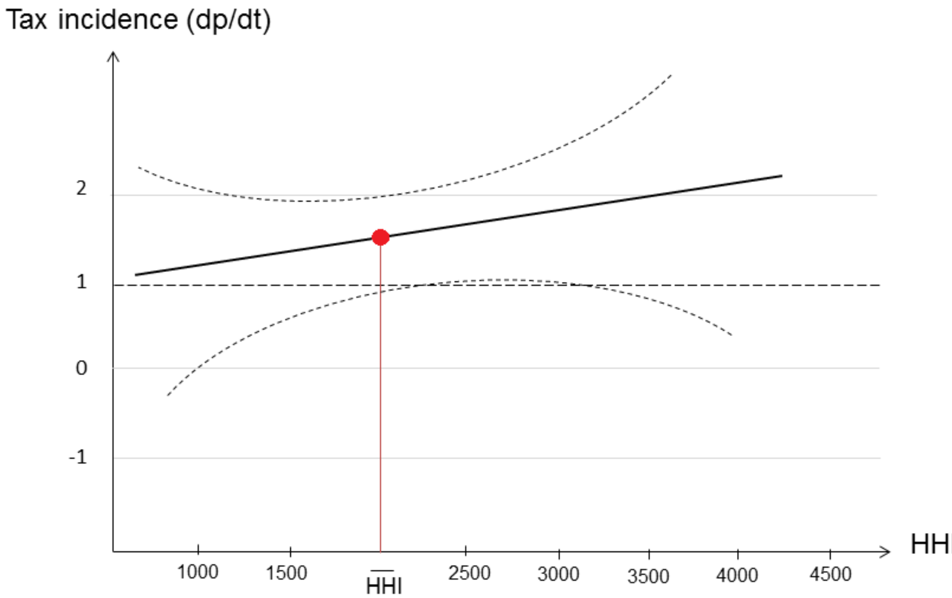

Figure 1.6: Interdependence of tax incidence and market structure: an alternative scenario

reasonable confidence, measure whether taxes are under- or overshifted in a particular industry. This is, in our opinion, an important and relevant policy result.

Third, one can easily imagine a more general application of our test. Essentially, a change in excise taxes is an exogenous (at least for an individual firm) shock to its marginal cost. As such, our theory could in principle go through for any exogenous cost shock to firms. This idea could be of interest to antitrust policy, as our test could identify whether exogenous cost shocks are over- or undershifted to consumers depending on market parameters, rather than say, potential collusion. We intend to study the potential implications for antitrust policy in future research.

Finally, we can turn to the welfare implications of our findings. Besley (1989) discusses the welfare effects of commodity taxation in oligopolistic markets. His Proposition 1 (Besley, 1989, p. 366) states that a marginal increase in excise taxes can be welfare improving if $E < 0$.[34] The corresponding expression to Besley's E in our model is $(\eta + k)$.[35] Hence, a necessary condition for marginal tax changes to be welfare improving is that they are passed on less than proportionally to consumers. This is the case in our sample. Thus marginal increases in excise taxes in the gasoline market in Canada might be welfare improving. Again, we argue that this is, particularly in the current policy discussion, an interesting result and should be explored further in future research.

[34] It should be noted that the Proposition 1 in Besley (1989) seems to present a typographic error that we take into account in the text.

[35] Note that Besley (1989) assumes a constant marginal cost, hence in his model $k = 1$.

1.6 Concluding remarks

The Canadian gasoline retail market is concentrated. Thus, the perfect competition assumption might be misleading when analyzing the effect of taxes on prices. In oligopolistic markets, taxes can be shifted forward less (more) than proportionally to retail prices; a possibility usually denoted by undershifting (overshifting). Generally, whether there is under- or overshifting depends on unobservable parameters of the demand and cost functions. In this paper, we devise an empirical test to assess the degree of tax shifting which is based on observables, namely an interaction term between taxes and market structure in a price equation.

We apply our test to the Canadian retail gasoline market. In our sample of monthly observations across 10 cities over the period $1991 - 1997$, we find that taxes are undershifted. The results are remarkably robust to a series of alternative specifications both regarding inference and instrumenting our main variables.

We would argue that our results improve earlier analysis of tax incidence in oligopolistic markets in an important direction. Most of earlier studies in concentrated markets (e.g. gasoline and cigarettes) either explicitly or implicitly assume perfectly competitive markets. We show that such an estimate of tax incidence might be biased when not specifying the model correctly, i.e. when not accounting for the interdependence of market structure and taxes. Further, policy conclusions might be inadequate.

In our data, by not allowing tax incidence to vary with market structure, we find a degree of pass-through of 0.18. Correctly specifying our model implies a tax incidence, evaluated at the mean, of 0.30, i.e. an increase of 67%. We also find that the degree of tax shifting depends heavily on market structure. While for the least concentrated markets we cannot reject that taxes are fully passed on to consumer prices, for the most concentrated ones taxes might be fully absorbed by producers. Quite obviously, policy conclusions regarding gasoline taxation might be quite different and should depend on the degree of concentration.

Our empirical test is easily applicable to other markets and regions. It requires data showing variation in tax rates and market structure. The Canadian example, where Provinces also set gasoline taxes, is a good illustration of the applicability. The U.S. might be another good example, since States tax gasoline and there is likely also considerable variation in market concentration. Further, our test could have even more general implications and could find its way into further analysis of tax policy and likely even antitrust issues such as collusion. In future work, we aim at linking the vast literature on tax competition with the tax incidence results described in this paper.[36] Another interesting issue to explore is whether and how our

[36] See, for example, Hayashi and Boadway (2001), Devereux et al. (2007) and Brülhart and Jametti (2006) among others.

results are affected by the presence of different size firms.[37]

[37] See Vigneault and Wen (2002).

Appendix 1.A Theoretical background

We base our test on a simple Cournot oligopoly model based on Besley (1989) where N firms in the industry choose their level of output taking prices and taxes as given. Firms are symmetric and, for simplicity, we take the number of firms as exogenously given, but perform comparative statics. Finally, we concentrate on the effect of excise taxes, the main tax instrument in our dataset.[38]

Let the inverse demand function be:

$$p(\sum q_i) \equiv p(Q) \tag{1.A.1}$$

where p is the consumer price, q_i is the output of firm i and $Q(\equiv \sum q_i \equiv q_i + Q_{-i})$ denotes the total output of the industry.[39]

The profit function of firm i is given by:

$$\pi_i(q_i) = p(q_i + Q_{-i})q_i - c(q_i) - \tau q_i \tag{1.A.2}$$

where τ is an excise tax on q and $c(q_i)$ is the cost function.

Standard assumptions are imposed in order to assure a stable symmetric Cournot equilibrium:

Assumption 1 *$p(Q) : \Re^+ \to \Re^+$ is twice continuously differentiable and $p'(Q) < 0$ for all Q such that $p(Q) > 0$.*

Assumption 2 *$c(q) : \Re^+ \to \Re^+$ is increasing and twice continuously differentiable with $c(0) > 0$, i.e. all firms face a fixed cost.*

Since we are focusing on symmetric equilibria, we can omit the subscripts and derive the first and second order conditions of the profit maximizing firm:

$$\text{FOC: } p'(Q)q + p(Q) - c'(q) - \tau = 0, \tag{1.A.3}$$

$$\text{SOC: } p''(Q)q + 2p'(Q) - c''(q) < 0. \tag{1.A.4}$$

We can re-express Equation (1.A.4) as:

$$\frac{p'(Q)}{N}(\eta + N + Nk) < 0, \tag{1.A.5}$$

[38] The model can be extended in many directions such as allowing for entry into the industry (Besley (1989)) or adding an *ad valorem* tax (Delipalla and Keen (1992)).

[39] Q_{-i} denotes the output of the industry produced by all the other firms but firm i.

where, as defined by Seade (1980), $\eta = \frac{Qp''}{p'}$ is the elasticity of the slope of the inverse demand and $k = 1 - \frac{c''}{p'}$ represents the relative slopes of the demand and marginal cost curves.[40]

Since $p' < 0$, we get the following necessary and sufficient condition for the SOC to hold:

$$\eta + N + Nk > 0. \tag{1.A.6}$$

Now, given symmetric firms:

$$p(Q) \equiv p(q_i + Q_{-i}) \equiv p(Nq), \tag{1.A.7}$$

plugging Equation (1.A.7) into the FOCs:

$$p'(Nq)q + p(Nq) - c'(q) = \tau. \tag{1.A.8}$$

Differentiating Equation (1.A.8) with respect to τ and rearranging, we obtain:

$$\frac{\partial q}{\partial \tau} = \frac{1}{p'(\eta + N + k)}, \tag{1.A.9}$$

and

$$\frac{\partial Q}{\partial \tau} = \frac{N}{p'(\eta + N + k)}. \tag{1.A.10}$$

Therefore,

$$\frac{\partial p}{\partial \tau} = p' \left(\frac{\partial Q}{\partial \tau} \right) = \frac{N}{N + (\eta + k)}. \tag{1.A.11}$$

Proposition 1 *Under perfect competition ($N \to \infty$) taxes are fully shifted onto consumers ($\frac{\partial p}{\partial \tau} \to 1$). As the market gets more concentrated, the degree of shifting ($\frac{\partial p}{\partial \tau}$) moves away from one (1). Indeed, under monopoly ($N \to 1$), the degree of shifting is the largest in absolute value.*

Proof 1 *Inspection of Equation (1.A.11) immediately proves Proposition 1.*

Equation (1.A.11) confirms that, under perfect competition, taxes are fully passed to consumers. Moreover, it shows that $\left|\frac{\partial p}{\partial \tau}\right| - 1$ is the largest for $N = 1$, i.e. under monopoly the degree of shifting is always the furthest away from one. We can now look at the conditions for under- respectively overshifting.

Proposition 2 *If $(\eta + k)$ is positive, $\frac{\partial p}{\partial \tau} < 1$ and the market undershifts taxes. On the other hand, if $(\eta + k)$ is negative, $\frac{\partial p}{\partial \tau} > 1$ and we are in the presence of overshifting.*

[40] We treat η and k as parameters, abstracting from second-order effects of η and τ around equilibrium. Note that this is indeed the case when working with the two most analyzed functional forms of demand analyzed in tax incidence literature i.e, linear ($\eta = 0$) and constant elasticity ($\eta = -\frac{1+\epsilon}{\epsilon}$) demand functions.

Proof 2 *Inspection of Equation (1.A.11) allows us to classify the cases of relevance for our analysis:*

$$\frac{\partial p}{\partial \tau} = \frac{N}{N + (\eta + k)} \begin{cases} < 1 & \Rightarrow \textit{undershifting} \\ = 1 & \Rightarrow \textit{full shifting} \\ > 1 & \Rightarrow \textit{overshifting} \end{cases}$$

Proposition 3 *The sign of $(\eta + k)$ equals the sign of the cross derivative of prices with respect to taxes and market structure.*

Proof 3

$$\frac{\partial \left(\frac{\partial p}{\partial \tau}\right)}{\partial N} = \frac{(\eta + k)}{(\eta + N + k)^2} \tag{1.A.12}$$

As $(\eta + N + k)^2 > 0$ for all η, N and k, the sign of Equation (1.A.12) equals the sign of $(\eta + k)$.

Corollary 1 *Let HHI be an inverse function of N. Then,*

$$\frac{\partial \left(\frac{\partial p}{\partial \tau}\right)}{\partial HHI} \simeq \frac{-(\eta + k)}{(N + (\eta + k))^2}.$$

Proposition 3 and its Corollary summarize the main contribution of our paper. As mentioned in Proposition 2, the sign of $(\eta + k)$ tells us whether we are in presence of under- or overshifting. Both η and k depend on the underlying parameters of the demand and cost functions and are therefore unobservable or inherently difficult to estimate. However, Proposition 3 shows that the sign of the cross-derivative of prices with respect to taxes (τ) and the number of firms (N) is equal to the sign of $(\eta + k)$. The empirical counterpart of this cross-derivative is an interaction term of taxes and market structure in a regression equation. Now, as is usual in an empirical context, market structure is often characterized by a concentration measure, such as the Herfindahl-Hirschmann Index (HHI), which is an inverse function of N. The Corollary shows that the interaction term of taxes with a concentration measure indicates the *opposite* sign of $(\eta + k)$.

Bibliography

Anderson, Simon P., Andre de Palma, and Brent Kreider (2001) 'Tax incidence in differentiated product oligopoly.' *Journal of Public Economics* 81(2), 173–192

Baltagi, Badi H. (2009) In 'Econometric analysis of panel data,' 4 ed. (Wiley, Chichester)

Baum, Christopher F, Mark E. Schaffer, and Steven Stillman (2003) 'Instrumental variables and gmm: Estimation and testing.' *Stata Journal* 3(1), 1–31

Besley, Timothy J. (1989) 'Commodity taxation and imperfect competition : A note on the effects of entry.' *Journal of Public Economics* 40(3), 359–367

Besley, Timothy J., and Anne Case (2000) 'Unnatural Experiments? Estimating the Incidence of Endogenous Policies.' *Economic Journal* 110(467), F672–94

Besley, Timothy J., and Harvey S. Rosen (1999) 'Sales taxes and prices: An empirical analysis.' *National Tax Journal* 52(2), 157–178

Brülhart, Marius, and Mario Jametti (2006) 'Vertical versus horizontal tax externalities: An empirical test.' *Journal of Public Economics* 90(10-11), 2027–2062

Cameron, Colin A., Jonah B. Gelbach, and Douglas L. Miller (2008) 'Bootstrap-based improvements for inference with clustered errors.' *The Review of Economics and Statistics* 90(3), 414–427

Chouinard, Hayley H., and Jeffrey M. Perloff (2007) 'Gasoline price differences: Taxes, pollution regulations, mergers, market power, and market conditions.' *The B.E. Journal of Economic Analysis & Policy* 7(1), 8

Delipalla, Sophia, and Michael Keen (1992) 'The comparison between ad valorem and specific taxation under imperfect competition.' *Journal of Public Economics* 49(3), 351–367

Delipalla, Sophia, and Owen O'Donnell (2001) 'Estimating tax incidence, market power and market conduct: The european cigarette industry.' *International Journal of Industrial Organization* 19(6), 885–908

Devereux, Michael B., Ben. Lockwood, and Michaela. Redoano (2007) 'Horizontal and vertical indirect tax competition: Theory and some evidence from the usa.' *Journal of Public Economics* 91(3-4), 451–479

Fullerton, Don, and Gilbert E. Metcalf (2002) 'Tax incidence.' In 'Handbook of Public Economics,' vol. 4 (Elsevier, North-holland) chapter 26, pp. 1787–1872

Harris, Jeffrey E. (1987) 'The 1983 increase in the federal cigarette excise tax.' *Tax Policy and the Economy* 1, 87–111

Hausman, Jerry, James H. Stock, and Motohiro Yogo (2005) 'Asymptotic properties of the hahn-hausman test for weak-instruments.' *Economics Letters* 89(3), 333–342

Hayashi, Masayoshi, and Robin Boadway (2001) 'An empirical analysis of intergovernmental tax interaction: The case of business income taxes in canada.' *Canadian Journal of Economics* 34(2), 481–503

Katz, Michael L., and Harvey S. Rosen (1985) 'Tax analysis in an oligopoly model.' NBER Working Papers 1088, National Bureau of Economic Research, Inc, July

Krzyzaniak, Marian, and Richard A. Musgrave (1963) 'The shifting of the corporation income tax.' (Johns Hopkins Press, Baltimore)

Lewis, Matthew (2008) 'Price dispersion and competition with differentiated sellers.' *Journal of Industrial Economics* 56(3), 654–678

Marion, Justin, and Erich Muehlegger (2011) 'Fuel tax incidence and supply conditions.' *Journal of Public Economics* 95(9-10), 1202–1212

Moulton, Brent R (1986) 'Random group effects and the precision of regression estimates.' *Journal of Econometrics* 32(3), 385–397

Moulton, Brent R (1990) 'An illustration of a pitfall in estimating the effects of aggregate variables on micro unit.' *The Review of Economics and Statistics* 72(2), 334–38

Palazzi, Pamela (2011) 'Taxation and innovation.' *OECD Taxation Working Papers, No. 9, OECD Publishing. http://dx.doi.org/10.1787/5kg3h0sf1336-en*

Seade, Jesus (1980) 'On the effects of entry.' *Econometrica* 48(2), 479–89

Seade, Jesus (1985) 'Profitable cost increases and the shifting of taxation : Equilibrium response of markets in oligopoly.' *The Warwick Economics Research Paper Series (TWERPS)*

Sen, Anindya (2001) 'Overshifting, firm conduct, and tax incidence in concentrated industries: Empirical evidence from the canadian cigarette industry.' *Mimeo.*

Sen, Anindya, and Peter G.C. Townley (2010) 'Estimating the impacts of outlet rationalization on retail prices, industry concentration, and sales: Empirical evidence from canadian gasoline markets.' *Journal of Economics & Management Strategy* 19(3), 605–633

Stock, James H., and Mark W. Watson (2008) ‘Heteroskedasticity-robust standard errors for fixed effects panel data regression.’ *Econometrica* 76(1), 155–174

Stock, James H., and Motohiro Yogo (2002) ‘Testing for weak instruments in linear iv regression.’ NBER Working Papers 0284, National Bureau of Economic Research, Inc, November

The Conference Board of Canada (2001) ‘The final fifteen feet of hose. The Canadian Gasoline Industry in the Year 2000’

Vigneault, Marianne, and Jean-Frans Wen (2002) ‘Profit taxes and the growth of fringe firms.’ *The Canadian Journal of Economics* 35(4), pp. 717–736

Wooldridge, Jeffrey M. (2003) ‘Cluster-sample methods in applied econometrics.’ *American Economic Review* 93(2), 133–138

Chapter 2

Corporate Flat Tax Reforms and Firms' Location Choices. Evidence from Switzerland

2.1 Introduction

The effect of fiscal policies on investment decisions has been studied in several sub-fields of economics such as industrial organization, economic geography and public economics.[1] This paper focuses on a particular investment made by the entrepreneur: firms' location choices.

Fiscal policy is crucial for firms deciding where to settle and there are several channels through which the impact of fiscal policy can make a given jurisdiction more or less attractive for the entrepreneur.[2] Taxation is probably the most important one but the provision of public goods by local governments has an important impact on corporate location decisions as well.[3]

The most relevant taxes regarding corporate location choices are the ones levied on profits and capital. In this paper, we concentrate on the former. Specifically, we aim at estimating the impact of a corporate flat tax reform on the attractiveness of a given jurisdiction for firms.

Our identification strategy is straightforward. We apply a differences-in-differences approach to estimate the impact of the reform (decided at the cantonal level) on the attractiveness of

[1] See, for example, Modigliani and Miller (1963), Miller (1977) and Cummins et al. (1996).

[2] In an important contribution to this literature, Carlton (1983) assesses the impact of fiscal policy on both location and employment decisions of new firms. He introduced the estimation of corporate location choices through the conditional-logit model (which is formally derived from a representative firm's stochastic profit function) and was among the first to study new business location. For more recent references see, for example, Barrios et al. (2012) and Devereux and Griffith (1998). For papers studying firm's location decisions using Swiss data, see Feld and Kirchgässner (2003) and Brülhart et al. (2012).

[3] See, for example, Kirchgässner and Pommerehne (1996) and Becker et al. (2012).

Swiss local jurisdictions. Interestingly, our data allow us to to control for potential confounding factors such as the level effect by controlling for the average corporate tax rate, and by applying a number of fixed effects.

Our results suggest that replacing a graduated rate tax (GRT) scheme with a flat rate tax (FRT) system has a negative and statistically significant effect on the number of firms.[4] On average, firms tend to prefer to settle in municipalities located in cantons where a corporate GRT schedule is applied. The interpretation of our estimates goes through the *insurance effect*. Bacher and Brülhart (2013) have defined this effect as follows: "Keeping the expected after-tax profits constant, progressive taxation reduces the variance of profits by more than linear taxation. As a consequence, tax progressivity serves as an insurance device: in bad times, an entrepreneur has to pay less than under a flat tax, whereas in good times the tax bill is higher." (Bacher and Brülhart (2013) p., 134).[5] In other words, given the reduction in the progressivity of corporate taxes generated by the flat tax reforms applied in Switzerland (see Section 2.3), the insurance effect arises as a potential explanation of the observed negative impact on the the number of firms.

This is an interesting result for several reasons. First it allows us to shed some light on the effects of corporate flat tax reforms, a particular reform that has been hardly assessed in previous empirical studies (See Section 2.2). Moreover, our results confirm the presence of the insurance effect in Switzerland that was previously found in Bacher and Brülhart (2013) using different data and a different identification strategy as well. In addition, our findings have important policy implications. Despite the negative impact of flattening corporate taxes on the number of firms, there has been an increasing number of Swiss cantons introducing flat corporate taxes since 1990. Even if this effect is small in magnitude, the reduction of the tax base in those jurisdictions applying such a reform should be considered by policy makers. Finally, in Section 2.6.3 we find that the negative impact of introducing a FRT is particularly strong for small firms. Policy makers might also want to take this into consideration when (for example) assessing the redistributive effects of a flat tax reform.

To sum up, our paper contributes to the existing literature in several ways. First of all, by estimating the effects of a flat tax reform using a differences-in-differences approach, it makes a step forward in order to close the existing gap between rhetoric argumentation and empirical evidence.[6] In addition, we specifically asses the impact of introducing a flat tax reform on

[4]Graduated tax schemes are often called progressive. Though, this denomination might lead to misunderstandings. As we will discuss later in this paper, a GRT is not necessarily more progressive than a FRT. Under certain conditions, a flat tax system can indeed be more progressive than a GRT.

[5]Other papers discussing the insurance effect are Cullen and Gordon (2006) and Cullen and Gordon (2007).

[6]"A notable and troubling feature of discussion of the flat tax is that it has been marked more by rhetoric and assertion than by analysis and evidence." (Keen et al. (2008), p., 713)

corporate taxes which has been largely disregarded with respect to personal income reforms. Finally, as we will discuss in next sections, flat tax reforms have several potential effects.[7] Our paper focuses on the impact on corporate location decisions. To the best of our knowledge, this has not been studied before as an outcome of flat tax reforms.

The rest of the paper is structured as follows. In Section 2.2 we present the existing literature in the field. Section 2.3 presents a brief description of the fiscal context in Switzerland showing the features that make the Swiss Federation an almost ideal setting to develop our study. In Section 2.4 we describe the data set. Section 2.5 describes the empirical framework and main estimation issues. In Section 2.6 we present and discuss our results and, finally, in Section 2.7 we provide some concluding remarks.

2.2 Literature background and context

Tax reforms have been largely studied in public economics literature.[8] This paper studies the impact of taxes on firms' location choices by assessing the effects of a specific reform on the tax schedule: a flat tax reform. Strictly speaking, "only a flat rate tax without any tax relief is a "pure" flat tax as in this case the share of tax payments to income is constant for the whole income range." (Paulus and Peichl (2009) p., 622). As it is nicely described by Keen et al. (2008), the term "flat tax" was originally associated with Hall and Rabushka (1984) and Hall and Rabushka (1987).[9] However, the flat tax concept has evolved from this precisely defined structure to a vaguer definition and flat tax reforms can actually differ from case to case. Indeed, most of flat tax reforms include both the flattening of personal and corporate income taxes. Some of them, also introduce changes in capital taxes and in the most extreme cases (such as the Slovakia's reform of 2004) even modifications on the VAT structure are also applied.[10]

This lack of unanimity in the definition is also reflected in the heterogeneity among the countries applying either GRT or FRT schemes. For instance; Japan, the United States and the United Kingdom rise graduate federal corporate income taxes. On the other hand, Canada,

[7]For instance, some papers discuss optimality issues related to these reforms (Diamond (1998); Keen et al. (2008)). Some study the improvements in compliance or the reduction in tax evasion (Andreoni et al. (1998); Hindriks et al. (1999)). Others, for example, focus on the growth impact of such a reform (Cassou and Lansing (2004); Stokey and Rebelo (1995)).

[8]See, for instance, Feldstein (1976), Auerbach and Hines (1988) and Auerbach (1992).

[9]The flat tax *à la* Hall and Rabushka is a consumption-type, origin-based value-added tax (VAT) supplemented by a (nonrefundable) tax credit against labor income. In other words, "their proposal is for a very precisely defined and coherent tax structure: a combination of a cash-flow tax on business income and a tax on workers' income, both levied at the same, single rate (with a personal allowance available against the wage tax)." (Keen et al. (2008), p., 713 – 714).

[10]For more details on the Slovakia's flat tax reform, see for example, Brook and Leibfritz (2005) and Moore (2005).

France, Germany, Italy, Spain and Switzerland apply flat-rate corporate taxes. Interestingly, when considering different tiers of government in a federation, both systems might coexist. This is the case in the United States and Switzerland. While in the former 31 states levy flat-rate corporate income taxes and 17 apply a GRT (the remaining three states do not tax profits); in Switzerland, cantons have been switching from graduate to flat tax schedules and, nowadays, 17 cantons (out of 26) apply FRT on profits.

Moreover, when it comes to assessing the impact of flattening corporate tax rates, the complexity of these reforms makes the data collection process and the definition of a neat identification strategy particularly difficult. For instance, one might be concerned about correctly disentangling the effects of flatness in itself and the level effect when empirically estimating the impact of such a reform. Keen et al. (2008) have put it as as follows: "The second wave “flat tax” reforms that have attracted so much attention have generally involved not only a flattening of the PIT but also a substantial reduction in rates (both average and marginal) in the upper part of the income distribution. Much of the flat tax rhetoric seems to be concerned more with the latter than with flatness in itself. There is, of course, a voluminous literature on the behavioral and revenue effects of tax rate changes. The consequences of flatness per se, however, have received little analytical attention." (Keen et al. (2008) p., 719).

For all these reasons, there exists a (sometimes misleading) conventional wisdom concerning FRT schemes. Let us highlight two ideas often accepted as true that are particularly relevant for our study: *i) flat tax reforms necessarily reduce the level of progressivity (with respect to the GRT scheme that was previously in place)* and *ii) flat tax reforms only concern personal income.* Both statements are false. We tackle the former point later in this section by giving some of the main references in the field. Moreover, in Section 2.3, we briefly describe the implications of the theoretical framework developed by Davies and Hoy (2002) showing that a (personal income) flat tax reform can either increase or decrease the progressivity level of the tax system. Regarding the second point, this might be one of the reasons explaining the considerable larger (theoretical and empirical) literature on personal income flat tax reforms with respect to flat tax reforms on corporate taxes. Therefore, although the scope of this paper is on profit taxation, we start by reviewing the literature on personal income reforms and, then, move to the (considerably smaller) literature assessing corporate flat tax reforms.

2.2.1 Personal income flat tax reforms

Personal income GRT and FRT schemes have been studied in public finance since many years. Already in the 50s, Blum and Harry Kalven (1952) stated: "Progressive taxation is now regarded as one of the central ideas of modern democratic capitalism and is widely accepted as a secure policy commitment which does not require serious examination. The single topic of this essay is the extent to which progressive taxation can be justified." (Blum and Harry Kalven (1952), p., 417).[11] Nevertheless, whether the optimal tax schedule should be a GRT or a FRT is still an opened question.

Moreover, this is an issue with important policy implications and, thus, the choice between these two tax systems has long been the subject of contentious political (and public) debate. In 1986, the Congress of the United States approved the biggest tax code overhaul in the nation's history.[12] As mentioned by the former Reagan's White House adviser, B. Bartlett, the Tax Reform Act of 1986 was probably approved because "...was really a coming together of the liberal idea of getting rid of tax loopholes with the conservative idea of flattening the tax rates...and so each side felt that they had something to gain by the effort."[13]. More recently, an opinion article published on the Wall Street Journal makes the following question "...(democrats) want to get rid of the deductions and raise tax rates at the same time. When has that ever worked?"[14]

In a federation such as the United States, the debate also seems to be a relevant one at the local level. For example, an article published on the Huffington Post based on the ongoing debate in Illinois state argues "What's going to happen to our income taxes in Illinois? Should we switch to a progressive tax system with different rates that rise as incomes go up? Should we maintain our flat system? Should our rate remain at the "temporary" 5 percent for individuals or should it drop down to 3.75 percent as the law now says it should. It's safe to say the income tax debate is THE hot topic in Illinois this year."[15]

The choice between graduated and flat tax schedules has definitively been a hot topic in the United States. Nevertheless, there has also been an intense debate in other countries. An article appeared in The Economist analyzes the introduction of flat tax systems in Eastern Europe and highlights that several countries in this region were already flattening their taxes while "Americans (were) talking about it."[16] One of the most important case-studies probably is the introduction of a flat tax in Russia in 2001. The Russian case was probably the trigger of the revival of this discussion both in academia and political discussions. Gorodnichenko et al. (2009) assess Russia's case using micro-data. Focusing on personal income taxes, the authors find that the reform decreased the levels of tax evasion and, to a smaller extent, had a positive productivity effect on the real side of the economy.[17]

[11]Other seminal papers studying the different implications of both tax systems are, for instance, Jakobsson (1976), Hemming and Keen (1983) and Hall and Rabushka (1984).

[12]For more details on the implications of this reform, see Feldstein (1995) and Auerbach and Slemrod (1997).

[13]http://npr.org/2011/10/17/141407285/times-have-changed-since-reagans-1986-tax-reform

[14]http://wsj.com/articles/SB10001424052970204138204576600760327683564

[15]http://huffingtonpost.com/matthew-dietrich/bringing-out-the-gloves-o_b_4762335.html?

[16]www.economist.com/node/3860731. For more details on the wave of flat tax reforms in eastern Europe, see also, Stephanyan (2003).

[17]For more details on the Russian flat tax reform see, for instance, Brook and Leibfritz (2005) and Gaddy and Gale (2006).

There are several arguments in favor (and against) of both FRT and GRT systems. Flat-tax supporters highlight, for instance, its simplicity, the potential improvements in compliance and the elimination of the inefficient loopholes and preferences in the tax code that are potential triggers of rent seeking. On the other hand, those in favor of a GRT argue that such a schedule helps maximizing the tax revenue from each income group and have an important re-distributional impact.[18] Strikingly though, the pros and cons of both systems are often approached in a descriptive way, without giving neither scientific theoretical support nor conclusive empirical evidence. A startling example is the discussion concerning equality that has been one of the core arguments in the GRT-FRT debate. Equality is one of the main arguments of GRT adherents. However, most of flat-tax supporters such as the Tea Party activist and candidate for the 2012 Republican Party presidential nomination, Herman Cain, also argue that flattening taxes rises equality.[19] Although its relevance and some theoretical papers on the effects of flat taxes on inequality, it is difficult to find scientific research showing empirical support for either of these opposite arguments. The main reference among these theoretical papers is Davies and Hoy (2002). The authors theoretically assess the inequality of after-tax distribution of (personal) income and prove the existence of critical flat tax rates such that inequality is higher, lower or the same as with the previous GRT scheme. Subsequently, a number of theoretical papers have taken up this point and extended their framework or tested it through simulation models.[20] In fact, another characteristic of previous literature on flat tax reforms is the lack of empirical estimations using Western countries' data. Most of the case studies are based on Eastern European economies such as the ones mentioned before, but the potential effects of flat tax reforms in Western countries have mainly been studied using simulation models rather than real data-empirical estimations.[21] One of the remarkable exceptions is the Swedish tax reform of 1991, "the most far-reaching reform in any industrialized country in the postwar period. It represents a thorough application of a strategy of rate cuts cum base broadening, and it has affected a myriad of economic incentives in a more or less substantial way."(Agell et al. (1996) p., 643). The Swedish reform introduced the so called Nordic dual income tax which separates capital income from the taxation of any other income. The flat capital income tax rate was set at 30%, in line with the already flat corporate tax rate. In other words, although the Swedish reform was broader than a flat tax reform as defined in this paper, it did include certain features

[18] See Diamond and Saez (2011).

[19] `http://usatoday30.usatoday.com/money/perfi/taxes/story/2011-10-10/herman-cain-9-9-9-tax-plan/50723976/1`

[20] Keen et al. (2008), for example, discuss the conditions for a flat tax reform to increase (or decrease) the level of progressivity while allowing for non-neutral revenue reforms.

[21] Paulus and Peichl (2009) simulates the effects of a flat tax reform on Western economies and give a complete review of other papers using similar simulation techniques.

that are generally observed in this kind of reforms.[22] There are some papers studying the effects of the Swedish reform. Auerbach et al. (1995), for instance, estimate a model for investment in equipment in order to assess the effects of the reform on investment. The authors conclude that the reform had a minor impact on investment and had little to do with the sharp drop in investment observed 4 years after its implementation.

2.2.2 Corporate income flat tax reforms

As mentioned before, the literature on corporate flat tax reforms is much scarcer than the one focusing on personal income ones. Some papers do focus on the progressivity of corporate taxes. Piketty and Saez (2007) provide estimates of U.S. federal tax rates by income groups in order to assess the progressivity level of the U.S. federal tax system. The authors find a sharp drop in progressivity mainly due to a reduction of corporate tax rates and in estate and gift taxes combined with an important change in the composition of top incomes away from capital income and toward labor income. Nevertheless, the focus of the paper is on the whole federal tax system, without looking at lower levels of government. Moreover, they analyze continuous changes during last 40 years rather than concentrating in particular shocks or reforms.[23]

There are some papers studying the potential effects of tax reforms on corporate taxes. Nevertheless, most of the papers looking at corporate flat tax reforms either do it as part of a broader flat tax reform usually including the flattening of personal income tax rates; or by exclusively concentrating on corporate tax reforms that might include the introduction a FRT scheme as part of the reform package. Feld (1995), for instance, discusses some of the structural issues that a flat tax *à la* Hall and Rabushka would imply and, hence, simultaneously tackle both personal and corporate income taxes. Similarly, Ventura (1999) considers a pure flat tax reform by exploring its general equilibrium consequences. Moreover, as a reform *à la* Hall and Rabushka has not been implemented yet, all these papers apply simulation techniques but none of them tackle this issue from an empirical perspective using real data. Also in this direction goes Keen et al. (2008). When analyzing the flat tax reforms on personal income taxes applied by Eastern European countries, the authors make several references to the different effects on corporate tax rates or corporate tax revenue. Nevertheless, the explicit goal of the authors is to assess the flat tax reforms on personal income and, thus, only look at corporate taxes as a second order effect. Moreover, the authors describe in detail several case-studies but do not

[22] For more details on the Swedish 1991 tax reform, see, the Report to the Expert Group on Public Economics "Swedish Tax Policy: Recent Trends and Future Challenges".

[23] Other papers analyze how the level of progressivity on corporate taxes impacts on different outcomes. Agliardi and Agliardi (2008), for example, discuss how different tax rules affect corporate liquidation policy and corporate behavior. Auerbach (2006) and Liu and Altshuler (2013) focus on tax incidence issues. Nevertheless, none of these papers exploit tax reforms.

empirically estimate the effects of the reforms.

Finally, there are three empirical papers that we would like to highlight. Diamond and Saez (2011) estimate the elasticity of corporate taxable income with respect to the average corporate tax rate. The authors use German tax return data to estimate their model and find that a reduction in the statutory corporate tax rate would reduce corporate tax receipts less than proportionally. Interestingly, their identification strategy is based on the changes to the corporate tax system introduced by the Tax Relief Act during 1998 − 2001. Despite the magnitude of this reform, this cannot be considered as a flat tax reform because it did not replace a GRT scheme with a FRT system. The schedule in Germany was already a FRT and "This tax reform significantly reduced the statutory CIT rate and simultaneously broadened the tax base by lowering depreciation allowances, restricting the use of a tax loss carryback, and changing the treatment of non-depreciable assets that lose and then regain value." (Diamond and Saez (2011), p., 119). Similarly, Richardson and Lanis (2007) asses the effects of a major reform on business taxes in Australia. Nevertheless, they do not focus on firms' location choices but rather on the determinants of the variability in corporate effective tax rates after the so called Ralph Review of Business Taxation reform. The authors exploit the modifications codified in the Income Tax Assessment Act of 1997 to identify these determinants. Nevertheless, as Diamond and Saez (2011), the reform the authors are assessing was a major one but was not a flat tax reform (the corporate tax system was already a FRT scheme before the reform). These two papers exploit major tax reforms on business taxes. Nevertheless, and even if they might have included modifications in the parameters defining the progressivity of corporate taxes, neither of these reforms implied a switch from a GRT scheme to a FRT system. Moreover, neither of these two papers focus on firms' location choices as we do. Finally, in Bacher and Brülhart (2013), the authors explore the implications of changes in the average tax burden, the progressivity of the tax schedule, and the complexity of the tax code for entrepreneurial activity proxied by the count of new firms in Switzerland. Results suggest a negative impact of average taxes and complicated tax codes on firm birth rates. On the other hand, tax progressivity has a positive effect on firm births. Interestingly, this paper focuses on corporate location choices in Switzerland as we do. Nevertheless, the identification strategy is completely different. The authors compute a progressivity measure based on the national distribution of capital and profitability across all sectors to assess the impact of the progressivity level of the tax system on the number of new firms rather than focusing on specific shocks or reforms as we do in this paper.

2.3 The fiscal context in Switzerland[24]

Switzerland is a highly decentralized country composed of three levels of government. The Swiss Federation has a unique fiscal system that makes this country an outstanding scenario to develop our study.

In 1998 the federal government reformed its corporate tax schedule by introducing several modifications. For instance, since then, capital is not taxed at the federal level and corporate taxes shifted from a progressive to a flat tax rate. The federal government currently taxes profits at a flat tax rate of 8.5%.

The lower tiers of government (cantons and municipalities) have important degrees of freedom concerning their fiscal competencies. Cantons are free to tax personal income and wealth as well as corporate profits and capital. Similarly, municipal governments have an important autonomy in levying taxes on either of these items.

The total tax revenue raised is roughly equally divided among the three levels of government. Moreover, while the federal government collects the main part of its tax revenue from indirect taxes, the VAT and specific consumption taxes like the mineral oil tax; cantons and municipalities strongly depend on tax revenues coming from personal and corporate income and wealth taxes. In both cases, personal income tax accounts for the biggest portion of total tax revenue (61% for cantons and 68% for municipalities) whereas corporate taxes on profit and capital represent 18% (16%) and wealth taxes only 8% (9%) of cantonal (municipal) tax revenue.

In the Confederation, both personal and corporate income tax rates are jointly determined by cantons and municipalities. The setting process of corporate taxes can be resumed as follows: In a first stage, each canton sets a tax schedule where, for example, a basic statutory tax rate and the level of deductions are defined. This tax schedule can only be modified by changing the cantonal tax law. Then, every year, cantonal parliaments set a cantonal multiplier to be applied to the statutory tax rate and municipalities (that take the cantonal tax schedule as given) do the same by setting a municipal tax multiplier on an annual basis.[25] In other words, unlike corporate tax rates (and interestingly for our identification strategy), the main characteristics of the corporate tax system such as its structure (i.e., the number of tax brackets to be applied) and the level of deductions are uniquely determined at the cantonal level. Hence, local jurisdictions

[24]In this section we only describe the characteristics of the Swiss fiscal system that are relevant for this paper. For a more complete description see, for example, Carey et al. (1999), Feld and Kirchgässner (2003), Parchet (2014), and the report edited by the Swiss Fiscal Conference, L'imposition des personnes morales (2012). Moreover, this section describes the general tax setting process representing the majority of cantons and municipalities in Switzerland. Particular cases and exceptions are taken into account when working with the data.

[25]There are cases in which other institutions such as parishes set their own tax multipliers applying a similar methodology but, because of data constraints, we only consider the tax multipliers set at the cantonal and municipal levels. These are, clearly, the most important ones. See, (Parchet).

do influence corporate tax rates but cannot determine the progressivity of the tax schedule.

A particular feature of Swiss corporate taxes adding heterogeneity among cantons arises from the fact that some of them base the calculation of the tax on profits, others on profitability, and some on a combination. In many cantons, for instance, tax rates are a progressive function of rate of return. This is calculated as profits divided by net worth. Thus, the corporate income tax and the capital tax are closely related.

2.3.1 The flat tax reforms applied by Swiss cantons

To estimate our model, we take advantage of the observed trend in the Confederation towards proportional corporate taxes. Since 1990, when Jura switched from a GRT to a FRT, other cantons have been switching towards flat schedules as well. As we can observe from Table 2.1, the number of cantons applying such a reform rose from 0 up to 14 during our sample period and, interestingly, no canton had switched from a flat to a progressive tax schedule.

All these reforms obviously implied the introduction of a single corporate income tax rate. Nevertheless, as mentioned before, flat tax reforms usually include other modifications in the tax system. The deductions or even the definition of the tax base are, often, modified while introducing flat taxes. Sometimes, other taxes such as personal income or capital ones are modified as a part of the reforms package. Unlike in other cases (See Section 2.2), the reforms introduced by Swiss cantons seem to have had the flattening of corporate tax rates as the main goal. Deductions, for instance, have been slightly modified.

In Table 2.2 we describe the most relevant features of the reforms considered in this paper.

Let us briefly highlight the main common points and differences. The first marked difference concerns the level of the post-reform tax rate. While only three cantons (Luzern, Saint Gallen and Thurgau) set the flat tax rate close to the lowest of the pre-reform rates (i.e., they fixed the single tax rate under the mean of the pre-reform lowest and highest values), five cantons did the opposite. Only one canton (Jura) set the post-reform tax rate above the highest of the pre-reform rates and, similarly, only one canton (Schaffhausen) set the post-reform flat-tax rate at a lower level with respect to the minimum of the pre-reform rates. Other interesting feature regards the other variable defining the progressivity of a tax scheme: deductions. Two cantons did not introduce any modification to the deductions from corporate income taxes. The other cantons applied minor modifications, mainly to the deductions from charity and donations and, sometimes, to the period for which previous loses can be deducted. In addition, some cantons also introduced modifications to capital taxes as part of the reform. While most of the cantons had already a proportional tax scheme for capital, Jura had a graduated system and, thus, introduced a FRT for both corporate income and capital taxes. The rest of the cantons either reduced the capital tax rates (five cantons) or left them unchanged (four cantons).

Table 2.1: Sample details

Canton	Abbreviation	Included in the municipal level database	N. of municipalities in the sample	Flat-Tax reform (year)
Aargau	AG	No	-	No
Appenzell Ausserrhoden	AR	No	-	Yes (1993)
Appenzell Innerrhoden	AI	Yes	6	Yes (1995)
Basel-Landschaft	BL	No	-	No
Basel-Stadt	BS	No	-	No
Bern	BE	Yes	371	No
Fribourg	FR	Yes	151	No
Geneva	GE	Yes	45	Yes (1999)
Glarus	GL	No	-	Yes (2009)
Graubünden	GR	No	-	Yes (2010)
Jura	JU	Yes	60	Yes (1990)
Lucerne	LU	Yes	86	Yes (1991)
Neuchâtel	NE	No	-	No
Nidwalden	NW	No	-	Yes (1995)
Obwalden	OW	No	-	Yes (1995)
Schaffhausen	SH	Yes	27	Yes (2008)
Schwyz	SZ	Yes	30	Yes (2010)
Solothurn	SO	No	-	No
St. Gallen	SG	Yes	81	Yes (2007)
Thurgau	TG	Yes	76	Yes (2006)
Ticino	TI	Yes	133	Yes (1995)
Uri	UR	No	-	Yes (2007)
Valais	VS	Yes	131	No
Vaud	VD	Yes	317	Yes (2002)
Zug	ZG	No	-	No
Zürich	ZH	Yes	171	Yes (2005)
Total	-	14	1685	17

Notes: 12 cantons were excluded of our sample when working with municipal level data because of data constraints regarding the effective average tax rate (EATR). A detailed discussion is given in the Appendix 2.7. Note that Schwyz is included in the database as a non-switcher canton because the reform was introduced in 2010 i.e., after the end of the period covered by our sample.

Table 2.2: Flat tax reforms: summary

Canton	Flat tax adopted	Corporate Income			Capital		Other changes
		Tax rates			Tax rates		
		Before	After	Changes in deduction Before	After		
ZH	2005	4%-10%	8%		1.5‰	0.75‰	The corporate income tax base was modified. Profits on securities and liquidations were not taxable any more after the reform.
LU	1991	4%-7.2%	4%	Deductions from charity and donations were introduced (up to 10% of taxable income with a cap of 1000 CHF).	1‰	1‰	The 32% cap for the total corporate tax (cantonal + municipal + church) was eliminated.
SH	2008	6%-10%	5%	The cap on deductions from charity and donations was increased from 10% to 20% of net income. Moreover, the possibility of deducing voluntary contributions to the federal government, cantons, municipalities for their institutions was introduced.	1.5‰	1‰	
AI	1995	4%-8%	7%	Deductions from housing maintenance and renovation were eliminated. Introduction of a 10% cap for deductions from charity and donations.	1.5‰	1.5‰	Minor modifications on the capital tax base.
SG	2007	4.5%-7.5%	4,50%	Deductions on charity and donations went from 10% to 20% of reported profits	0.2‰	0.2‰	
TG	2006	3%-7% with a maximum of 140.000 CHF	4%	Minor modifications to the deductions from charity and donations (introduction of the possibility of deducing voluntary contributions to the federal government, cantons, municipalities for their institutions).	1.5‰	0.3‰ with a minimum of 100 CHF	
TI	1995	5%-18% with a total maximum of 14%	13%	The period for which previous loses can be deducted was extended from 3 to 7 fiscal years. Deductions from charity and donations were introduced up to 5000 CHF.	3‰	3‰	Minor modification in the capital tax base definition (mainly regarding the foreign capital funds that are now treated as own capital funds).
VD	2002	4%-14%	9,50%	Introduction of deductions from research and development entrusted to third parties (up to 10% of taxable profits with a cap of 1 million CHF). Minor modifications to deductions from charity and donations (introduction of a 10% of net profits cap).	2‰	1.2‰	Minor modification in the capital tax base definition (an exception concerning the proportion of the capital represented by shares of public companies for which no dividend is issued was eliminated).
GE	1999	6%-14%	10%		2‰	1.8‰ and 2‰ for non taxable (on profits) firms	While before the reform, municipalities taxed corporate income on the same basis as the canton, after the reform they do it "sous forme de centimes additionnels". Change on the definition of taxable corporate income. Before the reform, the own capital was included in the formula to compute the taxable income.
JU	1990	2.3%-3.5% with a total maximum of 6.5%	4% without considering amounts smaller than 1000 CHF	Before the reform, the first deductions from transfers to pension funds for employees had no limit and the following ones were deductible up to 15% of the wages. After the reform, these limits were eliminated and the transfers to pension funds for employees are fully deductible). The period for which previous loses are deductible increase from 3 (4 under authorization) to 7 fiscal years.	0.6‰-1.25‰	1‰	The capital tax system also changed from a progressive to a flat tax scheme. Before the reform, if the cantonal multiplier exceeded the double of the statutory tax rate, it was subject to a referendum.

Notes: This table discuss the reforms applied by the cantons during our sample period. The focus is on the parameters defining the progressivity level of a tax system i.e., the tax rate and deductions. The table also gives information on capital tax rates and, when relevant, on other modifications that are worth mentioning. Note that, as one can observe in Table ??, Geneva, Glarus and Schwyz introduced a flat tax reform after 2008 which is the last year covered by our sample. Hence, this cantons are considered as non-switchers.

Following the theoretical framework developed by Davies and Hoy (2002) for flat tax reforms on personal income, one could expect to determine whether the introduction of a FRT increased (decreased) the level of progressivity with respect to the previous GRT based on two parameters, the marginal tax rate and the level of allowances or deductions. The authors show that the progressivity of after-tax distribution of income is monotonically declining in the flat tax rate and the associated level of basic allowance which generates the same tax yield.[26] Proposition 4 summarizes their main results.[27]

Proposition 4 *For any revenue neutral tax reform, which replaces a GRT with a FRT, there exists a critical flat tax rate (t_F) such that compared to the GRT, after-tax income progressivity is:*

1. *lower (for any inequality index) with any $t_F \leq t_F^l$,*
2. *higher (for any inequality index) with any $t_F \geq t_F^u$,*
3. *the same for a given inequality index at a specific flat tax rate between the lower and upper boundaries ($t_F^l < t_F < t_F^u$).*

The lower bound (t_F^l) corresponds to the flat tax rate which provides a revenue neutral solution if the deduction is kept at the same level as for the GRT. The upper bound (t_F^u) is given by the flat tax rate ensuring that individuals with the highest incomes pay the same tax under both schemes. Finally, note that in comparison to the GRT, both t_F^l and t_F^u should lie between the lowest and highest graduated tax rates.

The heterogeneity and complexity of flat tax reforms usually makes very difficult a clear identification of the bounds defined by Davies and Hoy (2002).[28] Moreover, the characteristics of the Swiss fiscal system makes this task a particularly hard one. Therefore, even if their framework is not enough to classify the reforms implemented among Swiss cantons as being more or less progressive than the GRT schemes they replaced, it helps us to highlight some features of these reforms that will be useful for the interpretation of our results. *i) To the extent that the flattening in tax rates is accompanied by a scaling back of the deductions, the reform will increase progressivity.* As shown in Table 2.2, this has not been the case in Switzerland, where most of the cantons either did not modify the deductions on corporate income or introduced minor

[26]Davies and Hoy (2002) derive these conditions focusing on revenue neutral reforms. Nevertheless, by applying the Hemming–Keen result for non-equal yield comparisons developed in Hemming and Keen (1983), Keen et al. (2008) describe that the results used above continue to apply when the reform is not revenue neutral.

[27]These regularities were derived for personal income taxes. Given the scope of our paper, we adapted them to a corporate tax framework.

[28]See, Paulus and Peichl (2009).

changes that actually softened the conditions regarding these deductions.[29] *ii) All else (including revenue) equal, adopting a flat tax is more likely to be progressive the higher is the single marginal rate it applies.*[30] Unlike the reforms implemented in some of the Eastern European economies (such as Latvia and Lithuania which both set the flat tax rate on personal income at the highest marginal tax rate prior to reform), in most of Swiss cantons the flat tax reform implied a reduction of the marginal tax rate for the highest incomes.[31] To sum up, the characteristics of the reforms applied in Switzerland suggest that the FRT schemes introduced by switcher cantons reduced the progressivity level of the corporate tax schedules.

2.4 Data and descriptives[32]

To estimate our model, we assembled a panel data set with information mainly coming from two different sources. First, the multi-annual Business Census (BC) carried out by the Federal Statistical Office that is the only exhaustive census to collect data on all private and public businesses and workplaces in Switzerland. The BC records establishments (of which there can be several per firm) and attributes them to a NACE sector according to their self-declared principal activity and gives information on the location and the employment level of all Swiss firms. The BC had been conducted three times per decade (i.e. in years ending with 1, 5 and 8) and took place for the last time in 2008.[33] Therefore, we avail of data for 7 years (1985, 1991, 1995, 1998, 2001, 2005 and 2008) over a 23-years period. This is a longer time-period compared with previous studies.[34] Second, we have assembled cantonal and municipal level data on local taxes and other control variables from a variety of sources.

Our aim is to assess the impact of corporate flat tax reforms on firms' location choices. Given that the decision of switching from a GRT to a FRT scheme is entirely taken at the cantonal level, one could argue that our data should be aggregated at this level. Moreover, working with cantonal data allows us to include all 26 Swiss cantons.[35] Nevertheless, analyzing the effect of

[29] Luzern, Thurgau and Ticino incorporated deductions on charity and donations and Schaffhausen and Saint Gallen increased the cap for these deductions from 10% to 20% of net income and reported profits, respectively. Similarly, Ticino and Jura extended the period for which loses can be deducted.

[30] As there are two relevant parameters defining the progressivity level of a tax scheme (the marginal tax rate and the level of deductions), it is only possible to choose one of them freely when imposing revenue neutrality.

[31] The only exception is Jura that set the post-reform tax rate at a higher level than the highest of the pre-reform bounds.

[32] We are thankful to Raphaël Parchet for having provided an important part of the information and data described in this section.

[33] The Business Census was conducted until 2008 when it was substituted by STATNET.

[34] Bacher and Brülhart (2013), for instance, observe their explanatory variables for only 5 years (2001-2005).

[35] The data constraints described in Section 2.4 and in Appendix 2.7 are mostly related to the effective average tax rate ($EATR$) which is (partly) defined at the municipal level. Thus, aggregating our data at the cantonal

our policy at the cantonal level does not allow us to control for heterogeneities that might be relevant to avoid confounding factors in our estimation. Most of the variables affecting firms' location decisions are municipally-defined. In particular the effective average tax rate ($EATR$) that is jointly defined by cantons and municipalities and is crucial to control for the level effect. Thus, aggregating our dependent variable at the cantonal level would generate an important loss of information that could bias our estimates. Finally, working with municipal-level data considerably increases the number of observations and, hence, allows us to rise the power of our estimations and to reduce the relative weight of smaller cantons.[36] Hence, our preferred specification is computed with municipal-level data. Nevertheless, for the sake of completeness, we estimate our model with aggregated data at the cantonal level as well.[37]

Table 2.3 provides summary statistics for all the variables both at the cantonal and municipal levels.

Our main dependent variable accounts for the total *number of firms*. At the municipal level it ranges from a minimum of 1 firm in several small localities to a maximum of more than $26,000$ in the city of Zürich. In addition, in Section 2.6, we consider the *number of firms with one employee* as an alternative dependent variable to test for heterogeneities in the effects of the reform.

Unlike recent taxation papers that focus on firm births or entry in order to reduce potential endogeneity issues, our dependent variable is given by the stock of firms. The main argument given by those studies is that they control (although imperfectly) for the potential simultaneity bias that might arise because of firms influencing the tax setting process through the tax base. The hypothesis is that entrants are supposed to be less likely to significantly influence pre-existing local tax rates. However, this is a secondary issue for us, given that our focus is on a policy decided at the cantonal level and, thus, less likely to be affected by this simultaneity bias. In other words, the cantonal decision of applying a GRT or a FRT scheme is unlikely to be affected by the (municipal) stock of firms. Nevertheless, even when the $EATR$ is an important regressor but not our main explanatory variable, we are aware that tax rates might create some concerns regarding potential endogeneity issues. In Section 2.5 we come back to this and other estimation issues.

Our main explanatory variable is a dummy variable that equals 1 whenever a certain canton

level would allow us to include all cantons in our database.

[36]As we explain in detail in Appendix 2.7, by considering municipal-level data we lose those cantons for which gathering data to compute the $EATR$ was impossible. On the other hand, the number of observations increases considerably and we end up with a panel of almost $1,700$ municipalities (belonging to a sub-sample of 14 cantons) accounting for roughly 60% of the total number of local jurisdictions.

[37]All tables in Section 2.6 show both specifications. Nevertheless, unless specified otherwise, the interpretation and discussion of the results are based on the estimations using municipal-level data.

Table 2.3: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Municipal level					
Dependent variables					
Number of firms	158.858	813.357	1	26172	11524
Number of firms with one employee	40.065	209.621	0	7602	11524
Independent variables					
Flat tax dummy	0.246	0.431	0	1	11524
Corporate tax rate	15.072	3.879	3.265	30.667	11524
% Inactive and unemployed	2.345	1.995	0	28.947	11524
Population (in 1.000)	26.329	3.215	6.351	43.171	11524
% Young (≤ 15)	19.715	3.721	0	43.636	11524
% Old (≥ 65)	14.211	4.567	2.446	57.447	11524
% Foreigners	10.853	8.826	0	53.569	11524
% German speaking population	52.593	43.043	0	100	11524
% Left-wing votes in national ballots	18.645	9.609	0	70.100	11524
Personal income tax rate	26.329	3.215	6.351	43.171	11524
% Protestant population	42.675	30.074	0	100	11524
Instrumental variable					
Average % left-wing votes in national ballots in neighbors	18.103	5.793	0	38.638	11524
Cantonal level					
Dependent variables					
Number of firms	14179.791	14748.157	774	70179	182
Number of firms with one employee	3613.764	3951.3	182	21038	182
Independent variables					
Flat tax dummy	0.264	0.442	0	1	182
Corporate tax rate	12.2	3.231	4.9	21.9	182
% Inactive and unemployed	2.8	1.8	0.5	8.5	182
Population (in 1.000)	274.614	284.658	13.285	1332.730	182
% Young (≤ 15)	18.2	2.4	11.4	24.2	182
% Old (≥ 65)	14.8	2.1	10.3	21.0	182
% Foreigners	16.5	6.4	6.2	38.1	182
% German speaking population	66.7	33.6	3.9	94.0	182
% Left-wing votes in national ballots	25.497	15.883	0	85.7	182
Personal income tax rate	23.103	4.917	10.76	32.08	182
% Protestant population	28.5	1.85	4.7	77.0	182

applies a flat tax schedule on corporate taxes and 0 otherwise. As it can be observed from Table 2.1, our more comprehensive sample includes 14 switcher cantons: Appenzell Auss, Appenzell Inn, Geneva, Jura, Lucerne, Nidwalden, Obwalden, Schaffhausen, St. Gallen, Thurgau, Ticino, Uri, Vaud and Zürich, and 12 cantons that did not switch: Aargau, Bern, Basel-Landschaft, Basel-Stadt, Bern, Fribourg, Glarus, Graubünden, Neuchâtel, Schwyz, Solothurn, Valais and Zug. In the sub-sample in which we consider municipal level data, there are 10 switcher cantons: Lucerne, Jura, Appenzell Inn., Ticino, Geneva, Zürich, Vaud, Schaffhausen, St. Gallen and Thurgau, and 4 cantons that have always applied a GRT system: Bern, Valais, Schwyz and Fribourg.

Concerning the rest of the regressors, the most relevant one is the $EATR$. This is a key variable in our setting given the relative importance of controlling for the level effect.

Gathering the data to compute the $EATR$ at the local level back to 1985 was a hard task and, unfortunately, it was impossible for some cantons. Moreover, as in the Confederation there is no firm-level data on profits or profitability, we followed Brülhart et al. (2012) in order to compute the $EATR$ by considering a firm with a median capital and profitability according to the distribution of all Swiss firms. As shown in Figure 2.1, the $EATR$ presents important variation in both time and the cross-sectional dimensions; ranging from a minimum of 3.26% to a maximum of 30.67%, roughly ten times higher.[38];[39]

Other than our dependent variable and main regressors described before, we also include a set of control variables. Those variables aim at controlling for time variant municipal- (or cantonal-) level heterogeneities. Time invariant ones are captured by municipal (or cantonal) fixed effects. *Personal income tax rates* and *population* are based on annual data, while demographic characteristics such as *% inactive and unemployed*, *% young (*≤ 15*)*,*% old (*≥ 65*)*, *% foreigners*, *% German speaking population* and *% protestant population*, are taken from the decennial Swiss census.

Finally, *% left votes in national ballots*, our instrumental variable, accounts for the votes received by the socialist and other left-wing parties in the previous national election.

[38]As it is described in the Appendix 2.7, the $EATR$ formula does not include include federal tax rates, which would only scale up these values.

[39]Gathering the data for the aggregated data at the cantonal level was more straightforward. The tax rates were directly taken from the Swiss Federal tax Administration's annual publication on the tax burden in the cantonal capitals. This publication provides information on the cantonal average tax burden and, hence, we follow Feld and Kirchgässner (2003) by using the tax burden of a representative firm with $2,000,000$ CHF of capital and a 8% rate of return on capital to compute the cantonal tax rates.

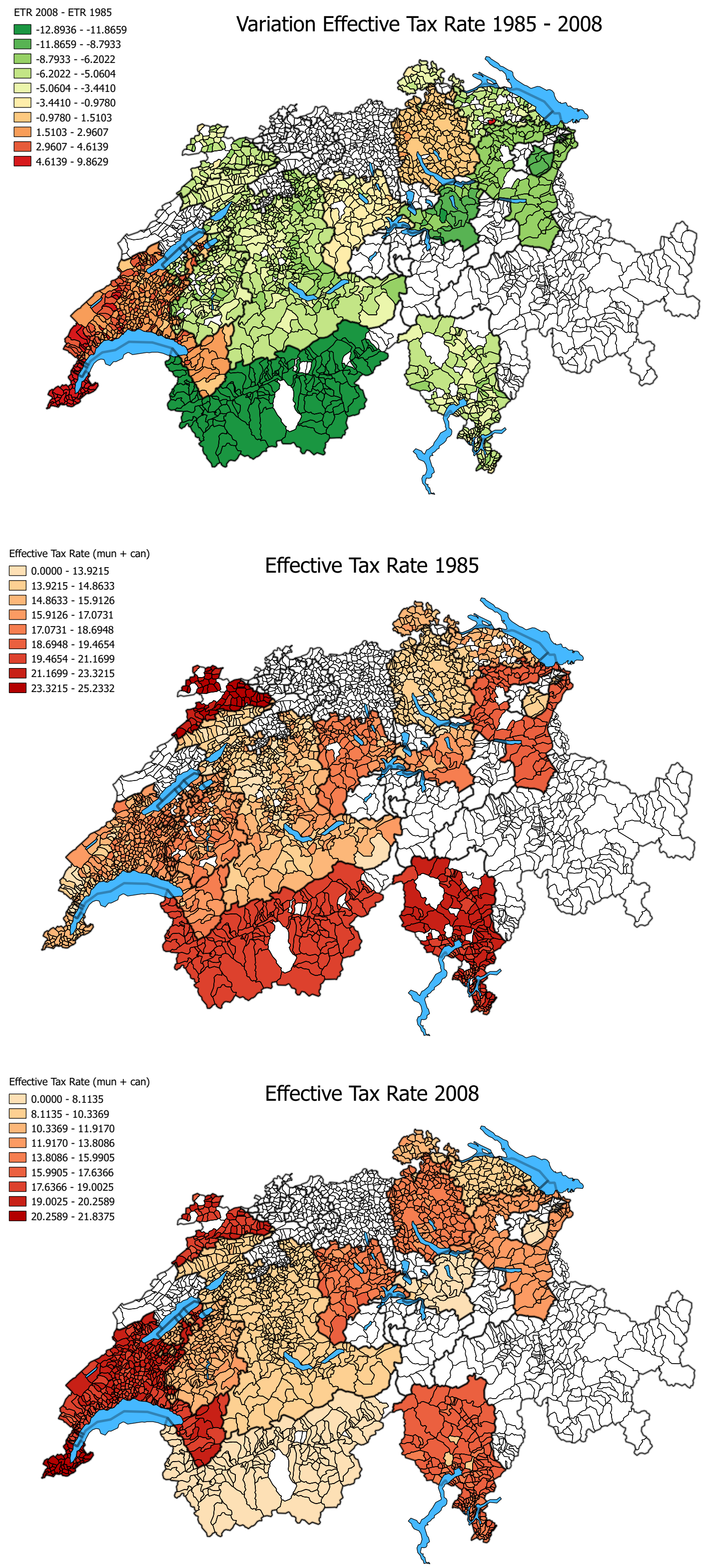

Figure 2.1: Effective average corporate tax rate: variation within and between municipalities

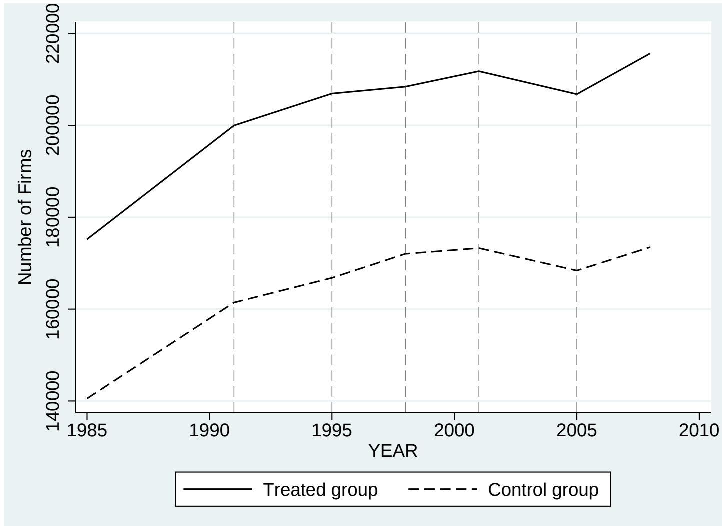

Figure 2.2: Trends of the number of firms for switcher and non-switcher cantons

2.5 Empirical framework and estimation

2.5.1 Empirical model

We estimate the impact of a flat tax reform on corporate taxes on the number of firms through the following model:

$$Y_{kt} = \beta FT_{kt} + \alpha \mathbf{X}_{kt} + \delta_k + \gamma_t + \epsilon_{kt}, \qquad (2.1)$$

where k denotes the geographical unit or area (either municipality or canton) and t the year. The dependent variable Y_{kt} accounts for the number of firms in the area k and year t. FT_{kt} is a dummy taking the value of 1 whenever a canton applies a FRT scheme and 0 otherwise. X_{kt} is the set of control variables previously described and δ_k and γ_t are, respectively, area and year fixed effects. Finally, ϵ_{kt} is the error term.

As mentioned before, since canton Jura introduced a flat tax reform in 1990, several other cantons have been switching from a GRT to a FRT. Therefore, we exploit the different timing of the implementation of these reforms and estimate our model in Equation (2.1) by applying a panel-based differences-in-differences approach. The necessary condition to interpret β as an unbiased coefficient is that the number of firms from the treated and untreated cantons follow the same trends. Figure 2 shows the evolution of the number of firms for both groups. The figure shows a common underlying trend for both switcher and non-switcher cantons which is not limited to the pre-treatment period.

2.5.2 Endogeneity

As we have briefly discussed in Section 2.4, we believe that our main regressor (FT_{kt}) is unlikely to present major endogeneity issues. The potential bias due to confounding factors (i.e., cantonal time-variant unobserved characteristics that systematically correlate with the decision of switching to a FRT scheme and affect the number of firms as well) should not be a major concern in our specification. Indeed, this potential bias is even less of a concern in our preferred specification, where we estimate Equation (2.1) using municipal-level data.

One could also be concerned about potential simultaneity bias arising through the tax rate. This would be a major issue if tax rates were clearly correlated to our flat tax dummy. In that case, the inclusion of such an endogenous regressor would bias the estimates of our main explanatory variable. In other words, there is a trade-off between controlling for the level effect by assuming the risk of potentially biasing our estimates or excluding the $EATR$ from our model and, thus, do not correctly disentangling the level effect from the impact of flatness in itself. We stick to the former strategy because our setting does not seem to present a systematic correlation between the tax rates and the flat tax dummy. Even if the introduction of a flat tax reform might be often taken as an opportunity to modify the tax rates, there is no reason to believe, *a priori*, that there exists a uni-directional relationship between both variables. Indeed, as one can observe from Table 2.2, the variation of corporate tax rates during the application of the flat tax reforms was quite heterogeneous with most of the cantons applying a post-reform tax rate between the pre-reform minimum and maximum rates and a few cantons applying a post-reform tax rate below (above) the lowest (highest) rate of the pre reform scheme. In addition, even if the reforms systematically affected the corporate tax rates in the same direction, the $EATR$ would always have a municipal component and, thus, corporate tax rates would vary within cantons. Hence, even in such a scenario, the estimated coefficient of FT_{kt} would still have a causal interpretation and, moreover, our estimates would be more precise by including the endogenous regressor than by excluding it from the model.

To sum up, we do not find endogeneity to be a main concern in our setting. Nevertheless, for the sake of correctness we tackle the potential simultaneity bias arising from the $EATR$ and, hence, we complement our baseline specification with an instrumental variables (IV) strategy. More precisely, we instrument the corporate tax rate of a given municipality with the average vote share obtained by left-wing parties in federal elections in neighbor municipalities within a ray of 15 kilometers and with a 10 years lag. Our strategy combines two standard approaches by using a political instrument that considers both the spatial and temporal dimensions.[40]

A valid instrument should satisfy two requirements: the relevance and the exogeneity con-

[40]For example, Chirinko and Wilsom (2010) exploit a political instrument in a spatial setting, while Brülhart et al. (2012) apply an instrument based on past elections.

ditions. Our instrument is relevant because voter's neighboring jurisdictions affected taxes in these jurisdictions in the same way that voter's preferences in municipality i affected its own taxation decisions and, moreover, the taxation level 10 years ago is likely to be correlated to the present tax rate.

Unlike the relevance condition (that can be tested through a weak instrument test), the exogeneity condition cannot be tested. Ideally, one would expect the lagged-neighbors voter's preferences (i.e., the instrument) to affect the number of firms (i.e., our dependent variable) uniquely through tax rates (i.e., the endogenous regressor).[41] Gibbons and Overman (2012) suggest that the the exclusion restriction is difficult to be satisfied if the instrument relies on the spatial dimension. In our setting, for example, one could think that an exogenous shock such as an economic crisis might reduce the number of firms and, at the same time, affect voting preferences, regardless the municipality of interest. If this was the case, the omitted variable bias would still be an issue in our estimation. This said, our strategy combines both the spatial and temporal dimensions. Hence, one could expect the exclusion restriction to be more likely to be satisfied. In our setting, the 10 years lag should help to reduce the potential effects of those common shocks. Moreover, in most of our specifications we apply municipal fixed effects and control for canton-specific time trends that would also reduce the effects of those potential common shocks. Therefore, one could argue that our instrument is exogenous, at least conditioned on the rest of our controls.

2.5.3 Inference

As it is nicely described by Cameron and Miller (2015), whenever regression model errors are correlated within clusters, not controlling for within-cluster error correlation can overstate estimation precision by generating misleadingly small standard errors, misleadingly narrow confidence intervals and, thus, large t-statistics and low p-values.

The need for such a control obviously increases with the magnitude of the within-cluster error correlation. Clustering is particularly an issue when applying difference-in-differences in a state-year panel like we do. Indeed, we need to adjust standard errors because of both within-canton correlation and serial correlation because shocks are not likely to be independent across cantons nor over-time. In our setting, the within-cluster error correlation is given by the fact of having our main explanatory variable (FT) defined at the cantonal level and our dependent variable disaggregated at the municipal one. Moreover, in our model, FT equals 1 for the year that the flat tax reform was introduced and every year thereafter. Hence, we are in presence of high serial correlation and, thus, the default standard errors are expected to be downwards-

[41] Note that by considering federal elections (instead of local ones) we rule out potential concerns on the exogeneity of the instrument coming from the presence of yardstick competition.

biased. One could argue that by applying cluster-specific fixed effects we partially control for cluster correlation. Nevertheless, in order to get valid standard errors, we need to compute them by using the cluster-robust estimate of the variance matrix (Cameron and Miller, 2015).

Once the need for computing cluster-robust standard errors is clear, the next important decision to make is the level at which to cluster. When working with cantonal-level data, the decision is quite straightforward. We compute a 2-way (canton-year) clustering in order to control, at the same time, for the potential error correlation coming from within-canton and serial correlation. The level at which to cluster is less evident when we move at our municipal-level data. As with the magnitude of the within-cluster error correlation, the need for clustering increases with the size of within-cluster correlation of regressors and with the number of observations within a cluster. Moulton (1986) and Moulton (1990), for instance, assess the case where individual outcomes (e.g. wages) are regressed on explanatory variables observed at a more aggregated level (e.g. employment growth at the state level). In other words, the issue comes from the policy variable taking the same value for all observations within each cluster. We follow Bertrand et al. (2004) and cluster the errors at one level higher than the one we would have chosen in absence of serial correlation. Hence, we cluster our standard errors at the cantonal rather than at the municipal level.

Unfortunately, we are in presence of another issue. The cluster-robust covariance matrix is consistent when the number of clusters $\rightarrow \infty$. In practice, the rule of thumb suggests that one should have, at least, between 20 and 50 clusters in order to avoid this issue. Given the low number of Swiss cantons, in our two specifications we are left with a too low number of clusters. More precisely, we end up with 26 clusters when working with cantonal-level data and 14 in the municipal-level setting. Concerning the few-clusters issue, the rule of thumb is similar to the one given by Bertrand et al. (2004): "There is no general solution to this trade-off, and there is no formal test of the level at which to cluster. The consensus is to be conservative and avoid bias and use bigger and more aggregate clusters when possible, up to and including the point at which there is concern about having too few clusters." (Cameron and Miller (2015), p., 17).

Finally, in our setting the concern is even higher because, in our preferred specification (municipal level data), we are working with unbalanced clusters.[42] Thus, the number of clusters to ensure a consistent estimation of the cluster-robust covariance matrix should be even higher than the 20 to 50 clusters suggested for the balanced case.[43] In order to account for this, we follow (Cameron et al., 2008) and also compute wild-bootstrap standard errors when working with local-level data. This is an alternative method that estimates the cluster-robust covariance matrix by randomly drawing clusters rather than individual observations and taking all

[42]For example, Vaud and Appenzell Inn. have 376 and 6 municipalities, respectively.

[43]See, for example, (Imbens and Kolesar, 2012) and (MacKinnon and Webb, 2015).

observations for each drawn cluster.

2.6 Results

2.6.1 Baseline results

Our baseline results are shown in Table 2.4.

Table 2.4: Flat tax reforms and the number of firms

	Cantonal level			Municipal level			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Flat tax dummy	-0.030	-0.036*	-0.013**	0.026	0.000	-0.022*	-0.017
	(0.030)	(0.020)	(0.006)	(0.029)	(0.024)	(0.012)	(0.022)
				P=0.485	P=0.957	P=0.172	-
Corporate tax rate		0.000	-0.002		0.004**	0.001	-0.003
		(0.002)	(0.002)		(0.002)	(0.002)	(0.017)
Canton FE	Yes	Yes	Yes	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Canton control variables	No	Yes	Yes	No	Nos	No	No
Canton x time trend	No	No	Yes	No	No	Yes	Yes
Municipal FE	No	No	No	Yes	Yes	Yes	Yes
Municipal control variables	No	No	No	No	Yes	Yes	Yes
R-squared	0.550	0.677	0.960	0.160	0.179	0.208	0.207
Kleibergen-Paap (F-stat)							7.50
N. Observations	182	182	182	11524	11524	11524	11524
N. Cantons	26	26	26	14	14	14	14
N. Municipalities	-	-	-	1685	1685	1685	1685

Notes: Intercept included in all regressions. The dependent variable is *Log(total number of firms)*. In columns (1-3), standard errors (in parenthesis) are clustered two-way by canton and year and they are clustered at the cantonal level in columns (4-7). In columns (4-7) below the standard errors we report the wild bootstrap p-values. The weak instrument test reports the Kleibergen-Paap (F-stat) of the first stage regression where the dependent variable is *corporate tax rate* and the instrument is the 10-years lag value of the average vote share obtained by left-wing parties in federal elections in neighbour municipalities within a ray of 15 kilometers. * $p < 0.1$, ** $p < 0.05$ and *** $p < 0.01$.

Whilst Columns (1), (2) and (3) show our results working with cantonal-level data, Columns (4), (5), (6) and (7) show the estimation of Equation (2.1) using data disaggregated at the municipal level, with Column (7) showing the results for the IV estimation described in Section 2.5.2.[44]

[44] As we are dealing with few clusters, in order to get a more precise estimation of the standard errors, all regressions are run using the command *regress* from Stata and considering differences from the mean (Cameron and Miller, 2015).

The first three columns show a negative effect of the flat tax reform on the number of firms in a canton. The more demanding specifications (in terms of included controls) are statistically different from 0. Instead, when moving to the municipal-level estimates, the simplest specification (where only municipal and year fixed effects are included) shows a positive (not statistically significant) effect of the *flat tax dummy* on the number of firms. As observed in Columns (5) and (6), as we increase the number of control variables the estimated coefficient decreases and, in our preferred specification, where we add our set of control variables and control for canton specific time trends, the coefficient turns negative and statistically significant (at the 10% level). Note that the coefficient turns negative after controlling for canton-specific time trend, which is a proxy for observable and unobservable cantonal time-variant characteristics.

As the dependent variable is the logarithm of the *number of firms* the estimated β_1 represents the semi-elasticity of number of firms with respect to the introduction of the flat tax reform. Hence, in terms of magnitude, the coefficient of the *flat tax dummy* in our preferred specification suggests that, on average, introducing a FRT scheme on corporate taxes decreases the number of firms by roughly 2.2%. For the average municipality in our sample, such a reform implies a reduction of roughly 3 firms.

As mentioned before, not controlling for the level effect could potentially be an issue in our setting. Nevertheless, our estimates of *corporate tax* show a rather small effect that, in our preferred specification, is not statistically significant.

Finally, in Column (7) *corporate tax rate* is instrumented as explained in Section 2.5.2. The coefficient of the *flat tax dummy* is in line with the one found in Column (6), although not statistically different from 0. The instrument is statistically significant but presents some concerns regarding the relevance condition. It does not pass the weak instrument test based on the two stage least squares (TSLS) bias (Stock et al. (2002) and Stock and Yogo (2002)). The reported F-statistic (7.5) is below the common critical value of 10 suggested by Staiger and Stock (1997) as a rule of thumb for the case with one endogenous regressor.[45] Nevertheless, the first stage regression (reported in the Appendix 2.7) between *corporate tax rate* and our instrument shows a positive and statistically significant coefficient (at the 5% level) and, moreover, in Section 2.5.2, we have already discussed why we think that our instrument explains an important part of the variation in the endogenous variable.

To summarize, on average, switching from a GRT to a FRT scheme reduces the number of firms in a given municipality. Nevertheless, the effect is rather small in magnitude and the precision of our estimates is not always the expected one, probably because we are identifying the impact of the policy over a low number of cantons.

[45] See also Kleibergen and Paap (2006).

2.6.2 Discussion and interpretation

The negative effect of flattening corporate taxes seems to be quite robust, at least qualitatively speaking. On average, firms prefer to locate in a jurisdiction where a GRT scheme is in place rather than where corporate taxes are flat. The interpretation of our findings goes through the so-called insurance effect.

Let us recall the definition of the insurance effect given by Bacher and Brülhart (2013): "Keeping the expected after-tax profits constant, progressive taxation reduces the variance of profits by more than linear taxation. As a consequence, tax progressivity serves as an insurance device: in bad times, an entrepreneur has to pay less than under a flat tax, whereas in good times the tax bill is higher. (Bacher and Brülhart (2013) p., 134). The mechanism through which this effect affects firms' location decisions is not straightforward. Let us thus clarify the intuition behind the insurance effect through a simple numerical application of the model presented in Bacher and Brülhart (2013).

We start by assuming a risk averse firm that, with equal probability, could make either a $50,000$ \$ profit (*bad* outcome) or a $150,000$ \$ profit (*good* outcome) in time $t+1$. Further, let's assume that in time t, the entrepreneur chooses to settle her firm either in jurisdiction i or j which only differ in their tax schedules: the former applies a proportional or flat tax schedule while the latter applies a progressive one. Indeed, while jurisdiction i implements a 20% flat tax rate, jurisdiction j applies a progressive tax schedule with two tax brackets: a 12% tax rate that applies to profits up to $50,000$ \$ and a 28% tax rate rate that applies to profits above $50,000$ \$. Thus, if the firm decided to locate in municipality i, it would make an after-tax profit of $40,000$ \$ under the *bad* scenario or a $120,000$ \$ under the good one. Therefore, the expected tax payments would equal $20,000$ \$ and the expected net profits would be $80,000$ \$. Similarly, if the firm located in jurisdiction j, its after-tax profit would be $44,000$ \$ under the *bad* scenario and $116,000$ \$ under the *good* one. Note that, both the expected tax payments and net profits are the same as those in jurisdiction i i.e., $20,000$ \$ and $80,000$ \$, respectively. However, the expected profit variability decreases if the firm decided to settle in jurisdiction j. Therefore, given the risk aversion assumption, the firm will prefer to locate in jurisdiction j where a progressive tax schedule is applied because the aforementioned *insurance effect* reduces the uncertainty on future profit realizations and, thus, one would expect that the introduction of a flat-tax schedule negatively affects the attractiveness of a municipality for firms.

In Section 2.3, we showed that a flat tax reform does not necessarily imply a reduction of the progressivity. On the other hand, we also showed that the reforms applied by Swiss cantons have, indeed, reduced the progressivity of the tax schedule. Hence, in Switzerland, the insurance effect is likely to be one of the factors explaining the negative impact of the introduction of a corporate flat tax reform on the attractiveness of local jurisdictions for firms.

2.6.3 Robustness checks

Our baseline results in Table 2.4 show the average effect of the introduction of a flat tax reform on the number of firms in a given jurisdiction. We have just explained why we consider the insurance effect to be a potential explanation for our findings. Now, if this is the case, one should observe that this effect is stronger for riskier firms.

There are some studies assessing the relationship between profitability and firm size. Ballantine et al. (1993) analyses the connections between variations in profit and loss rates among firms in small-firm and large-firm size classes as reflections of uncertainty finding that, within industries, such variations are particularly important for smaller firms. More recently, Lafrance (2012) finds an inverted u-shaped relationship between profit rates and firm size using Canadian data. An association between firm size, risk and return accounting for this profitability/size relationship may also exist. Some studies suggest that there is a risk-return trade-off i.e., higher rates of return are obtained by increasing risk. Indeed, in many models such as the capital asset pricing model (CAPM), risk is measured by the volatility in rates of return.[46] Concerning the heterogeneity among firms, small (and medium-sized) enterprises tend to take on more risk and to face more uncertainty. Lafrance (2012), for instance, found higher volatility in the rates of return for smaller firms, especially, the smallest. Moreover, models of equilibrium credit rationing assessing moral hazard and adverse selection issues also suggest that small firms may be particularly vulnerable (Stiglitz and Weiss (1981)). These models highlight that small firms are often informationally opaque i.e., smaller firms are a greater challenge for lenders because of difficulties in assessing risk due to, for instance, a lack of publicly available, transparent information (Cole et al. (2004)). Finally, small firms are also vulnerable because of their dependency on financial institutions for external funding. These firms simply do not have access to public capital markets. As a result, shocks to the banking system can have a significant impact on the supply of credit to small businesses. In a recent study using U.S. data, Mills and McCarthy (2014) find a sharp decline in bank lending to small businesses during the 2008 financial crisis and a relatively slow recovery.

Hence, as a robustness check, we estimate Equation (2.1) by only considering firms with one employee. The intuition behind this strategy is that small firms should be riskier and face higher uncertainty than bigger ones and, thus, should react more than the average firm to the introduction of a flat tax reform.

Table 2.5 presents exactly the same structure as Table 2.4 but the dependent variable is now the *number of firms with one employee*. The analysis at the cantonal level shows results that are in line with those of our first estimation. A flat tax reform negatively affects the number of uni-personal firms. As expected, our estimates are bigger in magnitude than those shown in

[46] See, for example, Lintner (1969).

Table 2.5: Flat tax reforms and the number of firms with 1 employee

	Cantonal level			Municipal level			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Flat tax dummy	-0.074*	-0.078**	-0.036*	0.036	-0.002	-0.071***	-0.089**
	(0.040)	(0.030)	(0.018)	(0.042)	(0.034)	(0.022)	(0.040)
				P=0.513	P=0.969	P=0.045	-
Corporate tax rate		0.000	-0.006*		0.005	-0.002	0.010
		(0.003)	(0.003)		(0.003)	(0.002)	(0.022)
Canton FE	Yes	Yes	Yes	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Canton control variables	No	Yes	Yes	No	Nos	No	No
Canton x time trend	No	No	Yes	No	No	Yes	Yes
Municipal FE	No	No	No	Yes	Yes	Yes	Yes
Municipal control variables	No	No	No	No	Yes	Yes	Yes
R-squared	0.648	0.736	0.949	0.119	0.138	0.159	0.156
Kleibergen-Paap (F-stat)							7.64
N. Observations	182	182	182	11330	11330	11330	11330
N. Cantons	26	26	26	14	14	14	14
N. Municipalities	-	-	-	1685	1685	1685	1685

Notes: Intercept included in all regressions. The dependent variable is *Log(total number of firm with 1 employee)*. In columns (1-3), standard errors (in parenthesis) are clustered two-way by canton and year and they are clustered at the cantonal level in columns (4-7). In columns (4-7) below the standard errors we report the wild bootstrap p-values. The weak instrument test reports the Kleibergen-Paap (F-stat) of the first stage regression where the dependent variable is *corporate tax rate* and the instrument is the 10-years lag value of the average vote share obtained by left-wing parties in federal elections in neighbour municipalities within a ray of 15 kilometers. * p < 0.1, ** p < 0.05 and *** p < 0.01.

Table 2.4 and, moreover, are all statistically significant.

These results are confirmed when using municipal-level data. In Column (6), our preferred specification, the estimate is negative and statistically significant (at the 1% level) and the coefficient is almost four times the one obtained in the full-sample estimation (Column (6), Table 2.4). Moreover, even in the more conservative specification in terms of inference (wild-bootstrap standard errors), the p-value confirms that the coefficient is statistically different from 0 (at the 5% level). When considering the sub-sample of uni-personal firms, switching from a GRT to a FRT scheme reduces the number of firms by more than 7%.

Once again, Column (7) shows the results for our IV specification. The reported F-statistic is slightly higher than the on in Table 2.4 but is still lower than 10. Thus, the same discussion regarding the weak instrument test applies. However, the coefficient of *flat tax dummy* is considerably lower than the one computed in Table 2.4 (it decreased from -0.017 to -0.089) and statistically significant at the 5% level.

As expected, these firms seem to value the reduction in the uncertainty on future profit realizations given by a progressive tax schedule more than the average firm. Hence, the sensitivity of these firms to the introduction of a flat tax reform is higher than the one of the average firm. Indeed, in all specifiations the estimates are, at least, two to three times the ones in Table 2.4. Hence, these findings seem to confirm that the insurance effect might be playing an important role in explaining the reduction of firms observed in switcher cantons.

2.7 Conclusion

This paper assesses the effect of introducing a flat tax reform on corporate income taxes on firms' location choices. Our results show that the effect of such a reform is, on average, negative but rather small. Our interpretation of these findings goes through the insurance effect. This effect suggests that, the reduction in the uncertainty on future profit realizations given by a progressive tax schedule should act as insurance for the entrepreneur and, thus, firms should prefer to locate in jurisdictions where a GRT scheme is in place. Our finding that smaller firms are more sensitive to the introduction of a FRT system than the average firm confirms our interpretation. Indeed, when estimating our model by uniquely considering uni-personal firms, the coefficients considerably increase in magnitude and are more precisely estimated.

Despite this negative impact, there has been an increasing number of Swiss cantons introducing flat corporate taxes since 1990. One could argue that a flat tax reform might have several effects other than reducing the attractiveness of a particular jurisdiction for firms. Nevertheless, the reduction of the tax base given by such a reform should be considered by cantonal authorities before deciding whether to switch to a GRT scheme or not. This could be a particularly relevant issue for small cantons, where the share of small firms is higher and, thus, the potential negative impact on their tax base would be stronger as well.

Appendix 2.A Effective average tax rate ($EATR$)

Based on statutory tax rates and average profits and capital stocks estimated from the national distribution of capital and profitability across all sectors, we computed the effective average tax rate ($EATR$), which is a key regressor in our model in order to control for the level effect. The $EATR$ for a firm settled in municipality i in canton c is as follows:

$$EATR = \frac{T^{\pi}_{ic}(\pi - T^{k}_{ic}k)}{(1 + T^{\pi}_{ic})\pi}, \tag{2.A.1}$$

where $T_{ic} \equiv \tau_c \times (\eta_c + \eta_{ic})$; τ_c is the basic statutory tax rate, η_c is the cantonal multiplier and η_{ic} is the multiplier applied by municipality i in canton c. Moreover, π denotes pre-tax profits and k is the own capital. Thus, $T\pi$ is the statutory corporate income tax rate and Tk is the statutory capital tax rate.

To compute the $EATR$, we have gathered data on corporate tax rates by asking for the cantonal and municipal multipliers directly to cantonal authorities. Where we did not received answer or where the data was not available for the period we are working with, we exploited the fact of many municipalities applying the same multiplier for both personal and corporate incomes because a cantonal law constrains them to do so. In these cases, we replicate the corporate income multiplier by the personal income one for which we have data for the totality of Swiss municipalities from 1980 to 2011 (Parchet, 2014). In addition, for the cases where there is no formal law constraining municipal tax authorities to set a unique multiplier, we computed (by canton) the correlation of both municipal multipliers based on yearly data coming from a sub-sample of more than 600 municipalities (representing roughly 25% of all Swiss municipalities) for the period 2001-2011 for which we have data on both tax instruments. In these cases, and in order to minimize the potential bias coming from errors in the data, we decided to keep in our sample only the cantons where this correlation was higher than 95%. For these cantons, again, we used the personal income multiplier. To sum up, we only consider for our study municipalities located in cantons where i) we have the real data on the local corporate income multipliers or ii) the tax multipliers for personal and corporate incomes are the same (either by cantonal law or by a non-written agreement or tradition showing a correlation of 95% or higher in our sub-sample). After this procedure, we end up with a sample of 1,689 municipalities which accounts for around 60% of total Swiss local jurisdictions and 70% of all firms. More precisely, our final sample is composed of the following 14 cantons: Zürich, Bern, Lucerne, Appenzell Inn., St. Gallen, Vaud, Valais, Jura, Schwyz, Fribourg, Schaffhausen, Thurgau, Ticino and Geneva.[47] Finally, the following 12 cantons were not included in our sample either because we did not get any data or because the correlation among the multipliers was lower than 95%: Uri,

[47] The first 8 cantons impose (by law) that personal income and corporate multipliers are the same. The latter 6 ones, were included because of high correlation between both tax instruments in our sub sample.

Obwalden, Nidwalden, Glarus, Zug, Solothurn, Basel-Stadt, Basel-Landschaft, Appenzell Aus., Graubünden, Aargau and Neuchâtel.[48] In the presence of two or more municipalities merging, the $EATR$ is computed by taking the average value of previous jurisdictions' $EATR$s.

[48]We are currently waiting for some cantonal authorities to send us the requested data. Hence, in near future, we expect to extend our sample by including, at least, some of the 12 cantons left out.

Appendix 2.B First stage regressions

Table 2.6: First stage regressions

	IV Table 2.4	IV Table 2.5
	(1)	(2)
% left-wing votes in neighbors $_{t-10}$	0.090**	0.091**
	(0.033)	(0.033)
Municipal FE	Yes	Yes
Year FE	Yes	Yes
Canton x time trend	Yes	Yes
Municipal control variables	Yes	Yes
R-squared	0.634	0.633
N. Observations	11524	11330

Notes: Intercept included in all regressions. The dependent variable is *corporate tax rate*. In all columns, standard errors (in parenthesis) are clustered at the cantonal level. * $p < 0.1$, ** $p < 0.05$ and *** $p < 0.01$.

Bibliography

Agell, Jonas, Peter Englund, and Jan Södersten (1996) 'Tax reform of the century - the swedish experiment.' *National Tax Journal* 49(4), 643–64

Agliardi, Elettra, and Rossella Agliardi (2008) 'Progressive taxation and corporate liquidation policy.' *Economic Modelling* 25(3), 532–541

Andreoni, James, Brian Erard, and Jonathan Feinstein (1998) 'Tax Compliance.' *Journal of Economic Literature* 36(2), 818–860

Auerbach, Alan J (1992) 'On the Design and Reform of Capital-Gains Taxation.' *American Economic Review* 82(2), 263–67

Auerbach, Alan J. (2006) 'Who Bears the Corporate Tax? A Review of What We Know.' In 'Tax Policy and the Economy, Volume 20' NBER Chapters (National Bureau of Economic Research, Inc) pp. 1–40

Auerbach, Alan J., and Joel Slemrod (1997) 'The Economic Effects of the Tax Reform Act of 1986.' *Journal of Economic Literature* 35(2), 589–632

Auerbach, Alan J, and Jr Hines, James R (1988) 'Investment Tax Incentives and Frequent Tax Reforms.' *American Economic Review* 78(2), 211–16

Auerbach, Alan J., Kevin Hassett, and Jan Sodersten (1995) 'Taxation and Corporate Investment: The Impact of the 1991 Swedish Tax Reform.' NBER Working Papers 5189, National Bureau of Economic Research, Inc, July

Bacher, Hans, and Marius Brülhart (2013) 'Progressive taxes and firm births.' *International Tax and Public Finance* 20(1), 129–168

Ballantine, John W, Frederick W Cleveland, and C Timothy Koeller (1993) 'Profitability, uncertainty, and firm size.' *Small Business Economics* 5(2), 87–100

Barrios, Salvador, Harry Huizinga, Luc Laeven, and Gaëtan Nicodème (2012) 'International taxation and multinational firm location decisions.' *Journal of Public Economics* 96(11), 946–958

Becker, Sascha O., Peter H. Egger, and Valeria Merlo (2012) 'How low business tax rates attract mne activity: Municipality-level evidence from germany.' *Journal of Public Economics* 96(9-10), 698–711

Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan (2004) 'How Much Should We Trust Differences-in-Differences Estimates?' *The Quarterly Journal of Economics* 119(1), 249–275

Blum, Walter J., and Jr. Harry Kalven (1952) 'The uneasy case for progressive taxation.' *The University of Chicago Law Review*

Brook, Anne-Marie, and Willi Leibfritz (2005) 'Slovakia's introduction of a flat tax as part of wider economic reforms.' OECD Economics Department Working Papers 448, OECD Publishing

Brülhart, Marius, Mario Jametti, and Kurt Schmidheiny (2012) 'Do agglomeration economies reduce the sensitivity of firm location to tax differentials?' *Economic Journal* 122(563), 1069–1093

Cameron, A. Colin, and Douglas L. Miller (2015) 'A practitioner's guide to cluster-robust inference.' *Journal of Human Resources* 50(2), 317–372

Cameron, A. Colin, Jonah B. Gelbach, and Douglas L. Miller (2008) 'Bootstrap-Based Improvements for Inference with Clustered Errors.' *The Review of Economics and Statistics* 90(3), 414–427

Carey, David, Kathryn Gordon, and Philippe Thalmann (1999) 'Tax reform in switzerland.' OECD Economics Department Working Papers 222, OECD Publishing

Carlton, Dennis W (1983) 'The location and employment choices of new firms: An econometric model with discrete and continuous endogenous variables.' *The Review of Economics and Statistics* 65(3), 440–49

Cassou, Steven P., and Kevin J. Lansing (2004) 'Growth Effects of Shifting from a Graduated-rate Tax System to a Flat Tax.' *Economic Inquiry* 42(2), 194–213

Chirinko, Robert S., and Daniel J. Wilsom (2010) 'Can Lower Tax Rates Be Bought? Business Rent-Seeking And Tax Competition Among U.S. States.' *National Tax Journal* 63(4), 967–93

Cole, Rebel, Lawrence G. Goldberg, and Lawrence White (2004) 'Cookie cutter vs. character: The micro structure of small business lending by large and small banks.' *Journal of Financial and Quantitative Analysis* 39(02), 227–251

Cullen, Julie Berry, and Roger Gordon (2006) 'Tax Reform and Entrepreneurial Activity.' In 'Tax Policy and the Economy,' vol. 20 (The University of Chicago Press) pp. 41–7

Cullen, Julie Berry, and Roger H. Gordon (2007) 'Taxes and entrepreneurial risk-taking: Theory and evidence for the u.s.' *Journal of Public Economics* 91(7-8), 1479–1505

Cummins, Jason G., Kevin A. Hassett, and R. Glenn Hubbard (1996) 'Tax reforms and investment: A cross-country comparison.' *Journal of Public Economics* 62(1-2), 237–273

Davies, James B., and Michael Hoy (2002) 'Flat rate taxes and inequality measurement.' *Journal of Public Economics* 84(1), 33–46

Devereux, Michael P., and Rachel Griffith (1998) 'Taxes and the location of production: evidence from a panel of us multinationals.' *Journal of Public Economics* 68(3), 335–367

Diamond, Peter A (1998) 'Optimal Income Taxation: An Example with a U-Shaped Pattern of Optimal Marginal Tax Rates.' *American Economic Review* 88(1), 83–95

Diamond, Peter, and Emmanuel Saez (2011) 'The Case for a Progressive Tax: From Basic Research to Policy Recommendations.' *Journal of Economic Perspectives* 25(4), 165–90

Feld, Alan L. (1995) 'Living with the flat tax.' *National Tax Journal* 48(4), 603–17

Feld, Lars P., and Gebhard Kirchgässner (2003) 'The impact of corporate and personal income taxes on the location of firms and on employment: some panel evidence for the swiss cantons.' *Journal of Public Economics* 87(1), 129–155

Feldstein, Martin (1976) 'On the theory of tax reform.' *Journal of Public Economics* 6(1–2), 77 – 104

Feldstein, Martin (1995) 'The Effect of Marginal Tax Rates on Taxable Income: A Panel Study of the 1986 Tax Reform Act.' *Journal of Political Economy* 103(3), 551–72

Gaddy, Clifford, and William G Gale (2006) 'Russia's FLat-Tax: Myths and facts.' *CESifo DICE Report* 4(1), 45–49

Gibbons, Stephen, and Henry G. Overman (2012) 'Mostly pointless spatial econometrics?' *Journal of Regional Science* 52(2), 172–191

Gorodnichenko, Yuriy, Jorge Martinez-Vazquez, and Klara Sabirianova Peter (2009) 'Myth and Reality of Flat Tax Reform: Micro Estimates of Tax Evasion Response and Welfare Effects in Russia.' *Journal of Political Economy* 117(3), 504–554

Hall, Robert E., and Alvin Rabushka (1984) 'Low tax, simple tax, flat tax.' *Eastern Economic Journal*

_ (1987) 'The flat tax.' *Journal of Policy Analysis and Management* 5(3), 598–607

Hemming, R., and M. J. Keen (1983) 'Single-crossing conditions in comparisons of tax progressivity.' *Journal of Public Economics* 20(3), 373–380

Hindriks, Jean, Michael Keen, and Abhinay Muthoo (1999) 'Corruption, extortion and evasion.' *Journal of Public Economics* 74(3), 395–430

Imbens, Guido W., and Michal Kolesar (2012) 'Robust Standard Errors in Small Samples: Some Practical Advice.' NBER Working Papers 18478, National Bureau of Economic Research, Inc, October

Jakobsson, Ulf (1976) 'On the measurement of the degree of progression.' *Journal of Public Economics* 5(1-2), 161–168

Keen, Michael, Yitae Kim, and Ricardo Varsano (2008) 'The "flat tax(es)": principles and experience.' *International Tax and Public Finance* 15(6), 712–751

Kirchgässner, Gebhard, and Werner W. Pommerehne (1996) 'Tax harmonization and tax competition in the European Union: Lessons from Switzerland.' *Journal of Public Economics* 60(3), 351–371

Kleibergen, Frank, and Richard Paap (2006) 'Generalized reduced rank tests using the singular value decomposition.' *Journal of Econometrics* 133(1), 97–126

Lafrance, Amelie (2012) 'Firm Dynamics: Variation in Profitability Across Canadian Firms of Different Sizes, 2000 to 2009.' The Canadian Economy in Transition, Statistics Canada, Economic Analysis, July

Lintner, John (1969) 'The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets: A Reply.' *The Review of Economics and Statistics* 51(2), 222–24

Liu, Li, and Rosanne Altshuler (2013) 'Measuring The Burden Of The Corporate Income Tax Under Imperfect Competition.' *National Tax Journal* 66(1), 215–37

MacKinnon, James G., and Matthew D. Webb (2015) 'Wild Bootstrap Inference for Wildly Different Cluster Sizes.' Working Papers 1314, Queen's University, Department of Economics, February

Miller, Merton (1977) 'Debt and taxes.' *Journal of Finance* 32(2), 261–75

Mills, Karen, and Brayden McCarthy (2014) 'The state of small business lending: Credit access during the recovery and how technology may change the game.' Harvard Business School Working Papers 15-004, Harvard Business School

Modigliani, F., and M.H. Miller (1963) 'Corporate Income Taxes and the Cost of Capital: A Correction.' *American Economic Review* 53(3), 433–443

Moore, David (2005) 'Slovakia's 2004 tax and welfare reforms.' IMF Working Papers 05/133, International Monetary Fund

Moulton, Brent R. (1986) 'Random group effects and the precision of regression estimates.' *Journal of Econometrics* 32(3), 385–397

Moulton, Brent R (1990) 'An illustration of a pitfall in estimating the effects of aggregate variables on micro unit.' *The Review of Economics and Statistics* 72(2), 334–38

Parchet, Raphaël (2014) 'Are local tax rates strategic complements or strategic substitutes?' IdEP Economic Papers 1407, USI Università della Svizzera italiana

Paulus, Alari, and Andreas Peichl (2009) 'Effects of flat tax reforms in Western Europe.' *Journal of Policy Modeling* 31(5), 620–636

Piketty, Thomas, and Emmanuel Saez (2007) 'How Progressive is the U.S. Federal Tax System? A Historical and International Perspective.' *Journal of Economic Perspectives* 21(1), 3–24

Richardson, Grant, and Roman Lanis (2007) 'Determinants of the variability in corporate effective tax rates and tax reform: Evidence from australia.' *Journal of Accounting and Public Policy* 26(6), 689 – 704

Staiger, Douglas, and James H. Stock (1997) 'Instrumental Variables Regression with Weak Instruments.' *Econometrica* 65(3), 557–586

Stephanyan, Vahram (2003) 'Reforming tax systems: experience of the baltics, russia, and other countries of the former soviet union.' IMF Working Paper 03/173, International Monetary Fund

Stiglitz, Joseph E, and Andrew Weiss (1981) 'Credit Rationing in Markets with Imperfect Information.' *American Economic Review* 71(3), 393–410

Stock, James H., and Motohiro Yogo (2002) 'Testing for Weak Instruments in Linear IV Regression.' NBER Technical Working Papers 0284, National Bureau of Economic Research, Inc, November

Stock, James H, Jonathan H Wright, and Motohiro Yogo (2002) 'A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments.' *Journal of Business & Economic Statistics* 20(4), 518–29

Stokey, Nancy L, and Sergio Rebelo (1995) 'Growth Effects of Flat-Rate Taxes.' *Journal of Political Economy* 103(3), 519–50

Ventura, Gustavo (1999) 'Flat tax reform: A quantitative exploration.' *Journal of Economic Dynamics and Control* 23(9-10), 1425–1458

Chapter 3

Market Structure and the Functional Form of Demand, the Missing Links between Tax Incidence and Tax Competition

3.1 Introduction

The tax incidence literature is unconcerned about tax competition issues. At most, the incidence of local and federal taxes is studied separately without accounting for any strategic interaction, neither vertical nor horizontal.[1] Indeed, traditional tax incidence models usually consider tax rates to be exogenously determined and focus on the pass-through of taxes to consumer prices without taking the tax setting-process into account.[2] On the other hand, several strands of literature such as optimal taxation and tax competition do focus on the tax setting decision but do not consider tax incidence issues. Standard tax competition models, for example, consider the strategic tax setting by different levels of government (or different jurisdictions belonging to the same tier of government) sharing the tax base but implicitly assume that the incidence of taxes is fully on consumers by assuming producer prices to be constant.[3] Therefore, the potential under-/overreaction of prices to a variation in tax rates is ruled out.

[1]Sen (2001) and Marion and Muehlegger (2011), for example, empirically assess the pass-through of tax rates by different levels of government in the cigarette and gasoline industries, respectively.

[2]Krzyzaniak and Musgrave (1963) were among the first to suggest that, in oligopolistic and monopolistic markets, taxes could be overshifted to final prices. Katz and Rosen (1985), Seade (1985) and Besley (1989) are among the main theoretical references having taken up their point. For a detailed review on tax incidence literature, see Fullerton and Metcalf (2002).

[3]See, for instance, Keen (1997) and Devereux et al. (2007).

Interestingly though, both strands of literature do have some common features. The functional form of demand, for instance, plays a key role in both frameworks. In a tax incidence setting, a linear demand function implies undershifting and an iso-elastic demand function results in overshifting of taxes.[4] Similarly, in a vertical tax competition framework, the sign of the reaction function is determined by the curvature of demand.[5] An iso-elastic demand function implies tax complementarity (i.e., a positive vertical reaction function) and a linear demand gives the opposite result: strategic substitutability (i.e., a negative reaction function).

As the functional form of demand, market structure plays a key role in both settings as well. Nevertheless, as we will show throughout this paper, whilst the role of the curvature of the demand function is clear and well-defined in both settings, this is not the case concerning market structure. In tax incidence settings, the importance of market concentration is fairly clear. A perfectly competitive market implies that taxes are fully shifted. In oligopolistic markets though, taxes can be passed more (less) than proportionally to consumer prices i.e., taxes can be overshifted (undershifted). Moreover, in imperfectly competitive markets, the level of market concentration (generally proxied by the number of firms in the industry) determines the degree of such an (over)reaction. The shifting is maximized in the monopoly case and minimized under perfect competition.[6] From a tax competition perspective, the role of market concentration is less clear. On the one hand, most of the empirical papers studying tax competition issues use data on excise taxes that are usually levied in highly concentrated industries such as the cigarette, gasoline and alcohol beverages ones.[7] Indeed, some of these empirical studies recognize the interconnection between taxes and market structure as one of the causes of endo-

[4]For the sake of correctness, two parameters define the under/overshifting condition in tax incidence models: the functional form of demand and cost functions. Though, as described by Seade (1985) and Besley (1989), under fairly standard assumptions and without too much loss of generality, the tax incidence condition is uniquely determined by the curvature of the demand function.

[5]Keen (1997) is among the first to show the importance of the functional form of demand to determine the sign of the vertical reaction function. Devereux et al. (2007) extend Keen's setting by allowing for horizontal competition (introduced by cross-border shopping) in the spirit of Kanbur and Keen (1993) and Nielsen (2001). In a recent paper, Agrawal (2015) goes one step forward an extends Devereux et al. (2007) by introducing multiple competing federal governments and, thus, by allowing for diagonal externalities i.e., fiscal externalities between neighboring jurisdictions that are of a different level of government. Interestingly, in all these settings, the functional form of demand plays is one of the key parameters defining the sign of the respective reaction functions.

[6]In Jametti et al. (2013), the authors empirically show that not accounting for the interaction of market structure and tax rates could lead to a misleading estimation of tax incidence.

[7]Harris (1987) is among the first to empirically study the incidence of commodity taxes by assessing the 1983 federal cigarette tax increase in the United States. More recently, Delipalla and O'Donnell (2001) analyze the incidence of ad valorem and specific taxes in the European cigarette market and DeCicca et al. (2013) focus on the impact of price search on the shifting of cigarette excise taxes. Kenkel (2005) and Marion and Muehlegger (2011) are two empirical papers focusing on alcohol beverages and gasoline markets, respectively.

geneity due to reverse causality bias, i.e. governments do influence market structure through tax rates but market concentration also has an impact on the tax setting decision through the tax base.[8] Nevertheless, at most, these studies have only tackled this issue as a potential source of endogeneity but none of them has assessed the impact of market structure on tax rates *per se*. Even more striking is the role of market structure in theoretical tax competition literature. By assuming constant producer prices, these settings explicitly rule out any under-/overreaction of prices and only allow for a full shifting of tax rates to prices.

To sum up, while tax incidence models consider taxes as exogenously determined, tax competition settings do not allow for a potential under-/overreaction of prices to taxes. The main goal of this paper is to fill this gap by giving a first step in the direction of setting a comprehensive theoretical framework where the tax setting process is endogenized and local governments explicitly internalize the possibility of a more than proportional reaction of prices to tax rates. The contribution of this paper is twofold. First, from a broad perspective, this model brings together two strands of literature that, in spite of several common points, have only been studied separately. The fact of formalizing the correspondence between the two main outcomes of both frameworks is an important contribution to the existing literature in public economics. Second, from a tax competition point of view, this model explicitly allows market structure to play a role in the tax setting process. Thus, the features of tax incidence settings that were ruled out from previous tax competition studies are now explicitly introduced in the first stage of the model. Allowing taxes to be under-/overshifted turns out to have an impact (through market structure) on the sensitivity of the vertical reaction function.

Our results confirm that the functional form of demand plays a key role in determining both i) whether taxes are under-, fully- or overshifted and ii) whether taxes are strategic complements or substitutes. Even if it is not possible to solve the model for the general case, an interesting correspondence between these two results based on the most studied cases in the literature (i.e. linear and iso-elastic demand functions) arises as one of the main outputs of the model.[9] Finally, what are the consequences of relaxing the assumption that producer prices are constant? The main output of strategic complementarity/substitutability does not change with respect to previous findings but, unlike previous models, the number of firms in the industry arises as one of the determinants of the vertical reaction function. Indeed, in this setting, market structure determines how sensitive local tax rates are to a given variation in the federal tax rate. In the iso-elastic case, for instance, the vertical reaction function is always positive (as in previous models) but decreasing on the number of firms. This last piece of information is absent in traditional tax

[8]See, for example, Becker et al. (2012) and Jametti et al. (2013).

[9]This is another common feature of both strands of literature. Most of the conclusions are drawn on the linear and iso-elastic demand cases. See, for example, Besley (1989) and Keen (1997), just to mention one of the main references of each framework.

competition models and is particularly relevant for taxes levied in highly concentrated industries.

The rest of the paper is structured as follows. In next section the model is set up and solved backward. Sections 3.3 and 3.4 assess the role of what we call the missing links between tax incidence and tax competition literature i.e., the functional form of demand and market structure, respectively. Finally, Section 3.5 provides some concluding remarks.

3.2 The model

3.2.1 Setting

This model extends a traditional Cournot one-stage game as the one developed in Tirole (1988) in two directions. First, and given the scope of the paper, we add an excise tax ($\tau = t_i + T$) to the profit function of the firm. t_i is the tax rate applied by the local government in state i and T is the excise tax rate applied by the federal one. to the profit function of the firm. Moreover, we add a first stage where local governments aim at maximizing revenue by choosing their tax rates t. The goal of the model is to endogenize the tax setting decision by assuming that local policy makers anticipate the reaction of firms to t and adjust their decisions in consequence. In other words, local governments take firm's under/overshifting of taxes into account when setting the tax rates.

There are three different agents in this economy: policy makers (federal and lower-tier governments), producers and consumers.[10] The federal government sets a tax rate T that is assumed exogenous for the rest of the agents. Then, in the first stage of the game, local governments in each state $j = 1, ..., S$ play Nash with respect to the federal government and react to T by setting t_j in order to maximize revenue $R_j = t_j X_j$, where X_j is the tax base.

There are $i = 1, ..., N$ profit-maximizing firms competing *à la* Cournot by choosing their level of output q_i so that $\sum_{i=1}^{N} q_i = Q$.

Finally, following Keen (1997), we characterize consumers' preferences by the indirect utility function $\nu(P) + \Gamma(g, G)$, where $\nu_i(\cdot)$ and $\Gamma_i(\cdot)$ are strictly concave; g and G are the quantities of local and federal public goods, respectively and P is the consumer price of the taxed good. We assume additivity in $(\cdot)$ in order to assure that the demand for the taxed good, $x(P) = -\nu'(P)$ (by Roy's identity), is independent of public expenditure.

The model is set as a two-stage game. In the first stage, the tax policy t is determined. In the latter one, firms maximize profits given the tax rates set in the previous stage and the equilibrium is determined. The model is solved backwards.

[10]The lower tier of government will be called local or state government throughout the paper.

3.2.2 Backwards solution

Second stage

Let us turn to the Cournot-Nash game in which identical firms compete by choosing their level of output q_i conditional on the expectations of their competitors' output levels. Let firm i's profit function be:

$$\pi_i = P(q_i + Q_{-i})q_i - c(q_i) - \tau q_i, \tag{3.1}$$

where q_i is the level of output of firm i, Q_{-i} is the output of all other firms in the industry and $P(Q)$ is the inverse demand function for market demand Q. Finally, $c(\cdot)$ is the cost function that we assume identical for each firm. Indeed, since our model focuses on symmetric equilibria, we assume symmetric firms. Thus,

$$Nq = Q. \tag{3.2}$$

Hence, we drop subscripts and re-express Equation (3.1) as follows:

$$\pi = P(Nq)q - c(q) - \tau q. \tag{3.1'}$$

The first and second order conditions for a given firm are

$$\pi' = P'q + P - c' - \tau = 0 \tag{3.3}$$

$$\pi'' = P''q + 2P' - c'' < 0. \tag{3.4}$$

Finally, solving Equation (3.3) for q, we get the following equilibrium expression for the firms' output:

$$\hat{q} = \frac{c' + \tau - P}{P'}. \tag{3.5}$$

First stage

We now move to the first stage of the game, where local tax rates are set.[11] As we only focus on the vertical interaction, we assume symmetric states ($t_j = t$); each consisting of a single representative consumer. In addition, we assume that the tax base is completely immobile across states. These two assumptions considerably simplify the model. First, we rule out horizontal competition and, second, by imposing a single consumer we can define the tax base for each state equal to the individual demand of the single consumer living in that jurisdiction i.e., $X = x(P)$.

[11] Let us clarify a notation issue. For the sake of comparability with previous tax incidence and tax competition studies, we decided to stick to the standard notation used in each framework. Thus, the notation in the first and second stages of the model are slightly different as once can observe by comparing, for example, the equations defining the first order conditions in each stage. Whilst in Equation (3.3) we use π' to indicate "the derivative of the profit function with respect to q", in Equation (3.6), "the derivative of the revenue function with respect to t" is indicated by $\frac{dR}{dt}$ rather than R'.

Indeed, using the equilibrium condition ($X = Q$), we can define the tax base in each state as $X = x(P) = Q$.

Local governments are Leviathans and, thus, aim at maximizing revenue $R = tX = tQ$ by setting t. Therefore, the first and second order conditions of the revenue maximizing problem are:

$$\frac{dR}{dt} = Q + t\frac{dQ}{dt} = 0 \tag{3.6}$$

$$\frac{d^2R}{dt^2} = 2\frac{dQ}{dt} + t\frac{d^2Q}{dt^2} < 0. \tag{3.7}$$

Now, solving Equation (3.6) for t by using $\frac{dQ}{dt} = \frac{dQ}{dP}\frac{dP}{dt}$, we obtain the following expression for the equilibrium tax rate:[12]

$$\hat{t} = -\frac{Q}{\frac{dQ}{dP}\frac{dP}{dt}}. \tag{3.8}$$

Finally, we can rewrite Equation (3.8) in *ad-valorem* terms as follows:

$$\frac{\hat{t}}{P} = -\frac{1}{\frac{dQ}{dP}\frac{P}{Q}\frac{dP}{dt}} = \frac{1}{\epsilon\frac{dP}{dt}}, \tag{3.9}$$

where $\epsilon = -\frac{dQ}{dP}\frac{P}{Q} > 0$ is the elasticity of the aggregate demand function.

As expected, by assuming $\frac{dP}{dt} = 1$, we are back to the standard formula present in previous tax competition settings indicating that the optimal tax rate (in *ad-valorem* terms) is inversely proportional to the elasticity of the tax base that was already derived in ,for example, Keen (1997) and Devereux et al. (2007).[13] By relaxing this assumption, we explicitly allow policy makers to consider tax incidence features when setting their tax rates. In other words, local governments recognize that taxes are not necessarily fully-passed to consumer prices but can also be under/overshifted; and take this into consideration when setting t. We come back to the implications of allowing for $\frac{dP}{dt} \neq 1$ in Section 3.4.

3.3 The effect of the functional form of demand

In Section we briefly discussed why we think that the functional form of demand and market structure are the missing links between tax incidence and tax competition models. Let us know formalize this idea.

[12]From the second stage we know that $P(Q(N, c, \tau))$. Thus, by applying the chain rule, we get $\frac{dQ}{dt} = \frac{dQ}{dP}\frac{dP}{dt}$.

[13]A few empirical papers assess the different pass-through depending of the level of government levying the tax (Chouinard and Perloff (2007), Marion and Muehlegger (2011)). Nevertheless, this remains an empirical issue and, as it is standard in theoretical tax incidence models, we assume that firms shift tax rates to consumers without considering this.

3.3.1 The impact of the functional form of demand on tax incidence

Let us follow the standard notation in tax incidence models that has been first defined in Seade (1980) and rewrite Equation (3.4) as follows:

$$\frac{P'}{N}(\eta + N + Nk) < 0, \tag{3.10}$$

where $\eta = Q\frac{P''}{P'}$ is the elasticity of the slope of the inverse demand function and $k = 1 - \frac{c''}{P'}$ measures the relative slopes of the demand and marginal cost curves. Using this notation, we can now differentiate Equation (3.3) to get:

$$\frac{dq}{d\tau} = \frac{1}{P'(\eta + N + k)}. \tag{3.11}$$

Thus,

$$\frac{dQ}{d\tau} = \frac{N}{P'(\eta + N + k)} \tag{3.12}$$

and, therefore,

$$\frac{dP}{d\tau} = P'\frac{dQ}{dt} = \frac{N}{N + \eta + k}. \tag{3.13}$$

Equation (3.13) shows the standard tax incidence condition that can be summarized as follows:[14]

$$\frac{dP}{d\tau} = \frac{N}{N + (\eta + k)} \begin{cases} < 1 & \Rightarrow \textit{undershifting} \\ = 1 & \Rightarrow \textit{full shifting} \\ > 1 & \Rightarrow \textit{overshifting} \end{cases}$$

Let us highlight some of the implications of Equation (3.13) that will be useful for the rest of the paper. First, in a perfectly competitive market ($N \to \infty$), taxes are fully shifted, i.e. $\frac{dP}{d\tau} = 1$. Second, once we leave the perfect competition scenario, i) the tax incidence condition depends on the curvature of the demand and cost functions and; ii) market structure does not determine the sign of $\frac{dP}{d\tau}$ but defines the degree of the shifting, i.e. no matter whether taxes are under- or overshifted, the shifting is maximized in the monopoly case and minimized as $N \to \infty$.

As we have already mentioned in Section 3.1, the curvature of the demand function is a key parameter in tax incidence literature. Let us now illustrate its importance by assuming linear costs ($c'' = 0$ and, thus, $k = 1$) and analyzing the implications of Equation (3.13) for the two most studied functional forms of demand, i.e. iso-elastic and linear demand functions.

[14]Most of tax incidence models analyze a game of the Cournot type. Interestingly though, Anderson et al. (2001) find a similar tax incidence condition in a differentiated product oligopoly *à la* Bertrand.

Iso-elastic demand function

If costs are linear, a necessary and sufficient condition for taxes to be overshifted is that $\eta < -1$.[15] If demand is of the constant elasticity type, this is always the case. Note that a demand elasticity $\epsilon > 0$, implies that $\eta = -\frac{1+\epsilon}{\epsilon} < -1$ for all ϵ. Indeed, in this case, Equation (3.13) can be re-expressed as follows:

$$\frac{dP}{d\tau} = \frac{N}{N - \frac{1+\epsilon}{\epsilon} + 1} > 1. \tag{3.14}$$

Thus, in the linear cost/iso-elastic demand case there is always overshifting.

Linear demand function

Similarly, with linear costs and a linear demand function ($P'' = 0$ and, thus, $\eta = 0$), Equation (3.13) is simplified as follows:

$$\frac{dP}{d\tau} = \frac{N}{N+1} < 1. \tag{3.15}$$

Thus, in the linear cost/linear demand case, taxes are always undershifted and overshifting cannot occur.

We have shown that, once costs are assumed to be linear, the curvature of the demand function is the key parameter defining whether taxes are under- or overshifted. Nevertheless, the intuition behind this concept and its effect on the incidence of taxes might not be straightforward. Let us thus show graphically how the tax incidence condition depends on the curvature of the demand function by analyzing the simplest possible case, where there is only one firm in the industry.[16]

In a monopolistic market, and assuming a linear cost function, the condition for overshifting is now as follows:

$$\frac{dP}{d\tau} = \frac{1}{2+\eta} > 1 \Leftrightarrow \eta < -1. \tag{3.16}$$

Note that $\eta < -1$ implies that the demand curve is steeper than the marginal revenue curve. Why? An increase in the tax rate of $\Delta\tau$ shifts the effective marginal cost from $MC^0 = c + \tau^0$

[15] As one can observe from Equation (3.13), the overshifting condition should include a second bound. For instance, in the monopoly case, the necessary and sufficient condition for overshifting should be $-2 < \eta < -1$ rather than $\eta < -1$. Similarly, in the duopoly case, it should be $-3 < \eta < -1$ and so on. This second bound (formally given by $\mid \eta \mid < \mid N+k \mid$) is systematically neglected and (implicitly) assumed to hold in the tax incidence literature. To the best of our knowledge, the only exception is Fullerton and Metcalf (2002). In page 32, the authors briefly analyze tax incidence in monopolistic markets and show that the condition for overshifting is $-2 < \eta < -1$. Though, in the rest of the chapter they refer to $\eta < -1$ as being a necessary and sufficient condition for overshifting. Because of comparability reasons and given that this second bound does not affect the main results of our model, in rest of the paper we follow previous studies and consider $\eta < -1$ to be the necessary and sufficient condition for overshifting.

[16] This application is an extension of Anderson et al. (2001).

to $MC^1 = c + \tau^1$. Thus, the equilibrium marginal revenue also increases by $\Delta\tau$. If demand is steeper than marginal revenue,

$$P' < (P'Q + P)' \Leftrightarrow P' < P''Q + 2P' \Leftrightarrow -1 < \underbrace{\frac{P''}{P'}Q}_{\eta}. \tag{3.17}$$

Now, $\eta < -1$ is always true if the demand is iso-elastic ($\eta = -\frac{1+\epsilon}{\epsilon} < -1$) and is never true if demand is linear ($\eta = 0 > 1$). Therefore, in the iso-elastic demand case (Figure 3.1) taxes are always overshifted and, if the demand function is of the linear type as in Figure 3.2, taxes are always undershifted.

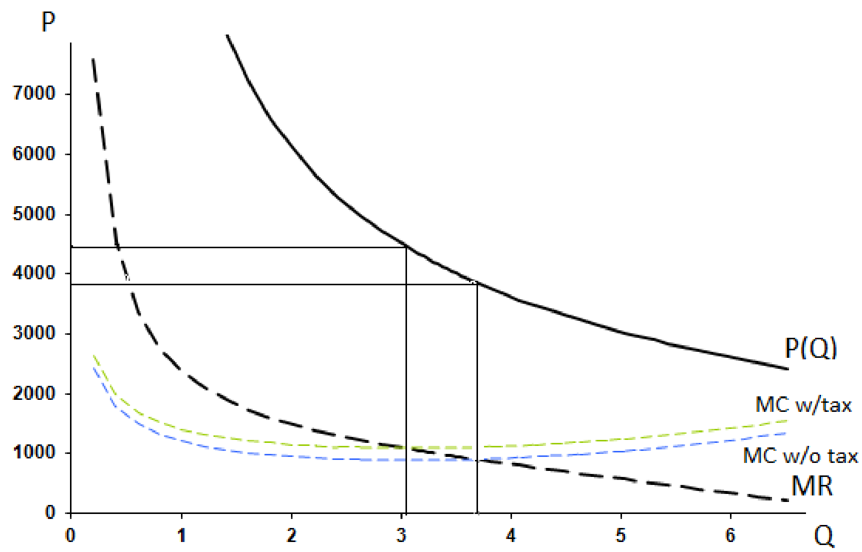

Figure 3.1: Tax incidence and the functional form of demand (Iso-elastic demand)

3.3.2 The impact of the functional form of demand on tax competition

One of the key features of the first stage of the game is given by the two tiers of government taxing the same good and, thus, sharing the tax base. From a tax competition perspective, we are interested in the strategic interactions arising because of this. How does a variation in T affects the state's choice of t? As discussed in Section 3.1, this question has already been deeply analyzed in tax competition literature. The main outcome of previous studies can be summarized in the following proposition:

Proposition 5 *The vertical reaction function* $\frac{dt}{dT}$ *depends on the functional form of the demand function. First, if* $x(P) = \bar{x}$ *so that individual demand is inelastic, then in the neighborhood of*

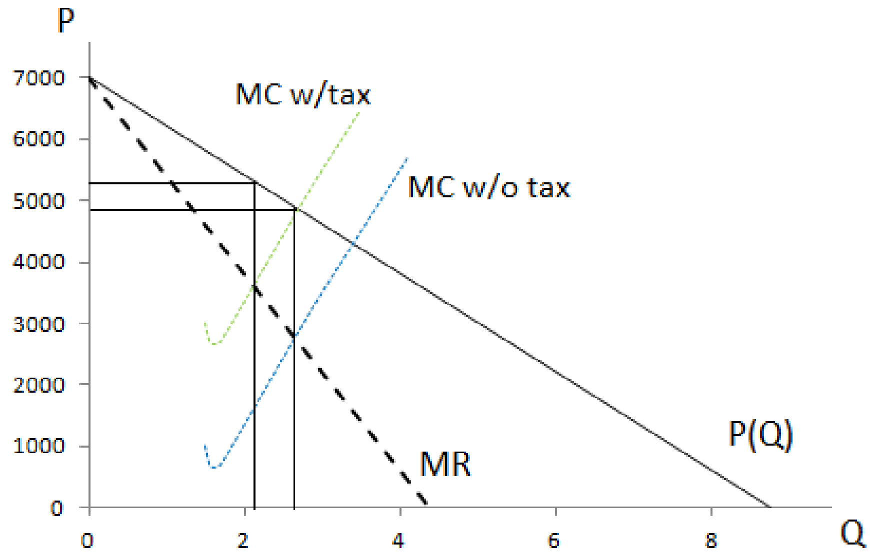

Figure 3.2: Tax incidence and the functional form of demand (Linear demand)

Nash equilibrium, $\frac{dt}{dT} = 0$. *Second, in the symmetric case, once we allow for individual demand function to be elastic, the sign of the reaction function is undefined for the general case. Indeed, the sign of* $\frac{dt}{dT}$ *depends on the elasticity of the demand function and, interestingly, the two most analyzed cases in the literature have the following implications:*

- *If demand is iso-elastic,* $\frac{dt}{dT} > 0$ *(t and T strategic complements)*
- *If demand is linear,* $\frac{dt}{dT} < 0$ *(t and T are strategic substitutes)*

Given the scope of the paper, our interest is on the role of the curvature of the demand function. Does the functional form of demand have an impact on the vertical reaction function studied in previous models? Once again, to answer these questions, let us concentrate on the two cases previously discussed.

Iso-elastic demand function:

Let us first recall the expression for the equilibrium tax rate (in *ad valorem* terms) derived in Equation (3.9),

$$\frac{\hat{t}}{P} = \frac{1}{\epsilon \frac{dP}{dt}}. \tag{9}$$

We are interested in the vertical reaction function i.e., we want to asses the reaction of state governments to a variation in the federal tax rate. To say it differently, we want to know how the equality in Equation (3.9) will be affected by a variation in T and, particularly, how t will adjust in order to restore it.

Plugging Equation (3.14) in Equation (3.9), we obtain:

$$\frac{\hat{t}}{P} = \frac{1}{\epsilon}\left(1 - \frac{1}{\epsilon N}\right). \tag{9.1}$$

An increase in T will rise the consumer price P and, thus, reduce the left hand side of Equation (9.1). Given that the elasticity of demand is constant ($\bar{\epsilon}$), the only way to restore the equality (in the fixed-N case) is through an increase in t. Thus, in the iso-elastic demand/linear cost case, $\frac{dt}{dT} > 0$ and taxes are strategic complements.

Linear demand function:

Let us now move to the linear cost/linear demand case. The starting point is, again, the expression for the equilibrium tax rate given by Equation (3.9):

$$\frac{\hat{t}}{P} = \frac{1}{\epsilon \frac{dP}{dt}}. \tag{9}$$

For the sake of simplicity, let us just re-express Equation (3.9) as follows:

$$\hat{t} = \frac{1}{-\left(\frac{Q'}{Q}\right)\frac{dP}{dt}}. \tag{9.2}$$

Plugging Equation (3.15) in Equation (9.2), we get:

$$\hat{t} = \frac{1}{-\left(\frac{Q'}{Q}\right)\frac{N}{N+1}}. \tag{9.3}$$

Finally, we apply the same reasoning as for the previous case. An increase in T will rise the consumer price P and, thus, Q will decrease. Given that the elasticity of demand is linear, the slope of the demand curve is constant ($\bar{Q'}$) and, therefore (in the fixed-N case), the equality in Equation (9.3) can only be restored by decreasing t. Thus, in the linear demand/cost case, $\frac{dt}{dT} < 0$ and taxes are strategic substitutes.

Let us thus summarize the first result of our model by the following conjecture:

Conjecture 1 *In the symmetric case, at symmetric Nash equilibrium, the following correspondence between the pass through of taxes into consumer prices and the vertical reaction function arises:*

- $\frac{dP}{d\tau} < 1 \Leftrightarrow \frac{dt}{dT} < 0$
- $\frac{dP}{d\tau} > 1 \Leftrightarrow \frac{dt}{dT} > 0$

The simple inspection of Conjecture 1 already shows how the model nicely merges the outputs of tax incidence and tax competition frameworks. Unfortunately, as stated in Proposition 5, in a tax competition framework one cannot expect to sign the reaction function $\frac{dt}{dT}$ for the general case. Hence, specific forms of demand and cost functions are often imposed in order to make the results more intuitive. This is also the case in this model. Nevertheless, we honestly believe that the correspondence described in Conjecture 1 and illustrated in Table 3.1 is a strong result and has some practical implications.

Table 3.1: Correspondence between the reaction function and the tax incidence condition

Tax incidenceTax competition	Strategic substitutes ($\frac{dt}{dT} < 0$)	Strategic complements ($\frac{dt}{dT} > 0$)
Undershifting ($\frac{dP}{d\tau} < 1$)	✓	Not possible
Overshifting ($\frac{dP}{d\tau} > 1$)	Not possible	✓

Let us suppose, for instance, that an econometrician aims at estimating the pass through of taxes in a given market but, as it is frequently the case, does not have reliable data on market concentration. Based on Conjecture 1, she will be able to infer whether taxes are under- or overshifted by only estimating the vertical reaction function.

3.4 The role of market structure

3.4.1 The impact of market structure on local tax rates

Let us now move to the impact of market structure. One first step to assess the role of market concentration in the this setting is through the direct impact of N on the tax setting decision i.e., $\frac{dt}{dN}$.

First, we totally differentiate equation (3.6) by applying the Implicit function theorem as follows:

$$\frac{dt}{dN} = -\frac{\frac{dF}{dN}}{\frac{dF}{dt}} = -\frac{\frac{dQ}{dN} + t\frac{d\left(\frac{dQ}{dt}\right)}{dN}}{2\frac{dQ}{dt} + t\frac{d^2Q}{dt^2}} = \frac{1}{D}\left[\frac{dQ}{dN} + t\frac{d\left(\frac{dQ}{dt}\right)}{dN}\right], \tag{3.18}$$

where $D = -\underbrace{\left[2\frac{dQ}{dt} + t\frac{d^2Q}{dt^2}\right]}_{=(3.7)} > 0$. Hence, the sign of $\frac{dt}{dN}$ is given by the sign of $\frac{dF}{dN}$:

$$\frac{dF}{dN} = \frac{dQ}{dN} + t\frac{d\left(\frac{dQ}{dP}\frac{dP}{dt}\right)}{dN}. \tag{3.19}$$

The presence of second derivatives makes this generally difficult to evaluate. Thus we assess $\frac{dt}{dN}$ by focusing on the linear and constant elasticity demand cases.

Constant elasticity demand function

Let us first re-express Equation (3.19) as follows:

$$sign\left(\frac{dt}{dN}\right) = sign\left(\frac{dF}{dN}\right) = sign\left[\underbrace{\frac{dQ}{dN}}_{(a)} + t\frac{d\left(\frac{dQ}{dP}\frac{dP}{dt}\right)}{dN}\right], \tag{3.20}$$

where

$$\frac{d\left(\frac{dQ}{dP}\frac{dP}{dt}\right)}{dN} = \underbrace{\frac{d\left(\frac{dQ}{dP}\right)}{dN}}_{(b)}\underbrace{\frac{dP}{dt}}_{(c)} + \underbrace{\frac{dQ}{dP}}_{(d)}\underbrace{\frac{d\left(\frac{dP}{dt}\right)}{dN}}_{(e)}. \tag{3.21}$$

The standard iso-elastic demand function is given by

$$Q = AP^{-\epsilon}, \tag{3.22}$$

where, $A > 0$ is the scaling factor and $\epsilon = -\frac{dQ}{dP}\frac{P}{Q}$ is the elasticity of demand. Thus, the inverse demand function is, thus, given by

$$P = \left(\frac{A}{Q}\right)^{\frac{1}{\epsilon}}. \tag{3.23}$$

The solution of the profit maximization problem for the CED is given by the following equilibrium values:[17]

$$\hat{Q} = A\left[\frac{\epsilon N(c+t)}{\epsilon N - 1}\right]^{-\epsilon}, \tag{3.24}$$

$$\hat{P} = \frac{\epsilon N(c+t)}{\epsilon N - 1}. \tag{3.25}$$

We use these expressions and our results in the second stage of the model to compute the required expressions in order to sign $\frac{dt}{dN}$ as follows:

$$(a)\frac{dQ}{dN} = \frac{\hat{Q}}{N}\frac{\epsilon}{\epsilon N - 1} = \frac{A}{N}\left[\frac{\epsilon N(c+t)}{\epsilon N - 1}\right]^{-\epsilon}\frac{\epsilon}{\epsilon N - 1} \tag{3.26}$$

$$(b)\frac{d\left(\frac{dQ}{dP}\right)}{dN} = -\frac{\hat{Q}}{N^2}\frac{\epsilon+1}{c+t} = -\frac{A}{N^2}\left[\frac{\epsilon N(c+t)}{\epsilon N - 1}\right]^{-\epsilon}\frac{\epsilon+1}{c+t} \tag{3.27}$$

$$(c)\frac{dP}{dt} = \frac{N}{N - \frac{1}{\epsilon}} = \frac{N\epsilon}{N\epsilon - 1} \tag{3.28}$$

$$(d)\frac{dQ}{dP} = -\epsilon A\left[\frac{\epsilon N(c+t)}{\epsilon N - 1}\right]^{-\epsilon-1} \tag{3.29}$$

$$(e)\frac{d\left(\frac{dP}{dt}\right)}{dN} = -\frac{1}{\epsilon(N - \frac{1}{\epsilon})^2} = -\frac{\epsilon}{(\epsilon N - 1)^2} \tag{3.30}$$

[17] The profit maximization problems for both the iso-elastic and linear demand cases are solved in Appendix A.

Therefore, from equations (3.20) and (3.21),

$$sign\frac{dt}{dN} = \frac{A}{N}\left[\frac{\epsilon N(c+t)}{\epsilon N-1}\right]^{-\epsilon}\frac{\epsilon}{\epsilon N-1} > 0 \tag{3.31}$$

Hence, in the constant elasticity demand and linear cost case, $\frac{dt}{dN} > 0$.

Linear demand function

Let the linear demand function be given by $Q = 1 - P$ and, thus, the inverse demand function be $P = 1 - Q$. Thus, the solution of the profit maximization problem gives us the following optimal values:

$$\hat{Q} = \frac{N(1-c-t)}{(N+1)} \tag{3.32}$$

$$\hat{P} = c + t + \frac{(1-c-t)}{(N+1)}. \tag{3.33}$$

Once again, to sign $\frac{dt}{dN}$ we need to compute the following expressions:

$$(a)\frac{dQ}{dN} = \frac{(1-c-t)}{(N+1)^2} \tag{3.34}$$

$$(b)\frac{d\left(\frac{dQ}{dP}\right)}{dN} = 0 \tag{3.35}$$

$$(c)\frac{dP}{dt} = \frac{N}{N+1} \tag{3.36}$$

$$(d)\frac{dQ}{dP} = -1 \tag{3.37}$$

$$(e)\frac{d\left(\frac{dP}{dt}\right)}{dN} = \frac{1}{(N+1)^2} \tag{3.38}$$

Therefore,

$$sign\left(\frac{dt}{dN}\right) = \frac{(1-c-t)}{(N+1)^2} + t\left((-1)\frac{1}{(N+1)^2}\right) = \frac{(1-c-2t)}{(N+1)^2}. \tag{3.39}$$

Hence,

$$\frac{dt}{dN} \gtreqless 0 \Leftrightarrow 1 - c - 2t \gtreqless 0 \tag{3.40}$$

In other words, in the linear demand/cost case, the impact of market structure can be either positive or negative depending on the following condition:

$$\frac{dt}{dN} \gtreqless 0 \Leftrightarrow t \lesseqgtr \frac{1-c}{2}. \tag{3.41}$$

As we mentioned already in Section 3.1, the relationship between taxes and market structure has been largely studied both in theoretical and empirical literature. Nevertheless, to the best of our knowledge, the impact of market structure on tax rates has not been assessed *per se*. Our results show that, in the linear cost/iso-elastic demand case, local tax rates are increasing in the number of firms in the industry.[18] One possible interpretation of this results might be related to welfare issues. As we discussed in Section 3.3, the shifting of taxes to prices is maximized in a monopolistic market and is minimized in perfectly competitive markets. This might be an incentive for the policy maker to apply higher tax rates to less concentrated industries.

3.4.2 The impact of market structure on tax incidence

Let us now briefly assess the impact of market concentration on the pass-through of taxes.[19] Taking the derivative of Equation (3.13) with respect to the number of firms in the industry, we obtain:

$$d\frac{\left(\frac{dP}{dt}\right)}{N} = \frac{\eta - \frac{d\eta}{dN} + k - \frac{dk}{dN}}{(N+\eta+k)^2}. \tag{3.42}$$

Equation (3.42) shows that the overall impact of market structure on tax incidence is composed by the main effects that run through N, η and k and the respective second order effects given by the impact of N on the latter two variables i.e., $\frac{d\eta}{dN}$ and $\frac{dk}{dN}$. Interestingly, the second order effects are not relevant when assuming linear costs ($k = 1 \Rightarrow \frac{dk}{dN} = 0$) and either of the two demand functions we are working with i.e., linear ($\eta = 0 \Rightarrow \frac{d\eta}{dN} = 0$) or constant elasticity ($\eta = -\frac{1+\epsilon}{\epsilon} \Rightarrow \frac{d\eta}{dN} = 0$) demand functions. To put it differently, when the demand function is of the constant elasticity type (and with linear costs), $d\frac{\left(\frac{dP}{dt}\right)}{N} = \frac{-\frac{1+\epsilon}{\epsilon}+1}{(N-\frac{1+\epsilon}{\epsilon}+1)^2} < 0$. On the other hand, in the linear costs/linear demand case, $d\frac{\left(\frac{dP}{dt}\right)}{N} = \frac{1}{(N+1)^2} > 0$.

3.4.3 The impact of market structure on tax competition

Traditional vertical competition models assume producer prices to be constant (or they are normalized to zero). Hence, consumer prices are given by $P = t + T$ and, therefore $\frac{dP}{dt} = 1$. Thus, these settings obtain the standard expression that the tax rate (in *ad-valorem* terms) is inversely proportional to the elasticity of demand (Equation (3.9)). As one can observe from Equation (3.13), the $\frac{dP}{dt} = 1$ condition is verified if and only if $\eta + k = 0$ or under perfect competition ($N \to \infty$). Assuming either of these two conditions to hold is quite a strong statement that deserves, at least, some comments. First, note that $\eta + k = 0$ is far from being the

[18] When demand is linear, the impact of N on t is inconclusive and depends on the relationship between the tax rate and the firm's cost function.

[19] A first step in this direction has been taken in the first chapter of this thesis where we empirically analyze the effect of market structure on tax incidence by introducing an interaction term of market structure and tax rates in a classic tax incidence regression. The authors show that the introduction of this interaction term is theoretically justified by the cross-derivative of tax incidence with respect to the number of firms in the industry $\left(\frac{d\left(\frac{dP}{dt}\right)}{dN}\right)$. Nevertheless, while the focus in Chapter 1 is mainly an empirical one; we now aim at tackling the effects of market concentration on tax incidence from a theoretical perspective.

general rule or even from representing the most important case in the literature. Indeed, under the two most analyzed scenarios (linear costs ($k = 1$) and, either linear ($\eta = 0$) or iso-elastic ($\eta = -\frac{1+\epsilon}{\epsilon}$) demand functions), $\eta + k \neq 0$. Second, it would be even more striking to justify $\frac{dP}{dt} = 1$ by assuming perfect competition. In particular, because most of these models focus on excise taxes that are usually levied in highly concentrated industries such as gasoline, cigarette or alcohol beverages markets. In other words, assuming constant producer prices and, thus, imposing $\frac{dP}{dt} = 1$ considerably simplifies the model but, on the other hand, such an assumption has implications that seem, at least, difficult to justify from an economic perspective.

Our model, instead, relaxes this assumption by explicitly allowing $\frac{dP}{dt} \neq 1$. Nevertheless, one might argue that, even after relaxing this assumption, the main output of the model is exactly the same as that of previous studies. In other words, the strategic complementarity/substitutability condition depends on the curvature of demand exactly as in, for example, Keen (1997). Let us thus briefly show how the output of this model differs from previous findings by taking the linear cost/iso-elastic demand case and applying the same reasoning as in Section 3.3.

In traditional tax competition studies, $\frac{dP}{dt} = 1$ and, thus, Equation (3.9) is simplified as follows:

$$\frac{\hat{t}}{P} = \frac{1}{\epsilon}. \tag{9.4}$$

An increase in T will rise the consumer price P and, thus, reduce the left hand side of Equation (9.4). Given that the elasticity of demand is constant ($\bar{\epsilon}$), t has to increase in order to restore the equality in Equation (9.4). Thus, taxes are strategic complements; exactly as in our setting.

By comparing Equations (9.1) and (9.4), one can already identify the main difference between previous studies and our setting. Whilst the number of firms (N) was absent in previous tax competition models, it is explicitly introduced in our setting. As we have shown, in a tax incidence framework, N does not determine the under-/overshifting condition but the degree of the shifting. Similarly, the number of firms does not define the sign of the vertical reaction function but determines how reactive local governments are to a variation in the federal tax rate. In other words, N does not modify the complementarity/substitutability condition but defines the sensitivity of t to a variation in T.

To make this point more clear, let us present a simple numerical application of the linear cost/iso-elastic demand model based on the U.S. cigarette market.[20] We calibrate our model by plugging the values for T, P and ϵ in order to show how the sensitivity of t to a 1% increase in T varies for different values of N. We take prices and taxes figures from Orzechowski and Walker (2012).[21] Regarding the price elasticity of cigarette demand, an important variance among

[20]Tables 3.4 and 3.5 and Figure 3.4 show the results for the linear cost/linear demand case.

[21]The annual compendium on tobacco revenue and industry statistics known as The Tax Burden on Tobacco

the different estimates is observed in the literature. The estimates seem to vary considerably depending, for instance, on the different methodologies and samples. As one could expect, the estimates seem to be highly dependent on the target group as well. Different studies focus on particular groups in order to cluster by age, sex, socioeconomic situation, educational attainment or even a particular characteristics such as pregnancy.[22] To calibrate our model, we take the estimates of Ding (2003) and Hana and Chaloupka (2004) and set the elasticity of demand equal to 1.4.[23]

To sum up, we first took P, T and the share of the final price explained by excise taxes (both state and federal ones) from Orzechowski and Walker (2012). Second, we plugged our constant elasticity value $\epsilon = 1.4$. Third, using Equation (9.1), we computed t and, finally, we imposed a 1% increase in T to compute the reaction of t for each value of N.

Tables 3.2 and 3.3 show the calibration of the model and Figure 3.3 illustrates the reaction functions when $\frac{dP}{dt} = 1$ is imposed (red-dashed line) and when there is no restriction on the shifting condition (blue-solid line).

As one can observe, in both cases $\frac{dt}{dT} > 0$. This reflects the complementarity condition that holds under both frameworks. Now, the straight-dashed line indicates that the reaction function is constant ($\frac{dt}{dT} = 0.1789$) and does not vary with N. On the other hand, the solid line shows how, in this setting, the sensitivity of t to a variation in T decreases with the number of firms in the industry. Indeed, note that the highest value of $\frac{dt}{dT}$ equals 0.6261 for the monopoly case and, as N increases $\frac{dt}{dT}$ decreases. In the limit, when $N \to \infty$, it converges to 0.1789. This makes sense, given that under perfect competition $\frac{dP}{dt} = 1$, which turns out to be the assumption made by previous tax competition studies. To put it differently, in our setting, a 10% increase in T would be followed by a reaction of local governments roughly lying between 6.3% and 1.8%, depending on the level of concentration of the industry. Previous settings, would only consider the lowest bound (1.8%) which, again, might be particularly misleading given the highest level of concentration observed in those industries where excise taxes are levied. The 2002 economic census published by the U.S. Department of Commerce shows that the largest four companies in the cigarette industry accounted for 95.3% of total shipments.[24]. In such a concentrated industry, one could expect the vertical reaction function to be much more sensible (and, thus, closer to the highest bound) than in an less concentrated industry such as machine shops, for

is produced by the economic consulting firm Orzechowski and Walker and published by the Federation of Tax Administrators.

[22]For a complete review on the estimates of the price elasticity of cigarette demand, see, Surgeon's General Report (2000).

[23]Youth is a particular sensitive group to price changes. We decided to set $\epsilon = 1.4$ because a value above 1.2 makes the comparability between the iso-elastic and linear demand cases easier. Nevertheless, our results are robust and hold for any $\epsilon > 0$.

[24]`www.census.gov/prod/ec02/ec0231sr1.pdf`

Table 3.2: Numerical application: Iso-elastic demand function (without restriction on $\frac{dP}{d\tau}$)

N	T	P	ε	η	No restriction on dp/dt										
					t	**dP/dt**	t/P	1/[ε (dP/dt)]	T'	P'	t'	t'/P'	dT (in %)	dt (in %)	**dt/dT**
1	101.00	564.60	1.40	-1.71	115.22	**3.50**	0.20	0.20	102.01	568.14	115.95	0.20	1.00	0.6261	**0.6261**
2	101.00	564.60	1.40	-1.71	259.26	**1.56**	0.46	0.46	102.01	566.17	259.98	0.46	1.00	0.2783	**0.2783**
3	101.00	564.60	1.40	-1.71	307.27	**1.31**	0.54	0.54	102.01	565.93	307.99	0.54	1.00	0.2348	**0.2348**
4	101.00	564.60	1.40	-1.71	331.27	**1.22**	0.59	0.59	102.01	565.83	331.99	0.59	1.00	0.2178	**0.2178**
5	101.00	564.60	1.40	-1.71	345.67	**1.17**	0.61	0.61	102.01	565.78	346.39	0.61	1.00	0.2087	**0.2087**
6	101.00	564.60	1.40	-1.71	355.28	**1.14**	0.63	0.63	102.01	565.75	356.00	0.63	1.00	0.2031	**0.2031**
7	101.00	564.60	1.40	-1.71	362.13	**1.11**	0.64	0.64	102.01	565.72	362.86	0.64	1.00	0.1992	**0.1992**
8	101.00	564.60	1.40	-1.71	367.28	**1.10**	0.65	0.65	102.01	565.71	368.00	0.65	1.00	0.1964	**0.1964**
9	101.00	564.60	1.40	-1.71	371.28	**1.09**	0.66	0.66	102.01	565.70	372.00	0.66	1.00	0.1943	**0.1943**
10	101.00	564.60	1.40	-1.71	374.48	**1.08**	0.66	0.66	102.01	565.69	375.20	0.66	1.00	0.1926	**0.1926**
11	101.00	564.60	1.40	-1.71	377.10	**1.07**	0.67	0.67	102.01	565.68	377.82	0.67	1.00	0.1913	**0.1913**
12	101.00	564.60	1.40	-1.71	379.28	**1.06**	0.67	0.67	102.01	565.67	380.00	0.67	1.00	0.1902	**0.1902**
13	101.00	564.60	1.40	-1.71	381.13	**1.06**	0.68	0.68	102.01	565.67	381.85	0.68	1.00	0.1893	**0.1893**
14	101.00	564.60	1.40	-1.71	382.71	**1.05**	0.68	0.68	102.01	565.66	383.43	0.68	1.00	0.1885	**0.1885**
15	101.00	564.60	1.40	-1.71	384.08	**1.05**	0.68	0.68	102.01	565.66	384.80	0.68	1.00	0.1878	**0.1878**
16	101.00	564.60	1.40	-1.71	385.28	**1.05**	0.68	0.68	102.01	565.66	386.00	0.68	1.00	0.1872	**0.1872**
17	101.00	564.60	1.40	-1.71	386.34	**1.04**	0.68	0.68	102.01	565.65	387.06	0.68	1.00	0.1867	**0.1867**
18	101.00	564.60	1.40	-1.71	387.28	**1.04**	0.69	0.69	102.01	565.65	388.00	0.69	1.00	0.1863	**0.1863**
19	101.00	564.60	1.40	-1.71	388.12	**1.04**	0.69	0.69	102.01	565.65	388.85	0.69	1.00	0.1859	**0.1859**
20	101.00	564.60	1.40	-1.71	388.88	**1.04**	0.69	0.69	102.01	565.65	389.60	0.69	1.00	0.1855	**0.1855**
21	101.00	564.60	1.40	-1.71	389.57	**1.04**	0.69	0.69	102.01	565.65	390.29	0.69	1.00	0.1852	**0.1852**
22	101.00	564.60	1.40	-1.71	390.19	**1.03**	0.69	0.69	102.01	565.64	390.91	0.69	1.00	0.1849	**0.1849**
23	101.00	564.60	1.40	-1.71	390.76	**1.03**	0.69	0.69	102.01	565.64	391.48	0.69	1.00	0.1846	**0.1846**
24	101.00	564.60	1.40	-1.71	391.28	**1.03**	0.69	0.69	102.01	565.64	392.00	0.69	1.00	0.1844	**0.1844**
25	101.00	564.60	1.40	-1.71	391.76	**1.03**	0.69	0.69	102.01	565.64	392.48	0.69	1.00	0.1841	**0.1841**
26	101.00	564.60	1.40	-1.71	392.21	**1.03**	0.69	0.69	102.01	565.64	392.93	0.69	1.00	0.1839	**0.1839**
27	101.00	564.60	1.40	-1.71	392.62	**1.03**	0.70	0.70	102.01	565.64	393.34	0.70	1.00	0.1837	**0.1837**
28	101.00	564.60	1.40	-1.71	393.00	**1.03**	0.70	0.70	102.01	565.64	393.72	0.70	1.00	0.1836	**0.1836**
29	101.00	564.60	1.40	-1.71	393.35	**1.03**	0.70	0.70	102.01	565.64	394.07	0.70	1.00	0.1834	**0.1834**
30	101.00	564.60	1.40	-1.71	393.68	**1.02**	0.70	0.70	102.01	565.63	394.41	0.70	1.00	0.1833	**0.1833**
50	101.00	564.60	1.40	-1.71	397.52	**1.01**	0.70	0.70	102.01	565.62	398.25	0.70	1.00	0.1815	**0.1815**
100	101.00	564.60	1.40	-1.71	400.41	**1.01**	0.71	0.71	102.01	565.62	401.13	0.71	1.00	0.1802	**0.1802**
1000	101.00	564.60	1.40	-1.71	403.00	**1.00**	0.71	0.71	102.01	565.61	403.72	0.71	1.00	0.1790	**0.1790**

Table 3.3: Numerical application: Iso-elastic demand function ($\frac{dP}{d\tau} = 1$)

N	T	P	ε	η	dp/dt=1										
					t	**dP/dt**	t/P	1/[ε (dP/dt)]	T'	P'	t'	t'/P'	dT (in %)	dt (in %)	**dt/dT**
1	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
2	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
3	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
4	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
5	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
6	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
7	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
8	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
9	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
10	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
11	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
12	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
13	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
14	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
15	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
16	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
17	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
18	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
19	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
20	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
21	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
22	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
23	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
24	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
25	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
26	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
27	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
28	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
29	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
30	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
50	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
100	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**
1000	101.00	564.60	1.40	-1.71	403.29	**1.00**	0.71	0.71	102.01	565.61	404.01	0.71	1.00	0.1789	**0.1789**

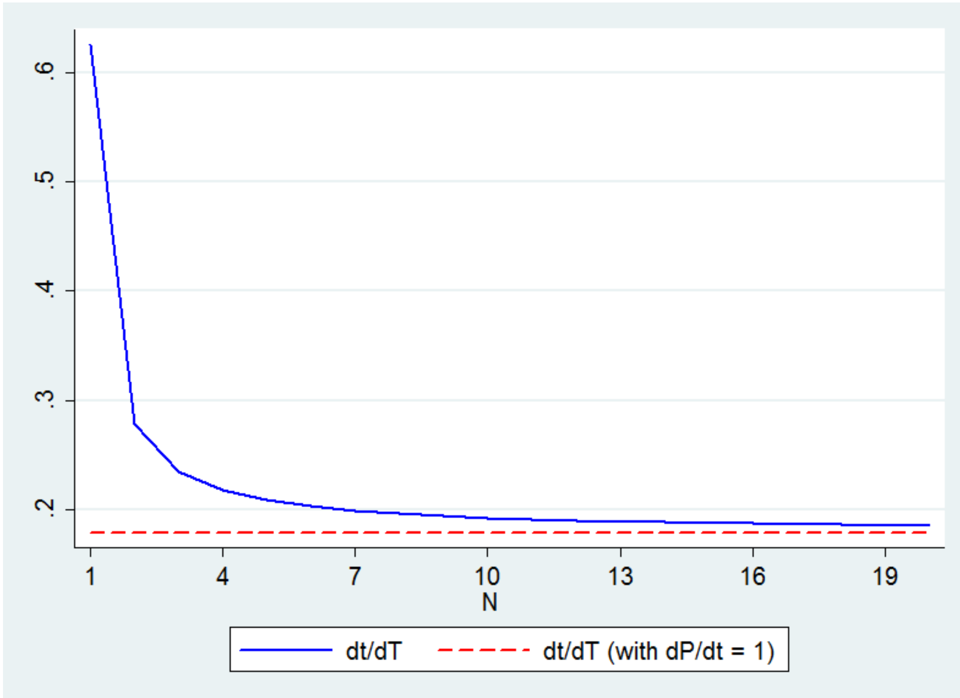

Figure 3.3: Sensitivity of the vertical reaction function (Iso-elastic demand)

which the four largest companies accounted for only 2.2% of total shipments. In other words, unlike previous settings, our model not only allows the federal policy maker to know whether local governments would increase or decrease their tax rates after a variation of the federal tax rate, but how important would this reaction be.

3.5 Conclusion

This model brings together two strands of literature that, in spite of several points in common, have been only studied separately. In both cases the curvature of the demand function is the key parameter defining determining both whether taxes are under/overshifted and whether lower- and higher-tier tax rates are strategic complements/substitutes. One of the main results of the model is, indeed, the formalization of the existence correspondence between the main outputs of tax incidence and tax competition frameworks. As it is shown in Conjecture 1, the undershifting (overshifting) of taxes implies perfect substitutability (complementarity). We honestly think that this is already a nice contribution to the theoretical literature in public economics.

Nevertheless, the main novelty of the model concerns market structure. One of the main features of the model is to endogenize the tax setting process by allowing local governments to internalize the possibility that taxes are over-/undershifted. In order to do this, we explicitly relax the assumption that producer prices are constant that is present in previous tax competition settings. Hence, the restriction that prices can only be fully-shifted to consumers is ruled out of the first stage of the game and, therefore, market structure plays a key role in the tax setting process.

Regarding tax competition, even if the number of firms does not modify the strategic complementarity/substitutability condition, it determines the sensitivity of local tax setters to a modification in higher-level tax rates. This piece of information was lost in previous tax competition settings. We think that our models nicely complements previous settings because it allows the federal policy maker not only to know whether lower-tier governments would rise or decrease their local tax rates given a variation in the federal tax, but also to assess how important such a reaction would be.

Appendix 3.A Solution of the profit maximization problem

3.A.1 Iso-elastic demand

Let the iso-elastic demand function be given by:

$$A = P^{-\epsilon}, \tag{3.A.1.1}$$

and, thus, the inverse demand function be

$$P = \left(\frac{A}{Q}\right)^{\frac{1}{\epsilon}}, \tag{3.A.1.2}$$

where $A > 0$ and $\epsilon > 0$.
Let the profits of a firm (in the symmetric case i.e., $Nq = Q$) with linear costs be:

$$\pi = Pq - cq - \tau q. \tag{3.A.1.3}$$

Thus, the first order condition is given by:[25]

$$P - c - \tau + P'q = 0 \Leftrightarrow \underbrace{\left(\frac{A}{Q}\right)^{\frac{1}{\epsilon}}}_{=P} - c - \tau + \underbrace{\left[\frac{1}{\epsilon}\left(\frac{A}{Q}\right)^{\frac{1}{\epsilon}-1}\left(-\frac{A}{Q^2}\right)\right]}_{=P'} q = 0, \tag{3.A.1.4}$$

Thus solving equation (3.A.1.4) for q, we get:

$$\hat{q} = \frac{A}{N}\left[\frac{\epsilon N(c+t)}{\epsilon N - 1}\right]^{-\epsilon}. \tag{3.A.1.5}$$

Using equation (3.A.1.5) and the symmetric equilibrium condition $Q = Nq$, we get:

$$\hat{Q} = A\left[\frac{\epsilon N(c+t)}{\epsilon N - 1}\right]^{-\epsilon}. \tag{3.A.1.6}$$

And, finally, plugging equation (3.A.1.6) into equation (3.A.1.2), we get:

$$\hat{P} = \frac{\epsilon N(c+t)}{\epsilon N - 1}. \tag{3.A.1.7}$$

3.A.2 Linear demand

Let the linear demand function be given by:

$$Q = 1 - P, \tag{3.A.2.1}$$

and, thus, the inverse demand function be

$$P = 1 - Q. \tag{3.A.2.2}$$

[25] Again, we assume that the second order condition holds.

Let the profits of a firm (in the symmetric case i.e., $Nq = Q$) with linear costs be:

$$\pi = Pq - cq - \tau q. \tag{3.A.2.3}$$

Thus, the first order condition is given by:[26]

$$P - c - \tau + P'q = 0 \Leftrightarrow \underbrace{(1-Q)}_{=P} - c - \tau - q = 0, \tag{3.A.2.4}$$

where $P' = -1$ and $1 - Q = 1 - Nq$.

Thus, solving equation (3.A.2.4) for q, we get:

$$\hat{q} = \frac{1-c-\tau}{N+1}. \tag{3.A.2.5}$$

Using equation (3.A.2.5) and the symmetric equilibrium condition $Q = Nq$, we get:

$$\hat{Q} = \frac{N}{N+1}(1-c-\tau). \tag{3.A.2.6}$$

And, finally, plugging equation (3.A.2.6) into equation (3.A.2.2), we get:

$$\hat{P} = c + \tau + \frac{1-c-\tau}{N+1} \tag{3.A.2.7}$$

[26]We assume that the second order condition holds and, thus, that the derived equilibrium is indeed a maximum.

Appendix 3.B Numerical application (Linear demand)

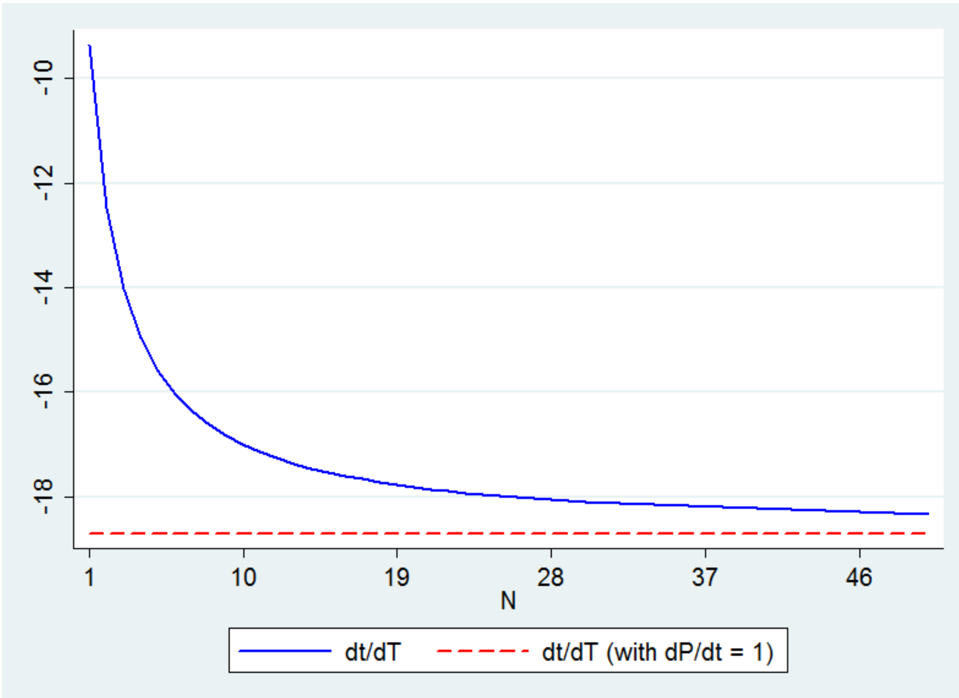

Figure 3.4: Sensitivity of the vertical reaction function (Linear demand)

Table 3.4: Numerical application: Linear demand function (without restriction on $\frac{dP}{d\tau}$)

N	T	P	Q	dQ/dP	ε	No restriction on dp/dt								
						t	**dP/dt**	T'	P'	Q'	t'	dT (in %)	dt (in %)	**dt/dT**
1	101.00	564.60	0.27	-0.05	104.56	10.80	**0.50**	102.01	565.11	0.24	9.79	1.00	-9.35	**-9.3519**
2	101.00	564.60	0.54	-0.05	52.28	16.20	**0.67**	102.01	565.27	0.47	14.18	1.00	-12.47	**-12.4691**
3	101.00	564.60	0.81	-0.05	34.85	21.60	**0.75**	102.01	565.36	0.70	18.57	1.00	-14.03	**-14.0278**
4	101.00	564.60	1.08	-0.05	26.14	27.00	**0.80**	102.01	565.41	0.92	22.96	1.00	-14.96	**-14.9630**
5	101.00	564.60	1.35	-0.05	20.91	32.40	**0.83**	102.01	565.44	1.14	27.35	1.00	-15.59	**-15.5864**
6	101.00	564.60	1.62	-0.05	17.43	37.80	**0.86**	102.01	565.47	1.36	31.74	1.00	-16.03	**-16.0317**
7	101.00	564.60	1.89	-0.05	14.94	43.20	**0.88**	102.01	565.48	1.58	36.13	1.00	-16.37	**-16.3657**
8	101.00	564.60	2.16	-0.05	13.07	48.60	**0.89**	102.01	565.50	1.80	40.52	1.00	-16.63	**-16.6255**
9	101.00	564.60	2.43	-0.05	11.62	54.00	**0.90**	102.01	565.51	2.02	44.91	1.00	-16.83	**-16.8333**
10	101.00	564.60	2.70	-0.05	10.46	59.40	**0.91**	102.01	565.52	2.24	49.30	1.00	-17.00	**-17.0034**
11	101.00	564.60	2.97	-0.05	9.51	64.80	**0.92**	102.01	565.53	2.46	53.69	1.00	-17.15	**-17.1451**
12	101.00	564.60	3.24	-0.05	8.71	70.20	**0.92**	102.01	565.53	2.68	58.08	1.00	-17.26	**-17.2650**
13	101.00	564.60	3.51	-0.05	8.04	75.60	**0.93**	102.01	565.54	2.90	62.47	1.00	-17.37	**-17.3677**
14	101.00	564.60	3.78	-0.05	7.47	81.00	**0.93**	102.01	565.54	3.12	66.86	1.00	-17.46	**-17.4568**
15	101.00	564.60	4.05	-0.05	6.97	86.40	**0.94**	102.01	565.55	3.34	71.25	1.00	-17.53	**-17.5347**
16	101.00	564.60	4.32	-0.05	6.53	91.80	**0.94**	102.01	565.55	3.56	75.64	1.00	-17.60	**-17.6035**
17	101.00	564.60	4.59	-0.05	6.15	97.20	**0.94**	102.01	565.55	3.78	80.03	1.00	-17.66	**-17.6646**
18	101.00	564.60	4.86	-0.05	5.81	102.60	**0.95**	102.01	565.56	4.00	84.42	1.00	-17.72	**-17.7193**
19	101.00	564.60	5.13	-0.05	5.50	108.00	**0.95**	102.01	565.56	4.22	88.81	1.00	-17.77	**-17.7685**
20	101.00	564.60	5.40	-0.05	5.23	113.40	**0.95**	102.01	565.56	4.44	93.20	1.00	-17.81	**-17.8131**
21	101.00	564.60	5.67	-0.05	4.98	118.80	**0.95**	102.01	565.56	4.66	97.59	1.00	-17.85	**-17.8535**
22	101.00	564.60	5.94	-0.05	4.75	124.20	**0.96**	102.01	565.57	4.88	101.98	1.00	-17.89	**-17.8905**
23	101.00	564.60	6.21	-0.05	4.55	129.60	**0.96**	102.01	565.57	5.10	106.37	1.00	-17.92	**-17.9244**
24	101.00	564.60	6.48	-0.05	4.36	135.00	**0.96**	102.01	565.57	5.32	110.76	1.00	-17.96	**-17.9556**
25	101.00	564.60	6.75	-0.05	4.18	140.40	**0.96**	102.01	565.57	5.54	115.15	1.00	-17.98	**-17.9843**
26	101.00	564.60	7.02	-0.05	4.02	145.80	**0.96**	102.01	565.57	5.76	119.54	1.00	-18.01	**-18.0110**
27	101.00	564.60	7.29	-0.05	3.87	151.20	**0.96**	102.01	565.57	5.98	123.93	1.00	-18.04	**-18.0357**
28	101.00	564.60	7.56	-0.05	3.73	156.60	**0.97**	102.01	565.58	6.19	128.32	1.00	-18.06	**-18.0587**
29	101.00	564.60	7.83	-0.05	3.61	162.00	**0.97**	102.01	565.58	6.41	132.71	1.00	-18.08	**-18.0802**
30	101.00	564.60	8.10	-0.05	3.49	167.40	**0.97**	102.01	565.58	6.63	137.10	1.00	-18.10	**-18.1004**
50	101.00	564.60	13.50	-0.05	2.09	275.40	**0.98**	102.01	565.59	11.02	224.90	1.00	-18.34	**-18.3370**
100	101.00	564.60	27.00	-0.05	1.05	545.40	**0.99**	102.01	565.60	22.00	444.40	1.00	-18.52	**-18.5185**
1000	101.00	564.60	270.00	-0.05	0.10	5405.40	**1.00**	102.01	565.61	219.55	4395.40	1.00	-18.69	**-18.6850**

Table 3.5: Numerical application: Linear demand function ($\frac{dP}{d\tau} = 1$)

N	T	P	Q	dQ/dP	ε	dp/dt=1								
						t	**dP/dt**	T'	P'	Q'	t'	dT (in %)	dt (in %)	**dt/dT**
1	101.00	564.60	0.27	-0.05	104.56	5.40	**1.00**	102.01	565.61	0.22	4.39	1.00	-18.70	**-18.7037**
2	101.00	564.60	0.54	-0.05	52.28	10.80	**1.00**	102.01	565.61	0.44	8.78	1.00	-18.70	**-18.7037**
3	101.00	564.60	0.81	-0.05	34.85	16.20	**1.00**	102.01	565.61	0.66	13.17	1.00	-18.70	**-18.7037**
4	101.00	564.60	1.08	-0.05	26.14	21.60	**1.00**	102.01	565.61	0.88	17.56	1.00	-18.70	**-18.7037**
5	101.00	564.60	1.35	-0.05	20.91	27.00	**1.00**	102.01	565.61	1.10	21.95	1.00	-18.70	**-18.7037**
6	101.00	564.60	1.62	-0.05	17.43	32.40	**1.00**	102.01	565.61	1.32	26.34	1.00	-18.70	**-18.7037**
7	101.00	564.60	1.89	-0.05	14.94	37.80	**1.00**	102.01	565.61	1.54	30.73	1.00	-18.70	**-18.7037**
8	101.00	564.60	2.16	-0.05	13.07	43.20	**1.00**	102.01	565.61	1.76	35.12	1.00	-18.70	**-18.7037**
9	101.00	564.60	2.43	-0.05	11.62	48.60	**1.00**	102.01	565.61	1.98	39.51	1.00	-18.70	**-18.7037**
10	101.00	564.60	2.70	-0.05	10.46	54.00	**1.00**	102.01	565.61	2.19	43.90	1.00	-18.70	**-18.7037**
11	101.00	564.60	2.97	-0.05	9.51	59.40	**1.00**	102.01	565.61	2.41	48.29	1.00	-18.70	**-18.7037**
12	101.00	564.60	3.24	-0.05	8.71	64.80	**1.00**	102.01	565.61	2.63	52.68	1.00	-18.70	**-18.7037**
13	101.00	564.60	3.51	-0.05	8.04	70.20	**1.00**	102.01	565.61	2.85	57.07	1.00	-18.70	**-18.7037**
14	101.00	564.60	3.78	-0.05	7.47	75.60	**1.00**	102.01	565.61	3.07	61.46	1.00	-18.70	**-18.7037**
15	101.00	564.60	4.05	-0.05	6.97	81.00	**1.00**	102.01	565.61	3.29	65.85	1.00	-18.70	**-18.7037**
16	101.00	564.60	4.32	-0.05	6.53	86.40	**1.00**	102.01	565.61	3.51	70.24	1.00	-18.70	**-18.7037**
17	101.00	564.60	4.59	-0.05	6.15	91.80	**1.00**	102.01	565.61	3.73	74.63	1.00	-18.70	**-18.7037**
18	101.00	564.60	4.86	-0.05	5.81	97.20	**1.00**	102.01	565.61	3.95	79.02	1.00	-18.70	**-18.7037**
19	101.00	564.60	5.13	-0.05	5.50	102.60	**1.00**	102.01	565.61	4.17	83.41	1.00	-18.70	**-18.7037**
20	101.00	564.60	5.40	-0.05	5.23	108.00	**1.00**	102.01	565.61	4.39	87.80	1.00	-18.70	**-18.7037**
21	101.00	564.60	5.67	-0.05	4.98	113.40	**1.00**	102.01	565.61	4.61	92.19	1.00	-18.70	**-18.7037**
22	101.00	564.60	5.94	-0.05	4.75	118.80	**1.00**	102.01	565.61	4.83	96.58	1.00	-18.70	**-18.7037**
23	101.00	564.60	6.21	-0.05	4.55	124.20	**1.00**	102.01	565.61	5.05	100.97	1.00	-18.70	**-18.7037**
24	101.00	564.60	6.48	-0.05	4.36	129.60	**1.00**	102.01	565.61	5.27	105.36	1.00	-18.70	**-18.7037**
25	101.00	564.60	6.75	-0.05	4.18	135.00	**1.00**	102.01	565.61	5.49	109.75	1.00	-18.70	**-18.7037**
26	101.00	564.60	7.02	-0.05	4.02	140.40	**1.00**	102.01	565.61	5.71	114.14	1.00	-18.70	**-18.7037**
27	101.00	564.60	7.29	-0.05	3.87	145.80	**1.00**	102.01	565.61	5.93	118.53	1.00	-18.70	**-18.7037**
28	101.00	564.60	7.56	-0.05	3.73	151.20	**1.00**	102.01	565.61	6.15	122.92	1.00	-18.70	**-18.7037**
29	101.00	564.60	7.83	-0.05	3.61	156.60	**1.00**	102.01	565.61	6.37	127.31	1.00	-18.70	**-18.7037**
30	101.00	564.60	8.10	-0.05	3.49	162.00	**1.00**	102.01	565.61	6.58	131.70	1.00	-18.70	**-18.7037**
50	101.00	564.60	13.50	-0.05	2.09	270.00	**1.00**	102.01	565.61	10.97	219.50	1.00	-18.70	**-18.7037**
100	101.00	564.60	27.00	-0.05	1.05	540.00	**1.00**	102.01	565.61	21.95	439.00	1.00	-18.70	**-18.7037**
1000	101.00	564.60	270.00	-0.05	0.10	5400.00	**1.00**	102.01	565.61	219.50	4390.00	1.00	-18.70	**-18.7037**

Bibliography

Agrawal, David (2015) 'Local fiscal competition: An application to sales taxation with multiple federations.' *Journal of Urban Economics*

Anderson, Simon P., Andre de Palma, and Brent Kreider (2001) 'Tax incidence in differentiated product oligopoly.' *Journal of Public Economics* 81(2), 173–192

Becker, Sascha O., Peter H. Egger, and Valeria Merlo (2012) 'How low business tax rates attract mne activity: Municipality-level evidence from germany.' *Journal of Public Economics* 96(9-10), 698–711

Besley, Timothy (1989) 'Commodity taxation and imperfect competition : A note on the effects of entry.' *Journal of Public Economics* 40(3), 359–367

Chouinard, Hayley H., and Jeffrey M. Perloff (2007) 'Gasoline price differences: Taxes, pollution regulations, mergers, market power, and market conditions.' *The B.E. Journal of Economic Analysis & Policy* 7(1), 8

DeCicca, Philip, Donald Kenkel, and Feng Liu (2013) 'Who Pays Cigarette Taxes? The Impact of Consumer Price Search.' *The Review of Economics and Statistics* 95(2), 516–529

Delipalla, Sophia, and Owen O'Donnell (2001) 'Estimating tax incidence, market power and market conduct: The european cigarette industry.' *International Journal of Industrial Organization* 19(6), 885–908

Devereux, M.P., B. Lockwood, and M. Redoano (2007) 'Horizontal and vertical indirect tax competition: Theory and some evidence from the usa.' *Journal of Public Economics* 91(3-4), 451–479

Ding, Alexander (2003) 'Youth are more sensitive to price changes in cigarettes than adults.' *The Yale Journal of Biology and Medicine* 76(3), 115–124

Fullerton, Don, and Gilbert E. Metcalf (2002) 'Tax incidence.' In *Handbook of Public Economics,* ed. A. J. Auerbach and M. Feldstein, vol. 4 of *Handbook of Public Economics* (Elsevier) chapter 26, pp. 1787–1872

Hana, Ross, and Franck J. Chaloupka (2004) 'The effect of public policies and prices on youth smoking.' *Southern Economic Journal* 70(4), 796–815

Harris, Jeffrey E. (1987) 'The 1983 increase in the federal cigarette excise tax.' *Tax Policy and the Economy* 1, 87–111

Jametti, Mario, Agustin Redonda, and Anindya Sen (2013) 'The power to pass on taxes. A test for tax shifting based on observables.' *Mimeo.*

Kanbur, Ravi, and Michael Keen (1993) 'Jeux Sans Frontieres: Tax Competition and Tax Coordination When Countries Differ in Size.' *American Economic Review* 83(4), 877–92

Katz, Michael L., and Harvey S. Rosen (1985) 'Tax analysis in an oligopoly model.' *National Bureau of Economic Research, Inc*

Keen, Michael (1997) 'Vertical tax externalities in the theory of fiscal federalism.' IMF Working Papers 97/173, International Monetary Fund, December

Kenkel, Donald S. (2005) 'Are Alcohol Tax Hikes Fully Passed Through to Prices? Evidence from Alaska.' *American Economic Review* 95(2), 273–277

Krzyzaniak, Marian, and Richard A. Musgrave (1963) 'The shifting of the corporation income tax.' (Johns Hopkins Press, Baltimore)

Marion, Justin, and Erich Muehlegger (2011) 'Fuel tax incidence and supply conditions.' *Journal of Public Economics* 95(9-10), 1202–1212

Nielsen, S/oren (2001) 'A simple model of commodity taxation and cross-border shopping.' *Scandinavian Journal of Economics* 103(4), 599–623

Orzechowski and Walker (2012) 'The 63rd version of the annual compendium on tobacco revenue and industry statistics - The Tax Burden on Tobacco'

Seade, Jesus (1985) 'Profitable cost increases and the shifting of taxation : Equilibrium response of markets in oligopoly.' *The Warwick Economics Research Paper Series (TWERPS)*

Sen, Anindya (2001) 'Overshifting, firm conduct, and tax incidence in concentrated industries: Empirical evidence from the canadian cigarette industry.' *Mimeo.*

Surgeon's General Report (2000) 'Reducing Tobacco Use: A Report of the Surgeon General.' *U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.*

Tirole, Jean (1988) *The Theory of Industrial Organization,* vol. 1 of *MIT Press Books* (The MIT Press)