INTERNATIONAL TAX COMPETITION IN EUROPE
THE CASE OF TRANSPORT FUEL EXCISES

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ABSTRACT

Globalization has brought about a substantial change in the international mobility of production factors and consumers over the last three decades. The international mobility of consumers materializes in cross-border shopping opportunities. If, due to the relatively high domestic tax burden, the consumers have to pay a much higher price for the same product at home than abroad, they are motivated to shop abroad. Therefore, countries with high tax burden can face the outflow of some domestic consumers – and thus part of their tax base – while countries with low tax burden can expect an inflow of foreign consumers. In tax rate decision governments consider the level of cross-border tourism and its effect on the tax base.

In this dissertation we examine whether European states compete with each other for tax revenues they collect on diesel sales. There are two important reasons why we chose diesel excise taxation as a subject of research. First, European diesel tax is promising field of tax competition research as in the setting of considerable international haulage activity and high tax burden, the sales of diesel can be considered as a mobile tax base. Since revenues of diesel tax are substantial, the assumption that states 'compete' for these tax revenues with their tax rates seems plausible.

In the theoretical analysis of diesel tax competition, similar to the literature, we use a game theoretic framework. Tax competition is modeled as a Nash game in which governments choose their revenue maximizing tax rates taking the rates of their competitors as given. We formulated two main hypotheses based on the analysis of the equilibrium of tax competition game. First, European states set their excise tax rates in mutual interaction, competing for tax proceeds. Second, diesel tax competition is asymmetric: large countries set higher excise tax rates than small countries. Our analysis includes the analysis of political business cycles as well. In this regard, we set up two hypotheses. First, governments manipulate diesel tax rates before general elections. Second, there is a systematic difference in fuel tax policies of governments with left and right majority.

For the empirical analysis of excise tax competition we apply the research methodology regularly used in the literature. The analysis is based on a multi-variable regression model in which the countries' diesel excise rate is explained by fiscal, economic and political variables and with the tax rate of their neighboring countries. To test our hypotheses, we estimate the fiscal reaction functions for national governments using data from 16 European countries (EU-15 minus Greece plus Norway and Switzerland) between 1978 and 2005. The regression equation is estimated – unlike the practice of most researchers – not by levels but the first differences of variables. The proposition on the asymmetric tax competition is thus tested indirectly, through testing the auxiliary hypothesis on the relationship between country size and tax change. To our best knowledge this is the first study that investigates the hypothesis of asymmetric tax competition in first-difference econometric models, guided by theoretical predictions.

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CHAPTER 1

INTRODUCTION

Governmental decisions are often dependent on the decisions of other governments. This is the case in the field of certain tax policy decisions. In the globalizing economy, industrial sectors can shift quickly and cheaply their operation from one country to another. At the same time, investors are increasingly sensitive to differences in tax levels. Any government setting high tax level risks the flee of investors and the reduction of its tax revenues. Setting low levels, on the other hand, can attract investors from abroad and result in higher tax revenues due to the wider tax base. The theory of tax competition predicts that governments facing mobile tax bases will compete for the overall tax base by setting their national tax rates.

If two countries tax the same product at a different rate, it may be reflected in the consumer price of the product. The saving obtainable through lower prices may drive consumers of the more expensive country to buy the product abroad, rather than at home. Countries with high tax burden can face the outflow of some domestic consumers – and thus part of their tax base – while countries with low tax burden can expect an inflow of foreign consumers. In tax rate decision governments consider the level of cross-border tourism and its effect on the tax base.

Globalization has brought about a substantial change in the international mobility of production factors and consumers over the last three decades. The most apparent change occurred undoubtedly in the mobility of capital goods. With the extraordinary growth and integration of money and capital markets, capital became an internationally mobile factor of production. As administrative and economic obstacles of capital investments in numerous

countries were dismantled or at least considerably decreased, taxation aspects in capital investment location choice are more and more important.

The international mobility of consumers materializes in cross-border shopping opportunities. If, due to the relatively high domestic tax burden, the consumers have to pay a much higher price for the same product at home than abroad, they are motivated to shop abroad. In cross-border shopping patterns, apart from price differences, the transaction costs of such shopping play an important role. For EU residents these costs are likely to have considerably decreased after the demolition of the internal borders (1992) and by the introduction of the common currency (1999).

The impact of tax policies on foreign capital investments is supported by empirical research (see e.g. De Mooij and Ederven 2003). Nevertheless, we have relatively few information on the occurrence and scale of cross-border shopping. This issue has been mostly analyzed within the United States on US – Canada relations and in the European context. In Europe fuel tourism is the most frequently discussed example of cross-border shopping (see e.g. Banfi et al 2005). According to a study recently carried out by the European Commission, high international mobility of diesel consumption is attributable primarily to the cost planning of road haulage companies. During their trip abroad, trucks with a big tank fuel up at cheaper fuel stations, i.e. in countries with lower tax burden on fuel (EU COM(2007)).

In this paper we examine whether European states compete with each other for tax revenues they collect on diesel sales. There are two important reasons why we chose diesel excise taxation as a subject of research. First, European diesel tax is promising field of tax competition research as in the setting of considerable international haulage activity (due to the

lack of internal borders) and high tax burden, the sales of diesel can be considered as a mobile tax base. This has been confirmed by studies analyzing fuel tourism in European countries (see part 2.3.3). Since revenues of diesel tax are substantial, the assumption that states 'compete' for these tax revenues with their tax rates seems plausible.

Second, from research on diesel tax competition many lessons can be drawn regarding the tax policy of the European Union. Since 1993, the Union regulates the excise tax rates of fuels, including that of diesel, by setting minimum tax rates. The aim of the regulation was to make excise tax rates of the various Member States converge. Despite the fact that excise is one of the most harmonized tax policy field, rate differences among Member States have hardly decreased over the last 15 years (see part 3.1). By revealing the characteristics of diesel tax competition we hope to find an explanation for the relative failure of the Union's minimum tax rate regulation.

In the theoretical analysis of diesel tax competition, similar to the literature, we use a game theoretic framework. Tax competition is modeled as a Nash game in which governments choose their revenue maximizing tax rates taking the rates of their competitors as given. We formulated two main hypotheses based on the analysis of the equilibrium of tax competition game. First, European states set their excise tax rates in mutual interaction, competing for tax proceeds. Second, diesel tax competition is asymmetric: large countries set higher excise tax rates than small countries. Our analysis includes the analysis of political business cycles as well. In this regard, we set up two hypotheses. First, governments do manipulate diesel tax rates before general elections. Second, there is a systematic difference in fuel tax policies of governments with left and right majority.

Our theoretical model extends Nielsen's (2001) analysis of commodity tax competition between countries of different size to allow for elastic individual demand for the taxed good. Nielsen formulated a Nash game between two governments to examine the impact of the difference on tax rates. Under the assumption of unit demand for the taxed good, Nielsen has shown that the tax set by the large country is higher than the one set by the small country. This result is parallel to that of Kanbur and Keen (1993) who examined tax competition between countries of equal size but with different population densities. The present work extends and refines the results of Nielsen (2001) on commodity tax competition. We demonstrate that once the assumption of perfectly inelastic demand is relaxed, country size influences – apart from the tax rate – the response intensity to tax level changes in neighboring countries. Unless the demand is perfectly inelastic, the large country reacts more strongly to tax changes in the neighboring country than the small country.

Our theoretical analysis was mainly inspired by the study of Devereux et al. (2007). Their study examines the commodity tax competition of gasoline and cigarettes in the US, theoretically and empirically. The authors simultaneously integrate and generalize previous theoretical works by examining the horizontal and vertical tax competition (i) in a standard theoretical framework, (ii) allowing area and population density to constitute the difference between the sizes of the countries, and (iii) assuming price elastic demand. However, the general theoretical framework provides little opportunity to draw analytical results. By building a less generalized model, allowing the demand to be price elastic, but conceptualizing spatial differences of countries only according to their area – we give a more accurate characterization of horizontal tax competition.

Our theoretic analysis draws two important conclusions. On the one hand, we prove that asymmetric tax competition is robust for the introduction of the inelastic, iso-elastic individual demand. On the other hand, we demonstrate that once the assumption of perfectly inelastic demand is relaxed, there is a systematic difference between the equilibrium responses of small and large countries not only in terms of tax rates set, but also in terms of the intensity of their responses. The large country with the higher tax rate reacts to tax changes in its neighbor with a higher intensity than the small country with a lower tax rate.

These results are significant for the empirical investigation of tax competition theory. On the one hand, the correct specification of reaction functions of the countries requires that the response intensity to neighbors' taxes could vary from country to country. On the other hand, while the relationship between country size and tax level can be analyzed in level models only, the relationship between country size and tax change, i.e. the indirect proof of asymmetric tax competition, can be tested in first difference models, too.

To our best knowledge, only two studies analyzed European diesel tax competition by econometric tools. Using cross-sectional data – 1998 fuel prices from 32 European countries – Rietveld et al (2005) found empirical evidence for asymmetric tax competition. Evers et al (2004) examined tax competition on panel data, largely similar to the one we use, and provided evidence for the existence of tax competition, but not for asymmetric tax competition.

For the empirical analysis of excise tax competition we apply the research methodology regularly used in the literature. The analysis is based on a multi-variable regression model in which the countries' diesel excise rate is explained by fiscal, economic and political variables

and with the tax rate of their neighboring countries. To test our hypotheses, we estimate the fiscal reaction functions for national governments using data from 16 European countries (EU-15 minus Greece plus Norway and Switzerland) between 1978 and 2005. We handle the endogeneity of the competitors' taxation decisions – similarly to the practice followed by the papers above – by using instrumental variables. Nevertheless, our approach differs from the the above mentioned studies in several respects.

The regression equation is estimated – unlike the practice of most researchers – not by levels but the first differences of variables. The proposition on the asymmetric tax competition is thus tested indirectly, through testing the auxiliary hypothesis on the relationship between country size and tax change. To our best knowledge this is the first study that investigates the hypothesis of asymmetric tax competition in first-difference econometric models, guided by theoretical predictions.

In the empirical investigation of tax competition we have to deal with the interactions of *many* countries. When defining the spatial structure of tax competition, we have to determine the circle of competing countries for each country and the relative weights of the decisions the countries make. Based on the features of international road freight traffic, we elaborate a weighting scheme that has not yet been used in the empirical literature.

Measuring the dependent variable of the analysis is a key issue in the tax competition research. We argue that the differences in the countries' tax burden can be captured with the excise tax rates. Therefore, we opt for the diesel excise tax rate as the dependent variable of analysis, in accordance with studies dealing with commodity tax competition between US states, but differing from studies analyzing fuel tax competition of European states.

We can state that our analysis provides weak evidence for the presence of diesel excise tax competition among European states for the whole period under examination but strong evidence for the period from 1995 to 2005. The fact that the contest of European states for consumers intensified from the mid-1990s is not so surprising considering that the creation of the single market became considerably advanced in this very period. With the demolition of internal borders and the introduction of the common currency, by the second half of the 1990s, obstacles to purchases abroad practically disappeared within the Union. The liberalization of the haulage market, which leads to a strong price competition and the extension of international haulage activity by creating a unified Trans-European transportation market, also evolved in this period. Accordingly, a number of changes occurred in the 1990s that are likely to have made fuel consumers – private and commercial users alike – more sensitive to international price differences. The mobility of tax bases became strong enough by this period to make the strategy of holding tax rates relatively low attractive for smaller countries and increase their tax revenues by conquering the tax base of other countries.

Our results confirm the theoretical prediction that large countries tend to react more strongly to tax changes in their neighbors than small countries do. To our best knowledge this is the first panel analysis that provides evidence for asymmetric tax competition in diesel excise taxes in Europe.

The hypothesis referring to the Cabinet composition of government is supported by the results as well: left-wing governments are associated with higher taxes than right-wing ones. This broadly supports the idea that the ideological orientation of governments has an effect over

macroeconomic policies pursued. In contrast, the hypothesis that governments manipulate diesel excise tax rates before general elections is not confirmed.

The dissertation is structured as follows: Chapter 2 provides a review of the most important theoretical and empirical issues of the tax competition literature. In Chapter 3, we have two goals. First, we aim to discuss the European Union's tax harmonization policy and its achievements, with special regard to the harmonization of fuel excise taxes. Second, in light of the practices of excise taxation in the Member States we attempt to evaluate the effectiveness of the minimum rate regulation in effect. Chapter 4 discusses the theoretical literature of commodity tax competition. In the first part we discuss the benchmark models of spatial tax competition, while in the second part we present the results of our theoretical research. Chapter 5 is devoted to empirically testing the propositions we formulated. Finally, in Chapter 6 we summarize the main findings of the research and draw some policy conclusions.

CHAPTER 2

INTERNATIONAL TAX COMPETITION

The aim of the Chapter is to give an insight into the most important questions of tax competition literature. First we analyze what challenges the international tax systems face posed by the globalization of the world economy and the process of European integration. By analyzing the international mobility of the most important production factors and the consumers, we point out the tax types in which the appearance of tax competition is the most probable. After this we summarize the most important conclusions of tax competition theory. In the course of this we confront the main forecasts of the theory with developments of tax policy in the past decades, and we react to the most controversial questions of tax competition literature. In the last part of the Chapter we briefly discuss some important results of empirical tax competition research.

2.1 The international interdependence of tax policies

The governments make their decisions in many cases dependent on decisions of other countries. The interdependence of governmental decisions can be observed for example while managing certain problems of environmental policy. It is characteristic of environmental policy measures that the costs arise in the country adopting the measure but a big part of the benefits arise in other countries, and in the case of global contaminants, in the whole world. Due to the absence of international coordination, typically less contamination is eliminated than what would be globally optimal. Furthermore, the interdependence of environmental policy decisions stimulates the governments to behave strategically. Each country would like

to achieve results by the efforts of another country, what might lead to postponing the measures, in other words, to the developing a kind of ’negative contention’.

Intensifying international competition can be experienced in certain tax policy decisions of the governments, too. In the globalizing world economy, where some industry sectors can relocate their pursuit from one country to another with relatively low costs, capital investors react to differences of tax burden more and more sensitively. By setting high taxes, a country risks frightening its investors away, thus, diminishing its tax proceeds. Whereas, with low tax rates it can tempt investors of other countries into the country, which, through increasing the tax base, flatters with increasing its income. According to the forecast of tax competition theory the governments facing the mobility of their tax base begin to compete with their tax rates to acquire the tax base.

The mobility of tax bases is one of the most important premises of tax competition theory, so, henceforth we first analyze the question: has there happened a substantial change in the international mobility of tax bases in the last three decades? Following this we come to review the theoretical and empirical results of tax competition theory.

2.2 The internationalization of markets

Beginning from the 1980s, the co-operation of the economies of the world was getting based on new fundaments. As a consequence of the increasing level of worldwide foreign direct investments (FDI), besides commodity trading, production has also become considerably internationalized. Multinational companies taking the leading roles in foreign capital investments control approximately 60 percent of world trade (internal and external trade together) and more than 30 percent of international trade (UNCTAD 2004).

Besides the liberalization of commodity and capital markets, the integration of post-socialist countries into the world economy and the appearance and strengthening of regional economic integrations – the European Union (EU), the North American Free Trade Agreement (NAFTA), the South American Free Trade Association (MERCOSUR), the Association of South East Asian Nations (ASEAN), the Commonwealth of Independent States (CIS) – also contributed significantly to the process mentioned above (Haufler 2001). Economic integrations based on continental co-operation tightened their economic relationship by dismantling obstacles of trade, or, in some cases overstepping this, by securing the free flow of production factors. In the strengthening of world trade integration the decreasing costs of telecommunication and transport services played an important role, too.

2.3 Mobility of production factors and consumers

Capital

Globalization brought about a substantial change in the mobility of production factors and consumers. The most apparent change occurred undoubtedly in the international mobility of capital goods. From the end of the 1970s on, numerous countries began to liberalize their money markets and to dismantle the obstacles of international capital movements. On the one hand barriers of purchasing foreign securities were abolished; on the other hand it was made possible for foreigners to purchase domestic securities. In this period hundreds of bilateral investment agreements were signed, aiming at providing a more favorable climate for investments.

As a result of this, in the last three decades, foreign direct investments increased extraordinarily. According to data published by UNCTAD the scale of foreign capital investments increased from the value of $55 billion in 1980 to near its thirty fold, $1392 billion in 2000 (UNCTAD 2004). Growth in the field of portfolio investments was also of a similar scale: their aggregate value increased from $219 to $1430 between 1990 and 2000 (Edwards and de Rugy, 2002). The importance of foreign capital flows is underlined by the fact that the ratio of all the gross private capital flows (FDI, portfolio and other capital investments) to GDP amounted to 29 percent on average in the world in 2000 (World Bank 2002).

As a consequence of the extraordinary growth and advanced integration of money and capital markets, capital became an internationally mobile factor of production. After administrative and economic obstacles of capital investments in numerous countries of the world were dismantled, or at least considerably decreased, taxation aspects in choosing the location of capital investments are more and more important. The impact of tax policies on foreign capital investments is confirmed by empirical research. A study examining FDI expenditures of American multinational companies found out that in response to a one percent higher profit tax in a given country, the inflow of American FDI into the country was 3 percent lower in the beginning of the 1990s (Altshuler et al 2003). Another study, analyzing the behavior of American capital owners came to the conclusion that in the period between 1996 and 2000 four countries with low tax burden (namely Luxembourg, Ireland, the Netherlands and Switzerland) attracted 38 percent of American FDI directed to Europe (Sullivan 2002). The analysis of De Mooij and Ederven (2003) also point out that in the last 20 years foreign capital investments became more and more sensitive to tax conditions (De Mooij and Ederven, 2003). The authors sum up the results of 25 antecedent empirical examinations and

state that in studies using more recent data the estimated tax elasticity of foreign direct investments tend to be higher than in studies using older data (De Mooij and Ederven, 2003).

Similar trends predominate in international portfolio investments, too. For instance, Edwards and de Rugy (2002) mention that after non-resident tax on interest and non-resident capital return tax in the US were abolished, the state of Miami became the bank of Latin America. According to the report of Genschel (2002), it means a serious challenge for tax authorities of the European countries, too, to tax financial earnings. Genschel writes – among others – that Belgian investors, in response to the introduction of a 25 percent tax at source in 1983, replaced a considerable part of their assets to the tax-free Luxembourg and the Netherlands. Having observed the deterioration of the competitiveness of domestic financial sector, the government was eventually enforced to abolish the tax at source in 1990 (Genschel, 2002). Austria (1984) and Germany (1993) had the same experience at the introduction of the tax at source (Genschel, 2002).

Labor

In the last 30 years the international mobility of the labor force also increased, however, the scale of the change here cannot be compared to that of the mobility of capital goods. Edwards and de Rugy (2002) claim that favorable tax conditions often play a role when deciding about working abroad. For example, the flow of well-qualified Canadian workforce into the US (brain drain) may be in connection with the lower income-tax rate of the US (Edwards and de Rugy, 2002). In spite of difficulties presented by cultural and language differences, migration motivated by entering employment abroad can now be observed in the countries of the European Union, too. Edwards and de Rugy (2002) note that 23 percent of people working in London are foreigners, the majority of whom came from countries of the EU where the tax

burden is high. The authors mention Ireland, too, where – in their opinion – advantageous tax conditions played a role in the U-turn of the outward migration trend (Edwards and de Rugy, 2002).

Consumers

The international mobility of customers materializes in cross-border shopping opportunities. If, due to the relatively high domestic tax burden, the customers have to pay a much higher price for the same product at home than abroad, the customers get the motivation to procure the product from abroad. In the formation of cross-border shopping, apart from price differences, the transaction costs of cross-border shopping play an important role, too. For customers of the EU member states these costs are likely to have considerably decreased after the demolition of the inner borders (1992) and by introducing the common currency (1999).

We have relatively few information on the occurrence and scale of cross-border shopping. This issue has been mostly analyzed within the United States, in US – Canada relations and in the context of European countries. Campbell and Lapham (2004) examined the relationship between the real exchange rate of the dollar and the turnover of US food stores, fuel stations and restaurants near the Canadian border. They found out that in periods when the US dollar depreciated against the Canadian dollar, the number of actors and employees in these sectors increased substantially. The correlation unraveled proves that the relative fall of US prices made a great number of Canadian customers to do part of their shopping on the American side of the border.

According to findings of researches focusing on cross-border shopping within the US, people living in border-lands of the States travel occasionally to other states to purchase cigarettes,

alcohol, fuel and to play lottery games (e.g. Beard et al. 1997, Flenor 1998, Garrett and Marsh 2002, Tosun and Skidmore, 2004). It is an interesting result of the researches that in some states relatively big numbers of the residents will travel to neighboring states to buy lottery tickets promising a higher prize than those of their own states. Garrett and Marsh (2002), having analyzed lottery sales data of Kansas and its neighboring states in 1998, came to the conclusion that lottery tourism both into and out of the state is remarkable. Kansas earned an income of $5.55 million from lottery sales to residents of Oklahoma, whereas it suffered a loss of $16 million because of lottery purchases of Kansas residents in the states of Nebraska and Missouri. Therefore the net balance of cross-border lottery sales for Kansas in 1998 was $10.5 million, which amounted to 5-6 percent of state income generated by lottery sales (Garrett and Marsh 2002).

The study of Asplund et al. (2007) examines how sales of alcoholic drinks in Sweden respond to changes in alcohol prices of the neighboring countries. According to estimates the elasticity of demand for alcoholic drinks in response to changes in alcohol prices abroad is -0.3 in the border-land. This value decreases to -0.2 as we move 250 kilometers away from the border and at a distance of 400 kilometers the elasticity takes the value of -0.1 (Asplund et al. 2007). Using the relationship unraveled above, the impact of price changes abroad on domestic tax income can be also estimated. According to calculations of the authors Denmark's tax reduction on alcoholic drinks by an average of 27 percent in 2002 lowered the tax income of the Swedish government arisen on sales of alcohol by about 2.2 percent (Asplund et al. 2007).

However, in connection with European countries one can hear mostly about fuel tourism. According to the estimate of Banfi et al. (2005) in the three regions of Switzerland bordering Italy, France and Germany 9 percent of domestic fuel sales were set out by purchases of

foreigners during the time between 1985 and 1997. Calculations of Bleijenberg (1994) show that in Luxembourg, in the retail, about two thirds of gasoline and diesel fuels is purchased by foreigners, which generates the government a tax income adding up to about 2-3 percent of GDP each year. Foreigners' diesel purchases denote a considerable share in Austria's domestic sales, too. According to model calculations of the Ministry of Environment in Austria, diesel purchases of foreign residents put out approximately 30 percent of total domestic turnover (EU COM(2007)). In the case of Germany a same kind of robust trend can be observed, but to the opposite direction. Diesel purchases of German residents in other countries exceed 10 percent of the whole German consumption (EU COM(2007)).

According to a study recently carried out by the Commission the high degree of international mobility of diesel consumption can be traced back primarily to the cost planning of road haulage companies. During their trip abroad, trucks with a big tank aim to fuel up at cheaper fuel stations, that is to say, typically in countries where the tax burden of fuel is lower (EU COM(2007)).

2.4 Tax competition theory

Tax competition is defined as the contest of governments for mobile tax bases. The literature on tax competition draws a distinction between horizontal and vertical tax competition. The horizontal tax competition is going on between equal governments, having own taxation rights – for instance independent states or local governments of a country. We talk about vertical tax competition when different governmental levels – like the federal and the state government of a federal state – compete with each other for the same tax base. In our paper we only discuss the topic of horizontal tax competition.

According to the theory, governments facing geographically mobile tax bases cannot raise taxes to the level that is the most favorable for them because by pursuing this they would risk the migration of their tax bases to the area of other countries. For instance, taxing capital excessively may result in that companies settle to other countries. Furthermore, high taxes on consumption may have the consequence that the consumers – due to high domestic prices – rather choose to go shopping to the neighboring countries. The same happens in both cases: the tax base of governments setting a high tax rate decreases in favor of governments setting a low tax rate. Therefore, according to the theory, governments planning rationally form their tax policies depending on tax policies of other governments.

2.4.1 The basic model of tax competition

The idea that the governments have to compete for mobile tax bases with their tax rates appeared first in the works of Zodrow and Mieszkowsky (1986) and Wilson (1986). We begin the introduction of tax competition theory by describing the train of thought and forecast of the Zodrow-Mieszkowsky model. After this we briefly review what kind of further edifications were resulted in by the literature on tax competition which evolves following the track of Zodrow and Mieszkowsky (1986) and Wilson (1986).

In the Zodrow-Mieszkowsky model, governments aspiring to maximizing the utility of residents compete with each other for tax proceeds laid on capital. The companies produce a homogeneous product by combining the workforce and capital goods of the residents. The global supply of capital is fixed but the capital goods are free to flow between the countries. Labour is internationally immobile. The products of the companies are purchased by the consumers and the governments. The governments produce the capital goods from these. The

governments cover the costs of procurement from taxes levied on capital. The taxation follows the country of destination principle, that is to say that the capital is taxed in the country in which it is used for production. The residents consume two products: private goods produced by companies and public goods produced by the governments.

The government's job is – while maintaining a balanced budget – to determine the utility maximizing level of public goods for a representative consumer and the requisite tax rate. The taxation of capital has the conclusion that a part of the capital goods flows to other countries. The capital stock of the given country decreases until the post-tax return on capital reaches the level of returns attainable in other countries of the world. Since the supply of capital is globally determined, a decrease in the capital stock of a country results in an increase of the same degree in the capital stock of other countries. This also means that the tax policy of a government – due to its impact on the common tax base – influences the welfare of other countries.

For solving the multi-actor decision situation, Zodrow and Mieszkowsky apply the Nash equilibrium concept. Each government defines the optimal tax rate for itself taking the taxation decision of the other government as given. According to the forecast of the model the tax rates building up the Nash equilibrium will be lower than those set when assuming closed borders – in other words, capital immobility. For every country, the tax rates formed in the tax competition result in a suboptimal level of public goods, thus, a social welfare that is lower than that can be potentially reached. Zodrow and Mieszkowsky also show that the while the number of the countries increases the tax competition generates more and more decreasing tax rates, thus, more and more increasing welfare loss.

What is the intuitive explanation of the result obtained in the Zodrow and Mieszkowsky model? In the background of the race to the bottom there is the external effect of tax policy. Governments facing international capital mobility decrease their tax rates in order to retain their tax base. The cutback of the tax rate infuences the tax bases of other countries negatively. However, the governments disregard this consequence when determining their own tax level – this is why the contention for tax base leads to too low tax rates.

Up to this day, this has been the most quoted result in the tax competition literature. This model result inspired the view, too, that was very popular mainly in the 1990s, according to which the strengthening of international competition for capital eventually leads to the total liquidation of taxes on capital.

In order to cover their needs for income, the governments, of course, can use multiple tax assets simultaneously. In an earlier study Zodrow and Mieszkowsky (1983) examined how the ratio of taxes levied on mobile and immobile production factors – capital tax and head tax – changes as the number of the countries increases. The authors show that as the number of competitor countries increases – in other words, as the competition for mobile resources increases – the tax levied on capital decreases and the head tax increases (Zodrow and Mieszkowsky 1983). That is to say that Zodrow and Mieszkowsky raised the idea first that amid the intensification of tax competition for capital the governments resort to increase the tax burden of the less mobile labour, making up for the income fallen out.

The analysis on tax competition by Zodrow and Mieszkowsky (1986) was focused on the taxation of production factors. In a similar theoretical framework, Mintz and Tulkens (1986) examine the causes and and consequences of the formation of tax competition in the field of

consumption taxes. The conclusions of the examination match in many respects the conclusions of Zodrow and Mieszkowsky (1986). The mobility of the tax base – which here relates to the opportunities of cross-border shopping – leads to competition for the tax base also in the case of consumption taxes and hereby it leads to tax rates differing from the socially optimal rates, and to a suboptimal level of public expenditures (Mintz and Tulkens 1986).

2.4.2 Extensions of the basic model

From researches examining the connection between the size and the tax policy of the countries, important and empirically testable analytical results were born. Examining the capital tax competition of a small and a large country, Wilson (1991) and Busovetsky (1991) came to the conclusion that in the equilibrium of the tax competition the large country sets a higher tax rate than the small one. The intuitive explanation of asymmetrical behavior is the following. If a country's demand for capital is a considerable part of the world's aggregate demand for capital then the country's tax policy has an effect on the international price of capital. For example, as a result of an increase in the tax rate, the international required rate of return of capital somewhat decreases. As the taxation change in the case of a bigger country capitalizes more, the taxation change of the large country changes the gross costs of capital only to a smaller degree (tax plus return), thus, the scale of in- and outflow of capital, than the taxation change of the same degree by the small country. So, the different behavior of the large and the small country is rooted in the different tax elasticity of their tax bases.

The different size leads to asymmetrical competition also in the case of consumption taxes. Kanbur and Keen (1993), having examined countries of different population density, and

Nielsen (2001), having examined countries of different size, came to the conclusion that the bigger countries set higher tax rates than the small ones. In the commodity tax competition the cutback of the tax rate generates two opposite effects. It has a positive effect on tax proceeds through the increase of the tax base – or the number of non-resident consumers – and a negative effect through the decrease of income per capita of consumers. For the country with the bigger population this last effect is relatively stronger than for the country with the smaller population. This is the explanation for the small country's more 'agressive' behavior.

2.5 Some empirical evidence on tax competion

The topic of tax competition among governments has received growing interest in the empirical public literature recently. The larger part of the empirical work has focused on capital tax competiton. Three recent papers (Altshuler and Goodspeed 2003, Bretschger and Hettich 2002, and Devereux et al. 2004), for example, examine whether OECD countries compete with one another over corporate tax rate in order to attract investment. All of the three papers find evidence that OECD countries have been setting tax rates strategically to attract mobile capital.

The empirical research of commodity tax competition has only recently started. The research was focused on excise taxes, playing the main role in the differentiation of international consumer prices. We summarized the publications written in this topic in Table 2.1, quoting the list of countries and taxes under examination as well as the methods of estimatation used. From the list one can see that most of the results available refer to the tax competition between the states of the US. These researches confirmed that US states set the excise tax of cigarette, alcoholic drinks and gasoline while competing with each other (Devereux et al.

2007, Egger et al. 2005a, Nelson 2002, Rork 2003). Egger et al. (2005a) found an evidence for asymmetric tax competition, too. In their research examining excise taxes of beer and wine, they pointed out that the size of the population has a positive effect on the rates of excise tax (Egger et al. 2005a).

To our best knowledge, commodity tax competition among the European countries has been examined only by three studies. The study by Rietveld et al. (2005), using 1998 data of diesel and gasoline prices of 32 European countries, confirmed the hypothesis of asymmetric fuel tax competition. In their econometric analysis, performed on panel data almost matching the database we used, Evers et al. (2004) could detect diesel tax competition but could not detect asymmetric competition. Egger et al. (2005b), having examined the average rate of commodity tax burden, came to the conclusion that the countries of the EU-15 determine their commodity tax rates while competing with each other.

Table 2. 1 Previous research on commodity tax competition

Reference	Countries and years studied	Taxes/prices studied	Method*	Variables measured in
Devereux, Lockwood and Redoano (2007)	States, USA; 1977-1997	Excise taxes on cigarettes and gasoline	IV	level
Egger, Pfaffermayr, and Winner (2005a)	States, USA; 1975-1999	Excise taxes on cigarettes, gasoline, beer and wine	IV	level
Egger, Pfaffermayr, and Winner (2005b)	EU15 countries plus Switzerland and Norway; 1965-1997	Implicit consumption tax rate (ratio of consumption tax revenue and private + government consumption)	IV	level
Evers, de Mooij, and Vollenbergh (2004)	EU15 countries plus Switzerland and Norway; 1978-2001	Diesel excise ratio (ratio of the excise tax and the price inclusive excises)	IV	first-differences
Nelson (2002)	States, USA; 1960, 1970, 1980, 1990	Excise taxes on cigarettes, gasoline, beer and distilled liquor	OLS	level
Rietveld and Woudenberg (2005)	32 European countries; 1998	Gasoline and diesel prices in US $	IV	level
Rork (2003)	States, USA, 1967-1996	Excise taxes on cigarette and gasoline, personal income tax, sales tax and corporate income tax	IV	level
Ryen and Rork (2003)	States, USA, 1967-2000	Implicit lottery tax (amount of sales collected but not redistributed as prices)	IV	level

*ML: maximum likelihood; IV: instrumental variables.

CHAPTER 3

TAX HARMONIZATION AND THE PRACTICE OF EXCISE TAXATION IN THE EU: THE CASE OF TRANSPORT FUEL EXCISES

In this Chapter we have two goals. First, we aim to discuss the European Union's tax harmonization policy and its achievements, with special regard to the harmonization of fuel excise taxes. Second, in light of the practices of excise taxation in the Member States we attempt to evaluate the effectiveness of the minimum rate regulation in effect.

To approximate excise tax levels the European Union introduced minimum rate regulation in 1992. However, the need of further approximation has been been put to the forefront by two developments in the 1990s. First, environmental considerations gained more political weight. Second, the liberalization of the haulage sector made the harmonized taxation of commercial motor fuels more pressing. Despite the declaration of the need of further harmonization, both the 1997 energy tax proposal and the 2002 proposal to amend the 1992 directive were rejected. This later suggested the substitution of the minimum rate system by a gradually decreasing fluctuation band system. The Energy Tax Directive adopted after lengthy debates in 2003 was much less ambitious than this. Instead of aiming at a single excise rate, it is confined only to the raise of minimum rates and keeps – albeit narrows down - the minimum rate gap between unleaded petrol and diesel. The target rate regulation came up again in the 2007 draft directive but was rejected by the Commission again. Despite the rejection of proposals aiming at stronger harmonization, we can conclude that important steps have been made in the excise rate harmonization from the early 1990s. As a result, excise tax is one of the most harmonized tax types in the EU.

In the second part of the Chapter we provide a brief review of the practice of excise taxation in the road transport sector of European countries. We will demonstrate that despite the harmonization steps, excise rate differences among Member States have hardly decreased over the last 15 years. In some cases, they may differ by up to 100 percent between neighboring countries.

3.1 Excise tax harmonization in the EU

The need to harmonize indirect taxes (sales, excise and other indirect taxes) has been spelled out already in the Treaty of Rome (Art. 93). The first harmonization steps for the restructuring of sales taxes focused on the introduction of value added tax (VAT). The deadline for realigning tax policies set by the internal market program of the Single European Act was 31 December 1992. The VAT system has been introduced in this framework and several other important moves have been made about the harmonization of excise taxes. Minimum rates have been set for both sales and excise tax leading to partial harmonization (the most advanced among the types of taxes) in both cases. Much less has been done in the field of direct taxes. Achievements were confined to the partial solution of the double taxation issue within the EU and the promotion of transborder economic activities (Őry 2003).

The forthcoming section provides an overview of indirect taxes, focusing on the harmonization of excise tax, with only sporadic references to direct taxes. Since we aim to reveal the motivations of EU's tax policy, it is important, that not only the implemented but also the planned (submitted) tax harmonization proposals are discussed.

The early days of tax harmonization

Tax harmonization goes back to the period before the Treaty of Rome as already at the foundation of the European Steel and Coal Community (1951) the parties recognized that national laws on indirect taxes create barriers to free trade in the common coal and steel markets.[1] They set up a committee of independent experts (*Tinbergen Committee)* in 1953 to prepare proposals on the possible direction of tax harmonization with regard to the common steel and coal markets.

The Treaty of Rome – in effect from 1 January 1958 – requires the community level harmonization of sales, excise and other indirect taxes (Art. 93(99)). The *Neumark Committee* – again made up by independent experts – analyzed the impact of the various tax systems of Member States on the free movement of goods and, in addition, their impact on non-discriminatory competition. They concluded that the cumulative multistage (cascade) sales tax system distorts competition and should be substituted by a value added type of system.[2] The Neumark Committee considered – apart from the approximation of sales taxes – the harmonization of excise taxes. By analyzing the structures and rates of excise tax they emphasized the need to harmonize taxes on road use and excise tax on mineral oils. The paper proposed the harmonization of direct taxes (company and income tax) at a later stage of the overall tax harmonization process.

[1] The agreement itself called for the pulling down of cumulative (cascade) taxation. (The countries becoming the signatories of the Treaty of Rome – with the exception of France - implemented the so-called cumulative multistage tax system.)

[2] The cascade type system can cause considerable tax accumulation as tax is levied at all stages of production on the full production value. Hence, the final tax burden does not only depend on the tax rate but also the number of stages. As such, it serves as an incentive for the creation of vertically integrated companies and thus distorting competition.

The first and second VAT draft directive proposal that laid the foundation of the VAT system were accepted – after modification - by the Council on 11 April 1967. The first Directive requires Member States to introduce a common, multistage, non-cumulative value added tax by 1 January 1970, the latest. [3] This deadline has been modified several times later on. The common VAT system covers all the stages of the commercial chain from production to retail distribution.[4] This would in theory guarantee fair competition in trade both at national and community levels.

Member States decided about the further integration and the creation of an economic and monetary union in 1969. The report prepared by the committee set up to analyze the implementation issues of the economic and monetary union (Werner Report) emphasized the need to harmonize VAT, excise and other taxes prohibiting the free movement of capital and suggested a 3-staged harmonization process. The first stage (1970-1971) would have included the introduction of a common VAT system, the approximation of excise and VAT rates. In the second stage (1972-1975), these rates would have been further approximated. The third stage would have involved the abandonment of tax borders and thus the implementation of the free movement of capital. The Commission has submitted several draft directives for the implementation of the program but the Council rejected most of them with the exception of VAT proposals. After lengthy debate, the Council approved the so-called 'Sixth VAT Directive' that is still the fundamental legal source of VAT harmonization efforts.[5]

The next important step in the harmonization of excise levels was the White Book of the Commission published in 1985 that outlined the physical, technical and financial (taxation)

[3] Directive 67/227/EEC
[4] The original proposal of the Neumark Committee left out the retail stage from the coverage of the tax system.
[5] Directive 77/388/EEC

barriers of the planned common market and the principles of their elimination.[6] The Commission set the deadline of 21 December 1992 for the legal harmonization necessary for the single market. In addition, the Commission submitted a policy package on the adjustment of VAT and excise tax to the requirements of the single market by proposing the introduction of a two-tier VAT system and the approximation of the structures and rates of excise taxes in the Member States. The VAT proposal have been modified but not approved as the Council considered it premature to introduce a common VAT system requiring the application of the tax laws of the country of origin. A transitory system has been introduced instead on 1 January 1993.[7] Its planned expiry was at 31 December 1996 but postponed until the final system is agreed upon. This transitory system combines the 'country of origin' and 'country of destination' type of taxation and allows for the abolishing of border control. The next important measure on the elimination of tax barriers of the single market was the approval of the directive on VAT rates in 1992 that introduced mandatory minimum rates: 15 percent for normal rates and 5 percent for reduced rates.[8]

The 1992 directive on the harmonization of excise tax

The 1992 directives (containing horizontal and product specific regulations) meant a major breakthrough in excise tax harmonization. Art 3(1) of the directive on horizontal measures defines the product scope: mineral oils, alcohol and tobacco products.[9] The structure of taxation (i.e. product definition, measurement and exceptions) and the rates are set in separate directives. Member States can levy further indirect taxes on these products justified on other – environmental protection or health policy – grounds (Art. 3(2)). The harmonization of excise

[6] The content of the White Book became legally binding at treaty level by the Single European Act.
[7] Directive 91/680/EEC and Directive 92/111/ EEC (its modification)
[8] Directive 92/77/EEC
[9] Directive 92/12/EEC

levels does not curtail the right of Member States to levy excise tax on other products (e.g. road tax or car registration tax) on the condition that it does not restrain free trade. Taxation is based on the destination country i.e. tax is collected in the country (using the respective national rate) where the product is consumed. The only exception is the private purchase of natural persons, where the principle of 'country of origin' prevails.

The harmonization of mineral oils excise taxes are set in Directive 92/81/EEC that has been taken out of effect by now. It defines 30 products, the tax is based on the quantity, and minimum rates are given for 1000 liters (at 15 Celsius).

The approximation of minimum rates is defined in Directive 92/82/EEC (modified by Directive 94/74/EEC) by setting such a rate for each product (see Table 3.1). The Directive required that the Council revise these rates biannually from 31 December 1994 but no revisions were made until 2002.

Table 3.1 Minimum excise tax rates as set by Directive 92/82/EEC

	EUR/1000 l
Petrol	337
Unleaded petrol	287
Diesel	245

Mineral oils provide the biggest revenue for Member States among the 3 product groups of the 1992 excise directives. While the final consumer pays excise tax on alcohol and tobacco products, the tax burden on mineral oils has considerable impact on industry and trade via production and transport costs (Őry 2003).

It is a common practice among the Member States to set higher rate for petrol than diesel. The advantageous position of diesel is due to the fact that dominant share was used by freight transport by the end of 1980s (only 15 percent of passenger cars used diesel). As such only approximately 10 percent of total diesel use can be attributed to private persons. Another justification for such minimum rate structure could be that the pre-tax price of diesel was somewhat higher as compared to petrol.

From 1 July 1998 domestic haulage markets have been fully liberalized. The reviving competition made the impact of cost differences due to country specific rates more and more sizeable. The White Paper entitled "European transport policy for 2010: time to decide" concluded that in the setting of liberalized haulage market, the major obstacle in the functioning of the common market is the lack of harmonized fuel taxation.[10] It emphasized the need to make tax policy more consistent by the common fuel taxation of commercial freight transport.

The 2002 draft directive for the modification of 1992 excise directives

The commission filed a proposal on the gradual excise tax harmonization of commercial diesel and the readjustment of the minimal rates for non-commercial diesel and unleaded petrol.[11] The draft directive had two aims: the enhanced protection of the environment (polluter pays principle) and the elimination of competition distortion problems in the liberalized commercial haulage market.

[10] COM(2001) 370
[11] COM (2002)410

The proposal – contrary to Directives 92/81/EEC and 92/82EEC - differentiates between commercial and non-commercial diesel consumption. The minimum rate regulation is substituted by a 'target rate' system i.e. 350 EUR/1000 liter for *commercial diesel* from 1 January 2003 that would be indexed to inflation. This would enable Member States to gradually narrow the deviation between their and the target rate (the range would be set as ± 100 EUR) and eventually reach the single harmonized rate of approx. 410 EUR by 2010.

For *non-commercial diesel* the proposal keeps the minimum rate regulation and set the same minimum rate as for unleaded petrol on the ground that the previous lower rate for diesel cannot be justified in any (e.g. environmental) grounds. The minimum rate for unleaded petrol is readjusted to internalize inflation from 287 to 360 EUR. The goal is that this rate would never supersede the rate of commercial diesel and would be continuously adjusted for inflation.

The draft was eventually rejected but the Commission confirmed that based on further impact studies it would reconsider the need for new legislation.

The approval of the energy taxation directive

The Commission first proposal to a community-level energy product taxation dates back to 1997.[12] The proposal was motivated by the need to have a better functioning common market but included environmental considerations as well. It extends the scope of vertical mineral oils directives to coal, lignite, coke, bitumen and its derivatives, natural gas and electricity (and co-generated heat). As these products used as fuels are direct or indirect substitutes, the

[12] COM 1997) 30 final

Commission opted for a common regulation. The proposal requires the increase of minimum rate for mineral oils and sets the minimum rate for other energy products. This proposal was an element of the policy package designed for the implementation of the Kyoto Protocol (1997).

The energy tax proposal was turned down by the Member States so the Commission modified it in 2001 and adopted in 2003.[13] The Energy Tax Directive extends the scope of the minimum rate system (beyond mineral oils) to all energy products and increase the rate for mineral oils set back in 1992. It enlists the taxable products (coal, natural gas, electricity) and their modes of use liable to taxation, i.e. as heating fuel or motor fuel (and not for uses in chemical reduction and in electrolytic and metallurgical processes). Fuels used in stationary motors and agricultural works are granted a reduced rate.

The Directive allows Member States to separate commercial and non-commercial diesel and to set different rate for each.[14] A lower rate can be set for commercial diesel with the condition that it is above the minimum rate set by the Directive and remains higher than the national rate in effect as of 1 January 2003. [15] This separation also allows for the excise tax rate approximation of non-commercial diesel and petrol.

The Directive calls for further efforts in the harmonization of commercial diesel rates. The Directive sets the minimum rate for each energy product, depending on their use (fuel,

[13] 2003/96/EC

[14] The Energy Tax Directive (article 7.3 of Directive 2003/96/EC) defines commercial diesel as gas oil used as fuel for the following commercial purposes: (i) the carriage of goods by motor vehicles intended exclusively for the carriage of goods by road and with a maximum permissible gross laden weight of not less than 7.5 tonnes; (ii) the carriage of passengers by a motor vehicle of category M2 or category M3 (as defined in Directive 70/156/EEC).

[15] The rate can only be lower than the 2003 rate if road charges are introduced to keep the overall tax burden constant, and the minimum rate is acknowledged. In practice this option only concerns the UK where the 2003 national rate was at least the double of the 2004 minimum rate.

industrial and commercial use, or motor fuel). It also provides transitional period until 1 January 2007 for Member States finding the introduction of minimum rate far too difficult.

Table 3.2 Minimum excise rates as set by Directive 2003/96/EC

	1 January 2004	1 January 2010
	EUR/1000 l	
Unleaded petrol	359	359
Diesel	302	330

The "Consultation paper on Narrowing Excessive Differences in the Tax Levels Applicable to Commercial Diesel" prepared by the Commission concludes that the practices of Member States are very different. Those without transitional period for the introduction of minimum rates apply 302-782 EUR/liter rates, with six Member States applying higher than 400 EUR/liter.

Draft proposal to amend the 2003 Energy Tax Directive

The Commission declared in its communication entitled *Keep Europe Moving – Sustainable mobility for our continent, Mid-term review of the European Commission's 2001 Transport White Paper* that it would analyze the option for narrowing the rate gap. The paper emphasize that transport policy is closely intertwined with energy policy, and should consider international environmental commitments, especially those in the Kyoto Protocol.

The Communication of the Commission entitled *Action Plan for Energy Efficiency: Realising the Potential* reinforced its motivation to propose new tax measures on commercial diesel in 2007 in order to approximate national rates that would alleviate the problem of 'refueling

detours' and consequently increasing energy efficiency of the haulage sector.[16] The Commission – after stakeholder consultations and the preparation of impact study – submitted its proposal in 2007 on the amendment of the 2003/96/EC Directive. The proposal considered the commercial use of diesel as motor fuel and the tax harmonization of non-commercial diesel and unleaded petrol, both used as motor fuel.[17]

The final draft directive submitted by the Commission aims at the reduction of competition distortion caused by excise level differences.[18] In addition, it is in harmony with the common transport policy and supports environmental protection efforts. The Commission studied 3 options (A, B and C, then C divided into C1 and C2) for the approximation of tax levels for commercial diesel. The original scenarios have been somewhat modified while preparing the impact study and a C+ sub variant has been added (see Table 3.3).

Table 3.3 The various options for excise tax rate approximation

	Option A	Option B	Option C1	Option C2	Option C+
Objective achieved in	No further intervention at Community level	2018	2012	2012	2012 and 2014
Minimum level of taxation (euros per 1000 l)	Minimum level of 302 until 2009 and 330 from 2010 onwards	Harmonized rate of 400	302 and from 2010 onwards, 330, indexed on inflation from 2012 onwards	302 until 2009, 330 from 2010 to 2011 and 359 (the same as unleaded petrol) from 2012 onwards	302 until 2009, 330 from 2010, 359 (the same as unleaded petrol) from 2012, and 380 from 2014
Fluctuation band	No	No	Yes	Yes	No

Source: COM(2007) 52 final SEC(2009) 171

Option A does not include any further community level intervention. Option B proposes the full harmonization of excise levels at the rate of 400 EUR/liter by 2018 in order to eliminate

[16] COM (2006) 545
[17] SEC(2007)170 and SEC(2007)171
[18] COM (2007) 52 final

competition distortion, and provides Member States with a higher level of freedom in setting the excise level for non-commercial motor fuels and thus could contribute to a more efficient environmental and energy policy. It keeps however the condition that the excise level of non-commercial diesel and unleaded petrol should be above that of commercial diesel. Option C involves the strong approximation of excise levels for commercial diesel. Member States could set their excise level within a fluctuation band defined with minimum and maximum rates. The width of the fluctuation band would gradually narrow down to 100 EUR by 2010. Option C1 and C2 offer different indexing methods for the excise rate. Just as in Option B, the excise level of non-commercial diesel and unleaded petrol should remain above that of commercial diesel in Option C1 and Option C2.

The Commission abandoned Option A and did not find Option B politically feasible. As the impact study showed negative consequences in both Option C1 and Option C2, it introduced a fifth scenario, i.e. Option C+. This option abandons the upper limit of the fluctuation band based on two justifications. Economic theory provides much weaker support for setting maximum rate as opposed to minimum rates as tax competition works in one direction: it decreases tax levels in all countries, most likely to suboptimal level. The practical reason is that the maximum rate question applies to only two Member States (Germany and the UK). It is quite unlikely that other countries would raise their excise tax level above the maximum considering the strong competition in the haulage market and its impact on market shares.

Option C+ foresees the increase of the minimum rate to 359 EUR/1000 liters in 2012, then to 380 EUR/1000 liters in 2014 in order to avoid the quick devaluation. This option is built on the assumption that the progressive increase of tax level for commercial diesel considerably decrease the degree of competition distortion at the haulage market and cut on ‘fuel tourism’.

The Member States are free to choose their own rate (above the minimum) and thus balance between the sustainability of their haulage sector, the internalization of environmental costs and the level of expected budgetary revenue.

The report of the Commission gives the following assessment of the different options. Option C+ would lead to the increase of excise level for commercial diesel in 8 Member States by 2012 and in 21 by 2014. From 2014 9 Member States would have to increase the excise tax rate on unleaded petrol. This option would result in a lower level of consumption of both diesel and unleaded petrol and lower level of pollution emission. In addition, it would cut on 'fuel tourism' and hence has positive budgetary effect.

Considering all this facts, the Commission decided to propose Option C+. The draft directive states that the best way to approximate excise levels on commercial diesel is by increasing the minimum rate as it facilitates the decrease of competition distortion, the level of 'fuel tourism' and total motor fuel consumption. It proposes a common minimum rate for commercial diesel and unleaded petrol from 2012 as both has similar environmental impact. The minimum rate would increase to 380 EUR/ liter by 2014 (see Table 3.4).

According to the draft directive, the separate treatment of commercial and non-commercial diesel in not mandatory. Member States can however distinguish between commercial and other use with the condition that they keep the community-wide minimum rate and that the rate of commercial diesel remains higher than the national rate in effect in 1 January 2003. The national rate of non-commercial diesel and unleaded petrol cannot be lower than that of commercial diesel. Only those countries can apply lower rate that that of 1 January 2003 that

introduce or has in operation a road charge system and the overall tax burden approximately remains constant.

Table 3.4 The community-wide minimum excise rates for commercial diesel

	1 January 2004	1 January 2010	1 January 2012	1 January 2014
	EUR/1000 l			
Unleaded petrol	359	359	359	380
Diesel	302	330	359	380

Source: COM(2007) 52 final SEC(2009) 171

3.2. The practice of road transport taxation in Europe

Taxes on motorization have historically been enacted for the purpose of raising general revenue and funds for financing construction of highways. During the last three decades, however, transportation taxes have been increasingly justified on other grounds and viewed as serving special purposes. Since the two oil price shocks in 1973-74 and in 1978-79, fuel taxes have also been considered as a tool of energy policy, directed to slowing down oil consumption in oil-importing countries. Subsequently, the 1980s have seen a growing awareness of the damages that road transport causes to the human health and the environment, and thus taxes on motorization have also been conceived of as an economic instrument serving to correct environmental externalities. Finally, escalating congestions in densely populated areas across Europe have called the attention to the potential application of transport related taxes as a second best means of road-user charges.

Inspite of the developments depicted above, road transport has remained an important source of tax revenue. All EU-15 Member States together with Norway and Switzerland rely heavily on a range of tax instruments to raise budgetary revenues from both private and commercial road users. However there is a large diversity in the adopted regimes in the Member States.

These differences apply both in terms of the overall dependence of budgetary revenue from road transport related taxes and in terms of the mix of instruments implemented (European Commission 1997).

3.2.1 Types of tax instrument

The tax instruments in use may broadly be divided into three categories: (i) taxes on the acquisition of a vehicle, (ii) taxes on the ownership of a vehicle and (iii) taxes related to the use of a vehicle (OECD 1999). The first category consists of taxes payable at the time of purchase or first putting into service of a vehicle, for example VAT and registration taxes. The second category covers recurring charges such as annual circulation taxes and insurance taxes that are imposed on a periodic basis and confer the right to drive on public roads. Finally, there are taxes that are directly or indirectly related to the use of a vehicle such as excise duties on fuel and motorway charges or other road user tolls (see Table 3.5).

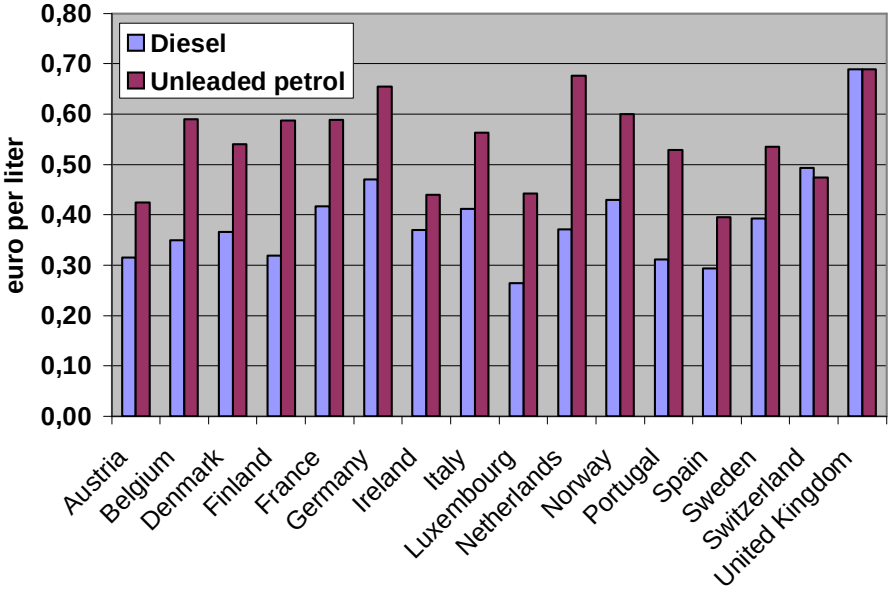
Table 3.5 Overview of transport related taxation

Basis of taxation	Tax	Note
Acquisition	VAT	All Member States levy VAT on acquisition of new vehicles according to the European Community VAT regime. The rates levied vary between 16 and 25 percent.
	Registration Tax	Registration taxes are levied in the majority of Member States. These taxes are either related to the base price of the vehicle, engine capacity, engine power, weight, fuel specific consumption, emissions standards or to a mix of all these factors.
Ownership	Circulation and insurance taxes	These taxes are due in connection with possession or ownership of a vehicle, such as circulation taxes, and are levied in all Member States, both on passenger cars and commercial vehicles. On passenger cars they are normally related to factors such as engine power, vehicle weight and age, energy consumption, fuel type and district of registration, amongst others.
Motoring	Fuel taxes (excise duty and VAT)	These are taxes directly or indirectly related to the use of vehicles.

All states impose VAT on the price of a new (privately-owned) car, with rates varying between 16 percent and 25 percent. Registration taxes are mainly levied on passenger cars, and Member States that uses such taxes usually apply reduced rates or exemptions for commercial vehicles. The registration tax, if applied, is usually value based. All Member States impose some kind of circulation taxes both on passenger cars and commercial vehicles. They are normally related to such factors as engine power or vehicle weight.

Tax instruments vary among countries of the Union to a great extent, both in the way of levying taxes and in the level of taxes. Cross-country differences in the tax burden can be illustrated on the example of a specific car (Vauxhall Astra 1600). The egistration tax exhibits large variation among countries ranging from 0 percent to 160 percent of the pre-tax price of the car. The circulation tax charged on the car ranged from 42 euro per year to 385 euro per year in 2000 (CBP 2000).

There is a large difference in the level of taxation on heavy good vehicles in the Union, also. For example, the annual vehicle tax levied on a 40 tonne truck was above 2000 EUR in Austria, Finland, Sweden and the United Kingdom, while it was below 500 EUR in Denmark and Portugal in 2001 (ECMT 2005).



Source: IEA: Energy Prices & Taxes 2006

Figure 3.1 Excise duties on motor fuels, 2005

Motor fuel levies are traditionally the most important taxes on motoring. Besides VAT, all Member States impose a very high level of excise taxes on all types of motor fuel. The average EU-17 gasoline and diesel excise rates were 165 percent and 116 percent, respectively, in 2005. Figure 3.1 shows the excise taxes on motor fuels across the EU-15, together with Norway and Switzerland. One important feature of fuel taxation in Europe is that countries tend to tax gasoline more heavily than diesel fuel, the only exceptions being Switzerland and the United Kingdom. It has to be noted, however, that the cross-country differences in the tax differential are substantial. Another observation, which applies for both fuels, is that the tax levels differ greatly from one country to the other. Despite the EU minimum rates of excise duty, the rates applied by the Member States have remained greatly different over the past 15 years. In some cases, excise duty rates may differ by up to 100 percent between neighboring countries. For example, excise duty on diesel applied in the United Kingdom was 0,689 euros per liter, while in the neighboring Ireland it was only 0,370

per liter in 2005, or in Germany it was 0,470, while in Luxembourg only 0,265 euros per liter in the same year. Since excise duties make up a significant part of the total price, the wide spread in tax levels creates a corresponding large divergence in consumption prices between Member States.

Most countries apply some form of user charges on their motorways. (In some cases, fees are also levied on the use of bridges and tunnels.) Austria, Denmark, Greece, France, Italy, Portugal and Spain levy road tolls; Denmark, Sweden, Germany and the BENELUX countries operate the "the Eurovignette" system; Austria as well as Switzerland use a vignette-type system on a national basis. Under the Eurovignette system all trucks over 12 tons have to pay a common user charge for the use of the highway network in the six Member States.

3.2.2 Revenues from road transport taxation

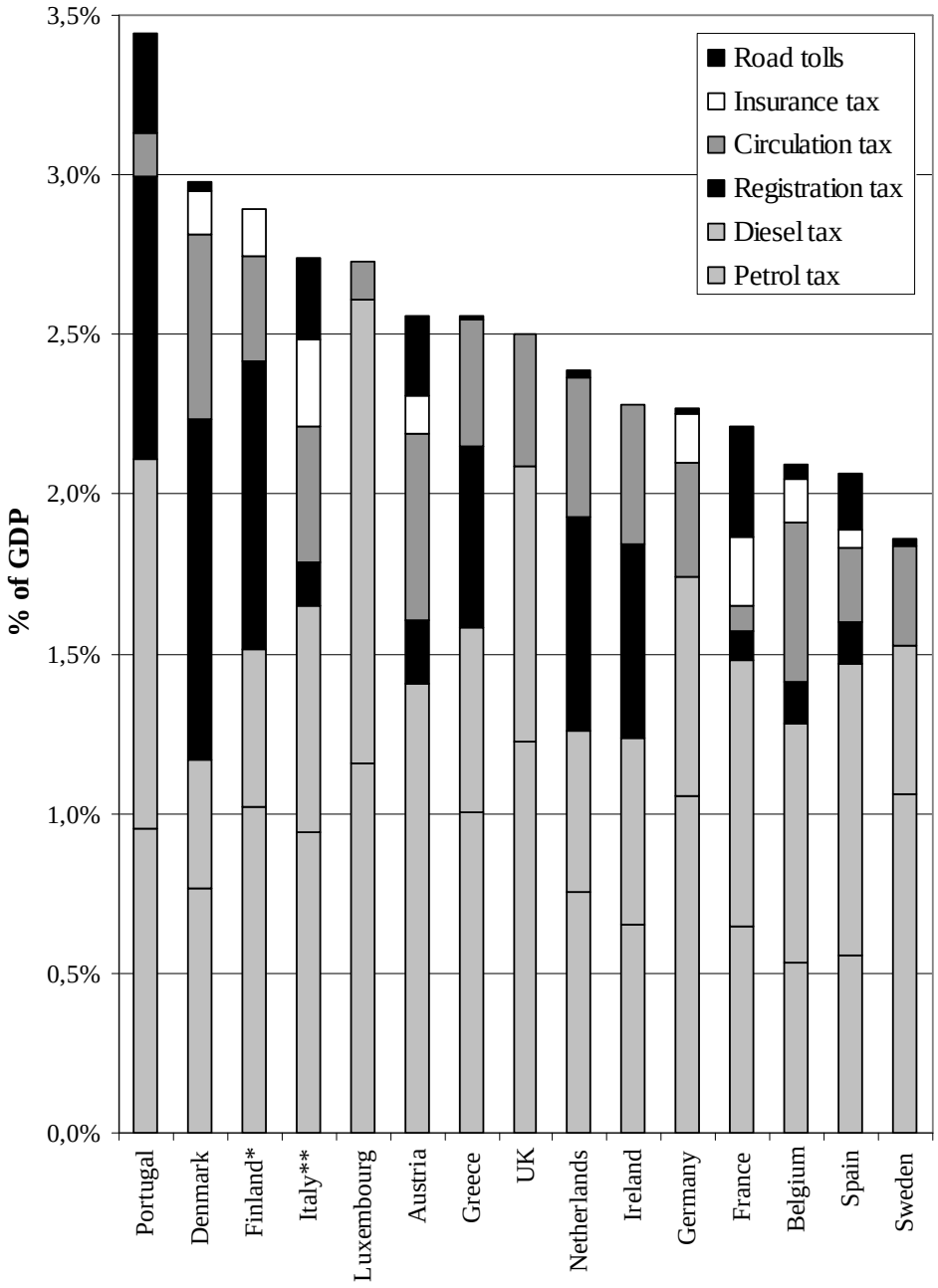
Taxes on motoring ensure significant budgetary receipts in all Member States. Tax receipts from road transport taxation accounted for about 5,5 percent of total tax revenues or for one-fifth of total indirect tax revenues in the EU-15 in 2002. In this context, transportation taxes are meant to be all indirect taxes (and charges) other than VAT.[19]

Figure 3.3 provides an illustration of the importance of road transport taxation for each Member State by relating the revenues from such taxes to GDP. Tax receipts from road transport related taxes ranged between 1,8 and 3,5 percent of GDP in 2002. The highest percentage was observed in Portugal while the lowest was registered in Sweden.

[19] Two caveats are in order. First, motorways are increasingly built and operated by concessionaire companies. In such cases, tolls are paid to the concessionaire companies and probably not contribute to the tax revenues collected by national and regional governments. Second, for some countries the information on revenue from taxes on motor insurance premium is missing (see notes to Figure 3-4).

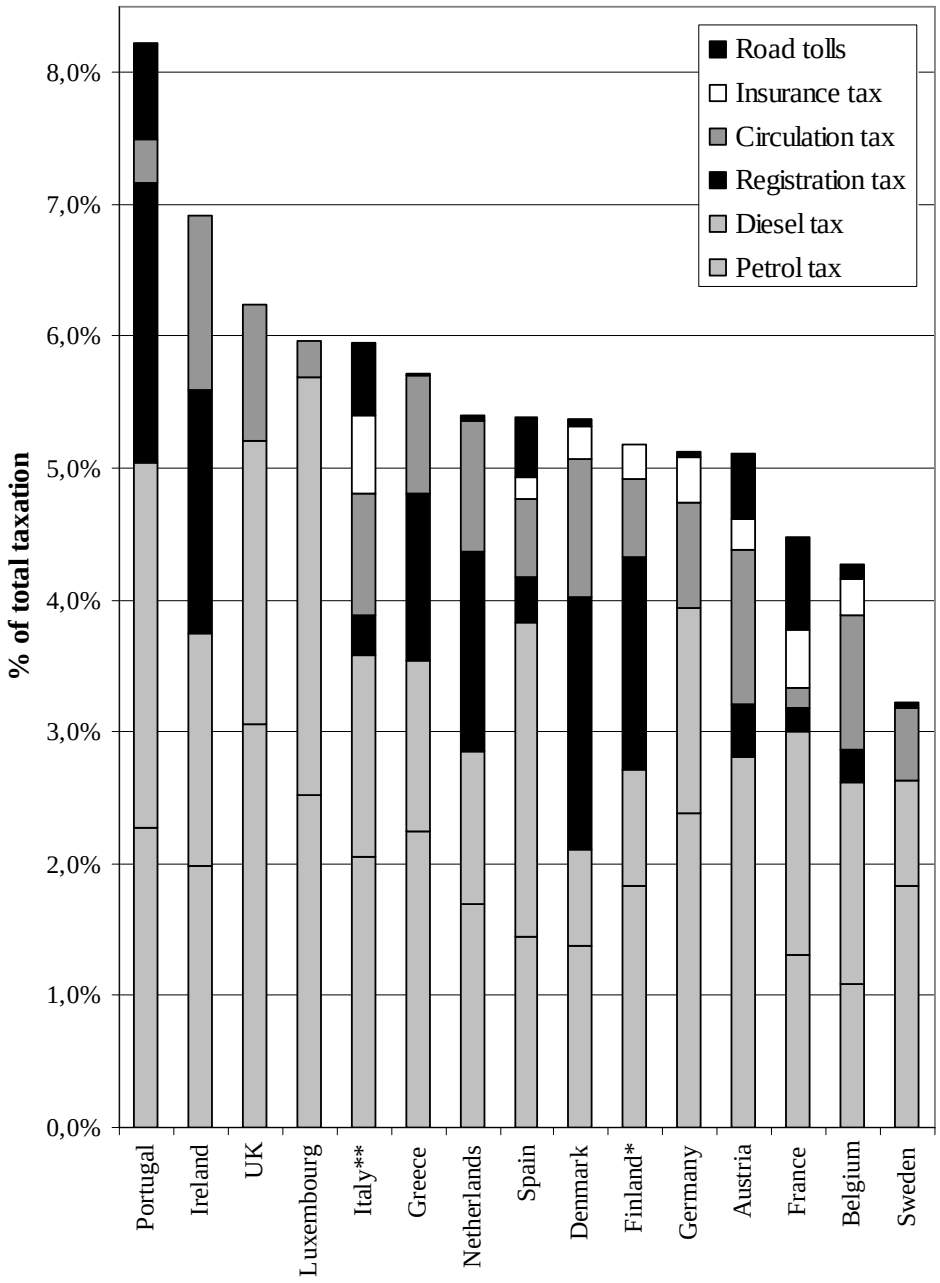
Figure 3.4 indicates the level of budgetary dependence from road transport related taxes in each Member States by relating the revenues to total tax receipts. It is apparent that the overall dependence of budget from transportation taxes varies greatly from one country to the other. The share of road transport tax revenues in total tax revenues ranged from 3,2 percent to 8,2 percent in 2002. Portugal is the most dependent among Member States, with more than 8 percent of its revenue accruing from road transport taxation.

As regards the relative weights of various levies on total revenue from road transport taxation, one point is worth mentioning. First, motor fuel taxes are by far the most important revenue raisers in most countries. On average, tax receipts from fuel excises contribute two-thirds of total revenue from road transport taxation.



Notes: * 2000 data; ** 2001 data; for Austria the petrol taxation level is also including diesel taxation; information on revenue from taxes on motor insurance premium is missing for Greece, Ireland, Luxembourg, the Netherlands, Portugal, and the United kingdom
Sources: ASECAP: Statistical Bulletin 2002; ACEA: European Automobile Industry Report 2004; EC: Excise Duty Tables 2003 (Tax Receipts – Mineral Oils); ECMT: Road Haulage Taxation Database; OECD: Revenue Statistics 1965 – 2004; OECD/EEA: Database on Instruments Used for Environmental Policy and Natural Resources Management

Figure 3.3 Road transport related taxes and charges as % of GDP, 2002



Notes: * 2000 data; ** 2001 data; for Austria the petrol taxation level is also including diesel taxation; information on revenue from taxes on motor insurance premium is missing for Greece, Ireland, Luxembourg, the Netherlands, Portugal, and the United kingdom
Sources: ASECAP: Statistical Bulletin 2002; ACEA: European Automobile Industry Report 2004; EC: Excise Duty Tables 2003 (Tax Receipts – Mineral Oils); ECMT: Road Haulage Taxation Database; OECD: Revenue Statistics 1965 – 2004; OECD/EEA: Database on Instruments Used for Environmental Policy and Natural Resources Management

Figure 3.4 Road transport related taxes and charges as % of total taxation, 2002

3.3. Summary

It was shown that excise taxation of the road transport sector has been an important source of budgetary revenue in all EU Member States. This is especially true of the excise taxes levied on motor fuels. Although transportation taxes have been increasingly viewed as a means of regulation in energy, environmental and in transportation policy, their revenue raising function has remained the most important. Since revenues of diesel tax are substantial, the assumption that states 'compete' for these tax revenues with their tax rates seems plausible.

We demonstrated that different mixes of tax instruments are applied in the EU Member States to tax the road transport sector. However, it is apparent that the fuel excise is the most important instrument everywhere. Nevertheless, we can find substantial cross-country differences in the tax levels. These differences are considerable in spite of the fact that the excise tax is one of the most harmonized taxes.

CHAPTER 4

THEORY OF COMMODITY TAX COMPETITION

In this Chapter we give an insight into the theoretical literature on commodity tax competition. Commody tax competition models examine how the opportunity of cross-border shopping influences the commodity taxes of neighboring countries. If two countries tax the same product at a different rate, it may be reflected in the consumer price of the product. The saving obtainable through lower prices may drive consumers of the more expensive country to buy the product abroad, rather than at home. Countries with high tax burden can face the outflow of some domestic consumers – and thus part of their tax base – while countries with low tax burden can expect an inflow of foreign consumers. In tax rate decision governments consider the level of cross-border tourism and its effect on the tax base.

In the models of commodity tax competition the analysis of the equilibrium of tax competition is based on the application of the Nash equilibrium concept, too. According to forecasts of the theory, tax competition results in a combination of taxes in which taxes set by each government are the best response to taxes of other countries. To put it in another way, tax competition calls forth tax rates, the unilateral deviation from which (by a given country) cannot increase tax revenues of the government.

Spatial models of tax competition examine how differences in the size and location of countries influence the taxation strategy of each county. Kanbur and Keen (1993), having analyzed the tax competition between countries with different population density, point out that in the equilibrium of the tax competition, the tax rate set by the larger country is higher

than that of the small one. Nielsen (2001) draws similar conclusions when examining the competition between countries of different size. In the contest for consumers, the larger country sets higher tax rates than the smaller one. In his multi-country model, Ohsawa (1999) examines how the countries' place in the center-periphery dimension impacts their taxation strategy. He shows that the farther from the center a country is located the higher the tax rate it sets.

All the three studies are based on the strongly simplified model of individual demand. They assume unit demand, in other words, perfectly inelastic consumer demand. In our research we analyze commodity tax competition on the theoretic bases laid by Nielsen, but with a less restrictive form of demand function.

Our theoretical analysis was mainly inspired by the study of Devereux et al. (2007). Their study examines the commodity tax competition of gasoline and cigarettes in the US, theoretically and empirically. The authors simultaneously integrate and generalize previous theoretical works by examining the horizontal and vertical tax competition (i) in a standard theoretical framework, (ii) allowing area and population density to constitute the difference between the sizes of the countries, and (iii) assuming price elastic demand. However, the general theoretical framework provides little opportunity to draw analytical results. By building a less generalized model, allowing the demand to be price elastic, but conceptualizing spatial differences of countries only according to their area – we give a more accurate characterization of horizontal tax competition.

4.1 Benchmark models of commodity tax competition

The literature on commodity tax competition has taken two rather different approaches. The seminal paper on commodity tax competition by Mintz and Tulkens (1986) analyzed tax competition in a general-equilibrium model of two countries trading in two goods with transport costs preventing complete equalization of tax-inclusive price. In this framework, each government chooses a tax that maximizes its representative resident's utility, given the preferences for the public good and the national budget constraints. The main aim of this strand of research has been to explore the inefficiencies liable to arise from uncoordinated tax setting.

The more recent contributions to the commodity tax competition literature have taken a different approach. The most prominent figures of this approach (Kanbur and Keen 1993, Nielsen 2001, Ohsawa 1999) set up simpler models in order to give a more precise characterization of the equilibrium resulting from commodity tax competition among *spatially* different economies. These authors typically set up a partial equilibrium model with a single taxed good and assume revenue-maximizing governments. Their models are often referred to as "asymmetric tax competition" models.

The motivation for these analytical studies is the numerous examples of cross-border shopping around the world. Cross-border shopping occurs when citizens of a country make a trip to the neighbor country to take advantage of the lower price outside the home country. Price differences among countries are often driven by international tax differentials. (The difference between smuggling and cross-border shopping is that the latter is for personal consumption and is small-scale.)

A number of studies have attempted to estimate the magnitude of cross-border shopping between neighboring countries with different prices. For the late 1980s, Fitzgerald et al. (1988) reports survey evidence that the residents of Ireland living in counties bordering Northern Ireland bought about two-thirds of their petrol and almost all of their alcoholic drink in the Northern Ireland. Gordon and Nielsen (1997) estimated the loss of VAT revenue to Denmark from cross-border shopping into Germany to be around 0,8 percent. Rietveld et al. (2001) cited a survey conducted by NEI (1997) that reported that with a price difference of 11 €-cent per liter, about 28 percent Dutch car owners in the 30 km wide-region toward the German border gas up their cars abroad, and additional 14 percent fuel up their tanks in Germany at least on some occasions. Using a panel data set for three regions of Switzerland bordering Italy, Germany and France, Banfi et al. (2005) showed that fuel tourism accounted for about 9 percent of total petrol sale in the three regions during the period 1985-1997.

The analytical studies on commodity tax competition typically consider two main issues:

1. They set up a Nash game among governments facing cross-border shopping and analyze the resulting Nash equilibrium in commodity tax rates.

2. They investigate how the non-cooperative equilibrium outcome changes with various forms of tax coordination such as the imposition of a minimum tax rate or complete tax harmonization, and how the countries involved are affected by them as compared to the benchmark case with no cooperation.

Spatial models are designed to examine how the various geographical aspects (such as differences in size, position and shape) may shape the Nash equilibrium outcome of tax competition. Spatial models are typically one-dimensional: they assume a linear market with countries lying on a line segment. (An exception is the study by Ohsawa and Koshizuka (2002), which examines how the curvature and the length of the border may effect the governments' taxing behavior in a two-country setting.)

Table 4.1 Classification and examples of the spatial tax competition models

	One-dimensional models	**Two-dimensional models**
Two-region models	Kanbur and Keen (1993) Nielsen (2001) Hvidt and Nielsen (2001) Wang (1999)	Ohsawa and Koshizuka (2003)
Multi-region models	Ohsawa (1999, 2003)	

Two-country models

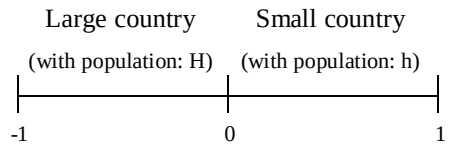
First we provide a short introduction into the two-country commodity tax competition models and then, based on the paper by Oshawa (1999), we shall examine whether the basic results can be extended to the multi-country setting.

Figure 4.1 provides a brief overview of two basic models: the one by Kanbur and Keen (1993) and the one by Nielsen (2001). Both authors represent tax competition as a Nash game between two governments who choose their tax rates so as to maximize their tax revenue taking into account the effect of the cross border-shopping induced by the tax difference. Their frameworks differ only in the way they represent the relative size of the two countries involved. In the former, the two countries differ by the density of population, while in the

latter they differ in their geographical extension. (Customers are distributed uniformly along the line segments in both models.)

The two models are built on very simple assumptions concerning supply and demand. Each consumer purchases just one unit of the good. (For simplicity, the valuation of the good is assumed to be high enough so as that all consumers choose to buy.) The production cost of the good is assumed to be zero, hence the market price of the good in each country is equal to the tax charged (denoted by t and T in the small and the large country, respectively). Assuming closed border, a revenue-maximizing government is able to extract the whole consumer surplus by setting the tax rate at the level of the reservation price of their residents. However, with an open border, governments face the following trade-off. By raising their tax above the tax set by the other government they induce some of their residents to travel to the border and purchase the good abroad. Although a higher tax rate results higher per capita revenue over those residents still shopping at home, the resultant increase in the number of cross-border shoppers lowers the percentage of residents continuing to purchase at home.

(a) Kanbur and Keen's model:



Cost of transportation: d
Ratio of population density: $\Theta = h/H$

Best reply functions:

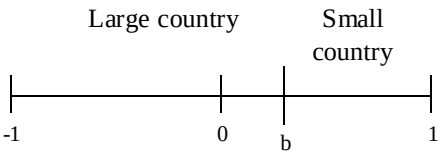
$$t(T) = \begin{cases} \frac{d}{2} + \frac{T}{2} & T \le d\sqrt{\Theta} \\ \frac{d\Theta}{2} + \frac{T}{2} & T \ge d\sqrt{\Theta} \end{cases}$$

$$T(t) = \begin{cases} \frac{d}{2} + \frac{t}{2} & t \le d \\ t & d \le t \le \frac{d}{\Theta} \\ \frac{1}{2}\frac{d}{\Theta} + \frac{t}{2} & t \ge \frac{d}{\Theta} \end{cases}$$

Nash equilibrium taxes:

$$t^* = d\left(\frac{1}{3} + \frac{2}{3}\Theta\right) \qquad T^* = d\left(\frac{2}{3} + \frac{1}{3}\Theta\right)$$

(b)Nielsen's model:



Cost of transportation: d
Border parameter: b

Tax revenue functions:

$$R(T,t) = T\left[1 + b + \frac{t-T}{d}\right]$$

$$r(t,T) = t\left[1 - b + \frac{T-t}{d}\right]$$

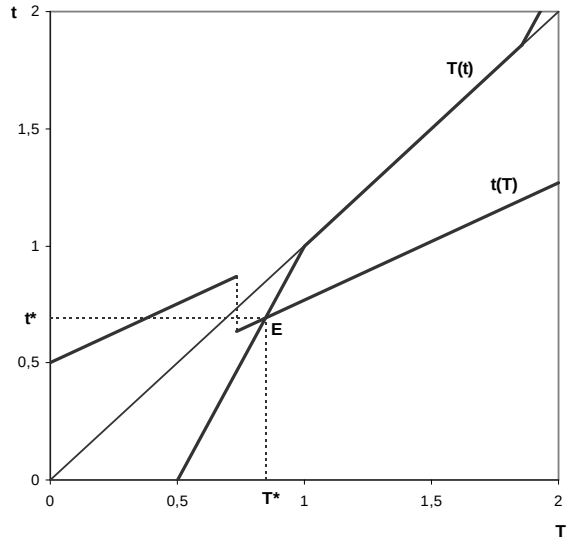
Best reply functions:

$$t(T) = \frac{d}{2}(1-b) + \frac{T}{2}$$

$$T(t) = \frac{d}{2}(1+b) + \frac{t}{2}$$

Nash equilibrium taxes:

$$t^* = d\left(1 - \frac{b}{3}\right) \qquad T^* = d\left(1 + \frac{b}{3}\right)$$



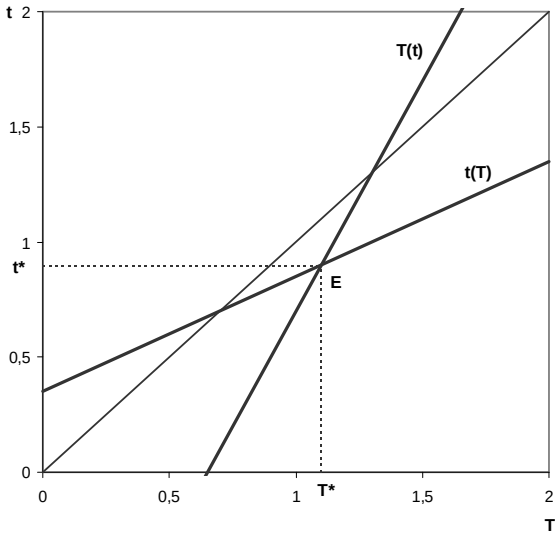


Figure 4.1 The commodity tax competition game

We illustrate the decision problem faced by the representative consumer using the model of Nielsen (as depicted in Figure 4.2). We assume that customers are evenly spread over the interval [-1;1] with unit density. The population of each country thus corresponds to its spatial extension. Population sizes are $(1 + b)$ and $(1 - b)$, respectively, where b stands for some border parameter $b > 0$. The relative size of the small country is thus measured by the ratio $(1 - b)/(1 + b)$. In Figure 4.2, distances are measured along the horizontal scale and buying cost incurred by the customers along the vertical scale. Suppose that $T > t$, i.e. the large country charges a higher tax than the small country. In this case, all residents of the small country will purchase the good at home incurring a cost of t. Some of the residents of the large country, ones who live close enough to the border, will make her purchase in the small country. Traveling to the border (and back) entails a cost of $d > 0$ per unit distance from the frontier. Cross-border shoppers hence incur a total cost of $(t + d)$. As shown in Figure 4.2, for consumers living in the line segment between m and b it is worth shopping abroad since the total cost of purchase fall below the prevailing home price T. At a price difference of $T - t$, the amount of cross-border shopping makes up of $(T-t)/d$. (In equilibrium: $(T^*-t^*)/d = 2b/3$.)

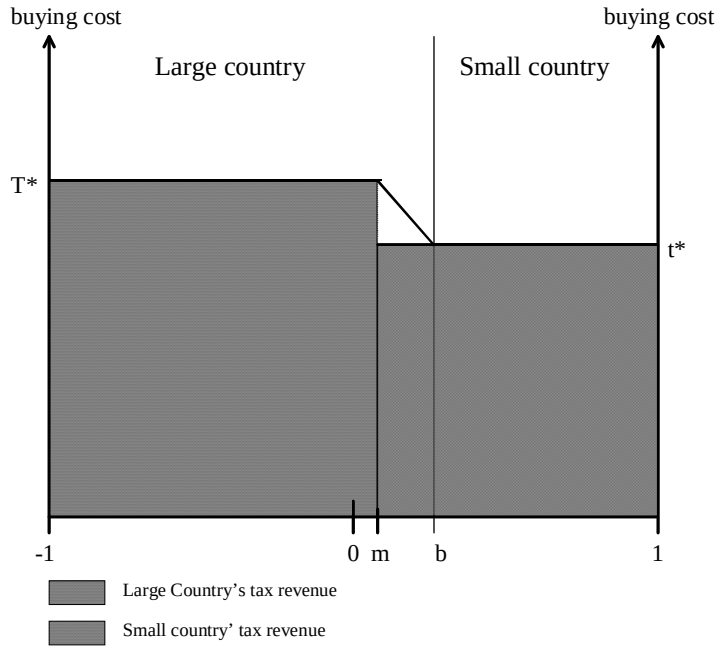


Figure 4.2 Taxing with cross-border shopping (Nielsen's two-country model)

Turning to the decision problem faced by the governments, we see that the difference in size introduces an important asymmetry into the revenue functions of the two governments. For any pair of unequal taxes (*T* and *t*), potential cross-border shopping consumers make up a greater percentage of residents in the small country than in the large country. As a result, the small country attaches a greater weight to attracting foreign consumers than the large country and therefore ends up charging the lower tax rate.

This is in fact the basic result of both Kanbur and Keen's as well as Nielsen's analysis: *the small country strictly undercuts the large country in equilibrium.* The two-competitor models explain, for example, the taxation behavior of Luxembourg, the smallest country in the former EU15. Luxembourg applies the minimum VAT rate (15 percent) on consumption and also sets the lowest excises on motor fuels among the former EU15 countries.

After proving the existence and the uniqueness of the Nash equilibrium in the two-country competition game, the two papers' authors derive some other interesting properties of the Nash equilibrium. Amongst others, they show that:

i) while the absolute tax revenue is higher in the large country, the per capita revenue is greater in the small country;

ii) while an increase in transport cost leaves the amount of cross-border shopping unchanged, it leads to an increase in equilibrium tax rates;

iii) the equilibrium tax difference *(T*-t*)* decreases as the disparity in size lessens.

A multi-country model

Ohsawa (1999) examines commodity tax competition in a multi-country framework. His tax competition model belongs to the family of Hotelling spatial competition models. As in Kanbur and Keen (1993) and Nielsen (2001), countries are located in a linear line segment, and, analogously to Nielsen, their sizes are captured in terms of geographical extension. Adopting a multi-country framework, Ohsawa can investigate how the relative position of a country in a linear world affects its behavior in the commodity tax setting game.

Ohsawa (1999) provides a closed analytical solution for the candidate of Nash equilibrium for the general case with N (≥ 2) countries. He proves that if a Nash equilibrium exists it is unique. He also proves that if the sizes of all countries are the same, the Nash equilibrium necessarily and uniquely exists, whatever the number of countries. For the three-country case, he derives the Nash equilibrium prices (as well as the necessary conditions for the existence of equilibrium) as a function of country sizes (*L1*, *L2*, *L3*) and transport cost.

Like in the two-country models, consumers' decision is led by the tax difference between the home country and the neighboring countries, as well as the transport cost of shopping abroad. For whom the former outweighs the latter it is worth shopping abroad, while for the rest shopping at their doorstep is more advantageous. At given taxes in the neighbors, a country can extend its market area by lowering its own tax rate, but at the expense of lowering its revenue from its original market area. When maximizing their tax revenue, governments face a similar trade-off as their counterparts in the two-country models of Kanbur and Keen (1993) and Nielsen (2001), except that the interior countries – having two neighbors – face cross-border shopping on both of their borders.

Figure 4.3 illustrates the three-country tax commodity competition outcome for two permutations of country sizes. Geographical and market boundaries of the core country are denoted by B_L and B_R, and M_L and M_R, respectively. When sizes of the three countries are the same, the core country undercuts its neighbors at the Nash equilibrium. This can be intuitively explained as follows. As opposed to peripheral countries (having the opportunity of gaining cross-border shoppers from just one foreign country), the core country can encroach on two foreign countries simultaneously by undercutting its neighbors. Hence, a similar tax reduction can enlarge twice as much the market area of the core country than that of the peripheral ones. This is why it is more profitable for the interior country to adopt an aggressive policy, as compared to peripheral countries.

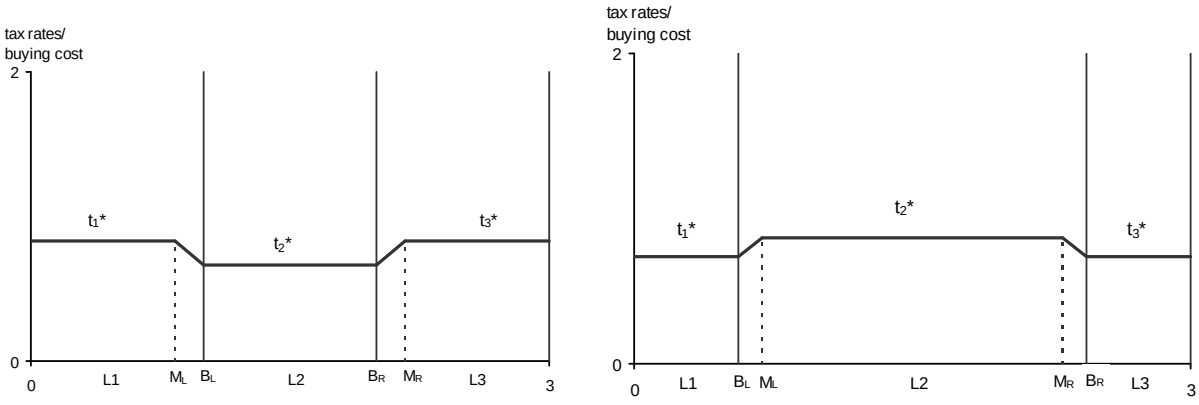


Figure 4.3 Taxing with cross-border shopping (Ohsawa's three-country model)

Note that the motives underlying the behavior of an interior country and that of a small country show some similarities. In both cases, the "large size" of the international market relative to the domestic market that affects the behavior of the tax setting authority.

Figure 4.4 illustrates the equilibrium tax rates for 10 countries of equal size. There are two main properties of the Nash equilibrium to be mentioned. First, the farther the country is

located from either market boundary, the lower its equilibrium tax rate becomes. Second, the equilibrium tax rates fall more slowly as we go from the peripheral area to the middle. Combining these two properties establish a U-shape tax rate structure (Ohsawa, 1999).

The U-shape tax structure is largely consistent with the VAT rates of the former EU15. Some of the peripheral countries like Denmark, Sweden and Finland set the highest VAT rates (25, 25, 22 percent, respectively) in the EU, while Germany lying at the central part of Euroope charges a relatively low VAT rate (16 percent), although both its country size and population is large (Ohsawa, 1999).

The main results of Ohsawa's analysis can be summarized as follows. The spatial configuration and the relative size of the countries simultaneously determine the Nash equilibrium outcome.

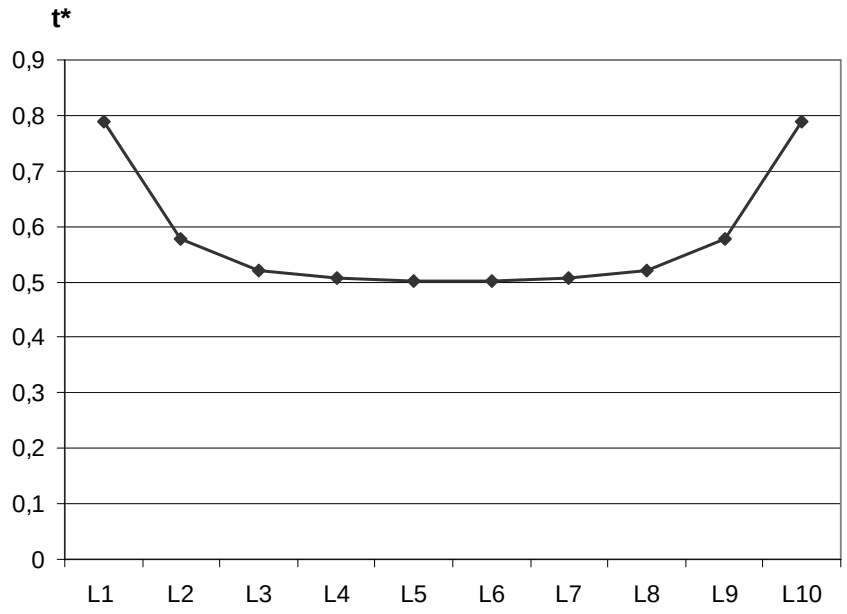


Figure 4.4 Nash equilibrium tax rates for 10 countries with equal size (Ohsawa's model)

Although a small country tends to set a lower tax than a big country, there is no clear-cut relationship between the ranking of the relative size of the countries and the ranking of their equilibrium taxes. Similarly, although a country that is closer to the market center tends to charge a lower tax than a country that is farther from it, there is no clear-cut relationship between the ranking of the relative position of the countries and the ranking of their equilibrium taxes (Ohsawa, 1999).

The major contribution of Ohsawa's model to the commodity tax competition literature is in that it derives the spatial pattern of tax rates in a multi-country setting. However, one has to recognize that the underlying mechanism for his model is the same as the one for the two-country model in Nielsen (2001). More specifically, the best reply function of a country in Ohsawa (1999) is similar to the one of a country in Nielsen (2001). The lack of recognition of this fact may result in wrongly specified empirical models, as will be shown on the examples of studies by Egger et al. (2005a, 2005b) below.

To see the similarities between the best reply functions in Ohsawa (1999) and Nielsen (2001) I represent Ohsawa's model in a slightly different way by using the notation of Nielsen (2001). We look at tax competition among N (≥ 3) countries, normalizing their aggregate size $\sum_i L_i$ to N. Following Nielsen we express the size of a country i as $1 + b_i$, where the value of b_i fall into the interval (-1, N-1), and $\sum_i b_i = 0$. The revenue functions of a peripheral country and of an interior country are defined as follows:

$$R_1 = \left[1 + b_1 + \frac{t_2 - t_1}{d}\right] t_1$$

$$R_i = \left[1 + b_i + \frac{t_{i-1} + t_{i+1} - 2t_i}{d}\right] t_i \qquad 2 \leq i \leq N\text{-}1;$$

Setting the derivatives of tax revenues with respect to own taxes equal to zero, we derive:

$$t_1(t_2) = \frac{d}{2}(1 + b_1) + \frac{1}{2}t_2 \qquad t_i(t_{i-1}; t_{i+1}) = \frac{d}{4}(1 + b_i) + \frac{1}{2}\left(\frac{t_{i-1} + t_{i+1}}{2}\right)$$

These are the best reply functions of a peripheral country and of an interior country, respectively. There are three important points to be considered. First, irrespective of the position of a country, its best response is dependent on the simple average of its neighbors' tax rates. Moreover, the measure of responsiveness is the same across all countries (1/2) and it is also equal to the parameter obtained in Nielsen (2001) (see also Figure 4.1). However, it also emerges that for peripheral countries the country size plays a more important role in determining the tax rate than for interior countries.

Tax coordination

The issue of tax competition has been on the agenda in the Euroopean Union for a very long time. In an open-border EU, differing VAT (or excise tax) rates may generate considerable cross-border shopping activity at the borders of member states. Governments faced by cross-border shopping are motivated to engage in tax competition. Unrestricted tax competition leads to lower tax rates and revenues, as compared to the closed-border case. One way out of this non-cooperative equilibrium is tax coordination.

A number of tax coordination initiatives have been proposed for lessening tax competition originating from cross-border shopping. Amongst others they include complete equalization of taxes, compulsory tax bands, or the imposition of a minimum tax rate.

The above introduced theoretical studies also explore the issues related to tax coordination. They assess the impacts of various tax coordination measures on equilibrium taxes and revenues using unconstrained tax competition as a benchmark. Our focus here will be on the minimum tax rate.

Note that the introduction of the minimum tax rate assumption does not change the basics of the tax competition models. They still analyze tax rate setting as a non-cooperative game, with the modification that each country's strategy set is constrained to taxes that are equal to or above the minimum level imposed.

The two-country models show that, at the new Nash equilibrium, the small country adjusts its tax to the minimum level, while the large country also increases its tax but to a smaller extent. Nevertheless, the basic result remains: the small country strictly undercuts the large country in equilibrium (see Figure 4.5). It is also shown that the introduction of the minimum tax rate benefits both countries, as it results higher tax revenues for both countries, as compared to the benchmark case (Kanbur and Keen 1993, Hvidt and Nielsen 2001).

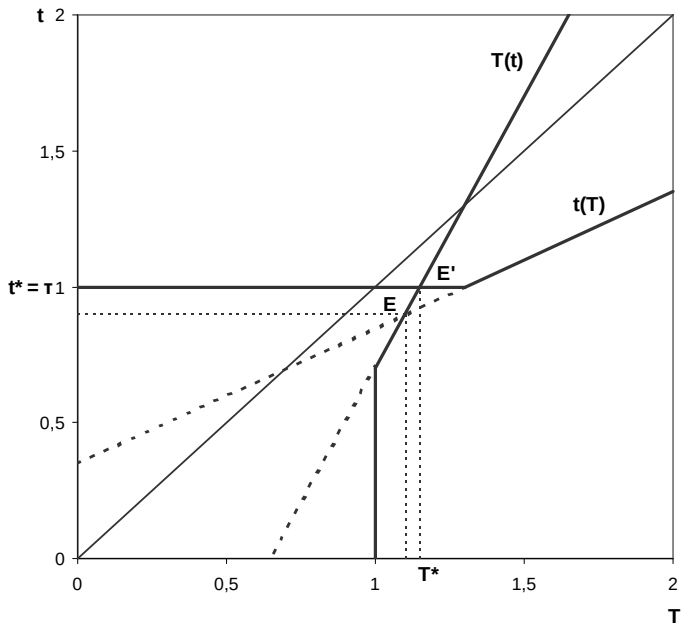


Figure 4.5 The Nash equilibrium with minimum tax rate (τ)(Nielsen's two-country model)

Ohsawa (2003) demonstrates, within his general model of N equal sized country, that under a minimum tax rate system all countries will charge a higher tax rate, as compared to the base case, with some interior countries adjusting to the minimum level (see also the Figures in the Appendix). This explains why most countries raised their VAT rates after the minimum standard rate system had been introduced. It also justifies why some countries like France and Denmark raised their VAT rates by several percent, although their former VAT rates had already met the minimum standard (Ohsawa 2003). Ohsawa also shows that all countries are better off by the minimum tax rate system; a result that is consistent with the findings of Kanbur and Keen (1993) as well as those of Hvidt and Nielsen (2001).

4.2. Commodity tax competition under price elastic demand

Our tax competition model belongs to the family of Hotelling spatial competition models. We represent tax competition as a Nash-game between two governments who choose their taxes so as to maximize their tax revenue while taking into account the effect of cross-border shopping induced by the tax-difference. The suggested model is an extension of Nielsen (2001) to allow for elastic demand for the taxed good.

The basic setup of the model

We consider two governments ($i = 1,2$) who compete over commodity tax bases. Each government imposes a specific excise tax τ_i on a commodity e.g. diesel. For simplicity, the production cost of the commodity is assumed to be zero ($p_i = 0$ for $i = 1,2$). The market price of the commodity in both countries is thus equal to the tax charged.

As in Nielsen (2001) the two countries lie on the interval $[-1;1]$ with a border between them at *b*. We assume that customers are evenly spread over the interval [-1;1] with unit density. The population of each country thus corresponds to its linear extension. Population sizes are $(1+b)$ and $(1-b)$, respectively. The relative size of the two countries is captured by the ratio $(1+b)/(1-b)$, which increases as *b* increases.

Since each retailer sells homogenous product, the consumers' decision on the location of shopping depends exclusively on the associated costs. This amounts to the price of the good when the consumer makes the purchase at home, and equals to the sum of the price of the good plus traveling cost when the consumer chooses to make the purchase across the border.

We assume that traveling to the border (and back) entails a cost of d per unit of distance traveled.

Up to this point the set up of our model is equivalent to that of Nielsen (2001). Our analysis departs from Nielsen (2001) by allowing the demand for the taxed good to be price elastic. In Nielsen (2001), each resident purchases one unit of the good irrespective of its price, i.e. the demand for the good is perfectly inelastic ($x(\tau)=1$). Instead, we assume that consumers have inelastic, iso-elastic demand. Thus, the form of the demand functions is $x(\tau)=\tau^{\varepsilon}$, such that $-1<\varepsilon\leq 0.$ Note that when individual demand is perfectly inelastic, that is $\varepsilon=0$, the model reduces to the Nielsen (2001) model. In other words our model encompasses the model of Nielsen (2001) as a special case.

Number of cross-border shoppers

We continue to derive the number of cross-border shoppers by characterizing the cross-border shopping decision. For simplicity, we assume that the representative consumer has a quasi-linear utility function. Thus the indirect utility for the consumer is given by

$$v(\tau,M)=M-\frac{1}{1+\varepsilon}\tau^{1+\varepsilon},$$

where M denotes the total income of the consumer and τ stands for the tax charged (which is equal to the market price of the good in our case). The indirect utility $v(\tau,M)$ expresses the amount of surplus that the consumer is obtaining when buying x at price τ. The cross-border decision can be characterized as follows. An individual in country i will purchase the good in the foreign country if and only if her surplus by doing so $v(\tau_j,M-gd)$ exceeds the surplus

from buying at home $v(\tau_i, M)$, where g stands for the distance between her location and the border. So, a consumer in i will cross-shop in j if and only if $\tau_i > \tau_j$ and

$$M - gd - \frac{1}{1+\varepsilon}\tau_j^{1+\varepsilon} \geq M - \frac{1}{1+\varepsilon}\tau_i^{1+\varepsilon}.$$

By rearranging the above expression, we can determine the furthest location away from the border g_m at which a consumer residing will opt for cross-border shopping. This is

$$g_m = \frac{1}{d(1+\varepsilon)}\left(\tau_i^{1+\varepsilon} - \tau_j^{1+\varepsilon}\right). \quad (1)$$

Since distance is equal to the number of consumers living within that distance, the above obtained expression is also an expression of the number of cross-border shoppers.

The Nash equilibrium

After establishing the relationship between the number of cross-border shoppers and taxes (τ_i, τ_j), we turn to examine the equilibrium pattern of government behavior. The objective of governments in the two countries is taken to be maximization of tax revenue. Governments are aware of how their taxes in relation to their neighbor's taxes determine the volume of cross-border shoppers, and choose their optimal tax level by taking the tax level in the neighbor country as given. In the equilibrium the tax chosen in each country is an optimal response to the tax chosen in the other country; i.e. neither of the two countries can increase its revenue by setting a tax different from its equilibrium strategy.

Tax revenue is given by the product of tax and tax base. Since all individuals have the same demand function $x(\tau)$, we can derive the tax base by multiplying the number of shoppers

with individual demand. When borders are closed, the tax base is comprised of the demand of all domestic residents. When borders are open, then the number of consumers in a country can be either larger or smaller than the number of its residents, depending on the direction of cross-border shopping. The country with the higher tax (lower tax) faces outward (inward) cross-border shopping and thereby has less (more) consumers than residents. Using the expression for the number of cross-border shoppers obtained in (1), the tax revenue for government in country 1 and country 2 (from now on the large country is denoted by 1) is then

$$R_1(\tau_1,\tau_2)=\left[1+b+\frac{1}{d(1+\varepsilon)}\left(\tau_2^{1+\varepsilon}-\tau_1^{1+\varepsilon}\right)\right]x(\tau_1)\tau_1$$
$$R_2(\tau_1,\tau_2)=\left[1-b+\frac{1}{d(1+\varepsilon)}\left(\tau_1^{1+\varepsilon}-\tau_2^{1+\varepsilon}\right)\right]x(\tau_2)\tau_2 \qquad (2)$$

Revenue maximization results in the following tax reaction functions:

$$\tau_1=\left[\frac{(1+\varepsilon)d(1+b)}{2}+\frac{1}{2}\tau_2^{1+\varepsilon}\right]^{\frac{1}{1+\varepsilon}}$$
$$\tau_2=\left[\frac{(1+\varepsilon)d(1-b)}{2}+\frac{1}{2}\tau_1^{1+\varepsilon}\right]^{\frac{1}{1+\varepsilon}} \qquad (3)$$

By solving the above equation system for τ_1 and τ_2, we receive the Nash equilibrium taxes of the game:

$$\tau_1^*=\left[(1+\varepsilon)d\left(1+\frac{b}{3}\right)\right]^{\frac{1}{1+\varepsilon}} \qquad (4)$$

$$\tau_2^* = \left[(1+\varepsilon) d \left(1 - \frac{b}{3} \right) \right]^{\frac{1}{1+\varepsilon}}$$

Now we are able to generalize Proposition 1. in Nielsen (2001) for all inelastic, iso-elastic demand.

Proposition 1.: There exits a well defined, unique Nash equilibrium for the tax competition game. It has a higher rate of tax in the large country than in the small country. The number of cross-border shoppers in the equilibrium is $2b/3$. *The Nash commodity taxes increase as the cost of traveling* d *increases. Increasing the disparity between the two countries, i.e. an increase in the border parameter* b *, is increasing the difference between the two taxes.*

The intuitive explanation of these results is as follows. With open borders, the tax base of the government becomes more sensitive to prices. In response to a tax increase the tax base shrinks not only as a result of a reduction in individual demand (as with closed-borders), but also as a result of a reduction in the number of shoppers in the country. The threat of cross-border shopping thus puts an additional constraint for governments on setting high taxes. This threat however differs for the two countries. Since people in the large country tend to reside further away from the border than people do in the small country, the large country's market is relatively more shielded from cross-border competition than that of the small country. (The distance of the average consumer's location from the border is $(1+b)/2$ in the large country, and $(1-b)/2$ in the small country.) This permits the large country to set tax higher than the small country.

We can evaluate the comparative static effect of a change in the elasticity of demand at tax equilibrium. Differentiating (4) with respect to τ_1 and τ_2, yields

$$\frac{d\tau_1^*}{d\varepsilon}=\frac{\tau_1^*}{(1+\varepsilon)^2}\left[1-\ln\left((1+\varepsilon)d\left(1+\frac{b}{3}\right)\right)\right] \quad \text{and} \quad \frac{d\tau_2^*}{d\varepsilon}=\frac{\tau_2^*}{(1+\varepsilon)^2}\left[1-\ln\left((1+\varepsilon)d\left(1-\frac{b}{3}\right)\right)\right]$$

In line with our expectation decreasing price-elasticity of demand (i.e. increasing ε) gives rise to increasing equilibrium taxes (at least when the cost of traveling is not "too high", i.e. if both $(1+\varepsilon)d(1+b/3)<e$ and $(1+\varepsilon)d(1-b/3)<e$ hold).

The tax reaction functions

In order to give a more precise characterization of governments' equilibrium behavior we now turn to analyze the properties of the tax reaction functions. We are interested in the slopes of the reaction functions, which shows how a given country's optimal tax responds to a change in its neighbor's tax. Taking the first derivatives of the reaction functions with respect to τ_1 and τ_2, yields

$$\frac{d\tau_1}{d\tau_2}=\frac{x(\tau_2)}{2x(\tau_1)} \quad \text{and} \quad \frac{d\tau_2}{d\tau_1}=\frac{x(\tau_1)}{2x(\tau_2)} \tag{5}$$

First note that the reaction functions are positively sloped: both countries raise its tax rate in response to an increase in its neighbor's tax rate. Further, in the special case when $\varepsilon=0$ and thereby $x(\tau_1)=x(\tau_2)=1$, i.e. in Nielsen model (2001), the reaction functions are linear and their slopes are 0.5. When the demand is not perfectly inelastic, that is when $-1<\varepsilon<0$, then the reaction functions are concave because $\frac{d^2\tau_1}{d\tau_2^2}=\frac{x'(\tau_2)}{2x(\tau_1)}<0$ and $\frac{d^2\tau_2}{d\tau_1^2}=\frac{x'(\tau_1)}{2x(\tau_2)}<0$. Let us now compare the slopes of the reaction functions for the two countries evaluated at the Nash

equilibrium taxes. Substituting (4) into (5) and taking the ratio of the two slopes so obtained, yields

$$\frac{\frac{d\tau_1}{d\tau_2}}{\frac{d\tau_2}{d\tau_1}} = \frac{\frac{x(\tau_2^*)}{2x(\tau_1^*)}}{\frac{x(\tau_1^*)}{2x(\tau_2^*)}} = \left(\frac{x(\tau_2^*)}{x(\tau_1^*)}\right)^2 = \left(\frac{1+\frac{b}{3}}{1-\frac{b}{3}}\right)^{\frac{-2\varepsilon}{1+\varepsilon}} \qquad (6)$$

This shows that for price-elastic demand ($-1<\varepsilon<0$) the reaction function of the large country has a higher slope than that of the small country. This leads to the following proposition:

Proposition 2.: The large country responds more strongly to a tax-change in its neighbor than the small country (given that individual demand is not perfectly inelastic). This differential increases as the disparity in country size b increases. (Difference in responsiveness is proportional to the difference in the initial tax levels which is proportional to the difference in size.).[20]

To develop an intuition for this result, we examine how a change in the domestic and the foreign tax affects the tax base of the large and the small country. As noted earlier, the tax base equals to the number of shoppers multiplied by individual consumption. Let $X_i(\tau_1,\tau_2)$ and $s_i(\tau_1,\tau_2)$ denote respectively the tax base and the number of consumers in country i. Hence the tax base is $X_i(\tau_1,\tau_2) = s_i(\tau_1,\tau_2)x_i(\tau_i)$. We first consider the effect of a marginal

[20] We conjecture, but cannot prove, that Proposition 1-2. hold for a wider class of demand functions than inelastic, iso-elastic demand functions. In fact, we could prove Proposition 1-2. for the function of $x(\tau) = 1/(1+\tau)$ (for proof see Appendix II). This function also belongs to the family of "inelastic demand functions" but with a price-elasticity that is increasing as the price is increasing.

change in the *foreign tax rate* on the tax base. Since $\frac{dX_1}{d\tau_2} = \frac{dX_2}{d\tau_1} = \frac{1}{d}x(\tau_1^*)x(\tau_2^*)$, we note that the effect of a change in the foreign tax rate has the same impact on the tax base in both the large and the small country.

Next we examine how a change in the *domestic tax rate* affects the tax base in the two countries.

$$\frac{dX_1}{d\tau_1} = s_1'(\tau_1^*,\tau_2^*)x(\tau_1^*) + s_1(\tau_1^*,\tau_2^*)x'(\tau_1^*)$$

$$\frac{dX_2}{d\tau_2} = s_2'(\tau_1^*,\tau_2^*)x(\tau_2^*) + s_2(\tau_1^*,\tau_2^*)x'(\tau_2^*) \qquad (5)$$

First note that a change in the domestic tax rate – say an increase – has two different effects on the tax base. The first terms in (5) capture the effect of the decrease in the number of shoppers (this is the "migration effect"), while the second terms capture the effect of the decrease in individual demand (this is the "demand effect"). The migration effect is weaker for the large country, partly because the number of shoppers is less responsive to a tax change in the large country ($s_1'(\tau_1^*,\tau_2^*) = -\frac{1}{d}x(\tau_1^*) > s_2'(\tau_1^*,\tau_2^*) = -\frac{1}{d}x(\tau_2^*)$), and partly because the loss of one consumer results in less reduction in domestic sale anyway, since $x(\tau_1^*) < x(\tau_2^*)$. (The reason that the large country faces less reduction in the number of its shoppers for a domestic tax increase has to do with the differing welfare effects of a tax change in the two countries. Since shoppers in the large country purchase at a relatively high price, they react to a price increase with less reduction in their consumption than shoppers in the small country who

purchase at a relatively low price. As result, the welfare effect of a marginal tax change – the main determining factor of cross-border shopping decision – is smaller for shoppers in the large country than for shoppers in the small country.)

Now we turn to consider the demand effect of a domestic tax increase. For a marginal increase in domestic tax rate, on the one hand the large country faces less reduction in individual consumption ($x'(\tau_1^*) < x'(\tau_2^*)$), but on the other hand it has a higher number of shoppers whose consumption is to decrease ($s_1(\tau_1^*,\tau_2^*) = \left(1+\frac{b}{3}\right) > s_2(\tau_1^*,\tau_2^*) = \left(1-\frac{b}{3}\right)$). Nevertheless, substituting the Nash equilibrium taxes into (5) yields

$$s_1(\tau_1^*,\tau_2^*)x'(\tau_1^*) = \varepsilon\left[(1+\varepsilon)d\right]^{\frac{\varepsilon-1}{\varepsilon+1}}\left(1+\frac{b}{3}\right)^{\frac{2\varepsilon}{\varepsilon+1}} > s_2(\tau_1^*,\tau_2^*)x'(\tau_2^*) = \varepsilon\left[(1+\varepsilon)d\right]^{\frac{\varepsilon-1}{\varepsilon+1}}\left(1-\frac{b}{3}\right)^{\frac{2\varepsilon}{\varepsilon+1}}.$$

So, in spite of the higher number of shoppers in the large country the overall effect of a marginal tax change on aggregate demand is lower for the large country than for the small country. In sum, the net effect of a domestic tax change (including both the effects of migration and demand) on the tax base is smaller for the large country than for the small country.

We now can provide an explanation for proposition 2. As shown, a change in the foreign tax rate has a symmetric effect on both governments' tax bases. In contrast, a change in the domestic tax rate affects the tax bases in the large and the small country differently. The tax base is less sensitive to a domestic tax increase in the large country than in the small country, because both the demand and the migration effects of a tax change are smaller here. When the tax in the neighboring country decreases then both country responds to this by decreasing its

own tax to win back some of its tax base. However, this response must be stronger for the large country, if it is to achieve the equivalent result.

It is useful to perform this analysis in the benchmark case of inelastic demand. If individual demand is perfectly price-inelastic, as in Nielsen (2001), then the single factor determining the tax base is the number of shoppers. Since the welfare effect of a price change is identical in the large and the small countries, a reduction in the domestic tax rate exerts the same impact on the number of shoppers in both countries. And since per capita consumption is also equal in the two countries, the revenue effect of a domestic tax reduction is the same. Thus, a domestic tax change has an identical effect on both country's tax bases. This explains why both countries in Nielsen model has the same response to a change in neighboring country's tax rate.

4.3. Summary

In our theoretical analysis, we extended and refined the results of Nielsen (2001) on commodity tax competition. We demonstrated that once the assumption of perfectly inelastic demand is relaxed, country size influences – apart from the tax rate – the response intensity to tax level changes in neighboring countries. Unless the demand is perfectly inelastic, the large country reacts more strongly to tax changes in the neighboring country than the small country.

The theoretical analysis was mainly inspired by the study of Devereux et al. (2007). Their study examines the commodity tax competition of gasoline and cigarettes in the US, theoretically and empirically. The authors simultaneously integrate and generalize previous theoretical works by examining the horizontal and vertical tax competition (i) in a standard

theoretical framework, (ii) allowing area and population density to constitute the difference between the sizes of the countries, and (iii) assuming price elastic demand. However, the general theoretical framework provides little opportunity to draw analytical results. By building a less generalized model, allowing the demand to be price elastic, but conceptualizing spatial differences of countries only according to their area – we give a more accurate characterization of horizontal tax competition.

Our theoretic analysis drew two important conclusions. On the one hand, we proved that asymmetric tax competition is robust for the introduction of the inelastic, iso-elastic individual demand. On the other hand, we demonstrated that once the assumption of perfectly inelastic demand is relaxed, there is a systematic difference between the equilibrium responses of small and large countries not only in terms of tax rates set, but also in terms of the intensity of their responses. The large country with the higher tax rate reacts to tax changes in its neighbor with a higher intensity than the small country with a lower tax rate.

These results are significant for the empirical ivestigation of tax competition theory. On the one hand, the correct specification of reaction functions of the countries requires that the response intensity to neighbors' taxes could vary from country to country. On the other hand, while the relationship between country size and tax level can be analyzed in level models only, the relationship between country size and tax change, i.e. the indirect proof of asymmetric tax competition, can be tested in first difference models, too.

CHAPTER 5

EMPIRICAL INVESTIGATION OF DIESEL EXCISE TAX COMPETITION IN EUROPE

In this Chapter we examine whether Euroopean states compete with each other for tax revenues they collect on diesel sales.We formulated two main hypotheses based on the analysis of the equilibrium of tax competition game. First, European states set their excise tax rates in mutual interaction, competing for tax proceeds. Second, diesel tax competition is asymmetric: large countries set higher excise tax rates than small countries. Our analysis included the analyis of political business cycles as well. In this regard, we set up two hypotheses. First, governments do manipulate diesel tax rates before general elections. Second, there is a systematic difference in fuel tax policies of governments with left and right majority.

The analysis is based on a multi-variable regression model in which the countries' diesel excise tax is explained by fiscal, economic and political variables and with the excise tax of their neighboring countries. To test our hypotheses, we estimate the fiscal reaction functions for national governments using data from 16 European countries (EU-15 minus Greece plus Norway and Switzerland) between 1978 and 2005. We handle the endogeneity of the competitors' taxation decisions – similarly to the practice followed by the papers above – by using instrumental variables. Nevertheless, our approach differs from those of the above mentioned studies from several respects.

The regression equation is estimated – unlike the majority of researchers – not by levels but the first differences of variables. The proposition on the asymmetric tax competition is thus tested indirectly, through testing the auxiliary hypothesis on the relationship between country size and tax change. To our best knowledge this is the first study that investigates the hypothesis of asymmetric tax competition in first-difference econometric models, guided by theoretical predictions.

In the empirical investigation of tax competition we have to deal with the interactions of *many* countries. When defining the spatial structure of tax competition, we have to determine the circle of countries a country competes with and the relative weights of the decisions the countries make. Based on the features of international road freight traffic, we elaborate a weighting scheme that has not yet been used in the empirical literature.

Measuring the dependent variable of the analysis is a key issue in the tax competition research. We argue that the differences in the countries' tax burden can be captured with the excise tax rates. Therefore, we opt for the diesel excise tax rate as the dependent variable of analysis, in accordance with studies dealing with commodity tax competition between the states of the US, but differing from studies analyzing fuel tax competition of European states.

Before presenting the empirical investigation we review the features of the European diesel market in the following section.

5.1. Some features of the European diesel market

Motor fuel markets are characterized by strong international competition. Due to the increasing integration, differences in retail fuel prices (excluding VAT) among EU Member States do not exceed 10 percent. Since the prices of the refined products are adjusted to the world market price of crude oil, petrol and diesel prices are characterized by strong volatility.

A key characteristic of fuel markets is a rather inelastic demand. According to estimations, short-run fuel price elasticities are between -0,2 to -0,3, with long-run elasticities being between -0,6 to -0,8 (Fulton and Noland, 2005). Thus a 10 percent increase in price does not result in an equivalent decrease in consumption even in the long run. The inelasticity of demand makes fuel a particularly attractive tax base. Higher prices induced by taxes do not decrease consumption significantly, and this enables governments to set relatively higher tax rates, and to realize higher tax revenues.

European countries tend to set the highest taxes on motor fuel over the world. Besides VAT, the excise duty levied ranged from 0,396 to 0,689 euros per liter on petrol and from 0,265 to 0,689 euros per liter on diesel in 2005 (the retail prices of the same products were 0,546 and 0,473 euros without tax, respectively). High tax rates in the EU Member States generate significant revenues. In the EU-15 countries, revenues from excise duties on diesel and petrol amount to 3 percent of the total tax revenues on the average, with above-5 percent-proportions in the United Kingdom, Luxembourg, and Portugal in 2002 (OECD Environmentally Related Database 2005).

As seen in Chapter 3, despite the EU minimum rates of excise duty, the rates applied by the Member States have remained greatly different over the past 15 years. In some cases, excise duty rates may differ by up to 100 percent between neighboring countries. For example, excise duty on diesel applied in the United Kingdom was 0,689 euros per liter, while in the neighboring Ireland it was only 0,370 per liter in 2005, or in Germany it was 0,470, while in Luxembourg only 0,265 euros per liter in the same year.

As a consequence of the characteristics of fuel market, the tax levied on diesel generates an increase in consumer prices equivalent to the tax level. This has both demand and supply side reasons – the strong market competition and the inelasticity of demand together explain that the tax burden is shifted to the consumers. The substantial tax differences across countries therefore lead to substantial differences in the consumer prices: consumers in countries with a higher excise duty rate face significantly higher prices in some cases than those in countries with lower excise duty rate. In case of private consumption, prices are also influenced by the VAT rates which can differ from country to country.) This may provide incentive for consumers in the high excise duty country to tank in the neighboring low excise duty country. The extent of the so emerging fuel tourism is in fact influenced by several factors, but is caused with no doubt by the differences in consumer prices.

According to a recent report issued by the Commission, fuel tourism in the EU Member States has reached a significant level in case of diesel fuel (EU COM(2007)). The most important participants of diesel fuel tourism are the road freight transport companies. Their international transport activity and the huge capacity of big trucks they use provide opportunity for buying fuel in the country where it is the cheapest. (A 40-tonne truck with an extra tank is able to cover 3000 kilometers on a single tank). The strong price competition that has now emerged

in the EU road freight transport market, as well as, the fact that fuel costs (including taxes) make up between 20 and 30 percent of the running costs of a road haulage business, provide a strong incentive for the road freight haulers to make use of fuel tourism as much as they can (EU COM(2007)).

Data on the volume and the budgetary effects of fuel tourism are only sparsely available. It is documented however that Luxembourg has reached an outstanding level of fuel tourism. Approximately two thirds of motor car fuel sold in Luxembourg was consumed by foreigners, generating tax revenue estimated to amount to 2 to 3 percent of GDP (Bleijenberg, 1994). Similarly, in the late 1990s, as a consequence of the increasing fuel price differences between Austria and its neighboring countries (mainly Germany, Italy and Hungary), Austria realized an increased fuel consumption of which a significant part was due to fuel tourism. Calculations available for Germany suggest a tendency opposite to that of Austria: the cross-border fuel purchases of German residents – estimated to amount to 10 percent of the total domestic turnover – resulted in tax revenue losses amounted to almost 2 billion euros in 2004. (The country's total revenue from diesel excise duty makes up to 15 billion euros. (EU)).

As integration progresses, fuel trade seems to have become a volatile tax base. A country that opts for setting high taxes has to face the fact that a part of its tax base is shifting to the neighboring countries. On the contrary, a country applying low taxes may expect an increase in its tax base. In light of the above evidence, diesel taxation in Europe seems to be a promising field of tax competition analysis.

5.2. Empirical investigation of diesel tax competition

5.2.1 Specification of the tax reaction functions

We test excise tax competition theory by estimating the tax reaction functions of national governments. We estimate the following regression equations:

$$\tau_{it} = \alpha + \beta \sum_{j \neq i} \omega_{ij} \tau_{jt-1} + \delta \sum_{j \neq i} \omega_{ij} \tau_{jt-1} \cdot Size_i + Size_i \gamma + \theta X_{it} + d_t \varphi + u_{it} \qquad (4.1)$$

where τ_{it} is excise tax, ω_{ij} are *a priori* determined weights, $Size_i$ is country size, $X_{i,t}$ is a vector of exogenous control variables, and d_t are fixed time effects. In what follows we provide a detailed justification for (4.1).

Identifying the competition

In the empirical investigation of tax competition we have to deal with the interactions of *many* countries. Therefore we need to take a view on the spatial structure of fuel tax competition. In particular, we have to determine which countries are in competition with one another. Because cross-border shopping typically takes place between contiguous countries, the usual approach followed is to limit the definition of competitor to neighboring jurisdictions. In our case it is not obvious whether this limitation is appropriate. As noted earlier, one salient feature of European fuel tourism is that it is assumed to be done mainly by international freight haulers. As trucks doing international trips often cross several countries before reaching their destination, an extension in the definition of competition over neighboring states might be warranted. Looking at the statistics of country-to-country flows in intra-EU road freight transport, it appears however that the great majority of trips by international road

haulers still takes place between geographical neighbors (Eurostat: Panorama of Transport). Therefore we find it justified in case of diesel excises also to restrict the geographical scope of tax competition to neighboring states. In case of two countries – Sweden and the United Kingdom – we allowed some modification to this approach. International data show that road haulers undertake considerable freight transport between England and the rest of the continent, relying on a network of ferry routes. For this reason we "linked" the United Kingdom with France, Belgium and the Netherlands. For the same reason, we connected Sweden to Denmark, too.

Even in this framework where countries compete exclusively with their neighbors, we have to deal with the issue that a country typically has more than one neighbor. The usual way to deal with this issue is to construct a weighting scheme that measures the extent to which a country's action affects another country in the process of competition by assigning a value to each pair of neighbors. So, we construct the "neighbor tax" variable for a country (i.e. the term $\sum_{j \neq i} \omega_{ij} \tau_{jt-1}$ in 4.1) – i.e. the tax-measure to which a country is expected to react – by taking the weighted average of the taxes in the country's neighbors. The weights used (ω_{ij}) reflect our assumptions about the relevance of other countries j in the process of interactions. In principle we would like to assign large weights when tax competition between two countries is likely to be strong.

We consider three weighting schemes for the regression analysis. The simplest weighting scheme – usually serving as a benchmark in empirical works – is *neighbor weights*:

$$\omega_{ij} = \begin{cases} 1/n_i & \text{if} \quad j \in N_i \\ 0 & \text{if} \quad j \notin N_i \end{cases}$$

where N_i is the set of countries bordering country i, and $n_i = N_i$. Using this weighting scheme, we assume that all neighbors' tax rates exert an equal impact on a particular country's tax rate.

Our second weighting scheme assigns weights based on the length of common borders. This is often called as *border length weights:*

$$\omega_{ij} = \begin{cases} l_{ij} / \sum_{j \in N_i} l_{ij} & \text{if} \quad j \in N_i \\ 0 & \text{if} \quad j \notin N_i \end{cases}$$

where l_{ij} is the length of border between country i and country j. It seems rational for governments to pay more attention to those neighbors with which they share a longer border, since at such borders the potential for cross-border shopping is likely to be higher.

Rietveld et al choose this weighting scheme to study fuel tax competition among countries in Europe (Rietveld et al 2005). A number of other studies investigating commodity tax competition among U.S. states use a similar method with the modification that weights are constructed to reflect population densities in the border regions as well (see for example Devereux et al 2007, Nelson 2002, Rork 2003).

Based on the distinctive feature of European fuel tourism, i.e. the involvement of road freight haulers, we constructed a new weighting scheme. In the suggested scheme weights are dependent on the volume of heavy motor vehicle traffic at common border crossings:

$$\omega_{ij} = \begin{cases} h_{ij} / \sum_{j \in N_i} h_{ij} & \text{if} \quad j \in N_i \\ 0 & \text{if} \quad j \notin N_i \end{cases}$$

where h_{ij} is the annual average daily traffic by heavy trucks at the border of country i and country j. We refer to this scheme as *traffic flow weights* from now on. The intuition for traffic flow weights is straightforward. Competition for diesel excises between two countries is likely to be stronger, the more heavy trucks are crossing their common border.[21]

The interaction term

In the regression equation (4.1) we made diesel tax to be dependent on neighbor tax, country size, and an interaction term between these two variables. The use of the interaction term (i.e. $\sum_{j \neq i} \omega_{ij} \tau_{jt-1} \cdot Size_i$) is justified by our theoretical findings in section 3. Our results showed that neighbor tax exerts a positive impact on the tax in both the large and the small country, and also that the large country has a greater response to any tax level in the neighbor country than does the small country. This holds irrespective of whether individual demand is taken to be perfectly inelastic or price elastic. However, we also see that the nature of the relationship between tax and neighbor tax differed for the two cases. While neighbor tax exerts the same impact on both countries' taxes in the price inelastic demand model, this impact is higher for the large country than for the small country in the price elastic demand model. Because we prefer the latter model (since we believe that, for diesel, the iso-elastic form of the demand function is more appropriate than the one of unit demand), we expect the magnitude of the

[21] The heavy truck motor traffic data are from the 2000 Combined Census of Motor Traffic and Inventory of Standards and Parameters on Main International Traffic Arteries in Europe by UNECE (UNECE 2003).

effect of neighbor tax will be dependent on country size. We allow for this by adding an interaction term between neighbor tax and country size to the model (4.1).

Timing of decision

In the theoretical model, tax competition is depicted as a simultaneous decision-making process. Every state anticipates correctly what other states will do, and then sets taxes that are always corresponding to the Nash equilibrium of the game. In reality, tax policy takes time to implement and it is more likely that governments choose their taxes in response to the observed past choices of rival governments rather than to the anticipated ones. For these reasons, we include the lagged value of the neighbor tax variable in the regression equation. Though we prefer the lagged specification, for comparison purposes, we will also estimate the contemporaneous version of the model.

Control variables

Our theoretical analysis focused on the issue of how international factors affect tax policy. In practice, tax policy is determined by both international and domestic political factors. Following the existing literature, we include a set of explanatory variables in the empirical model to control for the expected effects of domestic politics.

5.2.2 Data and variables

We estimate the model 4.1 using annual data on 16 Western European countries – the EU-15 less Greece plus Norway and Switzerland – over the period 1978-2005. Greece is left out because it does not have common border with any of the former EU member states.

Dependent variable

We take our data on diesel taxes from the IEA *Energy Prices & Taxes* database. This database provides information about prices and taxes for automotive diesel from 1978 onwards. As a measure for the diesel tax, we take excise levels, expressed in current EUR per liter (current ECU per liter before 1999) (VAT is not included, because it is reimbursed to commercial users irrespective of the location of purchase, i.e. whether it is home or abroad.) It is worth noting that previous studies on diesel tax competition in Europe used different dependent variables. Rietveld et al considered pump prices (total prices including all taxes), while Evers et al used the excise rate defined as a ratio of the excise and the price inclusive of excises. A potential advantage of end-user prices over taxes is that from the perspective of consumer it is the price at which they can purchase diesel that matters; i.e. the pre-VAT price for commercial users and the pump price for households. The disadvantage of this measure is however that what governments – the principle actors of tax competition – have direct control of is tax rather than price. The advantage of the tax ratio measure is that it is not sensitive to exchange rate fluctuations. It has the same disadvantage as total price, the decision variable for governments is the tax rather than the tax rate.

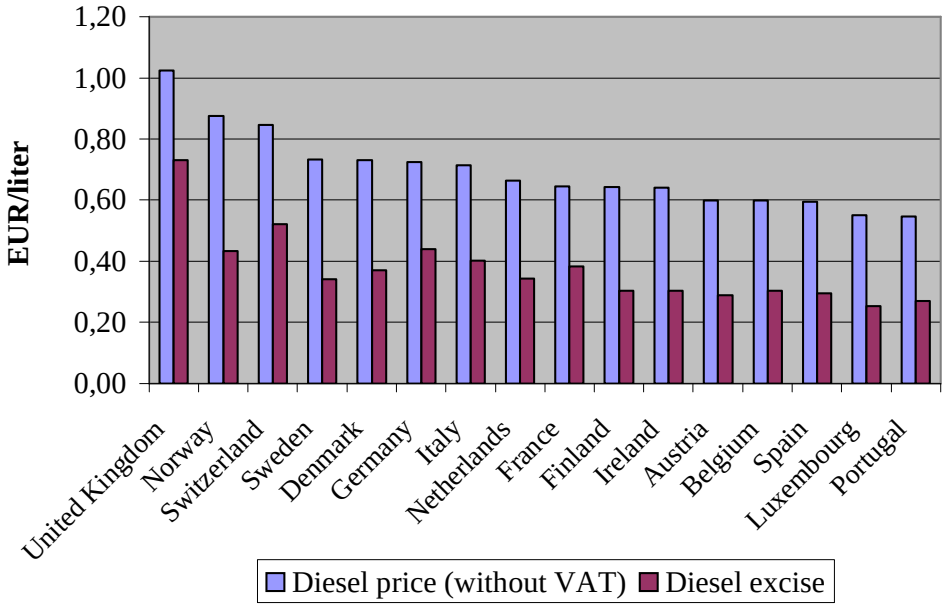


Figure 5.1 Diesel excises and prices, 2002

We have two further arguments for using excise taxes as dependent variable. First, a careful examination of prices and taxes reveals a strong correspondence between relative prices and relative taxes at least when it comes to comparing neighbors. Looking at the data from 2002 (see Figure 5.1.), we find only two instances where the rankings of two neighbors based on taxes differ from the rankings based on prices. Denmark charged a lower excise than Germany and Sweden, but it had a marginally higher total price than its neighbors. (Note however that price differential in both relations was less than 1 percent.)[22]

Second, tax variables containing producer prices raise an additional concern at least in the context of time series analysis. It is known that in European countries the producer prices of major oil product such as automotive diesel largely follow crude oil prices. This means that the country time series of total diesel price (or diesel tax ratio) contain a common component driven by oil price shocks. This is problematic because it becomes difficult for the statistical

[22] A further problem is that in most cases the net prices provided by IEA reflect prices charged for private customers. It is questionable to what extent the differences in these prices reflect the differences in prices charged for commercial users.

analysis to separate the correlation in neighbors' taxes attributable to actual tax competition from the correlation simply due to the effect of oil price shocks.

The measure of country size

In the theoretical analysis, we examined commodity tax competition between two countries with different size, where size was understood in terms of spatial extension. In the empirical model we examine tax interactions in the context of several groups of competing countries, and therefore it is not entirely clear for us whether we should use an absolute or a relative measure of country size. This issue has only been addressed in Egger et al and Egger et al, who solved the problem by adding the spatially weighted neighbors' size to the explanatory variables (Egger et al 2005a, Egger et al 2005b). We will estimate 4.1 using both the absolute and relative measures of country size ($Size_i$). We create the relative size variable by taking the ratio of country size and the spatially weighted neighbors' size. The latter is calculated using the same weights as those used to average neighbors' taxes. Thus when traffic flow weights are used to calculate the neighbors tax variable, then these weights are used to calculate the relative country size variable as well.

Following Nielsen (2001) we captured size in terms of spatial extension. However as suggested by Kanbur and Keen (1993) countries may differ in population densities, also (Kanbur and Keen 1993). The "size" of the domestic tax base is also dependent on the density of population. A large country with a relatively high population density gets even "larger" relative to its neighbor, and conversely it may become smaller if it is relatively sparsely populated. Kanbur and Keen (1993) analyzed commodity tax competition between two countries with equal extensions but different population densities. They find that, in the

equilibrium, the more densely populated country sets a higher tax that the one with lower population density. If we combine this result with the that of Nielsen (or the one obtained in the extended Nielsen in this paper), we receive that the outcome of tax competition is likely to be dependent on the differences in population rather than the differences in extension. This is why most studies on tax competition use population, labor force or GDP as a measure of country size. In contrast, Rietveld et al use purely spatial characteristics to measure country size (Rietveld et al 2005).

We consider two variables to measure country size: geographic area and GDP. Geographic area is the total surface area of a country (sq kmt). Our second variable is gross national product in 1990, expressed in currents ECUs. We use GDP because we think that the size of the road haulage industry in a country, of which we assume to play a leading role in fuel tourism, is better proxied by GDP than by population.

All together we consider four size variables: surface, relative surface, 1990 GDP, and relative 1990 GDP.

Table 5.1 Measures of country size

Surface (sq km)				GDP 1990 (million ECU)			
Size		Relative size		Size		Relative size	
France	551695	Germany	3,030	Germany	1215203	Germany	4,318
Spain	504782	France	2,565	France	979244	France	1,919
Sweden	449964	Sweden	2,525	Italy	892544	Sweden	1,863
Germany	357026	Spain	1,144	United Kingd	780822	Italy	1,863
Finland	338145	Italy	1,134	Spain	409466	United Kingd	1,544
Norway	324220	United Kingd	0,878	Netherlands	241656	Finland	0,575
Italy	301336	Finland	0,757	Sweden	190940	Spain	0,540
United Kingd	244820	Norway	0,723	Switzerland	185881	Norway	0,482
Portugal	92391	Ireland	0,287	Belgium	159791	Netherlands	0,343
Austria	83871	Austria	0,250	Austria	129587	Belgium	0,275
Ireland	70273	Netherlands	0,208	Finland	108403	Switzerland	0,177
Denmark	43094	Portugal	0,183	Denmark	107005	Portugal	0,144
Netherlands	41526	Belgium	0,123	Norway	91419	Denmark	0,125
Switzerland	41285	Denmark	0,111	Portugal	59149	Austria	0,118
Belgium	30528	Switzerland	0,104	Ireland	37448	Ireland	0,048
Luxembourg	2586	Luxembourg	0,008	Luxembourg	9961	Luxembourg	0,013

Source: World Bank: World Development Indicators, OECD: Economic Outlook, IMF: International Financial Statistics

In Table 5.1, we ranked countries according to their size. We provide four rankings, each corresponding to one measure of size suggested above. On observation is that besides obvious differences, rankings across all four measures are reasonably similar. To see this, it is useful to consider which countries are ranked "large" and "small" by each ranking.

We may divide the sample of countries into large and small countries on the basis of the median value. On this basis three out of the four rankings (surface, relative surface, relative GDP) yields the same division. Note also that twelve out of the sixteen countries fall into the same category (large or small) for all four groupings; we always find France, Germany, Italy, Spain, Sweden, the United Kingdom at the top of the table, while Austria, Belgium, Denmark, Ireland, Luxembourg, and Portugal are always at the opposite end.

For relative size variables, the value of 1 as the division between large and small can also be given a natural interpretation. Recall that in our two-country model the large country being larger than its neighbor has a relative size of more than 1. Thus we may divide countries into large and small countries on the basis of their relative size being higher or lower than 1. France, Germany, Italy, and Spain receives a value of higher than 1 by both measures, while Sweden, the United Kingdom receive a value of higher than 1 by one of the two measures. Furthermore, given that relative size is calculated using border length weights rather than traffic flow weights (see section 4.1), both of our measures rank exactly these six countries as large. This suggests that we may represent country size in the empirical analysis by a dummy variable that would take 1 for these six countries and 0 for the rest.

The evolution of diesel excise over the last three decades

Figure 5.2 shows the evolution of the average diesel excises separately in the groups of large and small countries between 1978 and 2005. Separate graphs show how the average taxes of neighbors evolved in the same period. Note that we provide two series of graphs: in the left panel the basis of grouping is surface size, while in the right panel it is 1990 GDP.

Figure 5.2 reveals that diesel excises have increased steadily in both the large and the small countries during the last three decades. From its initial level of 8 eurocents, it grew to 39 eurocent by the end of the period, a 500 percent increase. In 2005, the average excise in the small countries was around at 34-35 eurocent, while the corresponding figure in the large countries was at 43-44 eurocent.

At this level of aggregation, our data suggests that the evolution of diesel excise competition in Europe can be divided into two different "phases". In the first period, from 1978-1994, we see that the evidence is mixed about tax competition at best, while in the second period, from 1995-2005, we see a much stronger evidence for asymmetric tax competition to occur. In the first period, diesel excises increased at a similar rate in the two country groups. The large countries featured higher taxes than the small countries only when countries are grouped according to GDP. On the other, when they are grouped according to territory, we do not find significant tax differences between the two groups. In this period, the graphs depicting taxes and neighbor taxes also show contradicting evidence. Small countries tended to set lower taxes than their neighbors only in the first 8-10 year of the period, while large countries tended to set higher taxes than their neighbors only in the second 8-10 years of the period.

In contrast to the pre-1995 period, our graphs strongly indicate the presence of asymmetric tax competition in diesel excises in the period 1995-2005. In the second half of 1990s, taxes increased sharply in the large countries, but remained almost unchanged in the small countries, leading to a substantial tax gap between large and small countries by 2000 (We find the same tendencies whichever grouping is considered: the one based on surface or the one based on GDP.) The significant tax gap between large and small countries continued to remain after the year of 2000, and only started to narrow in 2004, after an increase in the minimum rate of excise duty enacted by EU in 2004. It also appears clearly that, in line with our theoretical predictions, small countries set lower taxes than their neighbors, and large countries set higher taxes than their neighbors in the post-1995 period.

In sum, the results from the initial analysis of the data are more or less compatible with the tax competition story. It also provided some indication that the intensity of tax competition has

changed since 1995. Therefore, in the econometric analysis we will test for a structural break in 1995 in European tax competition.

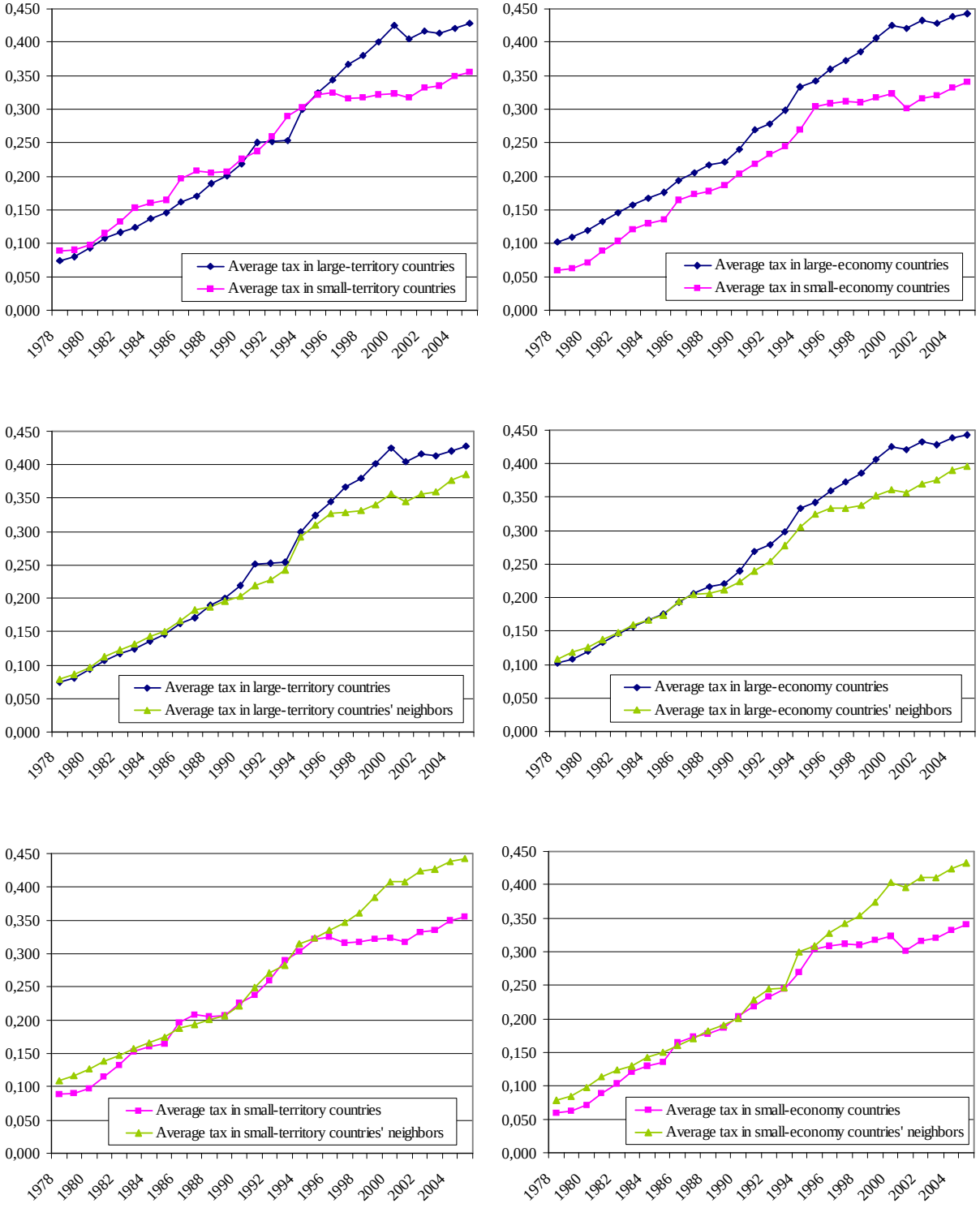


Figure 5.2 Evolution of diesel excises in the large and the small countries and their neighbors, EUR/liter (current values)

Domestic control variables

The theoretical analysis of tax competition focused on the issue of how international tax competition limit the ability of national governments to raise taxes. In practice, domestic political factors also have an effect on domestic tax policy. Our domestic control variables are shown in the table 5.2.

Table 5.2 Domestic control variables

Leftist/conserv gov	Cabinet composition (scaled from 5 to 1)
Election year dummy	Equal to 1 in the year of a parliamentary election and 0 otherwise
Government expenditure	General government final consumption expenditure divided by GDP
Government debt	General government debt divided by GDP
Government deficit	General government deficit divided by GDP
GDP per capita	Gross national product divided by population

We control for the political environment by an election dummy variable and an index for the party composition of governments. The inclusion of these variables is motivated by the political cycle theories. On the one hand, the opportunistic political cycles theory suggests that politicians alter tax policy before general elections to enhance their reelection chances. On the other hand, the partisan cycles theory suggests that conservative governments impose lower taxes than do leftist governments. Accordingly, we expect that diesel excises are lower in the years of general elections and when right-wing governments are in power. (The index for the party composition of governments is based on the Schmidt index, which is scaled from 1 to 5. It takes on 1 when the government contains only right-wing parties; 2 when the share of left-wing parties is less than 33 percent; 3 when the share of left-wing parties is less than

66 percent; 4 when the share of left-wing parties is more than 66 percent; 5 when all coalitional parties are left-wing.)

When governments face budget problem, they typically resort to raising taxes. We use three variables to control for changes in state fiscal conditions. These are: public expenditure, government debt, and budget deficit. We expect a positive impact of public expenditure and government debt on diesel tax rates and a negative one of budget deficit. Because these variables are potentially endogenous, we predetermined them.

Road infrastructure, with the exception of tolled motorways, is usually financed from tax revenues. Though motor fuel excises are not earmarked in most EU countries, they are often justified on the ground that they are required to cover the costs of construction and maintenance of transport infrastructure. Since road traffic is positively correlated with economic development, richer countries tend to have more developed road infrastructures. Thus countries with more developed economy need higher fuel taxes to finance their larger infrastructure needs. Following this line of reasoning we expect a positive impact of economic development, as measured by per capita GDP, on diesel excise rates.

Our specification also includes year fixed effects to control for unobserved influences common to all countries in a given year, such as business cycle effects. This will also address changes in the minimum excise rate set by EU regulation. (As mentioned earlier, the Council set minimum rates for diesel excise as of 1992. The minimum rate for diesel was fixed 0,245 ECU/euro per liter between 1993 and 2003, and raised to 0,302 euro per liter in 2004.)

5.2.3 Econometric issues

We must deal with several econometric issues in estimating 4.1. These are: non-stationary variables, endogenous variables, spatial error dependence, and serial correlation.

As it is seen earlier, diesel taxes are trending upward. Panel unit root tests provide strong indication that our tax variables are indeed non-stationary processes. Our macroeconomic variables in 4.1 are also integrated of order 1. Because of this and also in light of the structure of our panel (T > N), we choose to estimate the model in first-differences. We use one-year intervals in first-differencing.

However, applying first-differencing implies that we loose the possibility to investigate the relationships between the levels of variables (i.e. the connection between taxes and sizes of countries). This is the "price" we have to pay for getting a reliable estimation method. Fortunately, one implication of asymmetric tax competition can be tested in first-difference models, too. Recall that our extension to Nielsen generated two predictions about the effects of country size. It has been shown that large countries tend to set higher taxes, and also that they react more strongly to changes in other countries' tax rates than small countries do. Thus, in the first-difference specification, our main variable of interest is the interaction term between neighbors' taxes and country size. If we receive a positive and statistically significant coefficient estimate on the interaction term, this would provide indirect evidence in favor of the asymmetric tax competition among European governments.

Another issue that we have to deal with is the endogenity of the neighbor tax variable. Because of strategic interactions, the equilibrium taxes in different states are jointly

determined. That is, $\sum_{j \neq i} \omega_{ij} \tau_{jt}$ determines τ_{it}, and the latter determines the former simultaneously. This implies that the neighbor tax variable is correlated with the error term, and hence the ordinary least squares (OLS) estimator will be biased and inconsistent.

We adopt two alternative approaches to deal with the endogenity problem. First, we use OLS to estimate 4.1, but include the one-period lagged values of the neighbor tax variable as a regressor in the estimated equation. This is not a "compromise". Tax interactions are likely to happen with a time lag in reality, as we pointed out earlier (see section 4.1).

Our second approach is to estimate 4.1 by using two stage least squares (2SLS) (In the 2SLS estimations, also the lagged values of neighbor taxes are used.) In the first stage, we regress neighbor tax and the interaction term on a set of exogenous variables. In the second stage, we estimate 4.1 by using the predicted values of $\sum_{j \neq i} \omega_{ij} \tau_{jt-1}$ and $\sum_{j \neq i} \omega_{ij} \tau_{jt-1} \cdot Size_i$ obtained in the first stage as explanatory variables. In the first stage regressions, following the procedure suggested by the spatial econometric literature (Elhorst 2003, Kelejian and Prucha 1998), we include the weighted average of some of the neighbors' control variables and the same variables for the home state.

This procedure yields unbiased and consistent estimates given that the instruments are valid. A valid instrument has to meet two criteria. It has to be both uncorrelated with the error term, and correlated with the endogenous variable.

Out of the control variables we use only the two political variables as instruments. This is in contrast to the literature, where most empirical works implementing IV procedure use several

economic and fiscal aggregates as instruments. We do not think however that macroeconomic variables work very well as instruments in our case. Our concern stems from the fact that business cycles are correlated across countries in Europe. Thus the possibility of simultaneity from macroeconomic aggregates (like GDP per capita or government deficit) cannot be excluded.

Following Altshuler and Goodspeed (2003), the weighted average tax of the neighbors' neighbors is also included as instrument in the model. As argued by the authors, the tax rate of the neighbors of the neighbors of country *i* should be correlated with the tax rate of the neighbors of country *i*, but uncorrelated with the tax rate of country *i*. Thus it should be a good instrument. To understand the intuition, consider the example of Portugal. For Portugal we have to instrument the tax rate of Spain. We do this by using the tax rate in France. This instrument should be valid because France is a neighbor to Spain, but is not a neighbor to Portugal, and hence our theory both predicts that its tax does depend on the tax of the latter, but it does not on the tax of the former. (Note that the neighbors' neighbors rate for a country *i* is a weighted average of taxes of those countries that are neighbors to the neighbors of country *i* , *but* not neighbors to country *i*.)

The first stage regressions for the endogenous variables are specified as follows:

$$\sum_{j\neq i}\omega_{ij}\tau_{jt-1} = \alpha' + \beta'\sum_{j\neq i}\omega_{ij}Z_{jt-1} + \kappa' N_{it-1} + \delta'\sum_{j\neq i}\omega_{ij}Z_{jt-1}\cdot Size_i + \eta' N_{it-1}\cdot Size_i + Size_i\gamma' + \theta' X_{it} + d_t\varphi' + u_{it} \quad (4.2)$$

$$\sum_{j\neq i}\omega_{ij}\tau_{jt-1}\cdot Size_i = \alpha'' + \beta''\sum_{j\neq i}\omega_{ij}Z_{jt-1} + \kappa'' N_{it-1} + \delta''\sum_{j\neq i}\omega_{ij}Z_{jt-1}\cdot Size_i + \eta'' N_{it-1}\cdot Size_i + Size_i\gamma'' + \theta'' X_{it} + d_t\varphi'' + u_{it} \quad (4.3)$$

where Z is the set of controls used as instrument – including in this case the election dummy and the leftist/conservative index –, $\sum_{j \neq i} \omega_{ij} Z_{jt-1}$ is the weighted sum of neighbor covariates, and N is the weighted average of diesel excises of the neighbors' neighbors. In the second stage regression, the original values of $\sum_{j \neq i} \omega_{ij} \tau_{jt-1}$ and $\sum_{j \neq i} \omega_{ij} \tau_{jt-1} \cdot Size_i$ are replaced by the predicted values obtained from estimation of 4.2 and 4.3. (Because $Size_i$ is time invariant, it drops out from 4.1-3 when the first-difference version of the model is estimated.)

Unlike OLS, the instrumental variable approach is robust to spatial error dependence in the error term (Kelejian and Prucha 1998). Spatial error dependence can arise when the error term includes omitted variables that are themselves spatially correlated. If this problem is present, the OLS estimation of the model may indicate the presence of strategic interactions – i.e. spatial dependence through the neighbor tax – even though it is simply generated by spatially correlated errors.

Finally we allow for possible serial correlation by including an AR(1) term.

5.2.4 Results

Our main regression results are reported in Table 5.3 and 5.4. Table 5.3 presents OLS estimates, while in Table 5.4 we provide both OLS and 2SLS results. All models are estimated in first-differences. We are interested in the coefficient of the interaction term, which shows how the size of a country interacts with a change in its rivals' tax in determining the tax response of this country. In both tables we present estimation results with respect to all

four measures of country size. (In Table 5.3 and 5.4, we use traffic flow weights in computing the weighted averages of foreign taxes and country size.) In all cases, we include time fixed effects and correct for autocorrelation by using AR(1) term.

We begin with a discussions of the OLS results in Table 5.3. For each measure of country size, we present OLS estimates with and without controls. When controlling for domestic effects, we find that the coefficient of the interaction term is always positive, the expected sign, and is significant with respect to three measures of country size (surface, relative surface, and relative 1990 GDP). This confirms the theoretical prediction in section 3 that large countries tend to react more strongly to tax changes in their neighbors than small countries do. This in turn provides an indirect evidence for the existence of asymmetric tax competition, as both predictions are derived and consistent with the same theoretical model. (Though the exclusion of controls reduces the statistical significance of the coefficient of the interaction term, in one of the four cases it remains significant at 5 percent, while in two cases it remains significant at 10 percent.)

Of the control variables, three are highly significant. Cabinet composition of government is always positive and significant, indicating that left-wing governments are associated with higher taxes. This broadly supports the idea that the ideological orientation of governments has an effect over macroeconomic policies pursued. In contrast, our election dummy is not significant, though it has the expected negative sign. This suggests that politicians do not manipulate diesel taxes before general elections.

The budget deficit variable is also always significant at 5 percent. Its negative sign shows that high budget deficit is eventually followed by higher taxes. The coefficient of our single

economic variable, GDP per capita, is also significant and is of the expected sign. Richer countries tend to impose higher taxes on fuels, as expected. Finally, two of our control variables – public expenditure and public debt – are of the wrong sign, but are insignificant.

Our 2SLS results are tabulated in Table 5.4. In these regressions, cabinet composition of governments and the average diesel excise of neighbors' neighbors are used as instruments (We dropped the election dummy from the instrument list due to its weak explanatory power.) To make comparison easier, the OLS estimates from the previous table are also reported. For three of our four measures of country size we find that the interaction term is significant at 10 percent level.

Table 5.3 Change in diesel excise tax, 1978 – 2005, OLS estimates (traffic flow weights)

Country size is measured by	Surface		Relative surface		1990 GDP		Relative 1990 GDP	
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Change in Neighbors' tax *t-1*	-0,131	-0,263	-0,066	-0,173	0,013	-0,089	-0,037	-0,135
	(-1,163)	(-2,447)**	(-0,683)	(-1,889)*	(0,152)	(-1,105)	(-0,415)	(-1,628)
Change in Neighbors' tax *t-1* *Country size	0,008	0,011	0,014	0,019	0,001	0,004	0,013	0,018
	(2,011)**	(2,868)***	(1,716)*	(2,477)**	(0,547)	(1,579)	(1,695)*	(2,484)**
Change in Leftist/conserv gov.		0,031		0,032		0,032		0,032
		(2,123)**		(2,171)**		(2,171)**		(2,153)**
Election year		-0,017		-0,014		-0,017		-0,016
		(-0,764)		(-0,638)		(-0,730)		(-0,726)
Change in Government debt *t-1*		-0,043		-0,039		-0,036		-0,038
		(-1,158)		(-1,062)		(-0,968)		(-1,036)
Change in Government deficit *t-1*		-0,016		-0,016		-0,015		-0,015
		(-2,167)**		(-2,106)**		(-1,945)*		(-2,016)**
Change in Government expenditure *t-1*		-0,038		-0,014		-0,032		-0,013
		(-0,174)		(-0,062)		(-0,147)		(-0,060)
Change in GDP per capita		1,156		1,155		1,162		1,159
		(8,760)***		(8,732)***		(8,691)***		(8,756)***
AR(1)	0,262	0,377	0,263	0,381	0,256	0,374	0,262	0,380
	(5,201)***	(7,587)***	(5,226)***	(7,653)***	(5,074)***	(7,477)***	(5,196)***	(7,621)***
R-squared	0,17	0,33	0,16	0,33	0,16	0,32	0,16	0,33
No. of observations	400	400	400	400	400	400	400	400
Durbin-Watson stat	2,07	2,05	2,07	2,06	2,07	2,07	2,07	2,06
Time fixed effect	yes	yes	yes	yes	yes	yes	yes	yes

t-values in brackets.

* significant at 10%; ** significant at 5%; *** significant at 1%;

Table 5.4 Change in diesel excise tax, 1978 – 2005, OLS and 2SLS estimates (traffic flow weights)

Country size is measured by:	Surface		Relative surface		1990 GDP		Relative 1990 GDP	
Estimation method:	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Change in Neighbors' tax *t-1*	-0,263	0,005	-0,173	0,070	-0,089	0,180	-0,135	0,131
	(-2,447)**	(0,014)	(-1,889)*	(0,194)	(-1,105)	(0,611)	(-1,628)	(0,401)
Change in Neighbors' tax *t-1* *Country size	0,011	0,013	0,019	0,031	0,004	0,007	0,018	0,028
	(2,868)***	(1,822)*	(2,477)**	(1,898)*	(1,579)	(1,599)	(2,484)**	(1,825)*
Change in Leftist/conserv gov.	0,031	0,034	0,032	0,036	0,032	0,038	0,032	0,036
	(2,123)**	(2,112)**	(2,171)**	(2,194)**	(2,171)**	(2,382)**	(2,153)**	(2,239)**
Election year	-0,017	-0,023	-0,014	-0,020	-0,017	-0,025	-0,016	-0,023
	(-0,764)	(-0,846)	(-0,638)	(-0,731)	(-0,730)	(-0,898)	(-0,726)	(-0,857)
Change in Government debt *t-1*	-0,043	0,019	-0,039	0,025	-0,036	0,030	-0,038	0,026
	(-1,158)	(0,410)	(-1,062)	(0,540)	(-0,968)	(0,692)	(-1,036)	(0,583)
Change in Government deficit *t-1*	-0,016	-0,019	-0,016	-0,020	-0,015	-0,017	-0,015	-0,019
	(-2,167)**	(-2,235)**	(-2,106)**	(-2,260)**	(-1,945)*	(-2,038)**	(-2,016)**	(-2,165)**
Change in Government expenditure *t-1*	-0,038	-0,072	-0,014	-0,048	-0,032	-0,064	-0,013	-0,053
	(-0,174)	(-0,291)	(-0,062)	(-0,194)	(-0,147)	(-0,257)	(-0,060)	(-0,214)
Change in GDP per capita	1,156	0,998	1,155	1,007	1,162	1,024	1,159	1,008
	(8,760)***	(6,954)***	(8,732)***	(6,937)***	(8,691)***	(7,065)***	(8,756)***	(7,003)***
AR(1)	0,377	0,332	0,381	0,349	0,374	0,344	0,380	0,345
	(7,587)***	(6,798)***	(7,653)***	(6,951)***	(7,477)***	(6,822)***	(7,621)***	(6,873)***
R-squared	0,33	0,28	0,33	0,28	0,32	0,28	0,33	0,28
No. of observations	400	400	400	400	400	400	400	400
Durbin-Watson stat	2,05	2,04	2,06	2,04	2,07	2,05	2,06	2,04
Time fixed effect	yes	yes	yes	yes	yes	yes	yes	yes

t-values in brackets.
* significant at 10%; ** significant at 5%; *** significant at 1%;

In an earlier part of the study, when we examined the nature of fiscal interactions with the help of diagrams, we found trends implying asymmetrical competition only in diesel tax data stemming from after 1990. This is why we held it reasonable to do the statistical test in each period before and after 1995, too. The results of the estimates confirm our preliminary suspicions (Tables 5.5 and 5.6). In the models referring to the time between 1978 and 1994 the coefficient of the interaction term is mostly non-significant. Contrary to this, in estimates describing the period between 1995 and 2005, in seven models out of eight, the interaction term is significant at 5 percent. It is worth mentioning that we got a significant estimate for the coefficient of the interaction term in all of our four models using instrumental variables.

We can state that our analysis provides weak evidence for the presence of diesel excise tax competition among European states for the whole period under examination but strong evidence for the period from 1995 to 2005. The fact that the contest of European states for consumers intensified from the mid-1990s is not so surprising considering that the creation of the single market became considerably advanced in this very period. With the demolition of internal borders and the introduction of the common currency, by the second half of the 1990s, obstacles to purchases abroad practically disappeared within the Union. The liberalization of the haulage market, which leads to a strong price competition and the extension of international haulage activity by creating a unified Trans-European transportation market, also evolved in this period. Accordingly, a number of changes occurred in the 1990s that are likely to have made fuel consumers – private and commercial users alike – more sensitive to international price differences. The mobility of tax bases became strong enough by this period to make the strategy of holding tax rates relatively low attractive for smaller countries and increase their tax revenues by conquering the tax base of other countries.

Table 5.5 Change in diesel excise tax, 1978 – 1994, OLS and 2SLS estimates (traffic flow weights)

Country size is measured by:	Surface		Relative surface		1990 GDP		Relative 1990 GDP	
Estimation method:	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Change in Neighbors' tax *t-1*	-0,077	-0,218	-0,055	0,025	0,093	0,253	0,029	0,134
	(-0,404)	(-0,372)	(-0,333)	(0,049)	(0,605)	(0,496)	(0,186)	(0,270)
Change in Neighbors' tax *t-1* *Country size	0,009	0,022	0,019	0,024	0,001	0,001	0,010	0,014
	(1,373)	(1,981)**	(1,664)*	(1,274)	(0,256)	(0,184)	(0,997)	(0,761)
Change in Leftist/conserv gov.	0,042	0,048	0,040	0,044	0,039	0,042	0,039	0,043
	(1,973)**	(2,125)**	(1,912)*	(1,985)**	(1,826)*	(1,846)*	(1,843)*	(1,889)*
Election year	-0,036	-0,042	-0,037	-0,044	-0,037	-0,045	-0,037	-0,045
	(-1,197)	(-1,143)	(-1,215)	(-1,216)	(-1,202)	(-1,224)	(-1,217)	(-1,221)
Change in Government debt *t-1*	0,034	0,084	0,029	0,075	0,033	0,076	0,032	0,075
	(0,648)	(1,451)	(0,567)	(1,301)	(0,636)	(1,238)	(0,618)	(1,279)
Change in Government deficit *t-1*	-0,007	-0,009	-0,007	-0,009	-0,006	-0,008	-0,006	-0,008
	(-0,712)	(-0,859)	(-0,745)	(-0,881)	(-0,655)	(-0,736)	(-0,651)	(-0,762)
Change in Government expenditure *t-1*	-0,172	-0,244	-0,152	-0,191	-0,157	-0,181	-0,148	-0,178
	(-0,655)	(-0,824)	(-0,581)	(-0,652)	(-0,590)	(-0,609)	(-0,559)	(-0,603)
Change in GDP per capita	1,371	1,307	1,349	1,219	1,342	1,184	1,342	1,195
	(6,056)***	(5,635)***	(5,992)***	(5,609)***	(5,899)***	(5,409)***	(5,931)***	(5,533)***
AR(1)	0,429	0,458	0,433	0,429	0,413	0,392	0,420	0,405
	(5,287)***	(4,859)***	(5,366)***	(4,716)***	(5,064)***	(4,572)***	(5,173)***	(4,567)***
R-squared	0,28	0,26	0,28	0,28	0,27	0,26	0,28	0,27
No. of observations	224	224	224	224	224	224	224	224
Durbin-Watson stat	1,74	1,74	1,75	1,75	1,74	1,74	1,75	1,74
Time fixed effect	yes	yes	yes	yes	yes	yes	yes	yes

t-values in brackets.

* significant at 10%; ** significant at 5%; *** significant at 1%;

Table 5.6 Change in diesel excise tax, 1995 – 2005, OLS and 2SLS estimates (traffic flow weights)

Country size is measured by:	Surface		Relative surface		1990 GDP		Relative 1990 GDP	
Estimation method:	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Change in Neighbors' tax *t-1*	-0,387	-0,346	-0,222	-0,105	-0,175	-0,043	-0,220	0,080
	(-3,055)***	(-0,886)	(-2,013)**	(-0,224)	(-1,872)*	(-0,117)	(-2,260)**	(0,202)
Change in Neighbors' tax *t-1* *Country size	0,014	0,031	0,021	0,091	0,008	0,024	0,031	0,084
	(3,108)***	(2,322)**	(1,881)*	(2,516)**	(2,193)**	(2,412)**	(2,711)***	(2,530)**
Change in Leftist/conserv gov.	0,027	0,033	0,030	0,042	0,034	0,039	0,030	0,041
	(1,296)	(1,286)	(1,432)	(1,448)	(1,594)	(1,525)	(1,442)	(1,511)
Election year	0,005	-0,030	0,015	-0,005	0,005	-0,051	0,009	-0,025
	(0,146)	(-0,665)	(0,443)	(-0,097)	(0,146)	(-1,030)	(0,277)	(-0,520)
Change in Government debt *t-1*	-0,111	-0,074	-0,101	-0,029	-0,106	-0,098	-0,109	-0,063
	(-1,987)**	(-0,939)	(-1,783)*	(-0,329)	(-1,872)*	(-1,114)	(-1,929)*	(-0,704)
Change in Government deficit *t-1*	-0,031	-0,044	-0,028	-0,037	-0,027	-0,029	-0,027	-0,033
	(-2,354)**	(-2,725)***	(-2,071)**	(-2,094)**	(-2,004)**	(-1,814)*	(-2,030)**	(-2,005)**
Change in Government expenditure *t-1*	0,132	0,153	0,214	0,691	0,128	0,134	0,228	0,564
	(0,316)	(0,251)	(0,500)	(1,002)	(0,303)	(0,222)	(0,541)	(0,872)
Change in GDP per capita	1,028	0,949	1,042	0,982	1,067	1,013	1,062	0,993
	(6,420)***	(5,438)***	(6,388)***	(4,787)***	(6,513)***	(5,438)***	(6,570)***	(5,057)***
AR(1)	0,357	0,409	0,369	0,453	0,360	0,374	0,368	0,433
	(5,580)***	(5,046)***	(5,758)***	(4,830)***	(5,637)***	(4,531)***	(5,802)***	(4,880)***
R-squared	0,41	0,31	0,39	0,13	0,40	0,29	0,41	0,20
No. of observations	176	160	176	160	176	160	176	160
Durbin-Watson stat	1,86	2,21	1,89	2,28	1,97	2,20	1,90	2,25
Time fixed effect	yes	yes	yes	yes	yes	yes	yes	yes

t-values in brackets.

* significant at 10%; ** significant at 5%; *** significant at 1%;

Our estimates so far have been based on the traffic flow weights weighting system that we introduced. The weighting system influences the course of the statistical estimate at a number of points. On the one hand, it determines which countries are in competition with one another and what weight does the decisions of other countries represent in the decisions of the given country. In other words, it influences the key variables of the analysis: the neighbor's tax and the interaction term. On the other hand, in models where we measure the size of the countries relative to the sizes of their neighbors (relative area and relative GDP), it has an influence on the scale variables. Thirdly, when applying the method of two stage least squares, it has an impact on the estimation procedure itself, by influencing instrumental variables. Therefore it is important to look at the question as to how sensitive our results are to changes of the weighting system. In what follows we estimate our models applying further two weighting methods that are frequently used in the literature. On the grounds of our previous results we now concentrate on the period between 1995 and 2005.

In Table 5.7 we can see the results obtained by using border length weights. Although in three of the eight models the interaction term is significant, in comparison with our previous findings we got weaker results. The method of border length weights differs from the method of traffic flow weights in two important aspects. On the one hand, while in the former we weight the taxes of the competitors according to the length of the borders, in the latter, we weight it in accordance with the road haulage traffic crossing the borders. On the other hand, whilst in the former we let the United Kingdom compete only with Ireland and Sweden only with Finland and Norway, we assume in the latter that the two countries have competitors on the continent, too (for the United Kingdom, there are France, Belgium and the Netherlands, and for Sweden, there is Denmark). In order to see which one of the two aspects plays the decisive role in forming the results, we made the estimates with two variants of the standard

border weights weighting method, too. (As we discussed earlier, the border weights mean a weighting method in which all competitors are given the same weight.) In the first version the circle of the competitors corresponds to the border length weights, in the second version it corresponds to the traffic flow weights. The results are tabulated in Tables 5.8 and 5.9. Since the 2SLS estimates are also affected through the efficiency of our instruments, we had better rely only on the results of the OLS estimates, in order to answer the above question properly. Comparing the results of the two tables and those of Table 4.8., we see that the border weights estimate, which defines the circle of competitors according to traffic flow weights, gives results almost matching the estimate using traffic flow weights. On the score of this we can state that the weighting method proposed by us proved to be key in the analysis of European diesel tax competition with respect to identifying the circle of the competitors

Table 5.7 Change in diesel excise tax, 1995 – 2005, OLS and 2SLS estimates (border length weights)

Country size is measured by:	Surface		Relative surface		1990 GDP		Relative 1990 GDP	
Estimation method:	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Change in Neighbors' tax *t-1*	-0,392	-0,586	-0,222	-0,527	-0,175	-0,240	-0,113	-0,525
	(-3,164)***	(-1,384)	(-2,210)**	(-0,938)	(-2,026)**	(-0,621)	(-1,465)	(-0,533)
Change in Neighbors' tax *t-1* *Country size	0,011	0,037	0,012	0,090	0,004	0,028	0,001	0,034
	(2,977)***	(2,022)**	(1,888)*	(1,891)*	(1,768)*	(2,140)**	(0,875)	(1,698)*
Change in Leftist/conserv gov.	0,025	0,032	0,030	0,026	0,033	0,039	0,031	0,010
	(1,201)	(1,158)	(1,397)	(0,682)	(1,538)	(1,226)	(1,467)	(0,123)
Election year	0,008	-0,033	0,005	-0,089	0,004	-0,080	0,010	-0,193
	(0,236)	(-0,662)	(0,136)	(-1,175)	(0,122)	(-1,222)	(0,279)	(-1,207)
Change in Government debt *t-1*	-0,110	-0,086	-0,100	-0,116	-0,098	-0,112	-0,093	-0,216
	(-1,983)**	(-1,049)	(-1,778)*	(-0,965)	(-1,741)*	(-1,106)	(-1,650)	(-0,876)
Change in Government deficit *t-1*	-0,029	-0,043	-0,028	-0,033	-0,027	-0,023	-0,028	-0,027
	(-2,212)**	(-2,310)**	(-2,116)**	(-1,519)	(-2,028)**	(-1,199)	(-2,105)**	(-0,639)
Change in Government expenditure *t-1*	0,185	0,275	0,029	-0,304	0,064	-0,019	0,059	-1,473
	(0,443)	(0,415)	(0,068)	(-0,366)	(0,151)	(-0,027)	(0,137)	(-0,808)
Change in GDP per capita	1,043	0,992	1,044	0,918	1,049	1,013	1,030	0,676
	(6,522)***	(5,092)***	(6,379)***	(3,680)***	(6,399)***	(4,412)***	(6,256)***	(1,449)
AR(1)	0,369	0,431	0,354	0,194	0,361	0,267	0,367	-0,130
	(5,789)***	(4,149)***	(5,477)***	(1,901)*	(5,627)***	(2,813)***	(5,697)***	(-1,216)
R-squared	0,41	0,19	0,39	-0,37	0,39	-0,05	0,38	-4,05
No. of observations	176	160	176	160	176	160	176	160
Durbin-Watson stat	1,85	2,36	1,97	2,36	1,98	2,35	1,98	2,03
Time fixed effect	yes	yes	yes	yes	yes	yes	yes	yes

t-values in brackets.

* significant at 10%; ** significant at 5%; *** significant at 1%;

Table 5.8 Change in diesel excise tax, 1995 – 2005, OLS and 2SLS estimates (neighbor weights1, neighbors correspond to neighbors in traffic flow weights)

Country size is measured by:	Surface		Relative surface		1990 GDP		Relative 1990 GDP	
Estimation method:	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Change in Neighbors' tax *t-1*	-0,417	-0,573	-0,322	-0,455	-0,213	-0,265	-0,292	-0,263
	(-3,423)***	(-1,522)	(-2,842)***	(-1,256)	(-2,243)**	(-0,945)	(-2,975)***	(-0,869)
Change in Neighbors' tax *t-1* *Country size	0,014	0,039	0,030	0,103	0,008	0,026	0,032	0,087
	(3,280)***	(2,184)**	(2,592)**	(2,432)**	(2,043)**	(2,455)**	(3,196)***	(2,529)**
Change in Leftist/conserv gov.	0,029	0,028	0,031	0,028	0,033	0,026	0,030	0,030
	(1,381)	(1,135)	(1,473)	(1,107)	(1,580)	(1,083)	(1,464)	(1,232)
Election year	0,003	-0,027	0,009	-0,020	0,004	-0,051	0,003	-0,036
	(0,099)	(-0,588)	(0,258)	(-0,423)	(0,105)	(-1,066)	(0,089)	(-0,775)
Change in Government debt *t-1*	-0,130	-0,122	-0,119	-0,111	-0,106	-0,119	-0,120	-0,126
	(-2,311)**	(-1,438)	(-2,107)**	(-1,296)	(-1,876)*	(-1,485)	(-2,148)**	(-1,454)
Change in Government deficit *t-1*	-0,032	-0,045	-0,029	-0,036	-0,026	-0,026	-0,027	-0,032
	(-2,409)**	(-2,638)***	(-2,169)**	(-2,241)**	(-1,956)*	(-1,651)	(-2,090)**	(-2,072)**
Change in Government expenditure *t-1*	0,095	0,051	0,142	0,284	0,104	0,023	0,170	0,277
	(0,228)	(0,091)	(0,337)	(0,488)	(0,244)	(0,043)	(0,408)	(0,497)
Change in GDP per capita	1,017	0,945	1,044	1,006	1,067	1,073	1,064	1,032
	(6,406)***	(5,406)***	(6,482)***	(5,383)***	(6,524)***	(5,729)***	(6,667)***	(5,610)***
AR(1)	0,358	0,418	0,356	0,424	0,353	0,381	0,354	0,412
	(5,653)***	(4,836)***	(5,560)***	(4,795)***	(5,527)***	(4,790)***	(5,621)***	(4,918)***
R-squared	0,42	0,28	0,41	0,25	0,40	0,32	0,42	0,30
No. of observations	176	160	176	160	176	160	176	160
Durbin-Watson stat	1,87	2,18	1,88	2,22	1,95	2,17	1,89	2,22
Time fixed effect	yes	yes	yes	yes	yes	yes	yes	yes

t-values in brackets.

* significant at 10%; ** significant at 5%; *** significant at 1%;

Table 5.9 Change in diesel excise tax, 1995 – 2005, OLS and 2SLS estimates (neighbor weights2, neighbors correspond to neighbors in neighbor length weights)

Country size is measured by:	Surface		Relative surface		1990 GDP		Relative 1990 GDP	
Estimation method:	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Change in Neighbors' tax *t-1*	-0,440	-0,638	-0,254	-0,578	-0,209	-0,224	-0,142	-0,416
	(-3,501)***	(-1,628)	(-2,450)**	(-0,955)	(-2,271)**	(-0,579)	(-1,676)*	(-0,441)
Change in Neighbors' tax *t-1* *Country size	0,014	0,039	0,013	0,109	0,005	0,032	0,001	0,035
	(3,315)***	(2,209)**	(2,105)**	(1,893)*	(2,000)**	(2,236)**	(1,035)	(1,717)*
Change in Leftist/conserv gov.	0,026	0,031	0,030	0,030	0,032	0,040	0,031	0,015
	(1,239)	(1,160)	(1,397)	(0,709)	(1,523)	(1,218)	(1,442)	(0,195)
Election year	0,004	-0,033	0,003	-0,101	0,002	-0,085	0,008	-0,193
	(0,130)	(-0,696)	(0,076)	(-1,189)	(0,071)	(-1,259)	(0,243)	(-1,194)
Change in Government debt *t-1*	-0,114	-0,106	-0,102	-0,149	-0,100	-0,118	-0,094	-0,211
	(-2,069)**	(-1,362)	(-1,830)*	(-1,080)	(-1,791)*	(-1,154)	(-1,674)*	(-0,879)
Change in Government deficit *t-1*	-0,029	-0,044	-0,028	-0,031	-0,027	-0,023	-0,028	-0,026
	(-2,256)**	(-2,508)**	(-2,091)**	(-1,260)	(-1,989)**	(-1,122)	(-2,076)**	(-0,616)
Change in Government expenditure *t-1*	0,205	0,129	0,034	-0,299	0,075	-0,011	0,061	-1,327
	(0,496)	(0,221)	(0,079)	(-0,342)	(0,176)	(-0,016)	(0,141)	(-0,783)
Change in GDP per capita	1,039	0,972	1,052	0,887	1,060	1,000	1,038	0,659
	(6,550)***	(5,319)***	(6,446)***	(3,093)***	(6,476)***	(4,151)***	(6,308)***	(1,348)
AR(1)	0,372	0,427	0,350	0,123	0,355	0,244	0,362	-0,128
	(5,886)***	(4,565)***	(5,390)***	(1,124)	(5,529)***	(2,471)**	(5,611)***	(-1,281)
R-squared	0,42	0,27	0,40	-0,74	0,40	-0,17	0,38	-4,36
No. of observations	176	160	176	160	176	160	176	160
Durbin-Watson stat	1,84	2,25	1,96	2,29	1,97	2,37	1,97	2,02
Time fixed effect	yes	yes	yes	yes	yes	yes	yes	yes

t-values in brackets.

* significant at 10%; ** significant at 5%; *** significant at 1%;

In order to quantify the effects of tax competition, we computed the partial effect of the neighbor's tax at the median, lower and upper quartile values of the scale variables (Table 5.10). (For the calculation we used the parameters of the models referring to the period between 1995 and 2005, estimated with 2SLS.) Let us look first at the values obtained for the median. In an average country, a third to half of the changes of the diesel tax can be attributed to the tax changes in its neighbors. On the score of this we can state that tax competition played an important role in the diesel tax policy of European countries in the last ten years.

Table 5.10 Partial effect of neighbor tax on diesel tax (1995-2005)

	Surface	1990 GDP	Relative surface	Relative 1990 GDP
Evaluated at the median	0,175	0,367	0,356	0,504
Evaluated at the upper quartile	0,728	0,801	0,936	1,038
Evaluated at the lower quartile	-0,215	0,060	0,035	0,208

To what extent do the reactions of small and big countries differ from each other? In order to get a picture of this, we computed the partial effect of the neighbor's tax at the values of the lower and upper quartile of the country size variables, too. The calculations indicate a substantial difference between the behavior of small and large countries. While large countries responded to the change of taxes in their neighbors in one to one fashion, small countries responded to the change of taxes in their neighbors with a small change.

5.3 Summary

Our analysis provided weak evidence for the presence of diesel excise tax competition among European states for the whole period under examination but strong evidence for the period from 1995 to 2005. The results confirm the theoretical prediction that large countries tend to react more strongly to tax changes in their neighbors than small countries do. To our best

knowledge this is the first panel analysis that provides evidence for asymmetric tax competition in diesel excise taxes in Europe.

The hypothesis referring to the Cabinet composition of government is supported by the results. In accordance with the expectations, left-wing governments are associated with higher taxes than right-wing ones. This broadly supports the idea that the ideological orientation of governments has an effect over macroeconomic policies pursued. In contrast, the hypothesis that governments manipulate diesel excise tax rates before general elections is not confirmed.

CHAPTER 6

CONCLUSIONS

In this paper we examined whether European states compete with each other for tax revenues they collect on diesel sales. We demonstrated that European diesel taxation is promising field of tax competition research. First, in the setting of considerable international haulage activity (due to the lack of internal borders) and high tax burden, the sales of diesel can be considered as a mobile tax base. Since revenues of diesel tax are substantial, the assumption that states 'compete' for these tax revenues with their tax rates seems plausible.

Second, from research on diesel tax competition many lessons can be drawn regarding the tax policy of the European Union. Since 1993, the Union regulates the excise tax rates of fuels, including that of diesel, by setting minimum tax rates. The aim of the regulation was to make excise tax rates of the various Member States converge. Despite the fact that excise is one of the most harmonized tax policy field, rate differences among Member States have hardly decreased over the last 15 years (see part 3.1). By revealing the characteristics of diesel tax competition we provided an explanation for the relative failure of the Union's minimum tax rate regulation.

In the theoretical analysis of diesel tax competition, similar to the literature, we used a game theoretic framework. Tax competition was modeled as a Nash game in which governments choose their revenue maximizing tax rates taking the rates of their competitors as given. We formulated two main hypotheses based on the analysis of the equilibrium of tax competition game. First, European states set their excise tax rates in mutual interaction, competing for tax

proceeds. Second, diesel tax competition is asymmetric: large countries set higher excise tax rates than small countries. Our analysis included the analyis of political business cycles as well. In this regard, we set up two hypotheses. First, governments do manipulate diesel tax for political greediness. Second, there is a systematic difference in fuel tax policies of governments with left and right majority.

Our theoretical model extends Nielsen's (2001) analysis of commodity tax competition between countries of different size to allow for elastic individual demand for the taxed good. Nielsen formulated a Nash game between two governments to examine the impact of the difference on tax rates. Under the assumption of unit demand for the taxed good, Nielsen has shown that the tax set by the large country is higher than the one set by the small country. This result is parallel to that of Kanbur and Keen (1993) who examined tax competition between countries of equal size but with different population densities. The present work extended and refined the results of Nielsen (2001) on commodity tax competition. We demonstrated that once the assumption of perfectly inelastic demand is relaxed, country size influences – apart from the tax rate – the response intensity to tax level changes in neighboring countries. Unless the demand is perfectly inelastic, the large country reacts more strongly to tax changes in the neighboring country than the small country.

Our theoretical analysis was mainly inspired by the study of Devereux et al. (2007). Their study examines the commodity tax competition of gasoline and cigarettes in the US, theoretically and empirically. The authors simultaneously integrate and generalize previous theoretical works by examining the horizontal and vertical tax competition (i) in a standard theoretical framework, (ii) allowing area and population density to constitute the difference between the sizes of the countries, and (iii) assuming price elastic demand. However, the

general theoretical framework provides little opportunity to draw analytical results. By building a less generalized model, allowing the demand to be price elastic, but conceptualizing spatial differences of countries only according to their area – we give a more accurate characterization of horizontal tax competition.

Our theoretic analysis drew two important conclusions. On the one hand, we proved that asymmetric tax competition is robust for the introduction of the inelastic, iso-elastic individual demand. On the other hand, we demonstrated that once the assumption of perfectly inelastic demand is relaxed, there is a systematic difference between the equilibrium responses of small and large countries not only in terms of tax rates set, but also in terms of the intensity of their responses. The large country with the higher tax rate reacts to tax changes in its neighbor with a higher intensity than the small country with a lower tax rate.

These results are relevant for the empirical investigation of tax competition theory. On the one hand, the correct specification of reaction functions of the countries requires that the response intensity to neighbors' taxes could vary from country to country. On the other hand, while the relationship between country size and tax level can be analyzed in level models only, the relationship between country size and tax change, i.e. the indirect proof of asymmetric tax competition, can be tested in first difference models, too.

To our best knowledge, only two studies analyzed European diesel tax competition by econometric tools. Using cross-sectional data – 1998 fuel prices from 32 European countries – Rietveld et al (2005) found empirical evidence for asymmetric tax competition. Evers et al (2004) examined tax competition on panel data, largely similar to the one we use, and

provided evidence for the existence of tax competition, but not for asymmetric tax competition.

For the empirical analysis of excise tax competition we applied the research methodology regularly used in the literature on tax competition. The analysis was based on a multi-variable regression model in which the countries' diesel excise tax is explained by fiscal, economic and political variables and with the excise tax of their neighboring countries. To test our hypotheses, we estimated the fiscal reaction functions for national governments using data from 16 European countries (EU-15 minus Greece plus Norway and Switzerland) between 1978 and 2005. We handled the endogeneity of the competitors' taxation decisions – similarly to the practice followed by the papers above – by using instrumental variables. Nevertheless, our approach differs from those of the above mentioned studies from several respects.

The regression equation was estimated – unlike the majority of researchers – not by levels but the first differences of variables. The proposition on the asymmetric tax competition was thus tested indirectly, through testing the auxiliary hypothesis on the relationship between country size and tax change. To our best knowledge this is the first study that investigates the hypothesis of asymmetric tax competition in first-difference econometric models, guided by theoretical predictions.

In the empirical investigation of tax competition we have to deal with the interactions of *many* countries. When defining the spatial structure of tax competition, we have to determine the circle of countries a country competes with and the relative weights of the decisions the countries make. Based on the features of international road freight traffic, we elaborated a weighting scheme that has not yet been used in the empirical literature.

Measuring the dependent variable of the analysis is a key issue in the tax competition research. We argued that the differences in the countries' tax burden can be captured with the excise tax rates. Therefore, we opted for the diesel excise tax rate as the dependent variable of analysis, in accordance with studies dealing with commodity tax competition between the states of the US, but differing from studies analyzing fuel tax competition of European states.

We can state that our analysis provides weak evidence for the presence of diesel excise tax competition among European states for the whole period under examination but strong evidence for the period from 1995 to 2005. The fact that the contest of European states for consumers intensified from the mid-1990s is not so surprising considering that the creation of the single market became considerably advanced in this very period. With the demolition of internal borders and the introduction of the common currency, by the second half of the 1990s, obstacles to purchases abroad practically disappeared within the Union. The liberalization of the haulage market, which leads to a strong price competition and the extension of international haulage activity by creating a unified Trans-European transportation market, also evolved in this period. Accordingly, a number of changes occurred in the 1990s that are likely to have made fuel consumers – private and commercial users alike – more sensitive to international price differences. The mobility of tax bases became strong enough by this period to make the strategy of holding tax rates relatively low attractive for smaller countries and increase their tax revenues by conquering the tax base of other countries.

Our results confirm the theoretical prediction that large countries tend to react more strongly to tax changes in their neighbors than small countries do. To our best knowledge this is the

first panel analysis that provides evidence for asymmetric tax competition in diesel excise taxes in Europe.

The hypothesis referring to the Cabinet composition of government is supported by the results. In accordance with the expectations, left-wing governments are associated with higher taxes than right-wing ones. This broadly supports the idea that the ideological orientation of governments has an effect over macroeconomic policies pursued. In contrast, the hypothesis that governments manipulate diesel excise tax rates before general elections is not confirmed.

APPENDICES

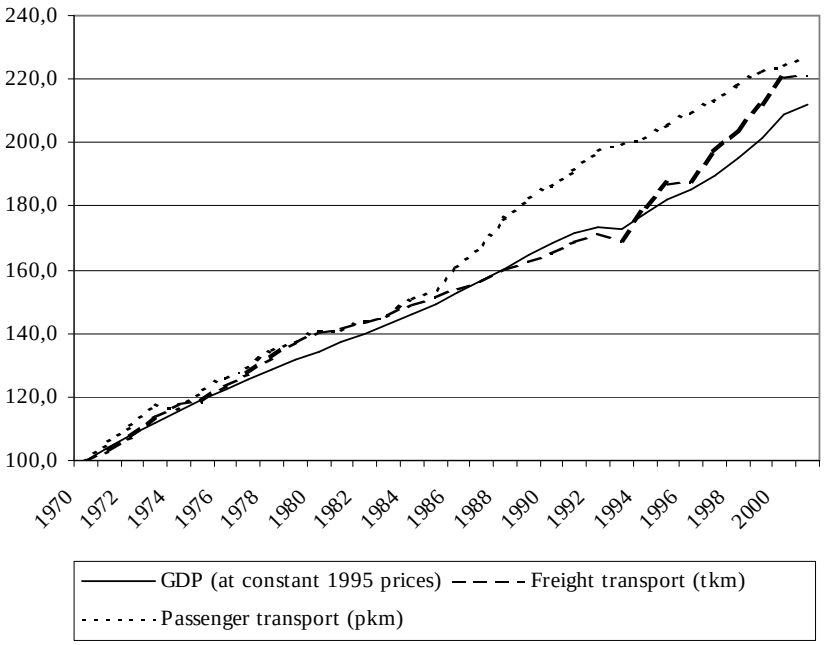
Appendix I

Development of goods and passenger transport

The aim of this Chapter is to provide background information on transport activities and their taxation in the EU-17. In the first section, I provide a snapshot of the main trends in freight and passenger transport in the EU-17 form 1970 to 2001. In the second section, I present a catalogue of road transport related taxes, along with a brief sketch of their structure and evolution over time.

General trends in freight and passenger transport

Transport is a major service industry in the EU-15: it generates an estimated 4 percent of total gross domestic product, and employs some 6 million people or around 4 percent of the total EU-15 workforce (EUROSTAT 2003). Transport services are essential for personal life and are at the center of economic activities. The progress toward an integrated European market, and the overall competitiveness of the EU economy is also greatly affected by the efficiency of its transport system.



Notes: freight transport: road, rail, inland waterways, pipelines, see (intra-EU)
passenger transport: cars, buss and coaches, railway, air
Sources: EUROSTAT, DG Energy and Transport

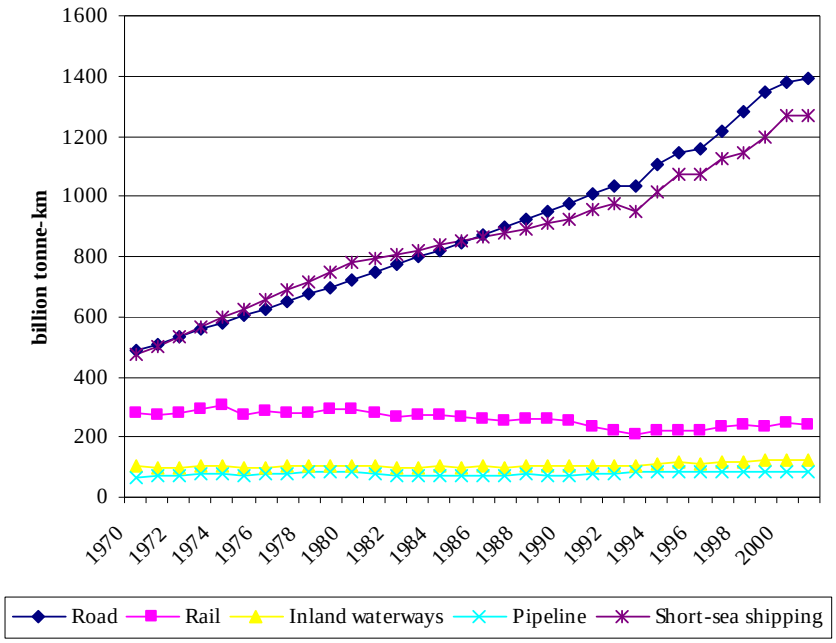
Figure 1. Economic and transport growth, EU-15 (1970=100)

One way to assess the growth of transport sector is by comparing it to the growth of GDP. Figure 1 reports the relative evolution of total transport volumes and that of total GDP for the EU-15 as a whole. Total freight transport (measured in tonne-kilometers) includes road, rail, inland waterways, pipelines and (intra-EU) short-sea shipping. Total passenger transport (expressed in passenger-kilometers) includes cars, buses/coaches, railways and (intra-EU) aviation. GDP trends are based on ECU/EUR in constant 1995 prices.

Figure 1 shows that both passenger and freight transport roughly followed the trend in GDP. Passenger transport displays a higher growth rate than GDP, notably between 1986 and 1992 and primarily due to the steady growth in private car transport. Freight transport grew in line with GDP until 1993, when it separated from it and grew much stronger since, primarily due to the integration of the European markets and the liberalization of road freight.

Freight transport

The freight transport boom since the early 1990s has been motivated by both demand- and supply-side developments. The main drivers on the demand side are primarily the opening up of the Eastern European countries, the integration of the European markets and globalization. These factors have boosted trade and facilitated the development of more complex production networks taking advantage of the removal of cross-border barriers and different labor cost among regions. This has usually resulted greater distances or more trips to cover along the supply chain, and thus to an increase in demand for freight transport. At the same time, lower prices and higher quality of transport services resulting from the liberalization of the road haulage market has provided a rebound (OECD 2003).



Sources: EUROSTAT, DG Energy and Transport

Figure 2. Freight transport trends in the EU-15 for different modes

Figure 2 shows that the considerable growth in freight transport over the last three decades has been almost entirely realized by road and maritime transport in the EU-15, while the share of rail, inland waterways and pipelines has declined substantially. Though transport volumes carried over inland waterways and pipelines were up slightly of their levels of 1970, on the whole they remain low. Rail transport even recorded a decline compared to 1970, though seems to be experiencing a slight rebound over the last decade. On the basis of tonne-km, roads, short-sea shipping, rail, inland waterways and pipelines, respectively, accounted for 44,7 percent, 40,7 percent, 7,8 percent, 4 percent, and 2,8 percent of total freight transport in 2001.[23]

One explanation for the increasing share of road transport at the expense of the other inland transport modes lies in the requirements of modern production and trade patterns. The general trend towards more flexible production methods (such as just-in-time production), along with customer needs for more tailored and specialized goods have led to lower stocks and more frequent deliveries of smaller quantities of goods, and thus to a demand for highly flexible transport services. This change in demand clearly favored road transport. In addition, while liberalization of the road transport market has almost been completed during the 1990s, the rail sector is just starting to open up. Deregulation of road transport has resulted in lower prices and improved quality of services, and thus has led to a strong boost for road transport (OECD 2003).

[23] Two caveats are in order. One concerns the limitation of tonne-kilometer measurement. Measuring in tkm captures the volume aspect of transport, but it is less reflective of other important aspects of transport such as value and traffic density (EUROSTAT 2000). For instance, when performance is measured in turnover, then roads remain the most important mode of transport, but it is followed by air transport that does not even appear when measuring in tkm. The other caveat is related to our exclusive focus on intra-European transport. At the global level the large majority of freight movements are made by ocean freight, with highest growth rate observed for aviation (OECD 2003).

When assessing the performance of road freight transport we also have to consider the fact that most investment in transport infrastructure has been in the road network over the last 30 years. Whereas the motorway network has more than tripled since 1970 in EU-15, the total length of railways line in use as well as the total length of navigable inland waterways has decreased (EUROSTAT 2003).

The situation in most of the member states is similar to the general trends and developments at EU-level, as described above. In what follows we concentrate on inland transport modes only (disregarding short-sea shipping). Table 1 reports the tonne-km figures by mode and the modal split of freight transport for each country and for the EU-15 as a whole. Table 1 underlines that road transport is the main carrier of goods for all Western European countries considered. For two-third of the countries, the share of road transport in total inland transport is greater than 70 percent. Nevertheless, Table 1 also indicates that in some countries rail- and inland waterways transport is also important in moving goods. For inland waterways, Netherlands and Germany show the largest values, and inland waterways also continue to be an important mode in Belgium and Luxembourg. The share of rail transport is considerable in Austria and Switzerland as well as in Finland and Sweden. For Austria and Switzerland this partly reflects the high level of combined (rail-road) transport in these countries.

Rail transport and inland navigation are usually considered to be competitive over long distances. Therefore their weights in the model split are usually higher when (only) international freight transport is considered. For example, the large majority of goods between the Netherlands and Germany has been forwarded over inland waterways. Another example is Switzerland, where three-quarters of the freight crossing the Swiss Alps have been carried by rail (EUROSTAT 2002)

Table 1. Performance and modal split of freight transport for inland transport modes, 2001

	Performance* (tkm)					Modal split (%)			
	Road	**Rail**	**Inland waterw**	**Pipeline**	**Total**	**Road**	**Rail**	**Inland waterw**	**Pipeline**
Austria	28,5	17,4	2,6	8,1	56,5	50,4	30,8	4,5	14,3
Belgium	40,0	7,1	7,6	1,6	56,2	71,0	12,6	13,5	2,8
Denmark	17,6	2,1	-	4,4	24,1	73,2	8,6	-	18,3
Finland	27,6	9,9	0,5	-	38,0	72,6	25,9	1,4	
France	273,7	50,4	6,7	21,1	352,0	77,8	14,3	1,9	6,0
Germany	353,0	74,5	64,8	15,8	508,1	69,5	14,7	12,8	3,1
Greece	19,6	0,4	-	-	20,0	98,0	2,0	-	-
Ireland	7,2	0,5	-	-	7,7	93,3	6,7	-	-
Italy	236,9	21,8	0,2	10,6	269,5	87,9	8,1	0,1	3,9
Luxembourg	2,4	0,6	0,4	-	3,4	71,2	17,1	11,7	-
Netherlands	45,0	3,8	41,9	5,8	96,5	46,6	4,0	43,4	6,0
Portugal	14,5	2,1	-	-	16,6	87,2	12,8	-	-
Spain	141,9	12,2	-	7,8	161,9	87,6	7,5	-	4,8
Sweden	30,0	19,5	-	-	49,5	60,5	39,5	-	-
United Kingd	156,9	19,4	0,2	11,6	188,1	83,4	10,3	0,1	6,1
EU-15	**1394,8**	**241,7**	**125,0**	**86,8**	**1848,3**	**75,5**	**13,1**	**6,8**	**4,7**
Norway	15,1	3,0	-	3,5	21,6	69,9	13,9	-	16,2
Switzerland	22,0	10,4	0,13	0,22	32,7	67,1	31,9	0,4	0,7

*Transport performed on the territory of the country, irrespective of the nationality of operator
Sources: EUROSTAT, DG Energy and Transport

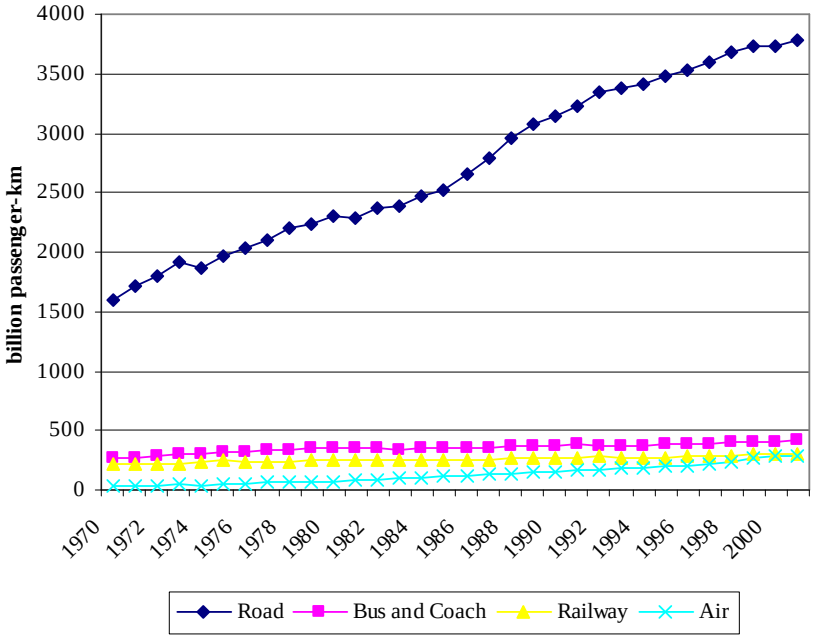
Passenger transport

Total passenger transport performance more than doubled in the EU-15 between 1970 and 2000. This growth is largely explained by the increased demand for personal mobility. People traveled an average of 35 km per day in 2000, while in 1970 they traveled an average of 17 km (EUROSTAT 2003).

Increased mobility is a complex phenomenon that concerns a wide range of demographic, economic and social factors, all of which affect demand for travel. Some of the most important factors include:

- a higher average disposable income (along with the increase in the number of households) resulting in a higher level of car ownership;
- increased labor force participation of women resulting in more work journeys;
- urban spread, leading to an increase in commuting;
- increased leisure time resulting in more holiday journeys and shopping and recreational trips (EUROSTAT 2003, OECD 2003).

Figure 3 underlines that the constantly growing demand for personal mobility has largely been met by a considerable increase in the use of private cars. Private car travel represented around 80 percent of total passenger transport in the EU-15 in 2001. The other modes of transport (i.e. buses and coaches, railways and aviation) had minor shares of less than 10 percent of total passenger-km traveled.



Note: Air: intra-EU and domestic passengers only
Sources: EUROSTAT, DG Energy and Transport

Figure 3. Passenger transport trends in the EU-15 for different modes

The levels and trends of motorization for each country and for EU-15 as whole are reported in Table 2. Car ownership increased by some 260 percent in last 30 years and reached 483 cars per thousand inhabitants in the EU-15 in 2001. Personal car usage more than doubled in the same period and stood at 10077 passenger-km per person per year. On average, households spent 11,4 percent of their total consumption on private car transport, which makes up around 83 percent of their total transport expenditure.

One reason for this spectacular growth in car ownership and usage is the general trend of individualization of work and everyday life in contemporary Western societies; which is reflected for example in the proliferation of single-person households (OECD 2003). Apparently, cars by providing a high degree of independence and flexibility have best matched peoples' needs for individual mobility.

Nevertheless, motorization rate across the member states shows wide disparities, ranging from just 312 cars per thousand inhabitants in Greece to 640 cars per thousand inhabitants in Luxembourg in 2001. Austria, Germany, Italy and Switzerland also had relatively high rates (with 521, 540, 575 and 504 cars per thousand inhabitants, respectively), while Denmark and Ireland recorded relatively low rates (with 350 and 362 cars per thousand inhabitants, respectively). Annual car-kilometers per capita are generally in the range of 8000 to 12000 across the EU-17. It is on average the Italians and the French who traveled the most by car with 12395 and 12292 km per year respectively, whereas the Spanish and the Greek people, with an average of 7063 and 7698 km per year respectively, traveled the less in 2001.

Table 2. Motorization and car usage trends by country

	Motorization level			Car usage			Household expenditure for transport (%)	
	1970	2001	1970-2001 Growth (%)	1970	2001	1970-2001 Growth (%)	2001 total	2001 private car
Austria	160	521	325	4406	8548	194	12,6	10,6
Belgium	213	462	217	4260	10499	246	15,2	14,3
Denmark	218	350	160	6756	10933	162	11,5	10,0
Finland	155	417	270	5145	10987	214	12,3	10,0
France	234	486	207	6001	12292	205	15,1	12,8
Germany	194	540	278	5078	8560	169	14,2	12,3
Greece	26	312	1211	978	7698	788	8,5	4,6
Ireland	133	362	271	3729	9063	243	10,6	8,0
Italy	189	575	304	3938	12395	315	12,2	10,4
Luxembourg	212	640	302	6192	11725	189	-	
Netherlands	197	420	213	5146	8825	171	11,8	10,4
Portugal	49	365	753	1590	8675	546	16,8	15,6
Spain	70	450	639	1904	7603	399	12,6	10,7
Sweden	284	452	159	6975	10297	148	12,5	10,6
United Kingd	214	431	201	5339	10390	195	14,8	11,0
EU-15	**184**	**483**	**263**	**4592**	**10077**	**219**	**13,7**	**11,4**
Norway	179	415	232	-	10642	-	-	-
Switzerland	-	504	-	6782	11697	172	-	-

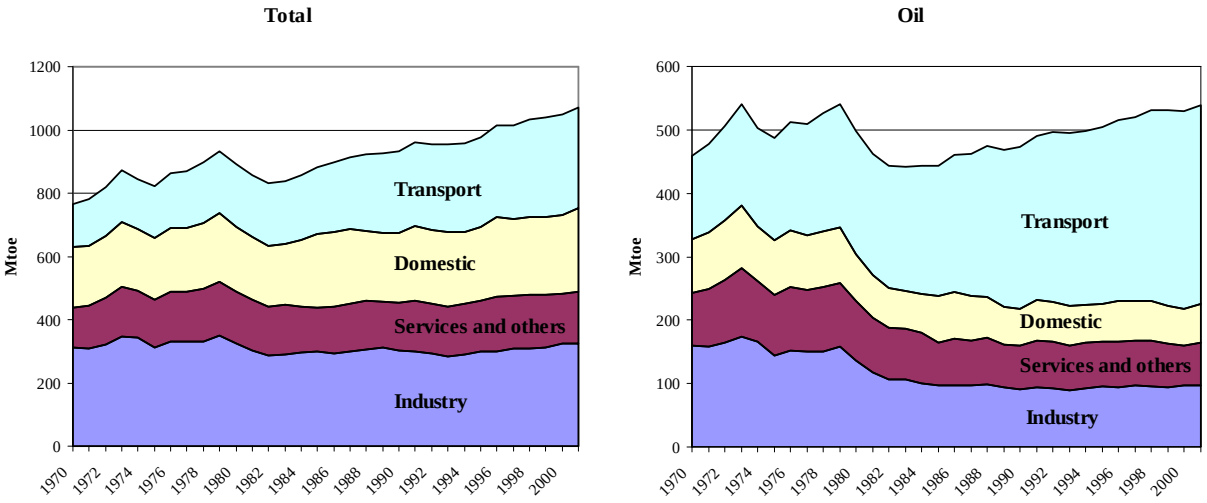
Note: Motorization level: number of passenger cars per 1000 inhabitants
Car usage: passenger-kilometer per person per year
Household expenditure for transport: final consumption in transport as a percent of total consumption
Sources: EUROSTAT, DG Energy and Transport

It is widely accepted that disposable household incomes are a key driver of motorization. A closer look at table 2 however suggests that factors other than income should also be important in determining motorization and car use patterns. These include, but not limited to, country size, the quality and extent of road network, the availability of public transportation and taxation. Denmark for example displays a very low level of car ownership relative to its living standards, which is due to the draconian high taxes levied on new cars. Germany that recorded a high level of car ownership had a low level of car usage in 2001, resulting largely from the former increases in fuel taxes (on top of increasing oil prices) (European Commission 2004).

Energy consumption in the transport sector

The transport sector (excluding maritime transport) accounted for approximately 30 percent of total energy consumption, which was roughly equal to the share of the industry sector, and for almost 60 percent of total oil consumption in the EU-15 in 2001. Energy consumption of the transport sector increased by more than 230 percent between 1970 and 2000 in the EU-15, and accounted for about 64 percent of the increase in energy use since 1970. While oil consumption more than doubled in the transport sector in the same period, it declined substantially in all other sectors of the EU economy, reflecting in part the little possibility of oil substitution in the transport sector. Within the transport sector road transport is by far the largest consumer of oil (with 82 percent in 2001), which also makes road transport a major source of greenhouse gas emissions (with 25 percent of total carbon dioxide emissions in EU-15 in 2001).

Although both cars and trucks have improved in fuel efficiency, it was barely enough to offset growth in freight and passenger transport. In addition, the tendency to purchase more powerful cars has also contributed to offsetting technical developments. As a result, total energy use has increased about as much as total transport activity in the EU-15 during the last 30 years (IEA 2004).



Note: final energy consumption is the sum of consumption by the different end-use sectors
Mtoe: million tonne-oil equivalents
Source: IEA: Energy Balances of OECD Countries

Figure 4. Evolution of final energy consumption in different sectors in EU-15

Appendix II

Proof of Propositon 1-2 with 1(1+*t*) demand function form

In this section I construct a simple theoretical framework that may serve as a background for first difference models on commodity tax competition. In the main text I argue that first difference models aimed at assessing asymmetric tax competition lack a theoretical framework. Existing theories show no connection between size and response once response is measured in tax-change.

The proposed model is an extension of Nielsen (2001) to allow for elastic demand for the taxed good. In Nielsen (2001), each resident purchases one unit of the good irrespective of its price, i.e. the demand for the good is perfectly inelastic ($x(t)=1$). In our model the individual demand function for the taxed good is taken to be

$$x(t)=\frac{1}{1+t}. \qquad (1)$$

Thereby we introduce a demand function into the model, which is though not perfectly inelastic, it still belongs to the family of "inelastic demand functions" with price elasticity of greater than –1 for all $p > 0$. Apart from this modification, the whole theoretical construct is equivalent to the one in Nielsen (2001). The model has two countries, together represented by the interval [-1,1]. We assume that customers are evenly spread over the interval [-1;1] with unit density. The population of each country thus corresponds to its linear extension. Population sizes are $(1 + b)$ and $(1 – b)$, respectively, where b stands for some border parameter ($b > 0$).

For simplicity the production cost of the good is assumed to be zero. Thus, the market price of the good in each country is equal to the tax charged (denoted by *t* and *T* in the small and the large country, respectively). We assume that traveling to the border (and back) entails a cost of *d* per unit of distance traveled.

For simplicity, we assume that the representative consumer has a quasi-linear utility function[24]:

$$U = (x, x_0) = u(x) + x_0 \qquad (2)$$

where x is the taxed good under consideration and x_0 involves all the other goods consumed by the consumer; i.e. the numeraire good. The utility maximization problem for this form of utility is

$$\max_x \quad u(x) - tx + M \qquad (3)$$

This has the first order condition

$$u'(x) = t \qquad (4)$$

[24] The quasi-linear function is often used in applied works. It is convenient because it results in a simple demand structure; demand is only dependent on price. This framework is appropriate as long as only a small fraction of total income is spent on purchasing the good to be considered. In such situations we can ignore the income effect associated with the purchase of the good. This framework seems to be satisfactory in our case too, since only a small fraction of all goods consumed by an individual is normally obtained through cross-border shopping.

which is also an expression of the inverse demand function for *x*. Combining (1) and (4) we obtain the explicit form of the utility function for the consumer

$$U = (x, M) = \ln(x) - xt + M \qquad (5)$$

By substituting the demand function into (5) we receive the indirect utility function

$$v(t, M) = M - \ln(t + 1) \qquad (6)$$

The indirect utility function expresses the amount of surplus that the consumer is obtaining when buying *x* at price *t*.

The cross-border decision can be characterized as follows. An individual in the large country will purchase the good in the small country if and only if her surplus by doing so $v(t, M - sd)$ exceeds the surplus from buying at home $v(T, M)$, where *s* stands for the distance between her location and the border. This is satisfied when

$M - sd - \ln(t + 1) \geq M - \ln(T + 1)$, or

$$\ln(T + 1) - \ln(t + 1) \geq sd \qquad (7)$$

Thus, the number of residents of the large country shopping abroad is

$$\frac{\ln(T + 1) - \ln(t + 1)}{d} \qquad (8)$$

Hence, the tax revenue in the large country and the small country, respectively amount to

$$R(T,t) = \left[1 + b + \frac{\ln(t+1) - \ln(T+1)}{d}\right] x(T)T \tag{9}$$

$$r(t,T) = \left[1 - b + \frac{\ln(T+1) - \ln(t+1)}{d}\right] x(t)t \tag{10}$$

We get the following two equations from revenue maximization

$$\ln(T+1) + T = c(1+b) + \ln(t+1) \tag{11}$$

$$\ln(t+1) + t = c(1-b) + \ln(T+1) \tag{12}$$

Unfortunately, we cannot solve (11) and (12) explicitly for T and t, respectively. In other words, we cannot provide an analytical solution for the best reply functions. Fortunately, however, we can derive the inverses of the best reply functions, which allow us to provide a graphical solution to the problem. The best reply functions of the two countries and the resulting Nash equilibrium are presented in Figure 1.

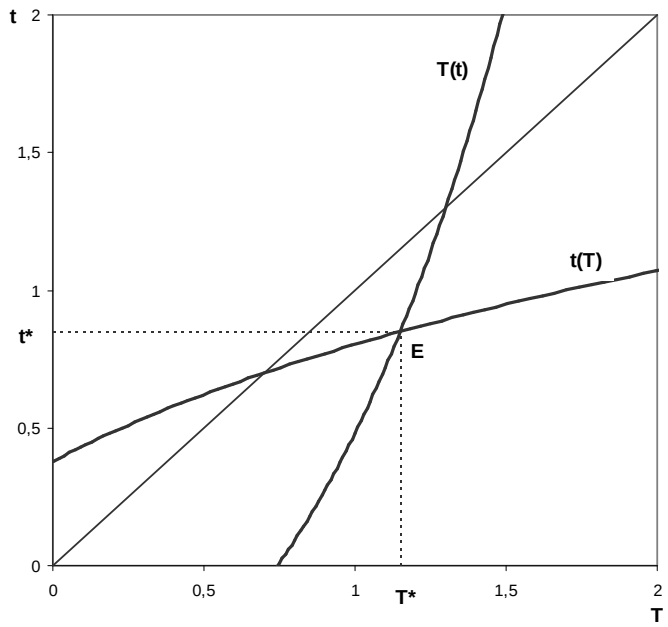


Figure 1. Best responses and Nash equilibrium in the extended model

The two equations (11) and (12) allow to solve for two unknowns, T^* and t^*. However we cannot provide an analytical solution. Fortunately, we are still able to establish some important properties of the Nash equilibrium.

Adding (11) to (12), we get

$$T^* + t^* = 2c \qquad (13)$$

Subtracting (12) from (11) we get

$(T^* + 2\ln(T^* + 1)) - (t^* + 2\ln(t^* + 1)) = 2cb$, or

$$T^* - t^* + 2\ln\frac{(T^* + 1)}{(t^* + 1)} = 2cb \qquad (14)$$

Since both $(T^*+\ln(T^*+1))$ and $(t^*+\ln(t^*+1))$ takes on non-negative values for any $T^*,t^* \geq 0$, and both are increasing in T^* and t^*, respectively, from (13) and (14) we established that the Nash equilibrium is necessarily and uniquely exists for any c,b $\geq$ 0. Further, since $\frac{(T^*+1)}{(t^*+1)}$ is strictly increasing in T^*-t^*, and thus $2\ln\frac{(T^*+1)}{(t^*+1)}$ is also strictly increasing in T^*-t^*, we proved that T^*-t^* is increasing if and only if when $2cb$ is increasing.

Our findings show that the most important results of the original model carry over to the extended model: *(i)* the reaction functions are positively sloped, *(ii)* the Nash equilibrium necessarily and uniquely exists, *(iii)* the small country strictly undercuts the large country and *(iv)* the equilibrium tax differences, T^*-t^*, increases as the disparity in size increases.

We can now turn to the examination of the empirically important issue, namely the question as to *whether we can establish a systematic relationship between* ΔT *and* Δt *in the extended model*. Using the Implicit Function Theorem we derive dT/dt and dT/dt within the neighborhood of the Nash equilibrium tax rates (T^*,t^*) from (11) and (12), respectively, and then we solve the such-obtained equations for dT and dt to get

$$dT = \frac{(T^*+1)}{(T^*+2)(t^*+1)}dt \qquad (15)$$

$$dt = \frac{(t^*+1)}{(t^*+2)(T^*+1)}dT \qquad (16)$$

where $\frac{(T^*+1)}{(T^*+2)(t^*+1)} = A$ and $\frac{(t^*+1)}{(t^*+2)(T^*+1)} = a$ measure, respectively, the responsiveness of the large country and the small country to a marginal tax-change in its neighbor.

Elementary calculations show that

$$A > a \qquad \text{for any } T^* > t^* \tag{17}$$

Using the Implicit Function Theorem we can show that there is a function $T = f(t)$ $(t = g(T))$ corresponding to the relationship defined by (11) ((12)). Both $f(t)$ and $g(T)$ are continuous and are increasing at a decreasing rate for all $t, T \geq 0$. Note also, that their first and second derivatives are the same at $t = T$. Hence, for any $T_1^* > t_1^*$, $\frac{\partial f(t_1^*)}{\partial t}\left(= \frac{dT}{dt}\right) > \frac{\partial g(T_1^*)}{\partial T}\left(= \frac{dt}{dT}\right)$, as is already shown in (17). Furthermore, for any $T_2^* - t_2^* > T^*_1 - t_1^*$ such that $T_2^* > T_1^*$ and $t_2^* < t_1^*$ (a restriction implied by the equilibrium condition: $T^* + t^* = 2c$), $\frac{\partial f(t_2^*)}{\partial t} - \frac{\partial f(t_1^*)}{\partial t} > \frac{\partial g(T_2^*)}{\partial T} - \frac{\partial g(T_1^*)}{\partial T}$. This latter implies that

$$A - a \text{ is increasing in } (T^* - t^*). \tag{18}$$

This shows that the difference in responsiveness to a tax-change increases as the equilibrium tax difference increases (as a response to an increase in the difference in size).

(Note that the relationship between dT and dt (dt and dT) can thought of as an estimate for the true relationship between ΔT and Δt (Δt and ΔT). However, as shown above, there is a

function $T = f(t)\,(t = g(T))$ corresponding to the relationship defined by (11) ((12)). Note that both $f(t)$ and $g(T)$ are increasing at a decreasing rate for all $t, T \geq 0$. Note also, that their first and second derivatives are the same at $t = T$. Hence, if $T_1 > t_1$, than for any $\varepsilon \in (0, \infty)$, $\Delta T > \Delta t$, where $\Delta T = f(t_1 + \varepsilon)$ and $\Delta t = g(T_1 + \varepsilon)$. Similarly, if $T_2 - t_2 > T_1 - t_1$ such that $T_2 > T_1$ and $t_2 < t_1$ (a restriction implied by the equilibrium condition: $T^* + t^* = 2c$), than $\Delta T_2 - \Delta t_2 > \Delta T_1 - \Delta t_1$. Thereby we proved that all what we showed for the relationships between dT and dt (dt and dT) in (17) and (18) also holds for the relationships between ΔT and Δt (Δt and ΔT).)

The above obtained results demonstrate that the extended version of Nielsen (2001), suggested by us, is a suitable theoretical framework for panel regression models estimating fiscal reaction functions in first differences. First, the model establishes that there is a systematic relationship between ΔT and Δt. Second, it shows that the (relative) size of a country has an unambiguous effect on its responsiveness to the tax-change in its neighbor. A small country is less responsive to the tax-change in its neighbor than a large country. Thus, the small country's undercutting behavior in the level model translates into less responsiveness on its side in the first difference model.

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