Commodity tax competition among European countries:
The case of diesel, petrol and cigarette taxes

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Abstract

This paper applies an asymmetric tax competition model to assess the importance of both neighboring countries' tax policy and country size in the setting of commodity taxes in European countries. This model predicts that small countries set lower commodity tax rates and respond less strongly to other country's tax rate than do large countries (Paizs, 2010). I test these predictions on a panel data set of 16 European countries. The data on diesel and petrol taxes span from 1978 to 2005, while the data on cigarette prices span from 1990 to 2007. The empirical analysis provides strong evidence for strategic interaction in the setting of diesel and petrol excises and confirms the effect of country size on the slope of the reaction function. It is also shown that strategic interaction between EU countries has intensified considerably in the 1990s. These findings confirm that it is tax competition that drives small European countries to set lower fuel tax rates than their larger neighbors since the 1990s and thereby also explains why the EU's minimum tax policy has failed to harmonize fuel taxes across member states. The evidence for cigarettes taxes is mixed.

Keywords: tax competition, asymmetric regions, commodity taxes, minimum tax, European Union
JEL classification: H70, H77, H87

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Introduction

There are two main reasons to expect that taxes on diesel, petrol and cigarettes are subject to the forces of tax competition in the European Union. Firstly, motor fuels and cigarettes are the most heavily taxed commodities in the European countries. Therefore, under the present purchased-based system there is an incentive for European consumers to buy these commodities in countries where the tax burden on them is lower. Secondly, the large size asymmetry between European countries should also act as catalyst for interstate tax competition. According to Kanbur and Keen (1993) and Wilson's (1991) analysis of "asymmetric tax competition", small jurisdictions tend to set lower tax rates than large jurisdictions, and the formers may substantially benefit from tax competition if differences between jurisdictions are sufficiently large.[1] This suggests that size asymmetry facilitates tax competition, since the larger is the difference between jurisdictions, the more likely is that small jurisdictions are better off under tax competition and therefore wish to initiate it in the first place.

The pattern of commodity tax rates and the available evidence on cross-border shopping in EU countries are consistent with the above argument. Small European countries tend to levy lower tax rates on diesel, petrol and cigarette than large countries do. For example, in 2005, the diesel excise level in small-sized countries was on average 15 percent lower than the diesel excise level in the large-sized European countries. In the same year, the average price of one pack of Marlboro was 4 euro in the small countries while it was 5 euro in the large countries.

There is also evidence that tax-induced cross-border shopping for motor fuels and cigarettes are occurring on a large scale at some borders. For example, in Germany where diesel is more expensive than in neighboring countries (due to higher excise duties), in 2004, 10 percent of all domestically consumed diesel was cross-border shopped, implying a tax revenue loss of Euro 2 billon to the German Treasury (Commission, 2007). On the other hand, in Austria where diesel is relatively cheap, it is estimated that 30 percent of fuel purchases on the domestic market is due to fuel tourism from neighboring countries (Austrian Energy Agency, 2009).

In a recent study on tobacco taxation in the EU countries (Commission, 2008), it was found that smuggling and cross-border sales of tobacco products in 2004 represented approximately 13 percent of the total EU tobacco market. Legitimate cross-border shopping accounted for 4 to 5 percent of the EU tobacco market, while illegitimate smuggling represented 8 to 9 percent of final sales. The study also notes that in a number of member states like in France, Germany and the United Kingdom, the share of non-domestically taxed tobacco consumption in total domestic consumption is more than 20 percent, i.e. well above the EU average of 13 percent (Commission, 2008).

Motivated by the above observations, this paper seeks to assess the importance of tax competition in the setting of motor fuel and cigarette taxes among European countries. For the empirical analysis I use a panel data of tax rates and prices from 16 European countries. The data on diesel and petrol excises span from 1978 to 2005, while the data on cigarette prices span from 1990 to 2007. Following the empirical literature on strategic interactions initiated by Case et al. (1993) I estimate tax reaction functions for national governments. The analysis contributes to the existing literature in a number of important ways. Firstly, in line with the theoretical prediction in Paizs (2010), I augment the reaction function equation with an

[1] In fact, Kanbur and Keen (1993) show that for any high pre-competition level of the tax rate there exists such a big size difference between the two countries that the small country would be better off with the tax competition outcome (Kanbur and Keen, 1993).

interaction term between foreign tax rates and country size. The interaction term captures the effect of country size on the slope of the reaction function.

Secondly, the regression analysis is conducted using the first-differences of variables to ensure the stationarity of the data. Although tax rates are often non-stationary processes, tax competition studies rarely apply a first-difference framework as it makes testing the level effect of country size difficult. Utilizing the fact that the interaction effect of country size enters into the first-difference equation exactly as in the level specification, I seek to test the theory by examining this effect.

Thirdly, in the literature, the endogeneity of tax rates in neighboring countries are usually treated by using instrumental variable technique. The typical approach is to predict the neighbors' tax rates by using the neighbors' economic and political characteristics as instruments. One potential criticism of this approach is that the neighbors' economic conditions are likely to be correlated with unobserved country characteristics due to the synchronization of business cycles across countries. To address this concern I depart from the standard approach by using only the neighbors' political covariates and the spatial lag of the endogenous variable to instrument for the neighbors' tax rate.

The main findings of the analysis are as follows. First, I find strong evidence for tax competition in diesel and petrol excises between European countries in the period 1978 to 2005. My estimation shows that 10 percent increase in the neighbors' excise tax rates on diesel induces 2.5 percent increase in a country's diesel excise rate. The effect for petrol excises is similarly strong. Second, consistent with the theoretical model of tax competition with elastic demand for the taxed good in Paizs (2010), I find strong evidence that country sizes affect the slope of the reaction function. The estimation shows that in response to a 10 percent increase in neighboring countries' diesel and petrol tax rates, an average large country raises its diesel tax rate by 4.4 percent while an average small country increases its tax rate only by 1.3 percent. For petrol I find that 10 percent increase in neighboring countries' tax rates induces a large country to raise its tax rate by 4.9 percent while a similar change in other countries' tax rates induces a small country to increase its tax rate only by 1.3 percent. Third, I show that strategic interaction in the setting of diesel excises has substantially intensified in the 1990s. These results are supportive of the view that it is the process of asymmetric tax competition that drives small European countries to set lower tax rates than their larger neighbors since the 1990s and thereby also explain why the EU's minimum tax policy adopted in 1993 has failed to harmonize fuel tax rates across member states.

I do not find robust evidence for tax competition in cigarette taxes. One explanation for this is that cigarette taxes are also used as a tool to combat smuggling and the two goals of reducing smuggling and responding optimally to the tax rates in neighboring countries can be in conflict. Large-scale organized cigarette smuggling is widespread in several European countries. The governments of these countries usually keep their cigarette tax rates low to reduce the level of illegal sales. It is likely that these countries are less willing to react to an increase in their neighbors' tax rates as it would undermine their effort to reduce smuggling. Therefore interstate tax competition is likely to play a less important role in determining these countries' tax rates, which explains the weak evidence of tax competition over cigarette tax rates found in this work.

The reminder of this paper is organized as follows. Section 2 provides a theoretical framework for the empirical analysis. Section 3 elaborates the econometric model, discusses the main issues in estimation and presents the data. Section 4 discusses the empirical results. Section 5 assesses the performance of the EU's minimum tax rate policy. Finally, Section 6 concludes with some policy implication of my results.

2 Theoretical background

Since the primary purpose of this study is to empirically analyze commodity tax competition, I restrict myself to summarize the main results of the underlying theory. I start with a summary of the standard model. This is followed by a description of the model that incorporates elastic individual demand for the taxed good as suggested by Paizs (2010).

2.1 The standard model

The standard asymmetric tax competition model describes a situation in which a small and a large country compete for the purchases of consumers by setting taxes in a strategic fashion. The two countries may differ in population density, as in Kanbur and Keen (1993) or in their geographical extensions as in Nielsen (2001). The following discussion is based on the theoretical model presented in Nielsen (2001).

The two countries lie on the interval $[-1;1]$ with a border between them at b. The population of each country corresponds to its linear extensions: $(1+b)$ and $(1-b)$, respectively. Each resident purchase one unit of the good irrespective of its price, i.e. the individual demand for the good is perfectly inelastic .Consumers may purchase the commodity in one of the following two ways: (1) the consumer can buy the good at her doorstep or (2) the consumer can cross-border shop for the commodity. In the latter case, the consumer has to travel to the border, incurring travel cost. It is assumed that travelling to the border (and back) entails a cost of d per unit of distance travelled. Suppose that the tax rate set in the country i is higher than the tax rate set in the country j, i.e. $\tau_i > \tau_j$. (For simplicity it is assumed that the price of the good is equal to the tax imposed on it.) Cross-border shopping is beneficial for those consumers in country i for whom the price saving, $\tau_i - \tau_j$, outweigh the cost of travelling dg, where g stands for the distance to the border. Thus the number of cross-border shoppers from country i to country j is $(\tau_i - \tau_j)/d$ (Nielsen, 2001).

From the perspective of a government, the possibility of cross-border shopping implies that its tax base is sensitive to the tax differential between the two countries. In the country with the lower tax rate, the government's tax base consists of the demand of all domestic consumers plus the purchases of cross-border shoppers from the high-tax country, while in the country with the higher tax rate the domestic tax base is reduced by the purchases of cross-border shoppers. Governments are assumed to be revenue maximizers. Assuming that they set their tax rates in a Nash manner, the following reaction functions are obtained (Nielsen, 2001):

$$r_1(\tau_2) = \frac{d(1+b)}{2} + \frac{1}{2}\tau_2 \qquad \text{and} \qquad r_2(\tau_1) = \frac{d(1-b)}{2} + \frac{1}{2}\tau_1 \tag{1}$$

Solving the above equation system for τ_1 and τ_2, result in the following equilibrium tax rates of the game:

$$\tau_1^* = d\left(1+\frac{b}{3}\right) \qquad \text{and} \qquad \tau_2^* = d\left(1-\frac{b}{3}\right) \tag{2}$$

As shown in (2), the main result of Nielsen' analysis is that the small country undercuts the large country in the equilibrium. The intuitive explanation for this result is the following. By reducing its tax rate, any government is able to attract additional consumers to its territory.

However the benefit from attaining an additional consumer has to be evaluated against the cost resulting from the lower per capita tax revenue. Given its smaller domestic tax base, the small country's government perceives this loss to be relatively smaller. Therefore the small country's government has a stronger incentive to attract cross-border shoppers and therefore it undercuts the large country in the equilibrium.

2.2 The extended model

Paizs (2010) extends the commodity tax competition model of Nielsen by allowing for the individual demand for the taxed good to be price elastic. This extension is motivated by the general notion that the demand for motor fuels and cigarettes are responsive to prices. Empirical works show that the short-run elasticity of motor fuels is in the range of -0.2 and -0.3 while the same numbers for the long-run elasticity is in between -0.6 and -0.8 (Fulton and Noland, 2005). Estimates of the price elasticity of demand for cigarettes in the European countries fall in the range of -0.5 to -0.7 (Gallus et al. 2006) Accordingly, Paizs (2010) represents the demand for the taxed good with a constant elasticity function with elasticity lower than one ($x(\tau)=\tau^{\varepsilon}$). The extended model results in the following reaction functions and equilibrium tax rates:

$$r_1(\tau_2)=\left[\frac{(1+\varepsilon)d(1+b)}{2}+\frac{1}{2}\tau_2^{1+\varepsilon}\right]^{\frac{1}{1+\varepsilon}} \quad \text{and} \quad r_2(\tau_1)=\left[\frac{(1+\varepsilon)d(1-b)}{2}+\frac{1}{2}\tau_1^{1+\varepsilon}\right]^{\frac{1}{1+\varepsilon}} \tag{3}$$

$$\tau_1^*=\left[(1+\varepsilon)d\left(1+\frac{b}{3}\right)\right]^{\frac{1}{1+\varepsilon}} \quad \text{and} \quad \tau_2^*=\left[(1+\varepsilon)d\left(1-\frac{b}{3}\right)\right]^{\frac{1}{1+\varepsilon}} \tag{4}$$

As can be seen from Eq. (4), Paizs (2010) also finds that the small country sets a lower equilibrium tax rate than does the large country. This shows that Nielsen's main result is robust to the introduction of price elastic individual demand. However, the two models generate different prediction about the slopes of the reaction functions. While in the inelastic demand model the reaction functions for the two countries are linear and equally sloped (as can be seen from Eq. (1)), in the elastic demand model the reaction functions are concave and their slopes are different for the two countries. From Eq. (3) and (4) it can be easily shown that the reaction function of the small country has a lower slope than that of the large country in the equilibrium when $-1<\varepsilon<0$. This means that, in contrast to the standard model, the price elastic demand model predicts that the two countries have a different response to a change in their neighbor's tax rate. The small country responds less strongly to a change in its neighbor's tax rate than does the large country. The intuitive explanation for this result is the following. As shown by Paizs (2010), the small country's tax base is more responsive with respect to a change in the own tax rate compared to the large country. Therefore, for the small country any increase in the tax rate causes a higher loss in the tax base than for the large country and thereby it feels less incentive to raise its own tax rate when the foreign tax rate increases.

The above discussion leads to the following hypotheses.

Hypothesis 1 (Kanbur and Keen, 1993; Nielsen 2001; Paizs, 2010) *A country's tax rate is positively related to the tax rates of its neighbors; i.e. the reaction functions are upward sloping.*

Hypothesis 2 (Kanbur and Keen, 1993; Nielsen, 2001; Paizs, 2010) *Countries that are small relative to their neighbors tend to set lower tax rates.*

Hypothesis 3 (Paizs 2010) *Small countries tend to respond less strongly to changes in their neighbors' tax rates than large countries do; the small country's reaction function is less steep than that of the large country.*

3. Empirical investigation

3.1. The econometric model

In this section I test the theory using a panel data set of fuel tax rates and cigarette prices from 16 European countries. This is done by estimating tax reaction functions for national governments. The theoretical framework above suggests the following empirical specification for the reaction functions:

$$\tau_{it} = \alpha_i + \beta \sum_{j \neq i} \omega_{ij} \tau_{jt-1} + \delta \sum_{j \neq i} \omega_{ij} \tau_{jt-1} \cdot Size_i + Size_i \gamma + \theta X_{it} + d_t \varphi + u_{it} \qquad (5)$$

where τ_{it} represents the diesel excise tax rate set by country i in period t, ω_{ij} are *a priori* determined weights, $Size_i$ denotes the time invariant variable for the size of country i, $X_{i,t}$ is a vector of relevant characteristics of country i in period t, and d_t is a set of year dummies. The weights ω_{ij} are used to aggregate foreign tax rates (relevant to the decision of country i) into a single variable $\sum_{j \neq i} \omega_{ij} \tau_{jt-1}$, which is hereafter called as neighbors' tax rate. The ω_{ij} are normalized, so that $\sum_{j \neq i} \omega_{ij} = 1$. In effect, each country is expected to react to the weighted average of the tax rates of its neighbors. I discuss in the next section the weighting schemes I use.

This specification is broadly consistent with the one used in other studies, except that my equation also incorporates an interaction term between neighbors' tax rate and country size. The inclusion of the interaction term follows from my theoretical model, which suggests that the effect of the neighbors' tax rates differ across countries according to their size.

I have chosen to estimate the model in first-differences to account for the fact that fuel tax rates as well as cigarette prices have been trending upward over the examined time period (see later). The panel unit root tests confirm that all the variables are stationary in their first-differences. Taking the first-differences of Eq. (5) gives

$$\Delta \tau_{it} = \beta \Delta \sum_{j \neq i} \omega_{ij} \tau_{jt-1} + \delta \Delta \sum_{j \neq i} \omega_{ij} \tau_{jt-1} \cdot Size_i + \theta \Delta X_{it} + d_t \varphi + u_{it} \qquad (6)$$

Note that the time invariant variable $Size_i$ drops out of the first-difference model. Therefore in this framework we cannot formally address the main prediction of the standard model that small countries levy lower tax rates then their larger neighbors. However, the interaction term enters into the first-difference equation exactly as in the level specification. Thus we can test the prediction from the more general model that suggests that small countries react less intensively to changes in neighbors' tax rates then large countries do. To be in line with the theoretical model, I demand that the total effect of a change in neighbors' tax rate, i.e.

$\beta + \delta \cdot Size_i$ would be positive and that this effect would increase with country size, i.e. $\delta > 0$.

Following from the assumption that the tax rates in different countries are jointly determined, the neighbor's tax rate and the interaction term in Eq. (6) must be treated as endogenous. I address the endogeneity problem in two ways. First, as indicated in (6), I use the lagged values of the endogenous variables for the estimation, which can be thought of as a partial solution for endogeneity. Second, I estimate (6) using the spatial two stage least squares (2SLS) procedure outlined in Kelejian and Prucha (1998). Under this procedure, the neighbors' exogenous explanatory variables are used to instrument for the neighbors' tax rate. In the first stage I estimate two reduced form equations, one for the neighbor's tax rate and one for the interaction terms, regressing the endogenous variable on the weighted average of the neighbors covariates ($\Delta\sum_{j\neq i}\omega_{ij}X_{jt-1}$), its interaction with size ($\sum_{j\neq i}\omega_{ij}X_{jt-1}\cdot Size_i$) and the home country's covariates (ΔX_{it}). For this procedure to yield unbiased estimates, the neighbors' covariates used as instruments should not be correlated with the error term. This condition is unlikely to hold for economic covariates, since the neighbors' economic conditions are likely to be correlated with unobserved country characteristics. This problem is usually ignored in the literature where empirical works implementing IV procedure typically use macroeconomic and/or fiscal variables as instruments. I will follow a more conservative approach and use the neighbors' political covariates to instrument for the neighbors tax rate. It is plausible to assume that a neighboring country's political covariates are exogenous to the own country's tax rate and, therefore, provided that they affect the neighboring country's tax rate, they can be used to identify the home country's strategic responses. I will investigate party composition of governments, an election year dummy and post-election year dummy variables as potential instrument. Further, following the method used in Altshuler and Goodspeed (2003) and also in Egger at al. (2005), I add the weighted average tax of the neighbors' neighbors as additional instrument. As argued by Altshuler and Goodspeed (2003), 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.[2]

3.2. The weighting scheme

If a country has more than one neighbor (competitor), the value of the neighbors' tax rate is calculated as the weighted average of the neighbor countries' tax rates. This procedure is widely used in the literature and enables us to keep the parameters to be estimated within reasonable limits. The construction of weights starts with determining which countries are in competition with one another. Since cross-border shopping typically takes place between contiguous countries, it is plausible to assume that countries typically view only their geographical neighbors as competitors. Accordingly, in case of petrol taxes and cigarette prices I calculate the average foreign tax rate (price) using *border weights.* Border weights are defined in the following way:

[2] 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*.)

$$\omega_{ij} = \begin{cases} 1/n_i & \text{if} \quad j \in N_i \\ 0 & \text{if} \quad j \notin N_i \end{cases} \tag{7}$$

where N_i is the set of countries bordering country i, and $n_i = N_i$.

While in case of petrol and cigarette cross-border purchases are typically made by private persons, in cross-border shopping for diesel commercial carriers (buses and trucks) play the main role. This motivated the construction of a weighing scheme based on cross-border commercial traffic. In the suggested weighting scheme, weights are dependent on the volume of heavy motor vehicle traffic at common border crossings:

$$\omega_{ij} = \begin{cases} h_{ij} / \sum_{j \in N_i} h_{ij} & \text{if} \quad j \in N_i \\ 0 & \text{if} \quad j \notin N_i \end{cases} \tag{8}$$

where h_{ij} is the annual average daily traffic by heavy trucks at the border of country i and country j.[3] I will refer to this scheme as *traffic flow weights* from now on. Using these weights I essentially assume that, in case of diesel, neighboring countries compete primarily for the fuel purchases by truck and bus drivers.

One problem in implementing (7) and (8) is how to handle direct traffic between two countries being separated only by narrow strip of see. For example, a large number of trucks travel between Sweden and Denmark without passing through a third country using ferry services. Since these vehicles constitute a potential for exploiting fuel price differences between these two countries, I treated Sweden and Denmark as neighbors to each others and considered the volume of traffic flow between them in calculating (7). For similar reasons, direct freight traffic flows between the United Kingdom on the one hand and France, Belgium and the Netherlands on the other were also considered in computing (7). To allow for a more direct comparison between border weights and traffic flow weights, my border weights apply the same definition of competitors as the traffic flow weights (but continue to attach equal weight to each competitor).

3.3. Data and variables

Dependent variable

The data on diesel and petrol tax rates are collected from the International Energy Agency's *Energy Prices and Taxes* database. This database provides information about prices and taxes for automotive diesel and petrol from 1978 onwards. As a measure for the fuel tax, I take excise levels, expressed in current EUR per liter (current ECU per liter before 1999). In a recent paper, Evers et al. (2004) use the tax ratio defined as a ratio of the excise and the price (inclusive of excises) to investigate tax competition in diesel excises among EU countries. I prefer the use of statutory tax rates over tax ratios for two compelling reasons. First, while the level of statutory rate in a country is exclusively decided by the government, tax ratios include the producer price of fuel which governments have no control over. Second, the producer price of fuel in every European country follows the world price of crude oil, implying that tax ratios are correlated across countries due to common oil price shocks. This means that for this

[3] The data on heavy vehicle motor traffic were taken from the UNECE's 2000 Combined Census of Motor Traffic and Inventory of Standards and Parameters on Main International Traffic Arteries in Europe (UNECE 2003).

tax variable it is more difficult to convincingly demonstrate that the interdependence of national tax polices is attributable to true strategic interactions and is not driven by common shocks.

For diesel and petrol I use a balanced panel of data from 16 Western European countries – the old EU-15 without Greece but including Norway and Switzerland – between the period 1978-2005. Greece has been left out because it has no common border with any of the former EU member states.

As compared to motor fuel tax rates, data on cigarette tax rates are more difficult to collect. Although the European Commission's Excise Duty Tables contain such information for EU member countries, they do not provide data for Norway and Switzerland and in case of Austria, Finland and Sweden the data series start from 1995. The data limitation on tax rates in the case of cigarette led me to use consumer prices (with taxes) as a proxy for the tax burden. Information on cigarette prices was taken from the Economic Intelligence Unit's (EIU) CityData database. This database contains pricing information on more than 160 products and services in 140 cities worldwide from 1990 onwards. The CityData provides information on the prices of two cigarette brands – Marlboro and a local brand – sold at two types of outlet (supermarket and mid-price retail outlet). As dependent variable I use the price of Marlboro sold at supermarket. For countries with more than one cities included in the database, the price of cigarette was calculated as the simple average of cigarette prices in these cities. The choice of using as dependent variable the prices of Marlboro cigarettes instead of the local brand was motivated by the observation that illegal sales of cigarettes mostly involves international brands (Joossens and Raw 1998).

For cigarette, I use a balanced panel of data from the same 16 Western European countries between the period 1990-2007.

Country size

My second key variable is country size. For each commodity I use two alternative variables to measure the size of a country. In case of diesel, these are the total surface area of the country (in square kilometers) and the value of its gross domestic product in the mid-year of the sample. In case of petrol and cigarettes, country size is captured by its total surface area and the size of its population in the mid-year of the sample. The former variable is consistent with the theoretical model in Nielsen (2001) while the latter corresponds to the model in Kanbur and Keen (1993) and in Paizs (2010). Previous empirical studies tend to use an absolute measure of country size, with the exception of Egger et al. (2005) and Jacobs et al. (2007) who use both domestic country size and the weighted country size of neighbors as explanatory variables. Because I estimate the model in first differences I prefer to measure country size in relative terms. The relative country size variable is computed as a ratio of domestic country size to the weighted country size of neighbors. The latter is calculated using the same weights as those used to average the taxes of neighbors (ω_{ij}).

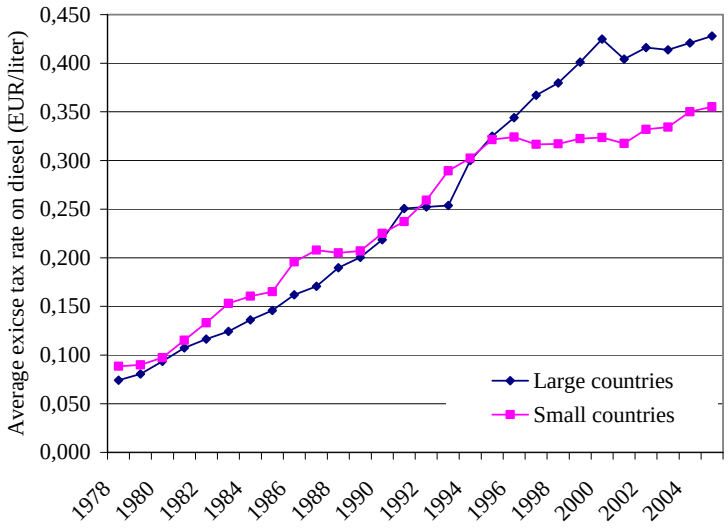
Control variables

I control for a number of other factors that may explain differences in fuel excise tax rates and cigarette prices across time and countries. I introduce two dummy variables controlling for the effect of electoral cycles: an election and post-election year dummy variables. To account for the possibility that left-wing and right-wing governments pursue different economic policies I

add an index that measures the party composition of governments[4]. The second set of explanatory variables focuses on the differences in fiscal conditions across countries. They include: public debt and budget deficit (both variables are measured as a percentage of GDP). Because these variables are potentially endogenous, they are predetermined. Finally, I control for economic development by including a measure of per capita GDP. I hypothesize a positive relationship between the level of fuel excise taxes and economic development on the basis that countries with more developed economies have to spend more on road infrastructure to meet their growing demands of road transport. Finally, I use a set of year dummies to control for unobserved influences common to all countries in a given year. The year dummies also pick up changes in the minimum excise rate set by the European Union since 1993. (The EU's minimum tax rate policy will be discussed in more detail in session 5.)

The development of fuel excises and cigarette prices

Figure 1: Development of diesel excises in the large and the small countries EUR/liter (current values)



Small countries: AU, BE, DK, IE, LU, NL, PT, SW
Large countries: DE, ES, FI, FR, IT, NO, SE, UK
Source: IEA Energy Prices and Taxes Database and own calculations

Figure 1-3 shows the development of diesel and petrol excises and cigarette prices over the last decades. In the figures I divided the sample into two country groups on the basis of median country size.[5] Figure 1 shows the evolution of the average diesel excises separately in the groups of large and small countries between 1978 and 2005. It can be seen that excise tax rates paid by diesel consumers have risen substantially in nominal terms over the last three decades. From its initial average level of 8 eurocent per liter it grew to an average of 34-35 eurocent per liter in the small countries group and to an average of 43-44 eurocent per liter in the large countries group. The figure also shows that the average tax rate levied by small

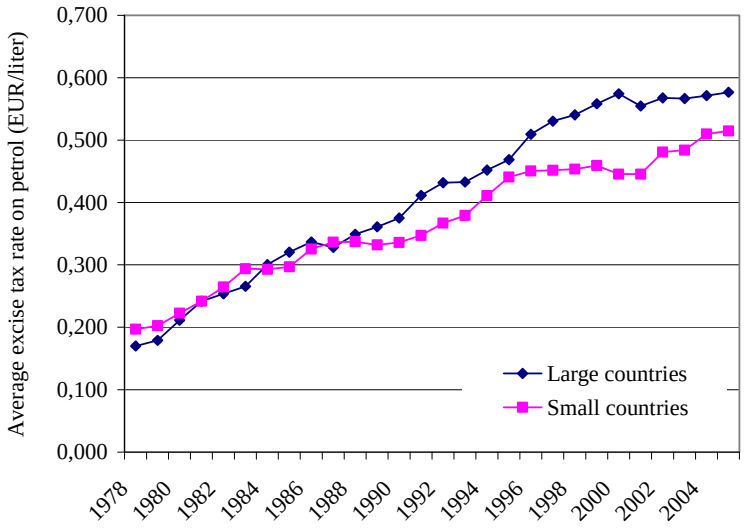
[4] The index for the party composition of governments is based on the Schmidt index, which is scaled from 1 to 5. It takes on 1 when the government contains only right-wing parties; 2 when the share of left-wing parties is less than 33%; 3 when the share of left-wing parties is less than 66%; 4 when the share of left-wing parties is more than 66%; 5 when all coalitional parties are left-wing.

[5] I find that all three country size variables result in the same country ranking by size. Finland, France, Germany, Italy, Norway, Spain, Sweden, and the United Kingdom are specified as large countries, while Austria, Belgium, Denmark, Ireland, Luxembourg, the Netherlands, Portugal and Switzerland are specified as small countries.

countries did not significantly differ from the one levied by large countries in the period 1978-1994. However, in the last ten years, this pattern has changed greatly. Since 1995, small countries levies significantly lower diesel taxes than large countries have done, which has led to a substantial tax gap between small and large countries. This gap continued to widen in the years between 1995 and 2000, then, subsequent to the increase in the EU's minimum tax rate, it narrowed a bit in 2004-5.

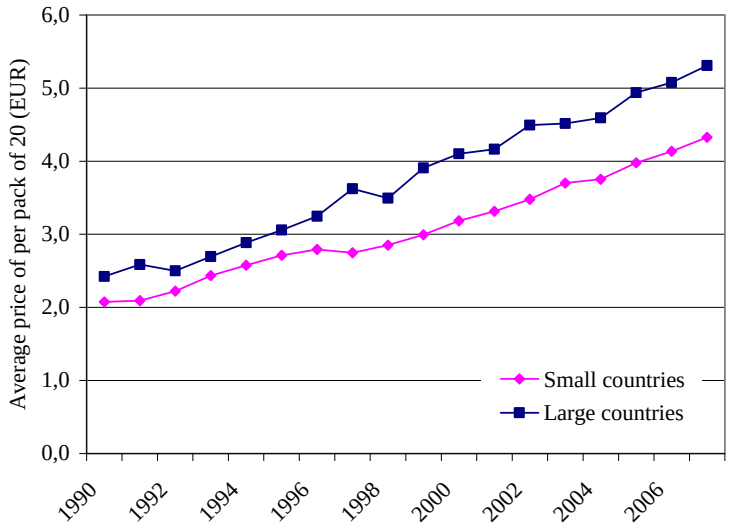
We observe similar tendencies for petrol excises, except that small countries started to undercut large countries already form the late 1980s (Figure 2).

Figure 2: Development of petrol excises in the large and the small countries (current values)



Small countries: AU, BE, DK, IE, LU, NL, PT, SW
Large countries: DE, ES, FI, FR, IT, NO, SE, UK
Source: IEA Energy Prices and Taxes Database and own calculations

Figure 3: Development of the prices of Marlboro cigarettes in the large and the small countries (current values)



Small countries: AU, BE, DK, IE, LU, NL, PT, SW
Large countries: DE, ES, FI, FR, IT, NO, SE, UK

Source: EIU CityData and own calculations

As can be seen from Figure 3, small countries tend to have lower cigarette prices over the entire period between 1990 and 2007. This suggests that small countries tend to levy lower tax rates on cigarette than large countries do. The tax gap between prices (taxes) in the two country groups tends to widen over time.

4. Results

The results are given by commodity in Table 1-3. They have the same format, i.e. there are four columns of results: in the first two, the country size variable is based on surface area (measured as the ratio of the home country's surface area to the weighted surface area of its neighbors), and in column 3 and 4 the surface-based measure of country size is replaced by its GDP-based (or population-based) equivalent. Each pair of columns includes first an OLS model (for purpose of comparison) and then a 2SLS model to account for the possibility that the neighbors' tax rate is endogenous. In all cases I correct for serial correlation by using AR(1) term. The presence of the interaction term in the equation implies that the marginal effect of the neighbors' tax rate depends on the country's size. I calculated the marginal effects at the median values of country size and reported them in the lower part of the table.

Diesel

Our key variables of interest are the neighbors' tax rate and the interaction term. We find that the coefficient of the interaction term is statistically significant and of positive value in all models presented in Table 1. The coefficients of the neighbors' tax rate are negative in the OLS models and positive in the 2SLS models. Based on the OLS estimates, the marginal effect of a change in neighbors' tax rate evaluated at the median value of country size is negative and small in magnitude for both measures of country size. However when we correct for endogeneity by using instrumental variable technique the estimated marginal effects become positive and relatively strong in both measures (as well as statistically significant). The results, which are remarkably similar across the two measures, indicate that in a median size country a 10 percent increase in the neighboring countries' tax rates induces around 2.5 percent increase in its own tax rate. These results confirm the presence of tax competition between EU countries in the setting of diesel excise taxes (Hypothesis 1).

Several of my control variables also show significant effects on diesel excise tax rates. The statistically significant positive coefficient on party composition of governments indicates that governments controlled by left-wing parties are more likely to increase diesel taxes. Government budget balance is found to have a negative impact, suggesting that higher budget deficit is eventually followed by higher diesel taxes. Finally, richer countries tend to levy higher diesel tax rates as indicated by the statistically significant and positive coefficient on per capita GDP.

Table 1: Estimates for diesel excise taxes (1978-2005) using traffic flow weights

Estimation method:	OLS	2SLS	OLS	2SLS
Change in neighbors' tax (t-1)	-0.169	0.083	-0.133	0.143
	(-1.231)	(0.248)	(-1.048)	(0.486)
Change in neighbors' tax (t-1)*Surface	0.019***	0.031***		
	(3.078)	(2.797)		
Change in neighbors' tax (t-1)*GDP			0.018**	0.029***
			(2.436)	(4.411)
Change in leftist/conservative government	0.032**	0.036***	0.032**	0.036***
	(2.581)	(2.806)	(2.584)	(2.951)
Election year dummy	-0.022	-0.023	-0.024	-0.027
	(-0.910)	(-0.979)	(-1.033)	(-1.170)
Post-election year dummy	-0.017	-0.016	-0.018	-0.018
	(-0.771)	(-0.458)	(-0.802)	(-0.514)
Change in government debt (t-1)	-0.038	0.027	-0.037	0.028
	(-0.610)	(0.397)	(-0.589)	(0.424)
Change in government deficit (t-1)	-0.016**	-0.019**	-0.015**	-0.018**
	(-2.373)	(-2.252)	(-2.256)	(-2.149)
Change in GDP per capita	1.153***	1.007***	1.157***	1.008***
	(4.537)	(4.259)	(4.480)	(4.170)
AR(1)	0.381***	0.345***	0.381***	0.341***
	(5.147)	(5.227)	(5.222)	(5.377)
Year dummies	yes	yes	yes	yes
R^2	0.326	0.274	0.326	0.276
No. of observations	400	400	400	400
Marginal effect	-0.073***	0.240***	-0.059**	0.263***
	(5.63)	(14.95)	(3.03)	(15.32)

Notes: Dependent variable is the change in excise tax rate on diesel;
t-statistics, F-statistics are in parenthesis;
* significant at 10%, ** significant at 5%, *** significant at 1% (statistical significance of the coefficients is calculated using White period system robust errors);
Neighbors' tax rate is calculated using traffic flow weights.
"Marginal effect" is the marginal effect of a change in neighbors' tax rate evaluated at the median level of country size variable (surface or GDP);
Instruments used in IV regression are described in text.

The main contribution of this paper is to explore the impact of country size on strategic interactions. The significantly positive interaction terms in the 2SLS models confirm the theoretical prediction that large countries respond more to changes in their neighbors' tax rate than small countries do (Hypothesis 3). To illustrate the importance of country size in influencing the slope of the reaction function I computed the marginal effect of neighbors' tax rate at the lower and upper quartile country sizes of the sample based on the coefficient estimates in Table 1. These calculations are presented in Table 4. We find that, for the surface-based measure of country size, the marginal effect of the neighbors' tax is 0.463 when evaluated at the upper quartile and is 0.130 when evaluated at the lower quartile. The same figures for the GDP-based country size measure are 0.637 and 0.182, respectively. These estimates show that the reaction of an "average" large country (i.e. a country with upper quartile territory) to changes in their neighbors' tax rates is more than three times higher than that of an "average" small country (i.e. a country with lower quartile territory). These results confirm that country sizes have a strong impact on the slope of the reaction functions for diesel excise taxes. While this finding is in agreement with the tax competition model allowing for price elastic individual demand, it is in strong contradiction to the standard

model based on inelastic demand. This shows that ignoring the possibility that the reaction of countries may differ according to their size may lead to strong empirical biases which underlines the importance of the theoretical extension in Paizs (2010).

Petrol

Table 2 presents the results for petrol taxes. As in the case of diesel excises, the marginal effect of the neighbors' petrol tax rate appears to be small in the OLS models. However, this picture changes radically when using instrumental variable technique. My estimation shows that in the median size country a 10 percent increase in the neighboring countries' petrol tax rates induces a 2.6 to 3.1 percent increase in its own petrol tax rate.

Furthermore – as in the case of diesel excises – I find positively significant coefficient on the interaction terms. The surface-based model indicates that the tax response of the average large country is 0.494 compared to only 0.139 for the average small country. In the population-based model, the corresponding figures are 0.252 and 0.545, respectively (Table 4). These results confirm that country size has a strong impact on the slope of the reaction functions for petrol excises (Hypothesis 3).

Table 2: Estimates for petrol taxes, 1978-2005 using border weights

Estimation method:	OLS	2SLS	OLS	2SLS
Change in neighbors' tax (t-1)	-0.025	0.084	0.003	0.224
	(-0.246)	(0.183)	(0.027)	(0.502)
Change in neighbors' tax (t-1)*Surface	0.012**	0.036***		
	(2.146)	(3.632)		
Change in neighbors' tax (t-1)*Population			0.009	0.019***
			(1.644)	(2.673)
Change in leftist/conservative government	-0.001	0.011	-0.001	0.010
	(-0.061)	(0.521)	(-0.067)	(0.532)
Election year dummy	-0.018	-0.012	-0.021	-0.023
	(-0.552)	(-0.330)	(-0.646)	(-0.642)
Post-election year dummy	-0.058**	-0.049	-0.060**	-0.059*
	(-2.049)	(-1.482)	(-2.087)	(-1.709)
Change in government debt (t-1)	-0.003	0.015	0.000	0.028
	(-0.058)	(0.247)	(-0.001)	(0.456)
Change in government deficit (t-1)	-0.020***	-0.023***	-0.019***	-0.021**
	(-2.914)	(-2.734)	(-2.855)	(-2.477)
Change in GDP per capita	1.088***	1.096***	1.091***	1.082***
	(3.713)	(4.111)	(3.654)	(3.983)
AR(1)	0.216***	0.220***	0.214***	0.215***
	(2.961)	(3.490)	(2.965)	(3.515)
Year dummies	yes	yes	yes	yes
R^2	0.247	0.201	0.247	0.213
No. of observations	400	400	400	400
Marginal effect	0.036**	0.266***	0.045	0.313***
	(3.68)	(7.75)	(2.10)	(6.80)

Notes: Dependent variable is the change in excise tax rate on petrol;
t-statistics, F-statistics are in parenthesis;
* significant at 10%, ** significant at 5%, *** significant at 1% (statistical significance of the coefficients is calculated using White period system robust errors);
Neighbors' tax rate is calculated using border weights.
"Marginal effect" is the marginal effect of a change in neighbors' tax rate evaluated at the median level of country size variable (surface or population);
Instruments used in IV regression are described in text.

Cigarettes

As can be seen in Table 3, the results for cigarettes are mixed even in the 2SLS models. The marginal effect of the neighbors' prices is found to be negative using the surface-based measure, which contradicts the theoretical prediction. Nevertheless when using the population-based measure the marginal effect of the neighbors' prices is positive and statistically significant, although only at the 10 percent probability level. In both 2SLS model the interaction terms have a positive and statistically significant coefficient.

I suspect that the weak evidence for cigarette tax competition between EU countries has to do with cigarette smuggling. As mentioned in the introductory section, current estimations show that in the European Union smuggling accounts for a larger share of non-domestically taxed cigarette consumption than do legitimate cross-border shopping. There are many forms of cigarette smuggling in the EU. One form is bootlegging, where a large amount of duty-paid cigarettes are purchased in low-tax countries and transported to high-tax countries to be sold illegally. In common with cross-border shopping, the main driving force behind bootlegging is the tax differential between neighboring countries. This implies that bootlegging is accounted for in the tax competition model presented above, since governments must respond similarly to the potential of bootlegging and cross-border shopping.

Although bootlegging of cigarettes is prevalent in the EU member countries, large-scale organized cigarette smuggling is generally considered a bigger problem. Large-scale smuggling is done in different ways in the EU. One way is when cigarettes are smuggled from third countries (typically from Russia, Ukraine and Belarus) without being declared at all. Another example involves the diversion of cigarettes which are officially designated for export to non-EU and therefore bear no state tax. In contrast to bootlegging, large-scale smuggling is done without paying duties.

While bootlegging and cross-border shopping is mainly driven by differences in tax rates, smuggling cannot be explained by tax levels alone. In fact, a number of countries with high rates of taxation on cigarettes like Denmark, Norway and Sweden do not have a high level of smuggling. As argued by Joossens and Raw (1998), large-scale cigarette smuggling is prevalent in countries with lax enforcement of laws and corrupt bureaucracies, and where it is common for people to purchase smuggled products.

Though cigarette smuggling is not primarily caused by high tax rates, countries with high level of smuggling usually keep their cigarette tax rates low in order to reduce the level of illegal sales. This implies that the incentive for countries to engage in tax competition may be altered under smuggling. For example, the response to an increase in neighboring countries' tax rates is likely to be weaker in countries where smuggling is soaring than in countries without smuggling. This suggests that tax competition plays a less important role in the setting of cigarette tax rates when smuggling is present. Therefore, the weak evidence for tax competition in cigarette taxes found above is likely to reflect the effect of large scale cigarette smuggling prevalent in certain areas of Europe.

Table 3: Estimates for cigarette prices, 1990-2007 using border weights

Estimation method:	OLS	2SLS	OLS	2SLS
Change in neighbors' price (t-1)	-0.149	-0.265	-0.129	0.209
	(-1.219)	(-0.452)	(-1.081)	(0.366)
Change in neighbors' price (t-1)*Surface	0.012*	0.027**		
	(1.953)	(2.432)		
Change in neighbors' price (t-1)*Population			0.010*	0.017**
			(1.767)	(2.305)
Change in leftist/conservative government	-0.021	-0.020	-0.022	-0.019
	(-1.132)	(-1.017)	(-1.152)	(-0.601)
Election year dummy	-0.017	-0.007	-0.018	-0.020
	(-0.580)	(-0.301)	(-0.615)	(-0.586)
Post-election year dummy	-0.020	-0.015	-0.018	-0.012
	(-0.783)	(-0.585)	(-0.715)	(-0.261)
Change in government debt (t-1)	-0.006	-0.031	-0.007	0.016
	(-0.096)	(-0.323)	(-0.112)	(0.212)
Change in government deficit (t-1)	-0.002	-0.006	-0.001	-0.003
	(-0.171)	(-0.451)	(-0.132)	(-0.314)
Change in GDP per capita	0.672***	0.766***	0.678***	0.726***
	(2.988)	(2.894)	(2.943)	(3.403)
AR(1)	-0.146	-0.166	-0.146	-0.178**
	(-1.175)	(-1.631)	(-1.204)	(-2.071)
Year dummies	yes	yes	yes	yes
R^2	0.200	0.188	0.202	0.123
No. of observations	272	272	272	272
Marginal effect	-0.088	-0.129*	-0.082	0.288*
	(1.91)	(3.03)	(1.56)	(2.76)

Notes: Dependent variable is the change in retail price of Marlboro cigarettes;
t-statistics, F-statistics are in parenthesis;
* significant at 10%, ** significant at 5%, *** significant at 1% (statistical significance of the coefficients is calculated using White period system robust errors);
Neighbors' tax rate is calculated using border weights.
"Marginal effect" is the marginal effect of a change in neighbors' tax rate evaluated at the median level of country size variable (surface or population);
Instruments used in IV regression are described in text.

Table 4: Marginal effect of neighbors' tax rate (neighbors' price) at the median and the lower and upper quartile levels of country size (surface or GDP/Population)

Country size	Diesel tax (1978-2005)		Petrol tax (1978-2005)		Cigarette price (1990-2007)	
	Surface	GDP	Surface	Population	Surface	Population
Lower quartile	0.130	0.182	0.139	0.252	-0.223	0.234
Median	0.240	0.263	0.266	0.313	-0.129	0.288
Upper quartile	0.436	0.637	0.494	0.549	0.043	0.500

Notes: The results are based on the 2SLS estimates reported in Table 1-3.

As seen earlier in Figure 1-3, small-sized European countries tend to set lower tax rates on diesel, petrol and cigarettes. This observation is consistent with Hypothesis 2, which predicted that smaller countries undercut larger ones. As shown in section 2, Hypothesis 2 and 3 are consistent with the same theoretical model. Therefore, the confirmation of Hypothesis 3 for diesel and petrol excises and partly for cigarette prices can be taken as an indirect evidence for Hypothesis 2. This shows that international tax competition drives smaller European countries to set lower tax rates on diesel, petrol and cigarettes. However, as it was seen in Figure 1, smaller countries set lower tax rates on diesel only from 1995. In case of petrol it holds from 1988 (see Figure 2). This may reflect that fuel tax competition between

EU countries has intensified over the last ten, fifteen years. To test this hypothesis formally, now I run the same regressions of Table 1 (Table 2) for the period before and after 1994 (1988). The results are reported in Table 5 and 6. For brevity, I only report the results from the instrumental variable estimations.

Table 5: 2SLS estimates for diesel excise taxes, separately for 1978-1994 and for 1995-2005

Period:	1978-94		1995-05	
Change in neighbors' tax (t-1)	0.020	0.114	0.167	0.152
	(0.090)	(0.431)	(0.423)	(0.415)
Change in neighbors' tax (t-1)*Surface	0.026**		0.039**	
	(2.108)		(2.489)	
Change in neighbors' tax (t-1)*GDP		0.017		0.056**
		(1.471)		(2.163)
Change in leftist/conservative government	0.046***	0.044***	0.045**	0.043**
	(3.643)	(3.283)	(2.121)	(2.236)
Election year dummy	-0.050	-0.051	-0.009	-0.018
	(-1.221)	(-1.285)	(-0.206)	(-0.449)
Post-election year dummy	-0.026	-0.029	0.014	0.025
	(-0.491)	(-0.559)	(0.395)	(0.746)
Change in government debt (t-1)	0.078	0.079	0.001	-0.034
	(1.284)	(1.215)	(0.008)	(-0.337)
Change in government deficit (t-1)	-0.008	-0.007	-0.041*	-0.039*
	(-0.788)	(-0.683)	(-1.918)	(-1.889)
Change in GDP per capita	1.229***	1.202***	0.883***	0.921***
	(5.937)	(5.585)	(2.615)	(2.630)
AR(1)	0.425***	0.403***	0.399***	0.400***
	(3.676)	(3.717)	(2.995)	(3.192)
Year dummies	yes	yes	yes	yes
R^2	0.274	0.268	0.224	0.257
No. of observations	224	224	160	160
Marginal effect	0.151*	0.184	0.364***	0.383***
	(2.41)	(1.20)	(5.92)	(3.20)

Notes: Dependent variable is the change in excise tax rate on diesel;
t-statistics, F-statistics in parenthesis;
* significant at 10%, ** significant at 5%, *** significant at 1% (statistical significance of the coefficients is calculated using White period system robust errors);
Neighbors' tax rate is calculated using traffic flow weights.
"Marginal effect" is the marginal effect of a change in neighbors' tax rate evaluated at the median level of country size variable (surface or GDP);
Instruments used are described in text.

The regression results in Table 5 are consistent with the findings in Figure 1. First, we observe that there is less evidence of tax competition between EU countries before 1994 than after. In the regressions for the period 1978-94, the neighbors' tax rate and the interaction term are jointly significant at 10 percent level for the surface-based country size variable, but statistically insignificant for the alternative measure. Similarly, the interaction term is found to have statistically significant impact only for the surface-based measure of country size. On the other hand, we find robust evidence of tax competition for the subperiod 1995-2005. In both regression models, the neighbors' tax rate and the interaction term are jointly significant with the interaction term being individually significant at 5 percent level. Second, my results also indicate that tax competition plays a much more important role after 1995. Note that the regression for the subperiod 1995-2005 yields higher parameter estimates for both the neighbors' tax rate and the interaction variables in both models. Before 1995, for example, the

coefficient on the interaction term is 0.026 but, after 1995, it is 0.039 for the surface-based measure of country size. The higher coefficient estimates imply that the importance of tax competition grows markedly after 1995. After 1995, the slope of the reaction function of the median sized country is 0.364, which is more than double the value obtained for the period before 1995 considering the specifications with the surface-based country size variable. The same pattern emerges when the GDP-based size variable is included.

Table 6: 2SLS estimates for petrol excise taxes, separately for 1978-1987 and for 1988-2005

Period:	1978-87		1988-05	
Change in neighbors' tax (t-1)	0.435	0.344	0.116	0.196
	(1.347)	(1.162)	(0.316)	(0.628)
Change in neighbors' tax (t-1)*Surface	-0.008		0.042**	
	(-0.726)		(2.427)	
Change in neighbors' tax (t-1)*Population		-0.007		0.032***
		(-1.232)		(2.796)
Change in leftist/conservative government	-0.022	-0.027	0.033	0.029
	(-0.727)	(-0.886)	(1.311)	(1.262)
Election year dummy	-0.128**	-0.121**	0.028	0.019
	(-2.308)	(-2.157)	(0.716)	(0.475)
Post-election year dummy	-0.124*	-0.117*	-0.022	-0.033
	(-1.855)	(-1.838)	(-0.451)	(-0.697)
Change in government debt (t-1)	0.009	0.001	0.030	0.040
	(0.150)	(0.020)	(0.411)	(0.629)
Change in government deficit (t-1)	-0.002	-0.002	-0.036***	-0.035***
	(-0.134)	(-0.129)	(-3.110)	(-2.921)
Change in GDP per capita	0.805	0.758	1.087***	1.114***
	(1.431)	(1.375)	(4.339)	(4.186)
AR(1)	0.005	0.006	0.307***	0.314***
	(0.049)	(0.061)	(4.951)	(5.088)
Year dummies	yes	yes	yes	yes
R^2	0.157191	0.166393	0.227822	0.227558
No. of observations	112	112	272	272
Marginal effect	0.395	0.311	0.328**	0.345**
	(0.99)	(1.28)	(3.04)	(3.94)

Notes: Dependent variable is the change in excise tax rate on petrol;
t-statistics, F-statistics are in parenthesis;
* significant at 10%, ** significant at 5%, *** significant at 1% (statistical significance of the coefficients is calculated using White period system robust errors);
Neighbors' tax rate is calculated using border weights.
"Marginal effect" is the marginal effect of a change in neighbors' tax rate evaluated at the median level of country size variable (surface or population);
Instruments used are described in text.

The same conclusions are reached for petrol excises as seen in Table 6. My estimations show no evidence of strategic interaction for the subperiod from 1978-1987. In contrast, I found strong evidence for tax competition for the subperiod 1988-2005. In both models, the neighbors' tax rate and the interaction term are jointly significant with the interaction term being individually significant at least at 5 percent level.

The above result comes as no surprise. The 1990s was a very important phase in the EU integration process. In this decade, with the abolition of internal borders and the introduction of common currency, the EU has removed most of the restrictions on consumer movements between member states. The late nineties have also witnessed the liberalization of the road haulage market, which has led to a strong price competition and boosted international

transport. These changes must have increased the sensitivity of European consumers and transport companies to international fuel price differences, which then set the stage for a more intense fuel tax competition between EU countries.

5. The minimum tax rate

In 1993, the European Union has introduced a minimum tax policy for the excise duties on alcoholic drinks, cigarettes and mineral oils (including diesel and petrol). The Community regulation of diesel and petrol taxes involves the setting of a minimum specific excise duty per unit of the product. The EU member states may not apply a lower excise tax rates on diesel and petrol than the specified minimum rates. At the outset, the minimum excise duty rate on diesel was 0.254 EUR/liter, which was increased to 0.302 EUR/liter in 2004. For petrol, the initial level of the minimum rate was 0.287 EUR/liter, which was increased to 0.359 EUR/liter in 2004.

The EU's minimum tax policy on cigarettes specifies a number of obligations for the member states. Firstly, excise duties levied on cigarettes must account for at least 57 percent of retail price inclusive of all taxes. Secondly, for the most popular price category the excise duty must not be less than 60 EUR per 1000 cigarettes (64 EUR as from 1 July 2006). Thirdly, in case of cigarettes, member states have to apply a mixed duty structure including both specific and ad valorem excises. The specific excise duty may not be less than 5 percent or more that 55 percent of the amount of the total tax burden on cigarettes.

It was expected that the minimum tax rate will narrow the tax band across member states and thereby it will reduce the incentive for cross-border shopping and tax competition. In the context of this study it would be interesting to examine if indeed the minimum rate has reduced the intensity of tax competition over fuel and cigarette tax rates. Unfortunately, the data does not allow me to formally address this issue. I cannot identify the effect of the minimum tax rate on tax competition separately from the (opposing) effect of the EU Single Market Program, because both measures were introduced in the same year, and the level of the minimum tax rate was unchanged between 1993 and 2003. However, I found in the previous section that strategic interactions in the setting of diesel and petrol excises between EU countries have intensified in the 1990s, suggesting that the minimum rate has not been very effective in combating tax competition.

Now I evaluate the EU's minimum tax measure from the perspective whether it has achieved its primary objective of harmonizing excises tax rates across the member countries.

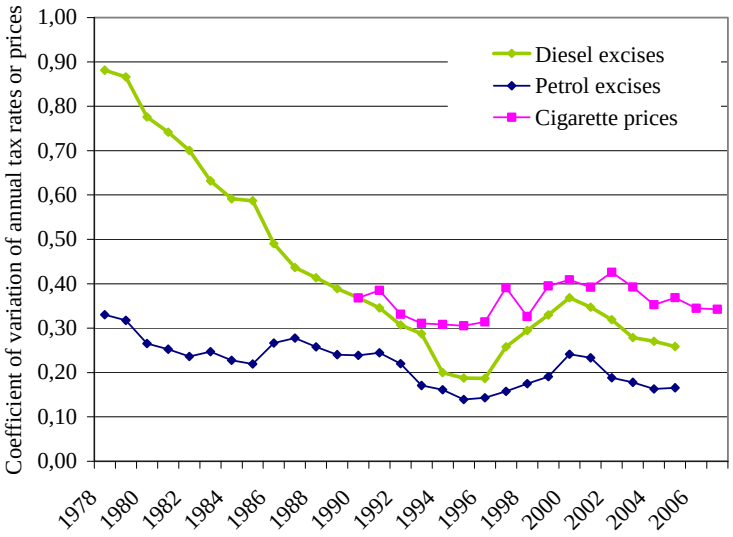
The impact of various tax harmonization measures on the outcome of tax competition has been studied intensively in the theoretical literature. Kanbur and Keen (1993) analyzed this issue in a two country model and showed that after introducing a minimum tax rate, which is binding for the small country, the small country adjusts its tax rate to the required minimum level whereas the large country raises its tax rate as well, though to a somewhat lesser extent. This indicates that the minimum tax rate reduces but does not eliminate the tax differentials between the two countries. The finding of Kanbur and Keen (1993) – also confirmed by others (Nielsen, 2001; Ohsawa, 2003) – suggests that the minimum tax rate is not the most appropriate measure to achieve harmonized tax rates when tax competition is asymmetric, and the larger are the size differences between countries, the less successful it can be.

In line with the theoretical prediction, small-size countries in Europe tend to levy lower tax rates on diesel, petrol and cigarettes than large-size countries do. As already shown in Figure 1-3, this process has started in the 1990s and led to a substantial gap in tax rates between large and small countries. For example, over the period 1995-05 the average excise tax rate on diesel in the small countries' group was on average 15 percent below the average

tax level in the large countries' group. Our interest is to see how this tax competition-induced differentiation of tax rates has affected the overall dispersion of tax rates across member states.

Figure 4 depicts the coefficient of variation of annual tax rates in the 16 European countries of the sample since 1978, separately for diesel and petrol. For cigarette the coefficient of variation of annual prices are shown. I start with discussing diesel excises.
We find that tax differences among EU countries had decreased steadily between 1978 and 1994. However, this process of convergence stopped in the mid 1990s and national tax rates started to diverge in 1995. Between 1995 and 2000 the coefficient of variation of annul tax rates among the 16 countries increased from 19 percent to 37 percent and then it started to decline again and stood at 26 percent at the end of the sample period. This, in combination with what has been said above, suggests that in the case of diesel excises asymmetric tax competition between the EU member states played an important role in the reversal of the convergence of tax rates. All in all, between 1992 (i.e. the year before the introduction of the minimum tax rate) and 2005 the coefficient of variation of excise tax rates on diesel has slightly declined for the entire 16 countries of the sample (from 31 to 26 percent), and slightly increased for the 14 member countries of the European Union (from 24 to 27 percent). Thus, the EU's minimum tax rate has not resulted in more harmonized tax rates across member states. This is in line with the theoretical work of Kanbur and Keen (1993) and confirms the inappropriateness of the minimum tax rate to harmonize tax rates under asymmetric tax competition.

Figure 4: Dispersion of commodity tax rates (prices) in European countries



Small countries: AU, BE, DK, IE, LU, NL, PT, SW
Large countries: DE, ES, FI, FR, IT, NO, SE, UK

Essentially, the same picture emerges when looking at the dispersion of petrol excise tax rates in European countries (see Figure 4). Although, between 1992 and 2005 the coefficient of variation of petrol excise levels has slightly declined both for the entire 16 European countries and for the 14 EU member countries, a clear trend of convergence over this period is not visible. Therefore what has been said about the weak performance of the EU's minimum tax policy in the case of diesel excise also holds for petrol excises.

The case of cigarettes prices also underlies the failure of the EU's tax harmonization efforts. The coefficient of variation of cigarette prices has not significantly changed over the

last 20 years either looking at the entire country sample or the 14 member states of European Union (see Figure 4).

Conclusions

In this paper I tested for the effect of strategic interaction between European countries in the setting of three commodity taxes based on a panel of 16 European countries. The data on diesel and petrol excises taxes span from 1978 to 2005, while the data on cigarette prices span from 1990 through 2005 for each country. The empirical specification in this paper differs from most other tax competition studies, as it allows the slope of the reaction functions to depend on the country size. Furthermore, the regressions are estimated in first-differences.

My main findings are as follows. There is strong evidence that European countries compete with each other in setting their diesel and petrol excise tax rates. For both diesel and petrol taxes my estimates show that in a median size country a 10 percent increase in the neighboring countries' tax rates induces a 2 to 3 percent increase in its own tax rate. Further, I find strong evidence that larger country size induces countries to react more aggressively to changes in their neighbors' tax rates, as suggested by Paizs (2010). My estimates reveal that the reaction of an average large country to a change in fuel tax rates in neighboring countries is 2-3 times higher than that of an average small country. This shows that ignoring the possibility that the reaction of countries may differ according to their size may lead to strong empirical biases which underlines the importance of the theoretical extension in Paizs (2010). Finally, there is evidence that strategic interactions between European countries have intensified since the 1990s.

I do not find robust evidence for tax competition in cigarette taxes. One explanation for this is that cigarette taxes are also used as a tool to combat smuggling and the two goals of reducing smuggling and responding optimally to the tax rates in neighboring countries can be in conflict. Large-scale organized cigarette smuggling is widespread in several European countries. The governments of these countries usually keep their cigarette tax rates low to reduce the level of illegal sales. It is likely that these countries are less willing to react to an increase in their neighbors' tax rates as it would undermine their effort to reduce smuggling. Therefore interstate tax competition is likely to play a less important role in determining these countries' tax rates, which explains the weak evidence of tax competition over cigarette tax rates found in this work.

This paper is most closely related to the work by Lockwood and Migali (2009) and Evers et al. (2004). Lockwood and Migali (2009) investigated the strategic interactions in the setting of four excises (wine, bear, ethyl alcohol and cigarette excises) between 12 EU countries. In contrast to this paper, they estimate the reaction function in levels. They find evidence for tax competition in all four excises after 1993 but could confirm the effect of country size on the level of tax rates only in the cases of wine and beer excises. Evers et al. (2004) investigate tax competition in diesel excise taxes among European countries. They use a database that in addition to the 16 countries considered in this paper also contains Greece but only covers the time period from 1978 to 2001. Like me, they estimate the reaction function equation using the first-differences of the data. Despite these similarities my empirical approach differs from theirs in a number of ways, including the measurement of tax burden and country size, the control and instrumental variables used, and the weighting scheme used to aggregate foreign tax rates. Evers et al. analysis also confirms the presence of tax competition in diesel excises over the examined period. However, my results differ from those obtained by Evers et al. in two important ways. Firstly, while I provide strong evidence for asymmetric tax competition between European countries for diesel taxation, they cannot

confirm the effect of country size on tax setting. Secondly, while I show that tax competition between EU countries has intensified in the 1990s, this issue is not addressed by Evers et al..

This paper is the first, to my knowledge, to examine tax competition in petrol tax rates among European countries using panel data. Like the case of diesel, my analysis confirms the presence of asymmetric tax competition between European countries and shows that strategic interactions have intensified since the 1990s.

The findings in this paper have important policy relevance. As suggested by the theoretical literature, under asymmetric tax competition the minimum tax rate will not result in harmonized tax rates across countries. Thus, the empirical evidence of asymmetric tax competition between European countries, provided in this study, explain why the minimum tax policy adopted by the EU in 1993 has failed to narrow the differences in diesel and petrol excise levels within the European Union.

Appendix: Descriptive statistics and data sources

Variable	Definition	Source	Mean	Std Dev	Min	Max
Dependent variable						
Diesel excise tax rate	Excise tax rate on diesel (EUR per liter)	IEA: Energy Prices & Taxes Database	0.244	0.141	0	0.796
Petrol excise tax rate	Excise tax rate on petrol (EUR per liter)	IEA: Energy Prices & Taxes Database	0.388	0.138	0.085	0.796
Cigarette price	Retail price of a pack of Marlboro containing 20 cigarettes (EUR per pack)	Economic Intelligence Unit: CityData database	3.142	1.340	1.360	8.450
Explanatory variables						
Neighbors' tax rate	Average excise tax rate on diesel in neighboring countries weighted after traffic flow weights (EUR per liter)	IEA: Energy Prices & Taxes Database and own calculations	0.251	0.124	0	0.796
Government deficit	General government deficit divided by GDP	OECD: Economic Outlook Database	-2.137	4.459	-15.272	15.767
GDP per capita	Gross national product divided by population (EUR per liter)	OECD: Economic Outlook Database	18 740	10 227	1 825	63 871
Government debt	General government debt divided by GDP	OECD: Economic Outlook Database	58.67	29.42	4.06	140.67
Election year dummy	equal to 1 in the year of a parliamentary election and 0 otherwise	Drazen (2005) http://www.tau.ac.il/~drazen/Data_Sets.html	0.27	0.45	0	1
Post-election year dummy		Drazen (2005) http://www.tau.ac.il/~drazen/Data_Sets.html and Wikipedia				
Leftist/conservative government	Cabinet composition of government captured by Schmidt-index, which is scaled from 1 (hegemony of right wing parties) to 5 (social democratic and other left parties)	Comparative Political Dataset, Armingeon (2005) http://ddcn.prowebis.com/study_detail.asp?studyid=763 and Wikipedia	2.56	1.42	1	5
Country size	Total surface area of a country (sq km)	World Bank: World Development Indicators	217 346	182 242	2 586	551 695

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