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Energy Economics 27 (2005) 79–92
Energy Economics
www.elsevier.com/locate/eneco

# Why fuel prices differ

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Available online 15 December 2004

**Abstract**

Fuel taxes differ largely between countries. This paper reviews a number of considerations from the theory of public finance that may explain these differences. Based on a multiple regression model, we find for tax competition in Europe that small countries tend to be more aggressive than large countries by charging lower fuel taxes to attract customers from neighbouring countries. There is strong evidence that fuel is just considered as one of the many sources for government expenditure: as the share of government expenditure in GDP is higher, the fuel tax tends to be higher. No support is found for the hypothesis that fuel taxes are higher in countries where externality problems are more severe (proxied by car density of the country). In this respect, the normative literature on pricing externalities has found little support in the realities of transport policy.


*Keywords:* Fuel price; Public finance; Tax competition

## 1. Introduction

Car drivers are confronted with widely varying fuel prices among countries. For example, a litre of gasoline costs about 120 US$cents in Norway, 65 cents in Greece and 32 cents in Ghana. A first possible cause of these price differences is that extraction costs of crude oil are different between oil-producing countries. Indeed, differences in extraction costs of various countries are substantial, but crude oil is relatively cheap to transport so that one may expect small variations of prices of crude oil among countries: the main effect of lower extraction costs is a higher rent in the pertaining countries.

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0140-9883/$ - see front matter 
doi:10.1016/j.eneco.2004.10.002

Table 1
Price levels and structure for Euro 95 fuel in six European countries (June 2003, in euro cents per litre)

| Country | Gas station price | Pretax price | Duty | VAT | Total tax % of the price |
|---|---|---|---|---|---|
| Belgium | 95.30 | 28.04 | 50.72 | 16.54 | 70.6 |
| France | 98.19 | 23.18 | 58.92 | 16.09 | 76.4 |
| Germany | 107.08 | 26.86 | 65.45 | 14.77 | 74.9 |
| Luxembourg | 75.70 | 30.38 | 37.21 | 8.11 | 59.9 |
| Netherlands | 113.50 | 31.80 | 63.52 | 18.18 | 72.0 |
| United Kingdom | 107.26 | 25.19 | 64.69 | 17.38 | 76.5 |

Source: Oil Bulletin 30 June 2003.
http://europa.eu.int/comm/energy/en/oil/bulletin_en.html.

A second factor that determines fuel prices concerns the cost of refining the crude oil and of distributing the fuel. Oil refineries may be different in terms of their costs and productivity, and spatial variations in distribution costs occur because of differences in infrastructure and distances to oil refineries. Given the limited number of oil companies active in most countries, there may be oligopolistic tendencies in the market. In addition, when fuel stations are local monopolists, they may charge a mark-up. In most countries, the share of refining and distribution of fuel in total costs is rather small, however, so that this is not an important explanation of price variations (see Table 1).

The third factor concerns taxes. In most countries, taxes form the largest component of the fuel price paid by consumers. For example, in the Netherlands, the tax share of the fuel price equals about 70%. This fact reveals that the most important source of variation in fuel prices must be taxes. A similar value is found in Japan. In other parts of the world, taxes on fuel are much lower. For example, the share of taxes in the fuel price of the USA is about 25%. In some countries in Africa and Asia, especially the oil-producing ones (for example Nigeria, Iraq and Iran), fuel prices are extremely low. Here, prices are even lower than the production costs.

Thus, on what basis do governments determine fuel taxes? Finding an answer to this question is the main aim of this paper. Based on the literature on public finance, we will discuss a number of considerations governments may have to determine the level of taxes (Section 2). In Section 3, we show empirical research for about 100 countries[1] to explain the fuel tax level, taking into account the perspectives found in the literature. Section 4 follows with refined estimates, and Section 5 concludes.

## 2. Reasons for taxing fuel

As a starting point, note that fuel appears to be an attractive base for taxation in all countries. A fuel tax is applied almost universally. For example, many developing

[1] An anonymous referee pointed out that a similar analysis may be applied to fuel price differences between regions within the same country (for example, the states within the USA) when the regions have the competence to determine the level of the fuel taxes.

countries do not impose a general income tax or a value added tax, but they do have a fuel tax. A main reason is that fuel taxes have a low cost of tax collection. Administration costs for the fiscal authority are low because the number of producing or importing firms (oil companies) is small. Furthermore, compliance costs for the taxpayers are low. In addition, it is difficult to avoid paying taxes. Given the large-scale nature of production and distribution of fuels, it is not easy to supply fuels on the market without being noticed by the fiscal authorities. Thus, almost all countries have imposed a system of fuel charges. However, the levels of the charges vary widely.

We list a number of considerations that may explain differences in levels of the taxes between countries.

First, fuel taxes may be charged to cover the costs of construction and maintenance of transport infrastructure. In this case, the fuel tax follows from the benefit principle saying that users of public services pay in accordance with the degree of benefits they derive (Musgrave and Musgrave, 1989). An example of such an interpretation of a fuel tax as a benefit tax is the gasoline tax in the USA. A more direct benefit tax would be the imposition of tolls, but—as noted above—fuel taxes have the advantage that they can be imposed at low cost by the fiscal authority. From this perspective, countries with a large road network, relative to the number of cars, need higher fuel taxes.

Second, the fuel tax may be just a source for general government expenditure. Thus, in countries with high government expenditures, taxes will also be high. A related consideration is that, where a government has a particular source of income such as large natural resources, it may refrain from imposing a fuel tax. To give some background on the share of fuel tax receipts as a percentage of total government revenues, we find a value of about 4–8% in EU countries. However, in other countries, the share is much higher. For example, Metschies (1999) indicates that, in sub-Saharan countries, the share is about 35%. In particular, in countries where civil war takes place, the fuel tax may be the largest tax source because it is so easy to collect. The other extreme consists of a group of oil-producing countries where the share is close to zero.

Third, equity considerations play a role. In low-income countries, the rich, who have a car, will be more affected by a fuel tax than the poor who will only experience the tax indirectly (for example, via public transport prices). This impact is in accordance with the ability to pay principle, which says that the rich should bear a relatively larger share of the tax burden than the poor. However, in higher-income countries, fuel consumption in connection with road use is not a luxury good (cf. Litman, 1999; Rietveld, 2003) so that, in higher-income countries, a government that follows this principle should look for alternative tax bases such as an income tax. However, since governments are usually reluctant to make drastic changes in tax systems, a fuel tax that was once motivated by the ability to pay principle may simply be retained even after its attractive equity effects have vanished in the course of time.

Fourth, in addition to this equity principle, the imposition of fuel taxes may be based on efficiency considerations. As spelled out by Musgrave and Musgrave, 1989), fuel is often chosen as a tax base because costs of tax collection are low and fraud is difficult. In addition, a fuel tax may be attractive when it leads to small distortions in the economy. This depends on the question to what extent fuel demand is inelastic. When demand for fuel would be inelastic, transport taxes would lead to small distortions because of a low excess burden, implying that the allocation by firms and consumers is only slightly affected by the imposition of the tax. Johansson and Schipper (1997) report an elasticity of fuel demand of about $-0.7$, the larger part of which is related to fuel efficiency changes, and the smaller part to changes in kilometres travelled and car ownership. In the case of demand with zero elasticity, such a distortion is entirely absent. This leads to the rule that taxes should be imposed such that the resulting relative changes in prices will be inversely proportional to the elasticity of demand of various products (Baumol and Bradford, 1970). If elasticity of demand would be closer to zero for high-income countries compared with low-income countries, this principle would imply that, in these countries, fuel taxes will be higher.

In an international context, tax competition may occur. Governments may impose low tax levels to attract consumers from other countries. This approach is an attractive way for a government to become popular because own residents pay lower taxes than they would otherwise do. As indicated in Kanbur and Keen (1993), small countries may impose low fuel taxes to attract traffic from neighbouring countries that otherwise would not be there. An example is Luxembourg that has low fuel taxes compared with its neighbours so that substantial cross-border fuelling and shopping trips evolve. In small countries, governments are more likely to be involved in tax competition than in large countries because the balance between gains and losses of tax receipts is more favourable here. For large countries, this tax competition phenomenon means that they adjust their taxes downward when small neighbours start competition to avoid losses of taxes and to avoid problems with owners of petrol stations near the border who demand compensation.

Sixth, a fuel tax may be charged to correct for negative externalities such as congestion and environmental pollution (see, for example, Verhoef, 1996). Usually, these negative externalities can be interpreted as ‘demerit goods’ (Musgrave and Musgrave, 1989). The explicit aim is to change behaviour and stimulate energy saving, implying that demand must be elastic, otherwise there will not be a behavioural effect. Note that this is contrary to the abovementioned principle of reducing the excess burden, which says that treasuries should focus on inelastic goods.

Finally, the level of fuel taxes will depend on the power of interest groups that succeed in reducing tax (see, for example, Frey, 1983; Persson and Tabellini, 2002. When car drivers or transport companies are powerful, this situation will have a downward pressure on taxes.

We proceed with an empirical analysis in which we examine the relevance of the above considerations. Of course, mixtures of these considerations may be found.

## 3. Explaining differences in fuel prices

To carry out an empirical analysis, we obtained a data set containing fuel prices (both gasoline and diesel prices) for about 100 countries in 1998.[2] Fuel prices are used instead of tax levels on “data availability”grounds. Fig. 1 presents the European part of the data set.

[2] http://www.zietlow.com/gtz/fuel.pdf (GTZ: Deutsche Gesellschaft für Technische Zusammenarbeit).

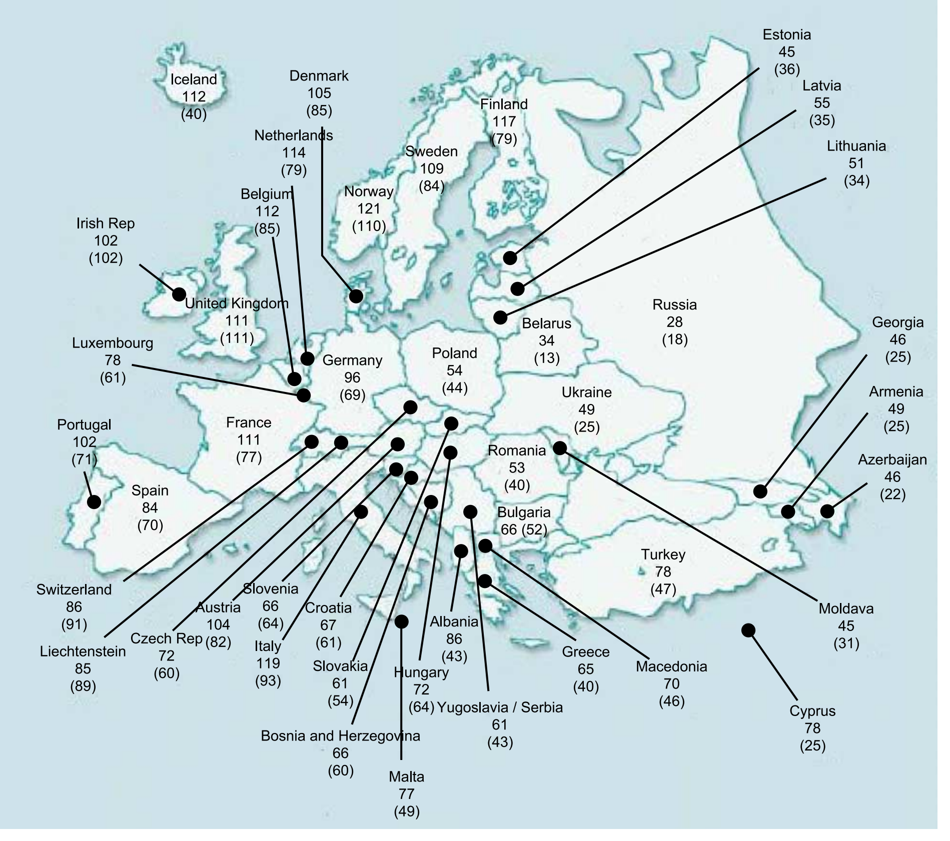


Fig. 1. Gasoline and diesel prices in US cents per litre for all European countries (diesel prices in brackets).

Fig. 1 shows a low fuel price (both gasoline and diesel) for Luxembourg when compared with its adjacent countries. This low fuel price is possibly due to the small size of Luxembourg, which causes cross-border fuelling trips to have much more influence on the total tax receipts than these trips in large countries such as Germany and France. Furthermore, Luxembourg is a very centrally situated country, and therefore it functions as a stop for many truck drivers that drive between North and South Europe. This same situation also seems to hold to some extent for Slovenia.

Considering the fuel prices outside Europe, some remarkable outliers can be noted. For example, the gasoline and diesel prices in OPEC countries such as Iran and Iraq are extremely low. Iraq has a gasoline and diesel price of 1 US cent per litre, Iran's gasoline price is slightly higher (8 cents), while its diesel price is about the same. Lastly, we note that the fuel price in Hong Kong is rather high when compared to the price in Hong Kong's adjacent country, China. The gasoline price in Hong Kong equals 136 cents per litre, while the gasoline price in China is about 28 cents per litre. A similar result is found for Singapore compared with its neighbour Malaysia.

The above explanation of the outliers in the data set is consistent with some of the considerations in the literature review in the previous section. For a less impressionistic view, we need a more systematic treatment of the relationship between fuel prices and underlying factors. Based on the factors in Section 2, we formulate the following variables to explain differences in fuel taxes. We use data availability as a guiding principle to arrive at operationalised measures (see Table 2).

Data of the variables mentioned in the table were collected for the 100 countries. Most of them, such as road length per number of cars and OPEC membership do not need explanation, but variables related to tax competition and border effects deserve a more detailed discussion. Furthermore, the institutional indicator (INSTIT) and the use of gross national income (GNI) per capita may not be entirely obvious and will therefore be shortly discussed below.

Tax competition is taken into account by considering the neighbour's fuel prices. The variable NEIGHBOURPRICE is constructed by calculating the average fuel price in the country's neighbours, weighted after the length of their joint borders.

Another variable that is relevant in the context of tax competition is an indicator of country size. Small countries have more to gain from tax competition than large countries. However, it is not just size (area), but it is also the geometry of a country that plays a role because what counts is to what extent domestic consumers can easily go to

Table 2
Summary of factors that affect fuel taxes

| Tax level consideration | Variable to be used | Symbol | Source |
|---|---|---|---|
| Benefit principle | Road length/number of cars | ROAD/CAR | World Road Statistics |
| Just a source for government expenditure | Government expenditure as a share of GDP | GOVEXP/GDP | World Bank |
| Presence of alternative tax base | OPEC membership | OPEC | |
| Equity; ability to pay | GNI per capita | GNI/CAP | World Bank |
| Efficiency; reduce distortions | Low price elasticity; Proxied by GNI per capita | GNI/CAP | |
| Tax competition | 1: Size of international market relative to domestic market | FOREIGN/DOMESTIC | Own data/World Bank |
| | 2: Price in neighbour country | NEIGHBOURPRICE | Own data/GTZ |
| Seriousness of negative externalities | Car density | CARDENS | World Road Statistics/ World Bank |
| Power of interest groups | Institutional indicator | INSTIT | Kaufmann et al. (2000) |

another country to take cheap fuel there. Thus, our purpose is to construct a variable that is a proxy for the relative importance of domestic demand for fuel compared with potential international demand. This variable will give an indication of the degree to which governments can gain from tax competition, or alternatively, have to protect themselves against tax competition. This variable, FOREIGN/DOMESTIC, is measured as follows:

$$\text{FOREIGN/DOMESTIC} = \frac{\text{share (surface of the ring with radius } r \text{ and} (r+\Delta))}{\text{country's surface}} \tag{1}$$

The numerator in Eq. (1) represents potential international demand, while the denominator proxies the domestic demand. In this way, FOREIGN/DOMESTIC represents the desired variable. It assumes high values for small countries. Potential international demand is measured by representing the country as a circle with radius $r$, determined by solving surf=$\pi(r)^2$ (surf is the country's surface in square kilometres). Suppose that the distance from where the driver is indifferent between fuelling in his country of residence or in the adjacent country equals 40 km ($\Delta$). In that way, the potential international demand for a landlocked country is the surface of the ring with radius $r$ and ($r$+$\Delta$). For a nonlandlocked country, this surface must be multiplied by the percentage of the country that borders land (share). For example, in The Netherlands, this share is about 60%.

The institutional indicator, voice and accountability (INSTIT), reflects the extent to which citizens can participate in selecting government and holds them accountable for the actions taken. This variable can be thought of as reflecting whether citizens and business can prevent arbitrariness in the behaviour of government and enforce good governance when needed. We use this variable as a proxy for countervailing powers against the influence of specific interest groups.

Finally, we use GNI per capita as an indicator of two pricing principles: the ability to pay and the efficiency principle. As explained in Section 2, in low-income countries, fuel consumption is a luxury good, which might motivate a high fuel tax, whereas, in high-income countries, this is no longer true. Hence, the ability to pay principle would suggest that, in low-income countries, the fuel tax should be high[3]. For the efficiency principle, a reverse reasoning holds. As price elasticity of demand tends to be lower for high-income countries, the distortions will be lower there.

[3] One might consider the GINI coefficient as another proxy for the equity principle applied to fuel price setting. Of course, the GINI coefficient is a well-known indicator of inequality and hence is closely related to equity concerns. The point we are considering here is that we want to have an indicator of the extent to which a fuel price increase would have adverse distributional effects, and, here, the average level of income is important given the decreasing income elasticity from low- to high-income countries.

Based on the variables included in Table 2, we estimate the following equation:

$$\begin{aligned} p_i = {} & a_0 + a_1 \mathrm{FOREIGN/DOMESTIC}_i + a_2\, \mathrm{NEIGHBOURPRICE}_i \\ & + a_3 \left(\mathrm{FOREIGN/DOMESTIC}_i{*}\mathrm{NEIGHBOURPRICE}_i\right) + a_4\, \mathrm{GNI/CAP}_i \\ & + a_5\, \mathrm{CARDENS}_i + a_6\, \mathrm{INSTIT}_i + a_7\, \mathrm{GOVEXP/GDP}_i \\ & + a_8\, \mathrm{ROAD/CAR}_i + a_9\, \mathrm{OPEC}_i + u_i \end{aligned} \tag{2}$$

where $p_i$ represents the fuel price in country $i$ in US cents per litre. Eq. (2) also includes an interaction variable between FOREIGN/DOMESTIC and NEIGHBOURPRICE. This allows us to test whether the small country effect is just reflected by a general decrease in fuel prices or whether this decrease depends on the price level in neighbour countries, as follows from the results found in Kanbur and Keen (1993).

Estimating Eq. (2) with OLS results in the estimated parameter values in Table 3. Cross-border fuelling seems to be a bigger issue in Europe than elsewhere because it

Table 3
OLS estimation results of fuel prices according to Eq. (2) (standard errors in brackets)

| | World | Europe |
|---|---|---|
| *(a) estimation results for gasoline* | | |
| Constant | 3.905 (7.338) | −6.269 (17.581) |
| FOREIGN/DOMESTIC | 10.922 (11.621) | −16.674 (30.749) |
| NEIGHBOURPRICE | 0.665*** (0.097) | 0.104 (0.176) |
| FOREIGN/DOMESTIC*NEIGHBOURPRICE | −0.200 (0.124) | 0.039 (0.302) |
| GNI/CAP | 0.00068** (0.00028) | 0.00142*** (0.00039) |
| CARDENS | 0.025 (0.067) | 0.071 (0.065) |
| INSTIT | −1.258 (2.721) | 3.244 (5.124) |
| GOVEXP/GDP | 0.521** (0.227) | 1.430*** (0.429) |
| ROAD/CAR | 3.868 (6.238) | 187.351** (72.913) |
| OPEC | −35.977*** (7.657) | – |
| $R^2$ | 0.696 | 0.863 |
| *(b) estimation results for diesel* | | |
| Constant | −3.439 (4.054) | −12.562 (13.006) |
| FOREIGN/DOMESTIC | 7.884 (6.588) | 20.429 (20.861) |
| NEIGHBOURPRICE | 0.827*** (0.069) | 0.541*** (0.125) |
| FOREIGN/DOMESTIC*NEIGHBOURPRICE | −0.171* (0.095) | −0.378 (0.278) |
| GNI/CAP | 0.00050*** (0.00018) | 0.00095*** (0.00026) |
| CARDENS | −0.012 (0.040) | −0.013 (0.048) |
| INSTIT | −0.371 (1.656) | 6.550* (3.815) |
| GOVEXP/GDP | 0.320** (0.140) | 0.686** (0.330) |
| ROAD/CAR | 6.723* (3.809) | 3.300 (56.128) |
| OPEC | −22.177*** (4.693) | – |
| $R^2$ | 0.848 | 0.916 |

World and Europe separately.

* Significant at 10%.

** Significant at 5%.

*** Significant at 1%.

has become easy to cross borders owing to European integration. Therefore, we also carry out an estimation of Eq. (2) for the 32 European countries included in the data set. Obviously, in this case, we exclude the OPEC dummy because Europe does not have any members of OPEC. Table 3a gives the gasoline case, and Table 3b the diesel case.

FOREIGN/DOMESTIC and CARDENS show no explanatory power on the fuel price at all; furthermore, INSTIT has no significant influence on the fuel price (this variable is significant merely in the European diesel case and still only at the 10% level). We exclude these variables from the regression model, which results in the estimated parameter values in Table 4.

Tables 3 and 4 show large differences between price setting in Europe and in the rest of the world. Therefore, we adopt an approach that uses European dummy variables when estimating relation (2) for the total data set. This approach consists of including a European dummy variable for every regressor. The dummy variable has value 0 for a non-European country, for a European country, this value is the same as the value of the corresponding regressor. Table 5 shows the results of this approach.

Tax competition seems to occur. The average price in the adjacent countries has a significant positive influence on a country's fuel price (except for the European gasoline case). This means that a country responds to a high fuel price in its neighbour countries by determining a fuel price of the same magnitude. A more important argument for the

Table 4
OLS estimation results of fuel prices according to Eq. (2) minus FOREIGN/DOMESTIC, CARDENS and INSTIT (standard errors in brackets)

| | World | Europe |
|---|---|---|
| *(a) estimation results for gasoline* | | |
| Constant | 5.876 (6.581) | −14.247 (14.781) |
| NEIGHBOURPRICE | 0.634*** (0.087) | 0.180 (0.157) |
| FOREIGN/DOMESTIC*NEIGHBOURPRICE | −0.081** (0.033) | −0.123*** (0.025) |
| GNI/CAP | 0.00059*** (0.00022) | 0.00165*** (0.00031) |
| GOVEXP/GDP | 0.583*** (0.196) | 1.565*** (0.403) |
| ROAD/CAR | 4.217 (6.145) | 151.882** (65.941) |
| OPEC | −35.125*** (7.424) | – |
| $R^2$ | 0.691 | 0.852 |
| *(b) estimation results for diesel* | | |
| Constant | −1.849 (3.677) | −6.532 (11.408) |
| NEIGHBOURPRICE | 0.790*** (0.062) | 0.516*** (0.112) |
| FOREIGN/DOMESTIC*NEIGHBOURPRICE | −0.060** (0.027) | −0.118*** (0.028) |
| GNI/CAP | 0.00044*** (0.00013) | 0.00106*** (0.00022) |
| GOVEXP/GDP | 0.358*** (0.122) | 0.735** (0.321) |
| ROAD/CAR | 7.001* (3.758) | 17.138 (51.536) |
| OPEC | −21.893*** (4.539) | – |
| $R^2$ | 0.846 | 0.901 |

World and Europe separately.

* Significant at 10%.

** Significant at 5%.

*** Significant at 1%.

Table 5
OLS estimation results of fuel prices according to Eq. (2), including European dummy variables minus FOREIGN/DOMESTIC, CARDENS and INSTIT (standard errors in brackets)

| | World | Europe |
|---|---|---|
| *(a) estimation results for gasoline* | | |
| Constant | 7.611 (9.333) | −14.247 (14.781) |
| Constant dummy | −21.859 (22.596) | |
| NEIGHBOURPRICE | 0.625*** (0.128) | 0.180 (0.157) |
| NEIGHBOURPRICE dummy | −0.445* (0.253) | |
| FOREIGN/DOMESTIC*NEIGHBOURPRICE | 0.056 (0.106) | −0.123*** (0.025) |
| FOREIGN/DOMESTIC*NEIGHBOURPRICE dummy | −0.179 (0.112) | |
| GNI/CAP | 0.00033 (0.00036) | 0.00165*** (0.00031) |
| GNI/CAP dummy | 0.00131** (0.00056) | |
| GOVEXP/GDP | 0.505** (0.243) | 1.565*** (0.403) |
| GOVEXP/GDP dummy | 1.060* (0.611) | |
| ROAD/CAR | 1.786 (6.115) | 151.882** (65.941) |
| ROAD/CAR dummy | 150.096 (92.012) | |
| OPEC | −33.534*** (7.393) | – |
| $R^2$ | 0.725 | 0.852 |
| *(b) estimation results for diesel* | | |
| Constant | 1.585 (5.249) | −6.532 (11.408) |
| Constant dummy | −8.117 (13.082) | |
| NEIGHBOURPRICE | 0.690*** (0.111) | 0.516*** (0.112) |
| NEIGHBOURPRICE dummy | −0.175 (0.161) | |
| FOREIGN/DOMESTIC*NEIGHBOURPRICE | 0.173* (0.090) | −0.118*** (0.028) |
| FOREIGN/DOMESTIC*NEIGHBOURPRICE dummy | −0.291*** (0.095) | |
| GNI/CAP | 0.00021 (0.00021) | 0.00106*** (0.00022) |
| GNI/CAP dummy | 0.00085*** (0.00031) | |
| GOVEXP/GDP | 0.284** (0.143) | 0.735** (0.321) |
| GOVEXP/GDP dummy | 0.450 (0.366) | |
| ROAD/CAR | 5.521 (3.607) | 17.138 (51.536) |
| ROAD/CAR dummy | 11.617 (54.252) | |
| OPEC | −20.159*** (4.349) | – |
| $R^2$ | 0.872 | 0.901 |

World and Europe separately.

* Significant at 10%.

** Significant at 5%.

*** Significant at 1%.

presence of tax competition is the significant negative influence of the interaction term FOREIGN/DOMESTIC*NEIGHBOURPRICE in Europe. In Europe, we expect that a country with a high value for FOREIGN/DOMESTIC, in general, a small country, will have a lower fuel price level than a country with a small value for FOREIGN/DOMESTIC, in general, a large country, supposing the same average fuel price in their adjacent countries (NEIGHBOURPRICE). This supports the theoretical results obtained by Kanbur and Keen (1993). Outside of Europe, this kind of tax competition is not present according to Table 5 probably due to the fact that it is more difficult to cross borders in the rest of the world. For example, city-states such as Singapore and Hong

Kong have higher fuel taxes than their neighbours, whereas the tax competition literature predicts that the taxes are lower. The point is that adverse effects on tax receipts by fuel fetching trips are prevented by imposing restrictions on border crossing traffic (still existent after Hong Kong joined China). In the case of Singapore, the problem is solved by requiring Singapore car users to have filled tanks when they leave the country by car (see Bruinsma et al., 2001).

The level of the gross national income per capita is also only relevant for the fuel price in Europe. GNI per capita is a proxy for both the "ability to pay" principle and the "small distortions" consideration. The first of these considerations is expected to play a bigger role outside of Europe because road use is not a luxury good in Europe. Since GNI per capita has no significant explanatory power outside of Europe, this consideration is not likely to be an explanation for differences in fuel prices. The significance of GNI per capita in Europe suggests that the inelastic character of fuel demand, especially in high-income countries, makes it an attractive base for tax collection.

Government expenditures have a significant positive influence on the fuel price. This applies to Europe as well as to the rest of the world. Thus, the consideration that fuel tax may be just a source for government expenditure is correct. Roadstock per car, proxy for the benefit principle, seems to have no influence on the fuel price neither in the European case nor in the world case. Being a member of the OPEC has a large negative influence on the fuel price. In the gasoline case, the price in an OPEC country is on average 34 US cents less than in a non-OPEC country. In the diesel case, this difference equals about 20 US cents per litre[4].

## 4. Refined estimates based on instrumental variables

There are some problems with the OLS estimation of Eq. (2) because one of the explanatory variables, the average fuel price in neighbour countries, is a function (average) of the dependent variable. Therefore, we now apply an approach with instrumental variables. First, we estimate the fuel price by using the following empirical relation (European dummy variables are not displayed for the sake of clearness).

$$\begin{aligned} p_i = {} & b_0 + b_1\mathrm{FOREIGN/DOMESTIC}_i + b_4\mathrm{GNI/CAP}_i + b_5\mathrm{CARDENS}_i \\ & + b_6\mathrm{INSTIT}_i + b_7\mathrm{GOVEXP/GDP}_i + b_8\mathrm{ROAD/CAR}_i + b_9\mathrm{OPEC}_i + u_i \qquad (3) \end{aligned}$$

In Eq. (3), there are no explanatory variables that are a function of the fuel price. By estimating Eq. (3) with OLS, an estimate for the fuel price is obtained, $\hat{p}_i$. This estimate can be used to calculate an estimate for the average fuel price in country $i$'s adjacent

[4] One might argue that, since the countries considered are very different in size, one has to make use of weighted least squares. We decided not to present the results because the relevant variable is in the domain of public policy: the number of people affected may vary considerably from country to country, but this does not really matter given our research objective. Results of the weighted least squares analysis are available on request. Most results are stable, but, for some explanatory variables, changes occur. The main conclusion remains intact that no support is found for the hypothesis that externalities form a motivation in fuel price setting.

countries, $\widehat{\text{NEIGHBOURPRICE}}_i$. Finally, we estimate the following empirical relation (European dummy variables are again not displayed for the sake of clearness).

$$\begin{aligned} p_i = a_0 &+ a_2\widehat{\text{NEIGHBOURPRICE}}i \\ &+ a_3\left(\text{FOREIGN/DOMESTIC}_i{*}\widehat{\text{NEIGHBOURPRICE}}_i\right) + \mathrm{a}_4\text{GNI/CAP}_\mathrm{i} \\ &+ \mathrm{a}_7\text{GOVEXP/GDP}_\mathrm{i} + \mathrm{a}_8\text{ROAD/CAR}_\mathrm{i} + \mathrm{a}_9\text{OPEC}_\mathrm{i} + \mathrm{u}_\mathrm{i} \end{aligned} \tag{4}$$

The results of this 2SLS approach are reported in Table 6. The differences between the OLS and the 2SLS approaches appear to be minor.

Table 6
SLS estimation results of fuel prices according to Eq. (4) (standard errors in brackets)

| | World | Europe |
|---|---|---|
| *(a) estimation results for gasoline* | | |
| Constant | 12.354 (12.538) | −14.673 (14.686) |
| Constant dummy | −31.282 (26.480) | |
| NEIGHBOURPRICE | 0.594*** (0.212) | 0.234 (0.181) |
| NEIGHBOURPRICE dummy | −0.260 (0.391) | |
| FOREIGN/DOMESTIC*NEIGHBOURPRICE | 0.061 (0.116) | −0.122*** (0.025) |
| FOREIGN/DOMESTIC*NEIGHBOURPRICE dummy | −0.180 (0.122) | |
| GNI/CAP | 0.00010 (0.00038) | 0.00159*** (0.00032) |
| GNI/CAP dummy | 0.00134** (0.00067) | |
| GOVEXP/GDP | 0.397 (0.267) | 1.483*** (0.424) |
| GOVEXP/GDP dummy | 1.026 (0.697) | |
| ROAD/CAR | 1.554 (6.646) | 150.314** (65.656) |
| ROAD/CAR dummy | 148.482 (100.112) | |
| OPEC | −30.370*** (8.178) | – |
| $R^2$ | 0.675 | 0.854 |
| | | |
| *(b) estimation results for diesel* | | |
| Constant | −3.311 (7.023) | −7.800 (12.616) |
| Constant dummy | −7.655 (15.167) | |
| NEIGHBOURPRICE | 0.877*** (0.173) | 0.585*** (0.171) |
| NEIGHBOURPRICE dummy | −0.221 (0.266) | |
| FOREIGN/DOMESTIC*NEIGHBOURPRICE | 0.141 (0.105) | −0.122*** (0.028) |
| FOREIGN/DOMESTIC*NEIGHBOURPRICE dummy | −0.260** (0.109) | |
| GNI/CAP | 0.00010 (0.00023) | 0.00101*** (0.00028) |
| GNI/CAP dummy | 0.00083** (0.00040) | |
| GOVEXP/GDP | 0.268 (0.162) | 0.667* (0.383) |
| GOVEXP/GDP dummy | 0.382 (0.439) | |
| ROAD/CAR | 5.521 (4.056) | 20.963 (57.057) |
| ROAD/CAR dummy | 16.625 (60.990) | |
| OPEC | −17.813*** (4.943) | – |
| $R^2$ | 0.838 | 0.878 |

World and Europe separately.

* Significant at 10%.

** Significant at 5%.

*** Significant at 1%.

## 5. Discussion and conclusion

Fuels are an attractive tax base for governments since costs involved in tax collection are low and tax evasion is difficult. The levels of the taxes imposed appear to differ strongly between countries. We survey several principles from the theory of public finance that may explain these differences. For example, we consider equity and benefit principles, efficiency considerations, tax competition and externality corrections. For tax competition, we conclude that, in Europe, small countries tend to be more aggressive than large countries by charging lower fuel taxes. Outside Europe, city-states such as Singapore and Hong Kong tend to do the opposite: they charge higher taxes than their neighbours, and, to avoid cross-border fuelling problems, they impose particular restrictions. The relevance of the benefit principle for fuel taxes is confirmed in Europe. Fuel taxes tend to increase with GNI per capita, which, as argued in the text, may both reflect relevance of equity principles (ability to pay) and efficiency principles (reduction of distortions given low price elasticities of demand). Furthermore, there is strong evidence that fuel is just considered as one of the many sources for government expenditure: when government expenditure as a share of GDP is higher, the fuel tax tends to be higher. Maybe, surprisingly, the statistical material gives no support to the hypothesis that fuel taxes are higher in countries where externality problems are more severe (proxied by car density of the country). This density variable captures both environmental externalities and congestion externalities. Thus, the normative literature on pricing externalities in transport has found little support in the realities of policy-making. On the other hand, one must realise that valuation of externality costs tends to increase with income per capita, and, for this variable, we found a positive effect for Europe. Finally, countries that are rich in oil resources, as proxied by OPEC membership, tend to have much lower oil prices.

## Acknowledgement

We thank two anonymous referees for helpful and constructive comments.

## Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.eneco.2004.10.002.

## References

Baumol, W.J, Bradford, D.E., 1970. Optimal departures from marginal cost pricing. American Economic Review 60 (part 1), 265–283.

Bruinsma, F.R., Rietveld, P., van Vuuren, D., 2001. Spatial graduation of fuel taxes; consequences for cross-border and domestic fuelling. Transportation Research 35 (part A), 433–457.

Frey, B.S., 1983. Democratic Economic Policy. Martin Robertson, Oxford.

Johansson, O., Schipper, L., 1997. Measuring the long-run fuel demand of cars; separate estimations of vehicle stock, mean fuel intensity, and mean annual driving distance. Journal of Transport Economics and Policy 31, 277–292.

Kanbur, R., Keen, M., 1993. Jeux sans frontières: tax competition and tax co-ordination when countries differ in size. American Economic Review 83 (part 2), 877–892.

Kaufmann, D., Kraay, A., Zoido-Lobatón, P., 2002. Governance Matters: II. Updated Indicators for 2000–01, World Bank Policy Research Working Paper, 2772.

Litman, T., 1999. Evaluating Transportation Equity. Victoria Transport Policy Institute, Victoria. www.vtpi.org/tdm/tdm13.htm.

Metschies, G., 1999. Fuel Prices and Taxation. Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ), Eschborn.

Musgrave, R.A., Musgrave, P., 1989. Public Finance in Theory and Practice. McGraw-Hill, New York.

Persson, T., Tabellini, G., 2002. Political Economics. MIT Press, Cambridge, MA.

Rietveld, P., 2003. Winners and losers in transport policy; on efficiency, equity and compensation. Button, K., Henscher, D. Handbook of Transport Systems, vol. 4. Elsevier, Amsterdam, pp. 585–601.

Verhoef, E.T, 1996. The Economics of Regulating Road Transport. Edward Elgar, Cheltenham.