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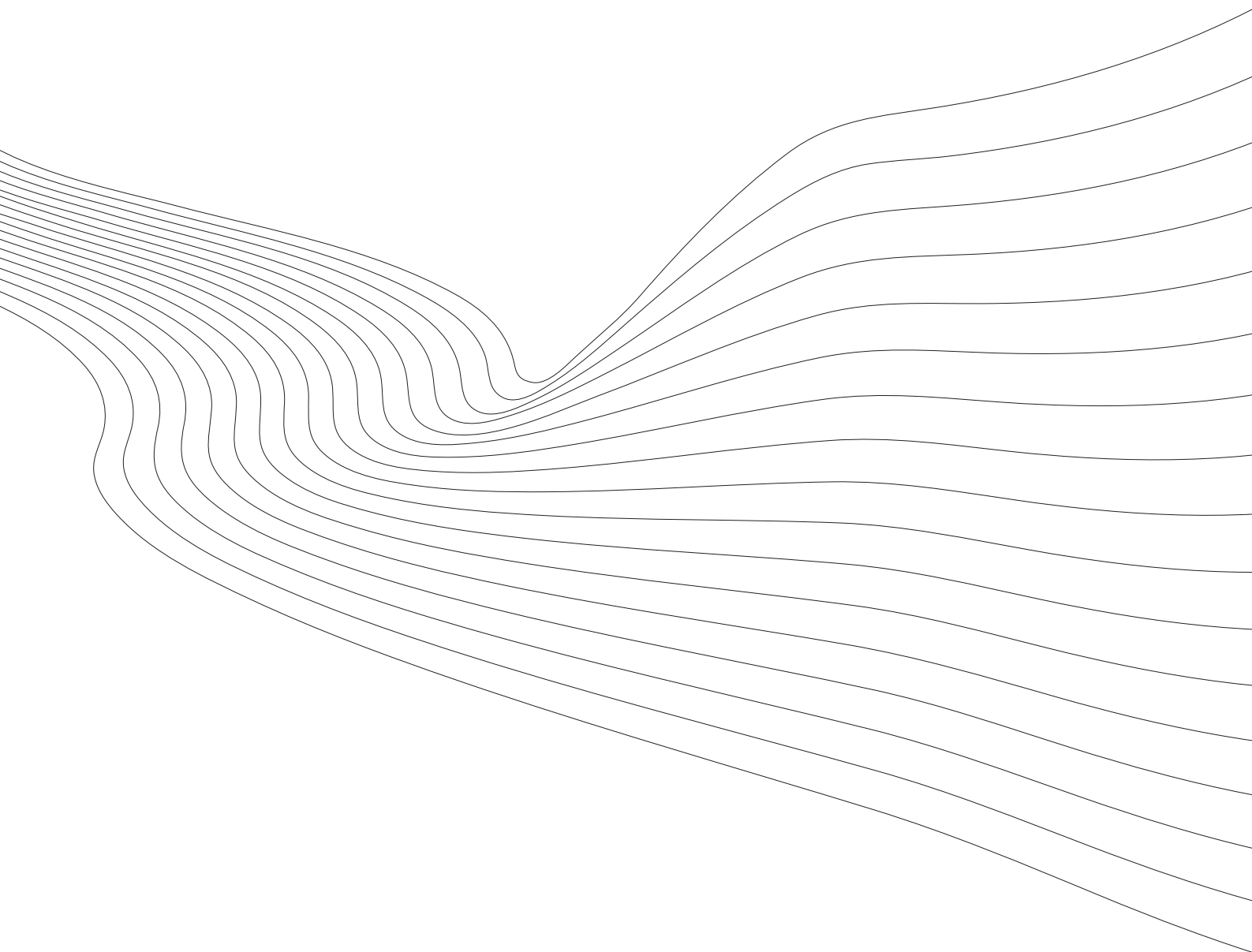
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# KOF Working Papers

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# **Diesel price convergence and mineral oil taxation in Europe**

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## **Abstract**

We empirically analyze convergence of European producer and consumer prices for diesel fuel and investigate the role of excise taxation. By comparing the speed of convergence of prices and taxes we find a surprisingly fast speed of convergence for consumer prices. While this can in part be explained by fuel tourism, the main driving force is producer price dynamics. Tax convergence contributes weakly to price convergence, but the overall effect is to slow down consumer relative to producer price convergence.

**Keywords:** price convergence, diesel, international taxation, European integration, panel unit roots

**JEL-Codes:** F15, H73, Q48, C23

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## 1. Introduction

In a world without barriers to trade or to the mobility of consumers, one would expect consumer prices to converge to the same level in all countries according to the “law of one price.” Despite some remaining obstacles to free movement, retail prices for diesel fuel should therefore tend to equalize in the European Union as well, given that substantial “fuel tourism” can be observed (see, e.g., Michaelis, 2004; Banfi et al., 2005; or Wlazkowski et al., 2007). However, whether cross-border shopping translates into price convergence involves a methodological problem which is a consequence of the high level of excise taxation levied on most mineral oil products.<sup>1</sup> While cross-border shopping puts substantial pressure on retail prices, Wlazkowski et al. (2007) argue that consumer price equalization requires two (further) components: tax convergence and the realization of arbitrage opportunities net of taxation. A priori it is not clear how strong consumer price arbitrage actually is and how relevant each of the two latter components is as a driving force on the supply side for observed retail price convergence for diesel fuel in the EU.

Tax convergence may follow either from direct policy measures, such as tax harmonization which has been proposed (but not yet introduced) by the European Commission (EU Commission, 2002, 2007), or indirect policy measures, such as tax competition (see, e.g., Evers et al., 2004; and Rietveld and van Woudenberg, 2005). Bentzen (2003) reports a tendency for indirect tax harmonization among OECD countries since the late 1970s. Net price arbitrage is supported on two different grounds: First, prices for mineral oil are assumed to be supply-side driven via the international spot markets (see, e.g., Balke et al., 1998), which puts pressure on producer prices in the

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<sup>1</sup> This issue is relevant not only in the case of diesel and other fuel types, but for all goods which are subject to a high level of excise taxation such as cigarettes or alcoholic beverages (see Cnossen, 2002).

first place. Second, the rules of international taxation – in particular, the ruling destination principle – are expected to enforce producer price convergence. However, a strong consumer price convergence is in contrast with these expectations as it is demand-side driven and more in line with the origin principle, an alternative rule for taxing products shipped across international borderlines.<sup>2</sup>

The aim of this note is to shed some light on the mechanisms leading to international retail price convergence. In order to do so, we provide empirical evidence on both price and tax dynamics in the market for diesel fuel. This allows us to assess the pressure on retail prices and helps to explain the relative importance of the two components described before, i.e., tax convergence and net price convergence. We start by investigating whether retail price convergence can be observed in the EU at all, as this will be an indicator for (successful) price arbitrage. These results are then compared with producer price convergence, thereby providing information on the net price arbitrage component in retail price convergence and on whether the destination principle holds. In the latter case, we expect producer prices to converge at a higher speed than consumer prices. Given that both consumer and producer price convergence can be observed, we will finally ask whether the net price arbitrage or the tax convergence component is more relevant for explaining this outcome. Furthermore, we briefly comment on whether there is a need for formal tax harmonization.

Our analysis proceeds as follows. In Section 2 we discuss tax and price convergence in more detail. Section 3 presents a brief description of the method of estimation and the data. In Section 4, by comparing the speed of convergence of prices and tax shares we

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<sup>2</sup> Note that the destination principle is relevant when it comes to delivering fuelling stations with diesel. Consumers, on the other hand, are free to fuel in any country without an obligation for border tax adjustment.

show that taxation has some impact on consumer price convergence, but the latter is nevertheless slower than producer price convergence. Section 5 deals with tax rates and tax amounts and provides an alternative approach to confirm the result that the observed speed of gross diesel price convergence can in part be explained by tax convergence, although taxation tends to slow down the speed of retail price convergence relative to producer price convergence. Finally, Section 6 concludes.

## **2. Price and tax convergence in the European Union**

In 2002, the European Commission proposed a first directive aiming at harmonizing diesel taxation in all EU member states until 2010 (see EU Commission, 2002). Since the initial directive was withdrawn in the legislative process, the European Commission started a new attempt to introduce these measures recently (see EU Commission, 2007).<sup>3</sup> The argument put forward to support harmonizing diesel taxation are fiscal problems possibly resulting from tax-induced fuelling behaviour or “fuel tourism.”<sup>4</sup> In the case of diesel fuel, this problem is expected to be particularly large because international freight hauliers are found to require their trucks on long-distance tours, which have large fuel tanks and a driving range of up to 3.000 kilometres, to refuel only in countries with low prices due to low taxation. This comes as no surprise as excise duty (excluding VAT) alone accounts for up to 18 percent of the running costs of road

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<sup>3</sup> The basic idea of the 2002 directive was to set a central tax rate (starting in 2003) at €350 per 1.000 litres with a band within which rates may fluctuate by plus or minus €100. While the central rate will annually be corrected on the basis of the harmonized Consumer Price Index, the band will fall to zero until 2010. Under the 2007 proposal, the minimum level of taxation will be raised in three steps to €380 per 1.000 litres.

<sup>4</sup> In addition, distortions of competition on haulage markets and environmental protection have been mentioned as further arguments (EU Commission, 2007).

haulage business (EU Commission, 2007). Since trucks account for a large share of diesel consumption in Europe and since the tax share in diesel prices is substantial in most countries, ranging between 44 percent (Luxembourg) and 86 percent (U.K.) in the long run average (Dreher and Krieger, 2008), international price competition is likely to be fierce. Private car owners – in particular in border regions – have become quite price sensitive, too (Michaelis, 2004; Banfi et al., 2005), putting further pressure on price levels. Retail price arbitrage is the likely result.

When retail price arbitrage goes along with existing tax differences, problems may arise in particular for high-tax countries. Since taxation drives a wedge between tax-inclusive (consumer) and tax-exclusive (producer) prices, retail price arbitrage may cause international producer price differentials. Comparing prices and taxes in two countries,  $A$  and  $B$ , in an international arbitrage equilibrium (assuming perfect markets) we get:

$$(p_A^c - p_B^c) = (p_A^p - p_B^p) + (T_A - T_B), \quad (1)$$

where  $p^c$  is the retail or consumer price,  $p^p$  the producer price and  $T$  the (excise) tax.

Note that from equation (1) follows immediately that retail price convergence may also be explained by both tax convergence and net price convergence, as pointed out by Wlazlowski et al. (2007). However, the relative importance of the two instruments cannot directly be deduced from equation (1) and will be one of the central aspects of our empirical investigation.

For  $T_A > T_B$ , retail prices equalization ( $p_A^c = p_B^c$ ) due to fuel tourism leads – at least in theory – to  $p_A^p < p_B^p$ . This, however, causes international goods production to be inefficient (this follows from Diamond and Mirrlees, 1971). Since fuel producers and sellers in high-tax countries have a competitive disadvantage when fuel tourism takes place, firms may opt to close down production facilities or fuelling stations or to leave



the country if taxes are not reduced. Often, national governments therefore consider lowering excise tax rates. Banfi et al. (2005), e.g., describe the case of Italian regions which had to introduce special tax markdowns in some border regions. In other (high tax) countries, such as Germany, similar measures are being discussed (Michaelis, 2004).

Given these incentives, the possibility of countries engaging in tax competition cannot be excluded. In terms of equation (1), we would observe pressure on tax rates such that at last  $p_A^c = p_B^c$ ,  $p_A^p = p_B^p$  and  $T_A = T_B \approx 0$ . With an EU directive on harmonizing diesel taxation, we would instead expect  $T_A = T_B > 0$ , which is preferable if positive tax revenues contribute to a country's economic welfare (e.g., when they are used for providing public goods) or to the internalization of environmental costs of fuel combustion.<sup>5</sup> Evers et al. (2004) present evidence for tax competition in the case of diesel excises. They find that a 10 percent higher tax rate in the neighbouring countries will induce a country to raise domestic tax rates by 2 to 3 percent, i.e., due to tax competition the level of taxation is restricted to be lower than governments would usually prefer. Rietveld and van Woudenberg (2004) show that tax competition is a European phenomenon only, with smaller countries being particularly aggressive when it comes to lowering tax rates.<sup>6</sup> If international tax competition plays a significant role in the diesel market, our empirical analysis should indicate a sufficiently fast speed of

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<sup>5</sup> This type of (Pigouvian) taxation may induce efficiency, as can be experienced by the rise in popularity of hybrid cars for example. As Gassebner et al. (2006) show, (lack of) energy efficiency is the main driving force of environmental pollution.

<sup>6</sup> This is in line with the findings from Kanbur and Keen's (1993) seminal paper on (direct) tax competition with asymmetric country sizes. Overall, the extent of tax competition between EU/OECD countries is subject to controversial debate. See Dreher (2006) for a recent overview and empirical analysis.

convergence of either tax rates or tax amounts levied on this product. Note that in the time span covered by our sample no formal steps towards tax harmonization at the EU level took place, such that tax competition may be a reasonable alternative explanation for tax convergence. Our test procedure can therefore (indirectly) give support or reject the tax competition results of Evers et al. (2004) and Rietveld and van Woudenberg (2004).

The seemingly obvious effects of fuel tourism and consumer price arbitrage need to be qualified by comparing them to producer prices. Many observers would argue that prices for diesel are mainly supply-side driven (e.g., Balke et al., 1998). Via highly efficient spot markets for mineral oil and mineral oil products producer price arbitrage is facilitated, such that international producer prices should converge at a particularly high speed towards a common level.<sup>7</sup> With existing tax differences consumer price arbitrage will be difficult to achieve under these circumstances ( $p_A^p = p_B^p$  and  $T_A > T_B$  lead to  $p_A^c > p_B^c$  according to equation (1)). This is even truer as in international taxation the destination principle applies. This principle implies that due to border tax adjustment both domestic and imported goods will be taxed at the same rate, such that consumer prices are equalized only within one country, but not between countries. International consumer price convergence becomes less likely under this scenario. Only the origin principle, according to which products are taxed in the country of purchase, may induce the full power of international consumer arbitrage. Under the destination principle, cross-border shopping may nevertheless be an important counterforce to producer price convergence and may – at the end of the day – lead to a substantial

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<sup>7</sup> While not being negligible, differences in extraction costs and refining costs are of minor importance. The same holds for potential oligopolistic tendencies in EU member states and local mark-ups (see Rietveld and van Woudenberg, 2005).

decline in consumer prices (or tax rates) in high-tax countries, which at given costs and taxes could drive firms out of the market. In our analysis, we will therefore compare the speed of convergence of consumer and producer prices. Nevertheless, we expect to find a relatively faster speed of producer compared to consumer price convergence when only *some* tax convergence (as estimated by Bentzen, 2003) takes place under the destination principle.

In general, this may put observed consumer price convergence into a different light as consumer arbitrage may possibly be less relevant than public debate suggests if retail price changes are mainly a consequence of producer price dynamics. Only if fuel tourism leads to harmful tax competition, as suggested by Evers et al. (2004) and Rietveld and van Woudenberg (2005), tax harmonization as proposed by the EU Commission may be a promising strategy. Given a relatively slow speed of convergence of consumer compared to producer prices, discretionary national tax policy – such as introducing green taxes on fuel – may still be possible and negative effects from fuel tourism may hardly need to be feared, as argued by Dreher and Krieger (2008). They show that retail price arbitrage in the European Union is too weak (yet) to level long run consumer price differences and that taxation of mineral oil products alone is able to cause market segmentation. Under these circumstances the role the tax convergence investigated in this note appears in a different light. With a high speed of convergence of producer prices, even diverging tax rates may still be compatible with (some) consumer price convergence. This makes a thorough analysis of tax convergence even more necessary and the main lesson to be learned from this exercise is that both producer and consumer prices as well as taxes need to be considered simultaneously when price convergence of highly excise taxed products or, more specifically, fuel tourism is investigated. This is because the existence of the tax wedge may buffer (or

accelerate) the impact of facilitated arbitrage caused by market integration on price convergence.

### 3. Data and Method

Our data is taken from the EU Oil Bulletin (EU Commission, 2007), containing weekly observations of “at the pump” prices for diesel. Consumer prices are denominated in ECU or Euro per 1000 litres. Based on information on taxes and duties we also derive producer prices. Our time series starts in January 1995 and ends with the EU enlargement in May 2004. Data is available for 15 countries.

We apply unit root tests as proposed by Levin et al. (2002) to examine stationarity and calculate the speed of convergence in prices and taxes. The optimal number of lags to be included has been determined using the Ng and Perron (1995) sequential  $t$ -test on the highest order lag coefficient. We estimate the following equation:

$$\Delta p_{it} = c_i + \alpha_i p_{it-1} + \sum_{z=1}^Z \beta_{it} \Delta p_{it-z} + \varepsilon_{it}, \quad (2)$$

where  $p_{it} = \ln(p_{it} / \bar{p}_t)$ ,  $\Delta$  is a first difference operator ( $\Delta p_{it} = p_{it} - p_{it-1}$ ) and  $\varepsilon$  is an error term;  $i$  and  $t$  represent country and time, respectively.  $Z$  is the optimal number of lags.

The speed of convergence can be calculated employing the formula  $\ln(0.5)/\ln(1 + \alpha)$ ,<sup>8</sup> where  $\alpha$  is the estimated coefficient of equation (2). By calculating the speed of price convergence for consumer prices, producer prices and taxes separately, we disentangle the share of tax harmonization in the convergence process from those unrelated to taxes.

The next section reports the results.

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<sup>8</sup> Note that this formula is an approximation and is only exact for AR(1) processes.

#### 4. Price Convergence and Tax Shares

Table 1 presents the results of our estimation. For consumer prices we do observe price convergence, which suggests that cross-border shopping or fuel tourism induces at least some consumer price arbitrage. There is no indication that market segmentation is sufficiently strong to avoid price equalization entirely under the law of one price. The approximate half life of a price shock is 33 weeks. According to Dreher and Krieger (2008), the estimated half-lives of price shocks range around one year in other studies using panel data (for other products than fuel) and around 4 to 6 years in cross-country analyses of the purchasing-power parities.<sup>9</sup> Here, retail prices are approximately halved even every 8 month which is surprisingly fast given that obstacles to arbitrage (transportation costs, limited information etc.) can never entirely be excluded. We would therefore suspect that according to Wlaskowski et al. (2007) net price arbitrage and/or tax convergence may have had an impact on retail price convergence as well (in addition to the pressure caused by fuel tourism). Our discussion of equation (1) suggests that the fast speed of convergence of net-of-tax prices on the spot markets, which is only 13 weeks for this time series (all estimates being highly significant), contributes substantially to the non-negligible speed of retail price convergence.

- Table 1 about here -

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<sup>9</sup> To the authors' knowledge there are no other panel data studies available, estimating the speed of convergence of diesel or gasoline prices. For OECD countries, international (gross) fuel price convergence has also been observed by Bentzen (2003) but without indication of convergence speed.

Given very fast converging producer prices, the role of tax convergence needs to be clarified. Possibly, taxes either diverge or converge at a very low speed such that consumer price convergence, which is driven by producer price changes according to equation (1), is in fact (strongly) reduced relative to producer price convergence. In order to assess these insights, we estimate the half life of a shock to tax shares in gross prices. As Table 1 shows, the speed of convergence is rather slow compared to those of diesel prices. There is no substantial difference in the half life of shocks for the excise tax share (45 weeks) and the overall tax share (excise plus VAT, 44 weeks). In order to be able to interpret this result, it is necessary to distinguish two cases. First, we look at the effect of tax share convergence alone, then we put it into relation to producer price convergence, thereby considering the decomposition of effects from equation (1).

For the first case, it is useful to recognize that in our data set countries with low producer prices also have low tax shares. The coefficient of correlation is 0.064 and highly significant. Comparing a high-price and a low-price country, this implies that there exists some ‘extra’ distance (compared to a world without taxation) between the countries’ consumer prices which follows from the tax differences. If tax shares converge, the ‘extra’ distance between consumer prices is reduced such that we observe a more rapid gross price convergence than we expect from price arbitrage alone.<sup>10</sup> Hence, tax share convergence indicates that the dynamics of taxes have positively contributed to consumer price convergence in the EU.<sup>11</sup> However, due to the rather slow speed of convergence any impact of tax share convergence can only be weak.

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<sup>10</sup> Note that this would not be the case would there be a negative correlation.

<sup>11</sup> Note that, given a positive correlation between tax shares and consumer prices, convergence of prices “at the pump” usually induces tax share divergence because the existing excise tax amount has to be related to a falling sales price in the high-price country and a rising sales price in the low-price country. The tax share must increase in the high-tax and fall in the low-tax country which implies tax share

On the other hand, when compared to net price convergence we find that taxation has in fact slowed down retail price convergence from the speed possible in a world without taxation. This finding, however, presupposes that both Wlaskowski et al.'s (2007) argument and relationship (1) hold, i.e., that producer price convergence translates directly into retail price convergence when no taxation takes place. If this is the case, the combination of fast producer price convergence and slow tax convergence leads to the “medium” speed of consumer price convergence. This confirms the findings by Dreher and Krieger (2008) who argue that taxation alone is able to cause segmentation of otherwise efficient markets.

## **5. Tax Rates and Tax Amount**

The weak positive effect of tax convergence on retail price convergence in general can be confirmed by considering VAT rates and excise tax amounts. As Figure 1 shows, producer prices for diesel have increased between 1995 and 2004, with an average monthly increase of about 0.31 Euro per 1000 litres. While VAT rates are neutral in terms of relative prices, constant excise taxes induce gross price convergence whenever net prices increase. This effect becomes even stronger if excise taxes (or the sum of excises and VAT<sup>12</sup>) converge. As we can see from the lower part of Table 1, both VAT rates and excise tax amounts converge over time, although at a very slow speed: the half life of a shock amounts to 64 weeks for excises and 70 weeks for VAT. The speed of convergence of the overall tax burden would be in the same range; however, the coefficient estimate is completely insignificant. Again there is evidence that tax

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divergence. This shows that tax convergence does not follow from gross price convergence, but partially explains consumer price convergence.

<sup>12</sup> For diesel fuel, excise taxation plays a dominant role compared to VAT taxation in Europe.

convergence contributes to consumer price convergence, but again the impact is only weak and – when compared to net price arbitrage – the overall effect is to slow down retail price convergence compared to a world without taxation. At the same time, other factors on the demand side, i.e. mainly price arbitrage due to cross-border shopping of private car owners and – in particular – freight hauliers, are likely to play independently an important role in explaining consumer price convergence.

Note that our estimates of both tax shares and rates support the findings of Evers et al. (2004) arguing that diesel taxes in Europe have been harmonized over the period 1978 to 2001. As the observed tax convergence (or harmonization) follows at least in parts<sup>13</sup> from tax competition (see also the results of Rietveld and van Woudenberg, 2004), tax competition has in fact played a significant but small role in consumer price convergence in the European diesel markets.

- Figure 1 about here -

## **6. Conclusions**

Our analysis has shown that there is surprisingly fast convergence of European consumer prices for diesel, which may – at least partly – be a consequence of cross-border shopping activities. However, we also observe an even faster speed of convergence for producer prices, as can be expected under the destination-country principle and supply-side driven price movements. Given that retail price convergence is to some degree affected by net price arbitrage and tax convergence, we can conclude

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<sup>13</sup> Note that the data set used by Evers et al. (2004) includes also some effects of the tax harmonization policy by the EU in the 1980s.



that price dynamics on the producer side, e.g., via international spot markets, may not be negligible and contribute substantially to equalizing consumer prices for diesel fuel.

In this context, the role of (excise) diesel taxation has been investigated as well, because any discussion focussing on price convergence or fuel tourism must take price dynamics and taxation simultaneously into consideration because of the high level of excise taxation which adds a specific problem to the analysis of international price convergence. Our findings show an ambiguous role of taxation in determining retail price convergence. On the one hand, tax convergence – possibly following from tax competition – tends to support consumer price convergence when the producer price side is excluded. The impact of tax convergence, however, is not overly strong. In EU member states both VAT rates and excise taxes (as well as tax shares) narrowed in the last decade which contributed (weakly) to consumer price convergence.

A comparison of tax convergence with price convergence shows, on the other hand, that taxation slowed down the speed of retail price convergence compared to a world without taxation. Consumer and producer price dynamics cannot be synchronized when excise taxation (with its specific dynamics) needs to be taken into account. From an EU perspective, taxation therefore induces an additional excess burden by hindering international price arbitrage. The resulting welfare loss to the entire EU therefore calls – according to the theory of fiscal federalism – for policy measures on a supranational (EU) level. Tax harmonization, as proposed by the EU Commission (2002, 2007), is a first step into this direction. It will be helpful to foster international price competition leading to price arbitrage which raises efficiency. The possibility of harmful unilateral tax policy of single EU member states will be reduced. However, from a national perspective tax harmonization may appear unattractive when discretionary tax policy

becomes impossible. Therefore, it must be feared that negotiations between EU member states may not lead to an optimal result.

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Table 1: Speed of Convergence, 1995-2004

	coefficient estimates	half life of shocks [in weeks]
consumer prices	- 0.0206*	33
producer prices	- 0.0516*	13
tax shares (only excise)	- 0.0154*	45
tax shares (excise + VAT)	- 0.0156**	44
overall tax burden (absolute values)	- 0.0102	[68]
excise taxes (absolute values)	- 0.0107*	64
VAT rates	- 0.0098*	70

Note: \*, \*\*: significant at the one and, respectively, five percent level

Figure 1: Producer prices for diesel, 1995-2004

