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Working Paper

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Arbeitspapiere der Nordakademie, No. 2004-04

Provided in cooperation with:
Nordakademie - Hochschule der Wirtschaft

ARBEITSPAPIERE DER NORDAKADEMIE

ISSN 1860-0360

Nr. 2004-04

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Do gasoline prices converge in a unified Europe with non-harmonized tax rates?

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December 2004

Abstract

The paper presents univariate and panel unit root tests for gasoline and oil price convergence over the last decade. We test for the absolute versus relative version of the LOOP and estimate the speed of convergence as well as its development over time. Our results show that the absolute version of the LOOP cannot be supported. Constant price differences between countries remain, caused mainly by existing tax differences. The relative version of the LOOP is strongly supported by the data. The speed of convergence increased over time, but differs for gross and net-of-tax prices. We can show that national tax policy by EU member states is not (yet) threatened by arbitrage due to cross-border shopping.

Keywords: price convergence, law of one price, gasoline, international taxation, European integration, panel unit roots

JEL-Codes: H7, F15, Q48, C2

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1. Introduction

The process of European integration has removed important barriers to the free movement of goods, services and factors of production, such as capital and labor. The Single European Act (1992) created an economic union, the Schengen acquis (1995) removed border controls and with the introduction of the Euro as the single European currency in 1999 (European Monetary Union) exchange rate volatility disappeared. Without trade barriers price transparency and thus competition in Europe was expected to facilitate arbitrage, such that prices for identical products eventually converge (*law of one price*, LOOP).

As a consequence of increasing integration, cross-border purchases of gasoline and oil products have become much easier over the last decade. In Germany, for example, "gasoline tourism" has become a common phenomenon (Michaelis, 2004) as in most neighbor countries fuel prices are lower. At the same time, many of these products are sold by international companies which sell their products all over Europe. Except for transportation costs, these companies can in principle offer their identical products for the same price everywhere. If the LOOP holds, we would therefore expect that price levels start to converge to a single European level.

The existing price differences, however, do not suggest that price convergence has actually taken place. Whether and to what extent this impression is correct will be analyzed in this paper. There are two different forms of price convergence to be considered, one referring to prices net of taxes, the other to prices including taxes. Arguably, the main source of international price differences is the wedge between consumer and producer prices created by heavy taxation of these products.[1] Under the destination-country principle (DCP) both domestic and imported goods are taxed at the same rate so that only producer prices may converge and goods production is internationally efficient.[2] Taxation according to the origin-country principle (OCP) implies that gross prices may equalize because of arbitrage due to cross-border shopping, regardless of tax differentials. Production efficiency may be distorted unless – despite of the OCP formally applying – producer prices converge at a significantly higher speed than consumer prices. In this case, discretionary national (green) tax policy is still sustainable and not prevented by arbitrage. We will show in the following that this scenario in fact applies to the situation in Europe.

[1] Gasoline tax revenue accounts for substantial shares of national budgets of the EU member states. For Sweden, their share is about 7 percent, while for all EU member states together the average is slightly less than 5 percent (own calculation, based on OECD Revenue Statistics, 2002).

[2] This presupposes that a tax adjustment takes place whenever goods cross the border.

However, even if price convergence takes place, it may not lead to the same price level but allow for some constant level difference between countries' price levels. This constant may be a consequence of geographic differences (and, thus, different transportation costs), differences in market power or – in case of consumer prices – taxation. It is therefore necessary to distinguish between the absolute and the relative version of the LOOP where under the relative version there is a non-zero constant.

Based on unit root tests for gasoline and oil price convergence over the last decade, our results show that the absolute version of the LOOP cannot be supported. Constant price differences between countries remain. This implies more support for producer price convergence than for consumer price convergence. Our results are thus in line with the outcome of taxation according to the destination-country principle (which is assumed to induce equal producer prices), although for two products the OCP applies formally.

The paper proceeds as follows. Section 2 investigates the markets for gasoline and oil products in Europe and discusses the potential effects of different tax principles on price convergence. The data is briefly introduced in section 3. Thereafter, section 4 presents our empirical results on convergence. We employ both univariate (4.1) and panel (4.2) unit root tests. Furthermore, we estimate the speed of convergence (4.3), test for the absolute versus relative version of the LOOP (4.4) and investigate whether the speed of convergence increased over time (4.5). Section 5 provides tests for robustness. Finally, section 6 concludes.

2. European integration and the prices for gasoline and oil products

The ultimate goal of European integration is the free movement of goods, services and production factors in order to allow market forces to evolve freely. Consequently – and in perfect markets – arbitrage should lead to a perfect international equalization of goods prices. Obviously there are some obstacles to perfect price convergence which will be discussed in the following.

2.1 The market for gasoline and oil products in Europe

The markets for gasoline and oil products are most important for European economies as these products are highly relevant input factors. Price movements are therefore closely monitored. A key characteristic of the markets is a rather inelastic demand which makes in particular gasoline an attractive source for tax revenue. Accordingly, most countries have introduced high tax rates for gasoline and oil products. Consider, e.g., euro super which is widely used for running private motor vehicles. Its price can be split into three components:

the cost price, the seller's margin including sales promotion, and taxes (gasoline excise tax and VAT). In European countries, the total tax share is between 62 and almost 77 percent of the sales price. Gasoline and oil products other than euro super are usually taxed at lower rates. This holds for diesel, heating gasoil and fuel oil, which our analysis considers as well. They are used – partly (diesel, gasoil) or entirely (fuel oil) – for commercial or industrial purposes. The demand elasticity of these products is usually higher than for euro super. Firms may consider moving production facilities to low-tax countries which prevents governments from levying excessive taxes on these products.

Regarding international tax differences, there are several possible explanations which result from specific national tax systems. However, there is also evidence that tax competition shapes the level of gasoline taxation (see, e.g., Evers, de Mooij and Vollebergh, 2004). The literature on tax competition suggests – among other things – that large countries like France or Germany tend to have a rather high tax load while in small countries it is often lower.[3] Actual sales prices for gasoline and oil products are in line with these observations, with high-tax countries having the relatively highest prices and vice versa.

This, however, presupposes that tax differentials are not compensated by large cost prices for raw material such as crude oil. Such compensation is rather unlikely because crude oil is traded mainly in international spot markets and its price is therefore very similar for all producers. The underlying commodity price level is one of the reasons why we would expect price convergence. Balke, Brown and Yücel (1998) find that – at least for the U.S. – shocks to crude oil and gasoline prices originate mainly with supply rather than with demand. While a co-movement of prices can thus realistically be assumed, level differences cannot be excluded; the absolute version of the LOOP would then not apply.

Production costs in the refineries differ, as well as transportation costs from the refinery to the buyers.[4] More generally, the specific geography of each country can potentially cause price differences. Nevertheless compared to the existing price differences "at the pump", production costs do not appear to be indicative of price discrimination although they certainly contribute to a regionalization or segmentation of gasoline markets. Other possible explanations for different prices are differences in the market structure or the price elasticities

[3] The fact that the highest tax rates can be found in the largest EU countries (for euro super these are France, the U.K. and Germany) has been explained by Kanbur and Keen (1993) in a model for international commodity tax competition with asymmetric country size. Due to differences in the price elasticities of demand, a small country will always undercut its large neighbor's tax rate because the revenue loss from the domestic population's gasoline consumption is more than outweighed by additional consumption from the neighbor country. On the other hand, lowering the tax rate in a large country results in a substantial revenue loss and will therefore be avoided, even if some consumers in the border region will buy in the small country.

[4] Refined products are harder and more expensive to ship than crude oil (Brown and Yücel, 2000).

of demand. In some countries markets are rather competitive; in others there are few large suppliers exerting market power. For several products cross-country differences in elasticities and implicit barriers to trade can actually be observed,[5] but again compared to tax differentials they do not appear to be the dominant reason for price differentials in the case of the gasoline market. In sum, we can conclude that if gasoline or oil prices differ between countries and/or products tax differentials are the most obvious among the possible explanations.

2.2 Principles of international taxation

In order to fully understand the role of taxation for price convergence, we need to take a closer look at the principles of international taxation. We will argue in the following that the speed of convergence of either producer or consumer prices indicates which tax principle can be sustained, regardless of whether this principle applies formally or not. It is always the faster converging time series of prices which determines the outcome.

In the theory of international commodity taxation, two basic principles can be distinguished, the OCP and the DCP. In general, there is an agreement that tax revenue from indirect taxation should be allocated to the destination country. In home country *H*, the relevant tax rate is therefore t^H which applies to both goods from home country producers and imported goods from foreign country *F*. The home country government is free to choose any tax rate it prefers. Goods production is internationally efficient because perfect price competition leads to an equalization of net-of-tax producer prices p^H and p^F:

$$p^H(1+t^H) = p^F(1+t^H) \Rightarrow p^H = p^F . \qquad (1)$$

International tax rate differentials ($t^H \neq t^F$) do not have an impact on consumer prices, i.e. gross sales prices, in country *H*. Assuming non-integrated goods markets, $p^H = p^F$ and $t^H \neq t^F$ imply that consumer prices $q^i = p^i(1+t^i)$, $i = H, F$, differ between countries: $q^H \neq q^F$. In the following, the DCP will be one of the benchmark cases for our analysis of gasoline prices. It assumes that price convergence takes place for producer prices only while consumer price differences remain. If both producer and consumer prices converge but producer prices converge at a higher speed, the outcome of the DCP is assumed to hold.

With perfectly integrated goods markets and the possibility of cross-border shopping, the outcome of perfect price competition with non-harmonized tax rates is equivalent to the outcome according to the OCP. There is no taxation of imported goods to which only the

[5] See EU Commission (2001) and the literature cited therein.

foreign tax rate t^F applies. Consumer prices equalize despite differing tax rates, such that goods production is internationally inefficient because producer prices differ:

$$q^H = q^F \Rightarrow p^H (1 + t^H) = p^F (1 + t^F) \Rightarrow p^H \neq p^F \quad \text{for} \quad t^H \neq t^F . \tag{2}$$

According to the rules of international taxation, the DCP is the relevant principle of taxation. However, in the European Union where cross-border shopping is easy and border controls have been abolished sufficiently strong price competition may override this principle. In fact, for private purchases the EU no longer follows the DCP. However, market segmentation may nevertheless prevent complete price equalization. The aim of our analysis is therefore to investigate which type of price convergence, consumer or producer price convergence, can be observed in reality and which tax principle can be sustained, given this information. The outcomes may differ depending on the product under consideration. For euro super and diesel, cross-border shopping may obviously take place while the import of fuel oil (which is used in large quantities for industrial purposes only) can easily be taxed according to the DCP.

Next to the polar cases described by DCP and OCP, one can think of scenarios in which neither consumer nor producer prices equalize. This may be the case under the DCP when price competition is imperfect in at least one of the countries. If, e.g., a firm in country *F* can exert market power and set producer prices above the competitive level (as assumed for country *H*, such that $p^H < p^F$) but tax rates are low in this country ($t^H > t^F$), the consumer price in *F* may nevertheless be lower than in *H* ($q^H > q^F$). Under the DCP, foreign products will not be bought in the home country. Neither producer nor consumer prices can equalize. Notice, however, that as soon as the possibility for cross-border shopping (according to the OCP) becomes available buyers from *H* will start to shop in *F*.

Whether consumer or producer prices converge (at a higher speed) has important policy implications. Consumer price convergence shifts the tax burden to the producers, which leads to a competitive disadvantage for firms in high-tax countries. Firms may opt to leave the country if taxes are not lowered. Countries may therefore engage in tax competition on this issue. Under the DCP, this is unlikely to occur but there is clearly an incentive for (illegal) cross-border imports. With increasing mobility of citizens, this principle cannot be sustained.

2.3 The law of one price

Arguably, in a world without transportation costs and with perfect price transparency, arbitrage would work perfectly well. Consumers would shop across the border in case of international price differentials, such that gross prices equalize. This scenario describes the absolute version of the LOOP and assumes that eventually gross price equalization can be expected, regardless of differences in tax rates or producer prices. Hence, the absolute version of the LOOP can directly be deduced from the OCP of taxation.

So far, research found little evidence for the absolute version of the LOOP. Only recently, some panel studies for selected products seem to support the convergence hypothesis, although convergence takes place at a very slow speed (see Goldberg and Verboven, 2001, for references). As results by Asplund and Friberg (2001) show, the LOOP may not even hold for identical products at the same location, if denominated differently.

In case of gasoline prices, consumer price convergence is not per se the most likely scenario. It has to be investigated whether price differentials can create sufficiently strong pressure on a country's gross prices, in particular if a country is rather large. Michaelis (2004) shows that Germans are willing to drive an additional 1.5 to 3 kilometres for each Euro cent price differential compared to a neighboring country in case of euro super and 2 to 4 for diesel.[6] Given the existing 2003 price differentials between Germany and its neighbors this relates to an average distance of about 30 to 35 kilometres. Often, in the border regions there are only few gas stations left on the side of the high-price country. Because of this, the pressure on prices may not trigger down into more central regions of the country and, therefore, countries also do not engage too heavily in price competition which puts pressure on tax rates.

While for cars the distance to the next cheaper country in terms of gasoline prices plays a significant role, trucks on long-distance tours have large tanks and may decide not to refuel in a high-price/high-tax country.[7] Evidence for the existence of strong incentives, particularly for international freight hauliers, to behave in this way has been presented by OECD (1997). The reason is that excise duty (excluding VAT) alone accounts for about 10 to 12 percent of the running costs of road haulage business (EU Commission, 2002).[8] Refuelling in low-price/low-tax countries is therefore an important competitive advantage and fuelling behavior becomes elastic in demand (Evers, de Mooij and Vollbergh, 2004). Trucks fuel diesel only and account for the larger share of all diesel-engined vehicles in Europe, therefore international price competition is likely to be fierce. In terms of price convergence, we would

[6] This estimate assumes restricted rationality in the sense that only the need for additional gasoline is included in the cost-benefit calculation of an individual, but not costs such as the wear out of the car or the expected costs of accidents. Considering perfect rationality implies lower distances per Euro cent of price difference.
[7] Large trucks have a cruising range of 1,500 to 3,000 kilometers (EU Commission, 2002).
[8] Excise duty (excluding VAT) represents about 60 percent of the pump price for diesel fuel, and fuel represents on average 15 to 20 percent of the running costs of road haulage business.

expect a faster speed of convergence for diesel than for euro super gasoline. For the future, this effect should become even more pronounced as a 2002 EU directive aims at harmonizing diesel taxation in all member states until 2010.[9]

Due to this indeterminacy regarding expected price convergence, it is useful to consider the relative version of the LOOP as well. Here, after an asymmetric price shock convergence takes place but level differences between countries may still exist. The reason for level differences lies with market segmentation which prevents perfect arbitrage. Competition cannot drive down prices to a common level. For the gasoline market, the absolute version of the LOOP seems to be too strong an assumption as noticeable price differences obviously exist. The question is therefore whether or not the relative version of the LOOP holds and how market segmentation may be explained.

In terms of the tax principles, the relative version of the LOOP fits to both the DCP and to any intermediate solution. If for producer prices the absolute version of the LOOP holds, there is evidence for the DCP to work smoothly. Otherwise, there exists some intermediate solution which implies markets are segmented.

Next to euro super and diesel, our analysis includes two further oil products for comparison: heating gasoil[10] and fuel oil with a sulphur content of less than 1 percent.[11] Heating gasoil is mainly used in private households, while fuel oil is for industrial purposes. Gasoil is usually bought locally as transportation is rather costly, so one would expect competition to be less fierce. It is also uncommon to shop for gasoil across the border. For fuel oil, a prediction is somewhat more difficult. Usually, firms cannot avoid national taxation, but on the other hand international competition for firms and investments might keep tax rates low.[12] As large firms usually have a rather strong market position in relation to oil suppliers and can easily buy fuel oil from foreign suppliers, strong price competition and low tax rates may lead to a high convergence speed. For this product the DCP applies, such that producer price convergence should occur.

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[9] See EU Commission (2002): Starting in 2003 a central tax rate will be set at €350 within 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 CPI, the band will be zero to zero until 2010.

[10] Notice that diesel gasoline is also known as *automotive* gasoil, while in this context we consider *heating* gasoil. Both varieties are almost identical, the difference is mainly in the use and in the level of taxation. Automotive gasoil is taxed at a higher rate. Heating gasoil can be distinguished from automotive gasoil through additives (heating gasoil is red-colored and contains *Solvent Yellow 124* as a chemical marker).

[11] Since 2003, fuel oil with higher sulphur content is no longer allowed in the EU.

[12] The extent of tax competition between EU/OECD countries is subject to controversial debate. See Dreher (2003) for a recent empirical analysis.

3. Data

The data is taken from the EU Oil Bulletin. According to Council Decision 1999/280/EC, each member state is required to provide information on crude oil supply prices and consumer prices of petroleum products on a weekly basis. We consider "at the pump" prices for four different products: euro super gasoline, diesel (automotive gasoil), gasoil (heating gasoil) and fuel oil. Prices are denominated in ECU or Euro. Given the information on taxes and duties, producer prices can easily be derived. The longest available time series starts in January 1994 and ends with the EU eastern enlargement in May 2004. This is equivalent to 505 weeks. While in 1994 only 12 countries are considered, starting in 1995 (EU northern enlargement) data for 15 countries is available.

4. Results on convergence

The LOOP implies that profit incentives and market forces induce the prices for the same product sold in different markets to tend to converge to the same level. This implies that the time series of relative prices is mean reverting, or stationary. To test for stationarity it is common practice to apply unit root tests, where rejection of the unit root hypothesis implies that the time series of relative prices are stationary, and will in the long-run converge. If the test fails to reject the unit root hypothesis, relative prices follow a random walk and any deviation in prices becomes permanent.

4.1. Univariate unit root test

We will first apply the Augmented Dickey-Fuller (ADF) test to each individual time series to examine whether the relative price series is stationary. 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 for each country and each product:

$$\Delta p_{ijt} = c_{ij} + \alpha_{ij} p_{ijt-1} + \sum_{z=1}^{Z} \beta_{ijt} \Delta p_{ijt-z} + \varepsilon_{ijt} , \qquad (3)$$

where $p_{ijt} = \ln(p_{ijt} / \overline{p}_{jt})$,[13] Δ is a first difference operator $(\Delta p_{ijt} = p_{ijt} - p_{ijt-1})$ and ε is an error term; i, j and t represent country, product and time, respectively. Z is the optimal

[13] This definition of price variation follows Cecchetti, Mark and Sonora (2002), O'Connell and Wei (2002) and Fan and Wei (2003). Our benchmark is thus the average price for each product at time t over all countries. We also perform tests with Germany and, respectively, France as benchmark country. Therefore, instead of testing whether prices in different countries converge to the cross-country average, we analyze whether prices in different countries converge to those in Germany or France. As one problem with this approach, however, the

number of lags. The constant term is included to capture country-specific characteristics, like taxes, market structure, the price elasticity of demand and specific geographics. As will be discussed in detail below, the individual country dummies capture whether prices converge to absolute price parity (zero mean) or relative price parity (non-zero mean).

Table 1 reports the countries where the univariate ADF test rejects the unit root hypothesis at conventional levels of significance. As can be seen from column 1, for consumer prices the unit root hypothesis is rejected in the minority of countries and products. At the ten percent level of significance, euro super converges to the law of one price in five countries only. For diesel, convergence can be found in 7 countries, for gasoil in 6 countries and for fuel oil in 8 countries. The actual number of countries in which the unit root hypothesis is rejected appears to be rather low. Obviously, there is little support for convergence according to the OCP. A closer look at tax rates reveals that there have been several tax rate changes over the 10-year time period in the data set. While VAT remained constant in most countries, excise taxes were in some countries raised twice in every year. The most significant changes happened to euro super, while excise taxes on fuel oil did hardly change. Hence, even if prices tend to converge, this may have been overcompensated by tax rate effects. Not surprisingly, price convergence occurred in most countries for fuel oil for which taxes do not play a significant role, such that mainly market forces determine prices.

Removing the impact of VAT and gasoline excise taxes, producer price convergence can be investigated next. A significantly larger number of converging countries indicates that DCP can be sustained. Column 2 of Table 1 confirms this expectation for euro super, gasoil and fuel oil. For euro super, the number of convergent countries doubles while for both gasoil and fuel oil the number increases by two countries. This implies that markets are sufficiently segmented such that market forces do not interfere with the DCP. On the other hand, taxation of all consumer goods should follow the same principle, which is the OCP within the EU, even if some other principle can be chosen as well. Furthermore, with expected further deepening of European integration additional pressure on consumer prices will most likely occur.

In our estimate, a first indication of the latter effect can be observed with diesel where the unit root hypothesis is rejected in one country less for producer prices than for consumer prices. Due to the increasing importance of international road haulage, convergence of “at the pump” prices occurs more often. However, a limitation of our results should be mentioned. Some countries which showed consumer-price convergence do no longer converge for

results are usually not robust to the choice of the base country (Parsley and Wei 1995, Papell 1997). We come back to this in section 5.

producer prices. A possible explanation is that on average increasing tax rates generate an artificial upward trend to which some countries converge to because prices in these countries increase in general. Without taxes, the general price increases can still be observed but the artificial upward trend is removed.

In summary, the univariate ADF tests provide support for the hypothesis of long-run price parity in the gasoline market for some countries and products, but not for others. For producer prices convergence is more pronounced than for consumer prices, except for diesel. In general, this provides evidence for the sustainability of the DCP. However, the Augmented Dickey-Fuller test is well known to have low power in distinguishing the unit root null from stationary alternatives (Maddala and Wu 1999); the test tends to reject the stationarity hypothesis too often, thus providing only a lower level of the number of countries with prices converging.

4.2. Panel unit root test

To overcome the problem of low power of the univariate ADF test, Maddala and Wu (1999) and Levin, Lin and Chu (2002), among others, proposed unit root tests based on panel data. The Maddala-Wu test is applicable to both unbalanced and balanced panel data sets and allows the autocorrelation coefficients to differ across panel members. Specifically, the Maddala-Wu test consists in first testing the unit root for each cross-sectional unit separately. Based on the p-values of the individual unit root tests, the overall test statistic is

$$-2\sum_{n=1}^{N}\log(p-value)_{ij}\ . \tag{4}$$

The test statistic follows a chi-squared distribution with 2N degrees of freedom; N being the number of countries.

The unit root test proposed by Levin, Lin and Chu (2002), to the contrary, imposes a cross-equation restriction on the first order autocorrelation coefficients; the coefficient α is not allowed to vary across countries but is restricted to be equal. The Levin-Lin-Chu approach is thus the more conservative test. Equation (3) is estimated jointly for all countries and products. The c_{ij} capture dummies for countries and, respectively, products that account for product-specific price differences that do not vary over time across countries. Like the other tests, the equation thus examines the relative version of the law of one price, and the absolute values of c_{ij} are of interest in itself, since large values would indicate market segmentation.

Following Goldberg and Verboven (2004), we estimate two types of panels. First, we only pool over countries and run regressions for each product separately. Second, we pool over countries and products. In both cases, the number of lags is determined employing the top-down approach of Campbell and Perron (1991). We start with lag length 15 and reduce the number of lags until the longest lag is significant at the five percent level at least.

Table 2 contains the results regarding consumer prices. Turning to the Maddala-Wu panel unit root test, the Table shows that we can reject the null of a unit root for all products at the one percent level of significance: There is a strong tendency for consumer prices to converge to the LOOP. This does in principle support the OCP which shifts the tax burden to producers. High-tax countries put thus a strain on their domestic firms' competitiveness, if they are taxed according to the DCP. However, it will be necessary to compare this result to the estimate of producer price convergence. Since we are dealing with a dynamic process, a faster speed of convergence of producer prices implies that the outcome of the DCP has been achieved more easily in the past.

Table 2 also contains the results for the Levin-Lin-Chu panel unit root tests. Since the panel has to be balanced for conducting the test – and we do not have observations for all countries in 1994 – we lose one year of data. In applying the panel test to gasoil and fuel oil, we have to omit Portugal, and, respectively, Ireland and Great Britain, again due to data availability. Those country/product combinations are thus also omitted from the pooled country/product analysis.

In column 1, we report estimates for the model pooled over countries and products; the models pooled over countries only are reproduced in columns 2-5. In column 1, our coefficient estimate for α is -0.04, with a t-statistic of -21.10. At the one percent level of significance, this exceeds the critical value reported by Levin, Lin and Chu (2002), so we reject the null hypothesis of a unit root. Looking at the results for individual products, the hypothesis of a unit root is rejected at the five percent level for euro super, and at the one percent level for diesel, gasoil and fuel oil.[14] Price convergence has taken place, however, only to a relative level as at least some country dummies significantly differ from zero and level differences exist.

As can be seen, not all country dummies are individually significant at conventional levels. They are, however, jointly significant at the one percent level in all equations. By dividing these fixed effects by $-\alpha$ of equation (3), the long-term systematic price differential across countries is obtained. For euro super, the long-term price differentials take values

[14] As one problem with the analysis, changes in nominal exchange rates might be responsible for observed convergence. Following Goldberg and Verboven (2004) we therefore also estimated equations including up to ten lags of the weekly changes in exchange rates to capture changes in cross-country price differentials resulting from short-term nominal rigidities. As it turns out, the exchange rate variables are always jointly insignificant at conventional levels. The estimated speed of convergence does not change when those variables are included.

between 27 percent below average (Greece) and 15 percent above (United Kingdom). Long-run price differentials are 22 percent below average in Luxembourg. The results show that long run diesel prices are approximately 24 percent lower than average in Greece, and 39 percent higher than average in the UK. Gasoil, to the contrary, is in the long run cheapest in the UK, and most expensive in Italy; the lowest long-term fuel oil prices can be found in Belgium and the highest in Denmark.

The main explanation for these level differences can clearly be deduced from looking at national tax rates, given that producer prices do not differ too strongly for the countries under consideration. Taking consumer prices, one can easily calculate the tax share for each unit of gasoline. The average tax share for euro super is highest in France (76.60 percent) and the U.K. (76.44), while it is lowest for Greece (62.03) and Luxembourg (62.00). This is in line with our empirical finding that long-term price differentials exceed the average most strongly in the U.K. and fell farthest below the average in Greece and Luxembourg. The results are similar for diesel (gasoil, fuel oil) where the highest tax share can be found in the U.K. (Italy, Denmark). For all products, the lowest tax share can usually be found in Luxembourg. For gasoil and fuel oil, however, the United Kingdom and, respectively, Belgium, are close to the number for Luxembourg. If price competition on the consumer side is not sufficiently strong, tax differentials will remain visible in consumer prices. The tax burden is carried by the consumers.

For comparison, we re-run the analysis employing producer prices instead of consumer prices. Following our discussion of tax principles, a persistence of consumer price differentials allows generally for producer price convergence according to the DCP. This, however, does not exclude the possibility that for producer prices level differences persist as well. But we would expect that supply side driven price dynamics and market segmentation on the consumer side will lead to faster convergence and smaller level differences in producer prices. From Table 3 it can be seen that in fact the coefficient α is greater in absolute terms, i.e. the producer price differential is reduced at a faster speed. Furthermore, as the individual country dummies show most countries are now much closer to the mean. For euro super, the long-term price differentials now take values between 19 percent below average (United Kingdom) and 10 percent above (Austria). Long run diesel prices are approximately 16 percent lower than average in France, and 14 percent higher than average in Ireland. The lowest producer prices for gasoil and fuel oil can be found in the United Kingdom and Austria (15 and, respectively, 22 percent below average), the highest in Italy and Portugal (13 and, respectively, 23 percent above average). This indicates that price convergence has mainly taken place on the producer price side rather than on the consumer price side. On the other hand, the number of significant country dummies provides a slightly different picture. For diesel, this number is higher for producer prices. This implies that for this product competition on the consumer price side is obviously quite strong. Thus, the DCP rather than the OCP is supported.

4.3. The speed of convergence

So far, we found that prices do converge and that this happens with different speeds. We can now estimate the exact speed of convergence. In order to do so, we calculate the approximate half life of a shock for all convergent price series of each product, using the formula $\ln(0.5)/\ln(1+\alpha)$,[15] where α again denotes the estimated coefficient of equation (3). The speed of convergence gives us some insights about the process of European integration and the potential need for adapting tax rules to a changing environment. A fast speed of convergence is an indication of well-functioning markets with rather strong competition. Again the distinction of producer and consumer prices may play a role. Analogous to the finding that price convergence is more relevant on the producer price side, we expect the speed to be faster on this side as well.

According to the results for consumer prices, the average half life ranges from 10 weeks for gasoil to 19 weeks for fuel oil, 33 weeks for diesel, and 41 weeks for euro super. Regarding producer prices, the average half lives amount to 8 weeks (fuel oil), 11 weeks (euro super) and 13 weeks (diesel and gasoil).

As expected, the speed of convergence is (except for gasoil) much faster for producer prices than for consumer prices. The existence of taxes as well as the changes of tax rates over time slow down and sometimes even counteract the process of convergence on the consumer price side. Together with the finding that level differences between (at least some) countries exist, this is additional evidence that market forces are not sufficiently strong to support gross price convergence. The DCP can in principle still be sustained. The most important implication of this finding is that governments have scope for discretionary tax policy as the tax burden can be shifted to consumers. In particular, the slow speed of convergence of the consumer price for euro super is in line with the relatively highest taxation per unit. Only gasoil generates an opposite result. Its consumer price converges fastest of all products, while it is slowest in terms of producer prices. In fact, consumer prices converge even faster than

[15] Note that this formula is an approximation and is only exact for AR(1) processes.

producer prices. This should, however, not be explained by particularly strong international consumer competition as gasoil is traded mainly locally.

In comparison to past estimates of the LOOP, our numbers nevertheless appear to be rather low. Cross-country analyses of the purchasing power parity, e.g., find half lives of 4 to 6 years (see Goldberg and Verboven, 2004). More recent studies using panel data get lower estimates of about one year. However, there are no other estimates of gasoline and oil price convergence, such that a direct comparison with our results is not possible.[16]

Given our results, only the consumer prices for diesel and euro super are close to previously estimated numbers for other products. One of the main reasons for the rapid price convergence might be the volume and the importance of these markets and the rather strong competition between suppliers. Furthermore, on these markets menu costs are very low. Even daily price changes create hardly any costs.

4.4. Absolute or relative version of the law of one price

The previous analysis has focused on the relative version of the LOOP as we allowed for a constant term, i.e. for level differences, in equation (3). Our first test in order to investigate whether the absolute or relative version of the LOOP holds was to check whether all (or at least some) of the constants differ significantly from zero in the univariate unit root tests of section 4.1. The number of constants can be calculated and compared for both series of relative prices. For consumer prices, the constant term is significant at the ten percent level in the majority of the regressions, supporting the hypothesis that the individual price series converge to relative rather than absolute parity. Out of the 15 regressions we run for each product, the intercept has been significant in ten countries for euro super, nine countries for diesel, eleven countries for gasoil, and ten countries for fuel oil. In other words, even if convergence occurs, fixed price gaps between countries remain. For the net-of-tax time series, the same calculation yields that the intercept term is significant in nine countries for euro super, seven countries for diesel and eight countries for gasoil. The number of significant intercept terms has instead risen to eleven countries for fuel oil. Except for the last finding, these results show again that the process of convergence is more relevant on the producer price side as there are fewer countries converging to the relative version of the LOOP only. For fuel oil, taxation plays only a minor role and gross and net prices hardly differ. Nevertheless, there has been a slow and steady increase in tax rates over time which may explain why there are more converging countries on the gross price side. The more interesting

[16] Bentzen (2003) shows convergence of oil prices, but does neither calculate half lives nor publish coefficient estimates.

observation in this context is, however, the large number of significant constants. This indicates that market segmentation is rather strong, most likely caused by differing market structures.

It is useful to confirm the findings derived from univariate unit root tests also by employing the panel unit root tests by Levin, Lin and Chu (2002). The equation we estimate is

$$\Delta p_{ijt} = \alpha_{ij} p_{ijt-1} + \sum_{z=1}^{Z} \beta_{ijt} \Delta p_{ijt-z} + \varepsilon_{ijt} \, , \tag{5}$$

which is the same as equation (3), except for that we omit the product/country dummies. Without those fixed effects, the hypothesis we are testing is whether the price differences are converging towards zero in the long-run.

Again we conduct the test for the pooled country/product sample and the individual product samples. As it turns out, the hypothesis of a unit root in consumer prices cannot be rejected at conventional levels of significance in any specification (the critical value according to Levin, Lin and Chu (2002) being -5.98 at the ten percent level) – there is no support for the absolute version of the LOOP. Consumer competition is not sufficiently strong to erode price differences. The question remaining unanswered, however, is whether tax differentials alone can explain the price differentials. To investigate the issue further, we re-run our analysis with all prices net of taxes. Obviously, if absolute price differentials are completely due to differences in tax rates, price differences might converge to zero once taxes are accounted for.

Turning to the Levin-Lin-Chu test, the null of a unit root is now rejected at the 5 percent and one percent level of significance for euro super and diesel, respectively, but not for fuel oil and gasoil if the product panels are tested individually. For those products which are taxed most heavily, taxation is the dominant explanation for market segmentation. Despite gasoline tourism and the application of the OCP, market forces are not strong enough to equalize price differentials entirely. This is good news for policy makers as it allows for discretionary national tax policy without distorting international efficiency of goods production. Hence, despite the fact that – for reasons of equal tax treatment of consumer goods – the DCP is no longer relevant its outcome can still be achieved in the markets for euro super and diesel.

This is different for gasoil and fuel oil where net-of-tax prices do not converge in absolute terms. Not only are taxes less relevant, but – as a locally traded good – gasoil cannot necessarily be expected to show international producer price convergence. For fuel oil, the result of the univariate analysis is confirmed. There is no clear evidence for absolute price convergence for either of the two series of price differentials. In terms of our discussion of tax principles, an intermediate outcome has been achieved which indicates strong influence of non-tax variables such as market structure. Our analysis, however, cannot exactly determine which factors these are.

In the pooled country/ product sample, we now find convergence to the absolute version of the law of one price, at the ten percent level of significance. Taking this broad view on prices for gasoline and oil products in Europe, we find that there is a tendency of producer prices towards becoming perfectly equalized over time. The desired outcome of the DCP, namely an internationally efficient goods production, has been achieved within the EU over the 10 year period our data cover. For policy makers, it is important to know whether this favorable situation is likely to continue in the future. This will be discussed in the following.

4.5. Did the speed of convergence increase over time?

Most observers expect that with the deepening of European integration arbitrage should become easier and that convergence to the LOOP will occur. In this section we examine whether markets became more integrated during the ten-year period from 1994 to 2004. If, particularly on the consumer price side, the process of price convergence has speeded up in the past, there is a good chance that this will continue in the future. Sustaining the DCP outcome will become more and more difficult, thereby eventually distorting production efficiency. If the speed is slow, changes will most likely be negligible for at least some time.

Following Goldberg and Verboven (2004), we address the question of progress in the speed of convergence in two ways. First, we estimate the convergence equation for two sub-periods of our sample, expecting the speed of convergence to be higher in the later period. Second, we introduce a trend variable to the unit root equation and interact it with the speed of convergence. Again, we would expect the speed of convergence to be higher in more recent years. However, if convergence reduced the absolute price differentials, price shocks may be eliminated more slowly – not because impediments to arbitrage did not diminish, but because price differentials to be eliminated are smaller as compared to the pre-integration period (Goldberg and Verboven 2004).

To investigate the effects of integration on the speed of convergence, we estimate:

$$\Delta p_{ijt} = c_{ij} + \alpha_{ij} p_{ijt-1} + \tilde{\alpha} \cdot trend \cdot p_{ijt-1} + \sum_{z=1}^{Z} \beta_{ijt} \Delta p_{ijt-z} + \varepsilon_{ijt} \, . \qquad (6)$$

We start by splitting our sample in two approximately equal sub-periods: 1995-1999 and 2000-2004. Again, we estimate separate equations for each product, and an equation pooled by countries and products. Table 4 contains the results for consumer prices for both sub periods and the corresponding changes. As can be seen, at the one percent level of significance the speed of convergence increased for all products, except for fuel oil, where the speed of convergence did not change significantly over time. Results for producer prices are reported in Table 5. Again, the speed of convergence increased significantly for all products, except for fuel oil. Surprisingly, however, the difference in the speed of convergence for producer fuel oil prices is also significant, but decreased. Comparing the estimated speed of convergence between consumer and producer prices is also of interest. As can be seen from the tables, producer prices converge faster than consumer prices in both periods of time, the exception being gasoil in the earlier period.

Three remarks concerning our results are in order. First, European integration has in fact led to an increase in the speed of price convergence. The important integration steps like the Schengen acquis or the monetary union had the desired effect of facilitating international arbitrage. This process is likely to continue in the future. Second, as expected, the speed of convergence has been faster for producer prices than for consumer prices in all sub periods. This is in line with our previous result that convergence can be found mainly for producer prices. Third, for the change in the speed of convergence between the sub periods the results are ambiguous for the two series of prices. While for diesel and gasoil the change is larger for producer than for consumer prices, the opposite holds for euro super. This implies that for the latter product the gap between the different speeds is becoming smaller. If this process continues in the future, eventually the speed of convergence will be higher for consumer prices. This would be an indication that at some time consumer price convergence according to the prevailing OCP will occur. Differing tax rates would then lead to a distorted international goods production. While it is not yet foreseeable whether and when this will happen, policy makers should be aware of the possibility that this development might become relevant in the future. Notice that the result for fuel oil cannot clearly be determined as one of the coefficients is insignificant. For producer prices, convergence has even slowed down. This confirms our suspicion that impact factors other than taxation play an important role.

Tables 4 and 5 also contain results for the interaction term in equation (6). As one problem with this approach, the distribution of the relevant test statistics is no longer known under the null of a unit root (Goldberg and Verboven 2004). Results are thus merely suggestive. The results of columns 16-20 show that the interaction term is almost always insignificant at conventional levels of significance.[17] It thus seems that faster convergence is offset by slower elimination of the reduced price differentials (which are the consequence of increased integration).

5. Robustness with respect to variations in the benchmark

To test for the robustness of our results, we replicate the previous analysis with France and Germany as benchmark countries. Instead of testing whether gasoline prices converge to the average of the EU-15 prices, we test for convergence to the German or, respectively, the French price levels. Germany is the largest EU country, with among the highest taxation of gasoline and oil products, and (transit) traffic is particularly heavy. The country may therefore have a strong impact on the development of gasoline and oil prices. France, on the other hand, is geographically the most central of the large EU member states. Overall, the estimates for Germany and France confirm our previous findings with the EU average as benchmark. Nevertheless some remarkable differences among the three benchmarks have been revealed.

This is particularly true for our univariate unit root tests. For German prices as a benchmark, there is strong evidence that price convergence takes place with producer prices rather than with consumer prices. In fact, for euro super and diesel there is not a single country which converges to the German consumer price level. On the other hand, producer prices converge in 10 countries for each of the products. For gasoil and fuel oil the number of converging countries increases only by one when considering producer prices. one candidate explanation for this surprising observation might be the additional green tax levied on euro super and diesel in Germany. From 2000 to 2003, this tax was increased by approximately €0.03 per litre and year. This additional upward trend has not taken place in any other country, so it proved to be an obstacle for convergence. However, except for the consumer prices of euro super and diesel the total number of converging countries is almost identical to the EU average benchmark which shows that prices in Germany follow a similar pattern of movement as the European average.

For French gasoil consumer prices, a similar result as for German euro super and diesel prices can be found. The number of converging countries increases from 1 to 10 when taxes are removed. The reason is again an extreme change in tax policy. In 2000 France was the only country in Europe to cut gasoil excise tax rates significantly (by approximately 60

[17] We also estimated equations where the fixed effects have been interacted with the trend variable, the hypothesis being that with increased integration long-term price differences would decline. We did not find any systematic evidence. Again, results do not change if the first difference of the exchange rate and its lags are included.

percent) after strong public protests against increasing oil prices. For the other products the number of converging countries changes hardly as there is only one country more or less when consumer and producer prices are compared. However, the total number of converging countries is rather low and ranges between 1 and 5 countries only. This implies that the movement of prices in France is rather different from the rest of Europe.

The Levin-Lin-Chu panel unit root test rejects the unit root hypothesis at the 1 percent level of significance and with a coefficient estimate for consumer price convergence of approximately -0.04 for all three benchmarks. This shows that our estimate is in general robust against the specification of the benchmark country as the overall speed of convergence is identical. Considering individual products, the estimated coefficients differ slightly between benchmarks. However, they also support the findings of the univariate unit root tests. For the German benchmark the coefficients for euro super and diesel are insignificant, for the French benchmark the speed of convergence is lowest for gasoil. The Maddala-Wu statistic shows the same pattern, except that it is insignificant for euro super in the French benchmark as well.

For producer prices all three benchmarks show the expected results. The coefficient estimates are almost identical for France and the EU average. The only remarkable difference is that with the German benchmark the speed of convergence is substantially higher compared to the other benchmarks. In this respect, German producer prices appear to be a benchmark explaining price movements in Europe quite well. One of the reasons for this result might be that German producer prices follow closely the development of crude oil prices at the spot markets due to strong supply-side competition. In our analysis it was nevertheless not useful taking Germany as the general benchmark because of the special behaviour of consumer prices due to the German green taxes.

6. Conclusion

The process of European integration aims at facilitating arbitrage in order to increase overall welfare of European citizens. Eventually any price differential due to artificial trade barriers or market segmentation should vanish, only differentials caused by differing transportation costs may remain. While this ultimate goal is in the citizens' interest, it may be in conflict with tax revenue goals of member states' governments. The taxation of gasoline and oil products is a major revenue source for most European governments. However, with open borders governments are not free to choose tax rates as citizens may decide to shop abroad if the destination-country principle in taxation cannot be imposed. In this case, the demand for these products is rather price elastic. Formally for euro super and diesel the origin-country principle holds, taxing the products in the country in which they are bought only. If cross-border shopping takes place, domestic tax rates may be under pressure to fall because consumer prices may equalize due to arbitrage. However, the question is whether arbitrage is sufficiently strong to induce this effect, thereby restricting the possibility of a national tax policy.

Our analysis investigated this question by considering European consumer and producer price convergence over the last 11 years. We found that evidence for consumer price convergence (indicating successful arbitrage) is far less than evidence for producer price convergence which supports the destination-country principle. Producer prices converge both in more countries and at a higher speed. However, neither consumer nor producer prices converge to the absolute version of the law of one price. Not only is arbitraging rather weak, but market segmentation still exists in the sense that level differences between countries remain permanently. In case of producer prices this may be explained by several reasons such as differing transportation costs, market power or price elasticities. For consumer prices, tax differentials have to be added to these arguments. Our findings are robust with respect to variations of the benchmark. This provides evidence that national tax policy regarding gasoline is still possible for EU member states as arbitrage is not sufficiently strong to erode price – and thus tax – differentials.

Whether this finding will hold in the future is questionable as further integration steps can be expected allowing for even better arbitrage opportunities. We found that the speed of price convergence has increased over time, although for both consumer and producer prices. In particular for diesel taxation changes can be expected as the demand for diesel becomes increasingly highly elastic due to long-range road haulage. Tax differentials will vanish in the future and national governments are already considering new sources of tax revenue. In Germany, for example, a new road-use fee for trucks will be introduced in 2005. However, our estimates show that so far there has been no need to react on European integration by changing tax rates.

Our analysis yielded another important result. While the analysis of price convergence based on the LOOP has focussed on gross consumer prices so far, we find that convergence may take place on the net-of-tax or producer price side as well, even if sales prices do not converge. Obviously, this result requires tax instruments beyond the VAT. As soon as specific excise taxes for a product play a significant role, this effect might prevail. Further research on this topic is needed in order to find out for which products this approach may become relevant. An obvious starting point would be to look at tobacco products which are highly taxed as well.

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Table 1: Univariate Augmented Dickey Fuller Test (03/01/1994-3/5/2004)

	Convergent countries (percent level)	
	consumer prices	producer prices
Euro Super	Finland (1) Ireland (5) Italy (1) Great Britain (5) Spain (10)	Belgium (5) Denmark (1) Finland (1) France (5) Germany (5) Great Britain (5) Ireland (5) Luxembourg (5) Netherlands (5) Spain (5)
Diesel	Finland (1) France (1) Great Britain (5) Italy (5) Netherlands (1) Spain (5) Sweden (1)	Denmark (5) Germany (1) Finland (1) Luxembourg (1) Netherlands (1) Spain (10)
Gasoil	Austria (10) Finland (10) Germany (10) Greece (1) Spain (1) Sweden (5)	Belgium (10) Finland (10) Germany (1) Great Britain (10) Luxembourg (10) Netherlands (1) Spain (5) Sweden (5)
Fuel oil	Austria (1) Belgium (5) Denmark (5) Finland (10) Great Britain (5)[a] Ireland (1)[b] Netherlands (10) Sweden (5)	Austria (1) Denmark (1) France (10) Germany (1) Great Britain (1)[a] Greece (1) Ireland (5)[b] Italy (5) Portugal (10) Sweden (10)

[a]: 28/10/2002-03/05/2004.

[b]: longest available time-series ranges from 03/01/1994-10/01/2000.

Table 2: Consumer Prices, Levin-Lin-Chu and Maddala-Wu panel unit root tests (2/1/1995-3/5/2004)

	(1)	(2)	(3)	(4)	(5)
	Panel[a]	Euro Super	Diesel	Gas	Fuel Oil
p_{ijt-1}	-0.04*	-0.0167**	-0.0206*	-0.0704*	-0.036*
Austria	-0.04*	-0.0011*	-0.0009	-0.0087*	-0.0110*
Belgium	-0.06*	0.0005	-0.0013**	-0.0338*	-0.0179*
Denmark	0.03*	0.0014**	0.0006	0.0330*	0.0270*
Finland	-0.03*	0.0017*	-0.0001	-0.0145*	0.0007
France	-0.04*	0.0010°	0.0002	-0.0079*	-0.0109*
Germany	-0.05*	0.0006*	0.0002	-0.0204*	-0.0159*
Greece	-0.05*	-0.0045*	-0.0050*	0.0013*	-0.0036*
Ireland	0.002*[,b]	-0.0018*	0.0009	-0.0132*	n.a.[d]
Italy	-0.002*	0.0015*	0.0022*	0.0457*	-0.0083*
Luxembourg	-0.07*	-0.0037*	-0.0043*	-0.0318*	-0.0151*
Netherlands	-0.02*	0.0025*	0.0004	0.0080*	-0.0041*
Portugal	-0.02*[,c]	-0.0011°	-0.0034*	n.a.[d]	-0.0035*
Spain	-0.05*	-0.0033*	-0.0031*	-0.0148*	-0.0052*
Sweden	0.02*	0.0012**	0.0015**	0.0242*	0.0263*
United Kingdom	0.01*[,b]	0.0025*	0.0081*	-0.0345*	n.a.[d]
Maddala-Wu Statistic[e]		62.48*	83.11*	100.56*	84.82*
Number of lags	1	9	9	13	10
Country/ Product dummies	Yes	No	No	No	No
Country dummies	No	Yes	Yes	Yes	Yes

Notes:

*, **, °: significant at the one, five and, respectively, 10 percent level.

[a]: Fixed effects are averaged for Euro Super, Diesel, Gas and Fuel Oil.

[b]: Average excludes Fuel Oil due to missing observations.

[c]: Average excludes Gas due to missing observations.

[d]: Country not included due to missing observations.

[e]: Maddala-Wu test statistic based on the univariate ADF of Table 1.

Table 3: Producer Prices, Levin-Lin-Chu and Maddala-Wu panel unit root tests (2/1/1995-3/5/2004)

	(1)	(2)	(3)	(4)	(5)
	Panel[a]	Euro Super	Diesel	Gas	Fuel Oil
p_{ijt-1}	-0.06*	-0.0607*	-0.0516*	-0.0509*	-0.0839*
Austria	-0.013*	0.0059*	0.0043*	-0.0021	-0.0187*
Belgium	-0.029*	-0.0009	0.0011	-0.0073*	-0.0155*
Denmark	-0.035*	0.0017	-0.0010	0.0062*	-0.0093*
Finland	-0.008*	-0.0007	0.0033**	-0.0037*	0.0072*
France	-0.011*	-0.0107*	-0.0080*	0.0017	-0.0052*
Germany	-0.005*	-0.0056*	-0.0034*	-0.0032**	-0.0161*
Greece	-0.032*	0.0001	-0.0072*	-0.0034**	0.0054*
Ireland	-0.009*[,b]	0.0032**	0.0073*	0.0058*	n.a.[d]
Italy	-0.020*	0.0038*	0.0016	0.0068*	-0.0008*
Luxembourg	0.034*	0.0011	-0.0016	0.0003	-0.0057*
Netherlands	0.001*	0.0054*	0.0027**	0.0062*	0.0068*
Portugal	-0.015*[,c]	0.0037*	-0.0030**	n.a.[d]	0.0193*
Spain	0.011*	-0.0018	-0.0018	-0.0050*	0.0132*
Sweden	0.006*	0.0009	0.0055*	0.0005	0.0065*
United Kingdom	0.0004*[,b]	-0.0115*	-0.0046*	-0.0077*	n.a.[d]
Maddala-Wu Statistic[e]		102.13*	143.86*	82.15*	140.29*
Number of lags	1	9	9	13	10
Country/ Product dummies	Yes	No	No	No	No
Country dummies	No	Yes	Yes	Yes	Yes

Notes:

*, **, [o]: significant at the one, five and, respectively, 10 percent level.

[a]: Fixed effects are averaged for Euro Super, Diesel, Gas and Fuel Oil.

[b]: Average excludes Fuel Oil due to missing observations.

[c]: Average excludes Gas due to missing observations.

[d]: Country not included due to missing observations.

[e]: Maddala-Wu test statistic based on the univariate ADF of Table 1.

Table 4: Did the Speed of Convergence in Consumer Prices Increase Over Time?

	1995-1999				
	(1)	(2)	(3)	(4)	(5)
	Panel[a]	Euro Super	Diesel	Gasoil	Fuel Oil
p_{ijt-1}	-0.04*	-0.01	-0.01	-0.09*	-0.07**
Country/product dummies	Yes	No	No	No	No
Country dummies	No	Yes	Yes	Yes	Yes
	2000-2004				
	(6)	(7)	(8)	(9)	(10)
	Panel[a]	Euro Super	Diesel	Gasoil	Fuel Oil
p_{ijt-1}	-0.09*	-0.06*	-0.07*	-0.14*	-0.09*
Country/product dummies	Yes	No	No	No	No
Country dummies	No	Yes	Yes	Yes	Yes
	Changes from (1995-1999) to (2000-2004)				
	(11)	(12)	(13)	(14)	(15)
	Panel[a]	Euro Super	Diesel	Gasoil	Fuel Oil
Δp_{ijt-1}	0.05*	0.05*	0.06*	0.05*	0.02
	Interaction with trend term				
	(16)	(17)	(18)	(19)	(20)
	Panel[a]	Euro Super	Diesel	Gasoil	Fuel Oil
p_{ijt-1}	-0.04*	-0.01	-0.02	-0.06*	-0.04*
trend*p_{ijt-1}	-0.00001	-0.00002	-0.00002	-0.0004	-0.00002

Notes:

*, **: significant at the one and, respectively, 5 percent level.

[a]: Fixed effects are averaged for Euro Super, Diesel, Gas and Fuel Oil.

Table 5: Did the Speed of Convergence in Producer Prices Increase Over Time?

	1995-1999				
	(1)	(2)	(3)	(4)	(5)
	Panel[a]	Euro Super	Diesel	Gasoil	Fuel Oil
p_{ijt-1}	-0.09*	-0.08*	-0.05*	-0.08*	-0.13*
Country/product dummies	Yes	No	No	No	No
Country dummies	No	Yes	Yes	Yes	Yes
	2000-2004				
	(6)	(7)	(8)	(9)	(10)
	Panel[a]	Euro Super	Diesel	Gasoil	Fuel Oil
p_{ijt-1}	-0.10*	-0.10*	-0.13*	-0.19*	-0.10*
Country/product dummies	Yes	No	No	No	No
Country dummies	No	Yes	Yes	Yes	Yes
	Changes from (1995-1999) to (2000-2004)				
	(11)	(12)	(13)	(14)	(15)
	Panel[a]	Euro Super	Diesel	Gasoil	Fuel Oil
Δp_{ijt-1}	0.01*	0.02**	0.08*	0.11*	-0.03**
	Interaction with trend term				
	(16)	(17)	(18)	(19)	(20)
	Panel[a]	Euro Super	Diesel	Gasoil	Fuel Oil
p_{ijt-1}	-0.05*	-0.04	-0.02	-0.04	-0.09*
trend*p_{ijt-1}	-0.00002*	-0.0001	-0.0002	-0.00003	-0.00002

Notes:

*, **: significant at the one and, respectively, 5 percent level.

[a]: Fixed effects are averaged for Euro Super, Diesel, Gas and Fuel Oil.

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