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Abstract:
Two decades have passed now since the oil price shocks of the 1970s and since then energy prices have - apart from short periods of price instability - evolved relatively smoothly in the industrialized countries. Energy taxes in many countries differ markedly thereby causing differences in final energy prices, but as similar tax levels are becoming more common, e.g. in the European Union, convergence concerning energy prices might be expected to appear. In the present paper national gasoline price data covering the time period since the 1970s for a sample of OECD countries are used in order to test for this often addressed topic of convergence. The empirical part of the paper applies different time series based tests of convergence, where gasoline prices exhibit convergence for most OECD-Europe countries in the case where US$ is used for measurement of the energy prices indicating a convergence or tax harmonization process is taking place for these countries.

Keywords: Gasoline prices; Price convergence; Gasoline tax harmonization.

JEL Classification: Q4 – Energy.

1. Introduction

During the last couples of decades there have been no energy price shocks similar to the events in the 1970s and early 1980s. In many cases consumers still experience energy price increases where the reasons can be e.g. increased taxation of energy products due to fiscal or environmental considerations. Basically, many energy prices are heavily influenced by oil prices, e.g. the spot price of crude oil will not only influence the prices of final oil products but will usually also cause comovements in the price paths of substitutes like e.g. natural gas - with some time lags and price level differences, of course. As oil prices are determined internationally reflecting global demand and supply conditions - with exceptions such as the potential influences from organizations like OPEC - all countries will face similar import/export prices of oil. Therefore, when international oil prices are developing rather smoothly over time, the energy prices of at least oil products should be expected to become more and more similar across especially the industrialized (OECD) countries, where national prices are most likely to reflect the real costs of fuels as given by world market prices. Of course, national taxation of energy differs among countries and cause significant price differences even within the OECD area, but still some convergence in national energy prices might be expected. In line with the international efforts to deal with the question of global warming further political pressure for introducing or increasing energy taxes must be expected - at least in the majority of the industrialized countries - which will reduce international differences in final energy prices. Especially among countries in the European Union some energy tax convergence must be expected to take place, as part of the ongoing economic integration in Europe and this will further strengthen the case for energy price convergence.

In order to test for any signs of convergence in energy prices in the OECD area the price of premium gasoline has been selected for analysis as this is a well-defined product where data for market prices of gasoline (i.e. including national taxes) are available for the time period since the oil price shocks of the 1970s. The hypothesis to test is whether there are significant signs of convergence in the national prices of premium gasoline - measured in relevant price units - in the OECD area. The question of convergence is often addressed in the economic literature, especially concerning income convergence among nations. In relation to energy economics both topics related to energy consumption levels and energy price comovements have been investigated, e.g. Serletis and Kemp (1998), Bentzen (1998), Serletis and Herbert (1999), Engsted and Bentzen (1996). The first part of the paper - section 2 -

deals with the data set and gives a short graphical description of the development in gasoline prices in the OECD area. Besides the presentation of the gasoline price data in section 2 the concept of convergence in relation to prices is also discussed. The followings sections 3, 4 and 5 deal with the alternative testing methodologies in relation to convergence, i.e. mainly time series approaches, and also report the specific test statistics. Finally, section 6 concludes on the question of which kind of convergence is most likely taking place concerning OECD gasoline prices.

2. Data sources and the development in OECD gasoline prices

All data concerning gasoline prices are obtained from *The World Energy Database* produced by *ENERDATA s.a.,* (France), where also data for economic variables such as exchange rates and purchasing power parities - used when converting national prices to a common price basis - are available. Most of these data are from official sources or organizations producing primary data e.g. the OECD/IEA, The World Bank, etc.

The gasoline prices refer in all cases to premium gasoline as these data are available for the time period 1978 to 2002, where e.g. data for unleaded gasoline only appears from the mid-1980s and onward. The various gasoline prices are nearly perfectly correlated over time and hence for a time series analysis of convergence the premium gasoline allows the most extensive dataset to be applied. These kinds of energy price data are usually available in both national currencies, US dollars and purchasing power parities (ppp), i.e. the latter being $ppp-prices, as well as converted to constant prices. For the purpose of this paper the gasoline prices must be converted to a common unit as the question of price convergence among OECD countries refers to whether the absolute levels of these prices converge over time or not. As gasoline prices are to a high extent determined by world market oil prices, the development over time of the national gasoline prices for OECD countries will be highly correlated, although they need not be similar in absolute values due to e.g. national taxation.

Twenty OECD countries have been selected for this analysis of which fifteen are from Europe: Austria, Denmark, Finland, France, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the UK. The five non-European countries are: Australia, Canada, Japan, New Zealand and the USA. The geographical distinction corresponds rather well to differences in energy taxes, with a relatively low level of gasoline taxation in the latter group of five non-

European countries (with Japan as an exception in the later years). For the European countries the ratio between final consumer prices of gasoline and the same prices exclusive of all taxes is in many cases very high which is why any trends towards tax harmonization, e.g. in relation to European Union policies, will eventually also show up as convergence in gasoline prices. Figure 1 exhibits the gasoline price data for a selected set of countries and in Figure 2 data are split into two groups - with Group1 being the five non-European countries and Group 2 the fifteen European OECD-countries.

Figure 1 about here

The price developments in Figure 1 - although strongly influenced by exchange rate fluctuations - clearly reveal the differences between countries like the USA with relatively low gasoline prices reflecting spot market prices (Rotterdam gasoline prices in Figure 1) and Europe, where most countries like France and the UK have experienced increasing gasoline prices since the oil price shocks of the 1970s.

Figure 2 about here

As data for twenty countries enter the analysis of price convergence only the group averages are exhibited in Figure 2, but including the USA as the country with the lowest gasoline prices. The prices in purchasing power parity dollars for the non-European countries do not deviate much form the US$- prices when evaluated as a group average, where Group 2 (Europe) behaves rather differently due to foreign exchange rate volatility. Therefore, especially for the European countries also differences concerning the tests for price convergence must be expected to differ with respect to these alternative price variables. From both Figure 1 and Figure 2 it is obvious that gasoline prices differ in levels - and probably also with respect to time trends - between Group 1 and Group 2, and therefore the convergence tests presented in the next sections all use the two group average gasoline prices when testing for price convergence of a specific country. This methodology is often applied in the empirical studies of e.g. income convergence, where the average income level is used or the tests are performed in relation to a group's leader (e.g. the USA with the highest income level). In the present case it does not seem relevant to test for convergence towards for example US gasoline prices which differ markedly form European gasoline prices - and the latter will probably not be lowered very much in the future for fiscal and environmental reasons.

The gasoline prices in nominal values will be used in the analysis as there is no need to convert to e.g. constant ppp-dollars (95\$ppp), where the application of a deflator - whether common or country-specific - not necessarily improves the interpretation of price differences between countries in the context of convergence, where prices measured in e.g. US$ per litre can be meaningfully applied. Nominal gasoline prices in both US$ and $ppp, i.e. converting to international dollars using the purchasing power parity rates, will be included in the analysis and the interpretation of (eventual) convergence will not be the same for these cases. Therefore, two hypotheses will be stated - and formally tested in the later sections - related to the respective prices as presented in the following parts.

The first hypothesis relates to prices measured in nominal US$. The national prices of gasoline are given in local currencies and including national gasoline taxes, i.e. final consumer prices, and then converted to US$ by applying the exchange rates. Usually, this will introduce erratic fluctuations in the variables due to exchange rates volatility of the US$ versus national currencies and therefore be of no or little relevance when analysing for example income convergence. But in the present case prices are the topic of analysis and for national gasoline prices they are to a high extent determined by exactly a US$-price due to the world market for oil products being denominated in US$, e.g. crude oil prices. Generally, there will be three major cost components in national gasoline prices as these are determined firstly by international oil prices, e.g. measured as US$ import prices of gasoline, and secondly by costs related to activities as conversion, distribution, transportation, market imperfections, etc. and finally, the national gasoline taxes, which in many countries are similar in magnitude to the former cost components. Therefore, the national consumer prices are influenced by both the international prices of oil products and the exchange rate versus the US$ and hence, when converting the final prices back to US$ price differences will presumable to a high extent reflect differences in national gasoline taxation. Of course, the other cost components may differ between countries as well as lags related to the foreign exchange rates (vs. US$) concerning oil import prices and consumer gasoline prices, the latter converted to US$ with some time lag. From these considerations the first hypothesis is: time series convergence in nominal US$ prices of premium gasoline will primarily indicate equalization or convergence in national taxation of gasoline.

The second hypothesis relates to gasoline prices measured in purchasing power parity prices, i.e. $ppp. Thereby, as the national price levels form the basis of the ppp-rates - substituting the foreign exchange rates when converting from national prices to \$ppp - the information in these prices of a specific good will be a comparison between gasoline prices and the general price level of the respective countries. Purchasing power parities represent a basket of goods for a specific country and when the price of gasoline is calculated in these terms, convergence will indicate that the gasoline prices relative to the national price levels are similar between countries. They will not indicate absolute convergence in the sense discussed in the former part when measuring in US\$-prices, as a \$ppp-price of gasoline simply represents the price in national currency and the ppp-rate. If these \$ppp-prices of gasoline for the OECD countries convergence it indicates that the OECD country-specific relative prices of gasoline are similar. The causes for eventual convergence in the ppp-terms may be energy taxation equalization between countries as formerly discussed, but of course, many other economic factors will influence the relative price between gasoline and the general price level in each of the countries.

Before the gasoline price data are used in the convergence analysis, the time series properties of the variables are analysed. Many economic time series variables, also including energy consumption and fuel prices, are often found to be non-stationary in levels and consequently, the Dickey-Fuller tests are performed for all the price variables in order to investigate for stochastic trends - which is an import part of time series tests of convergence. The DF-test whether a variable X is integrated, I(1), or stationary, I(0), is done with a time trend for all variables where the inclusion of a deterministic trend will give power to a hypothesis of trend-stationarity - although some of the series, cf. Figure 1, do not seem to contain a linear trend. The results are shown in Table 1.

The conclusion from Table 1 is somewhat mixed as the null hypothesis of non-stationarity of the gasoline price variables was rejected in close to one-third of the cases where trend-stationarity seems to be a more likely characteristic with short-run fluctuations in oil prices clearly reflected in the gasoline prices. But still, most of the empirical evidence is in favour of a unit root hypothesis, which is further tested in the time series based tests for convergence.

Table 1 about here

3. Testing for β-convergence

Originally, the convergence test methodology was developed for studying the convergence of real income (GDP) for a cross-section of economies. In relation to growth issues one of the main concepts of convergence, called *absolute β-convergence* has been applied [1] - which has also gained popularity in other research areas such as e.g. price convergence, Camarero et al. (2000). Consumption converges in the β-sense if countries with low initial values of the respective variable(s) - gasoline prices in this case - face higher growth rates in these variable(s) than the other countries in the sample. Denoting the gasoline price (log values) in country *i* at time *t* by $p_{i,t}$ the measure of convergence is derived from the following regression, with *t-n* indicating the first period in the sample:

$$p_{i,t} = \alpha + (1-\beta)\, p_{i,t-n} + \varepsilon_{it} \qquad (1)$$

The estimate of β reveals the rate of convergence where a value close to 1 indicates (absolute) convergence in the sense that all prices converge towards a common level (α) and the opposite conclusion of 'no convergence' implies a parameter estimate, which does not deviate significantly from zero.

Table 2 about here

The estimate of β is 0.65-0.69 for the alternative gasoline prices implying some overall convergence and additionally, the standard errors indicate the parameter levels to differ significantly from zero at conventional critical levels. Therefore, the empirical evidence favours the β-convergence theory as far as the null hypothesis of 'no convergence' is significantly rejected.

Testing for convergence by using the β-methodology can be criticized because only initial and final values of the gasoline price levels are used and, therefore, the resultant parameter estimates may be sensitive to the specific values of these observations. This is one of several drawbacks of such a measure of convergence, and has recently been critically commented in a number of studies, Bernard and Durlauf (1991, 1995, 1996), Greasley and Oxley (1997), Harris and Trainor (1999). Therefore, a pure time series test methodology seems more appropriate to give full evidence on the convergence hypothesis.

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[1] See Sala-i-Martin (1995) for a more formal treatment on the convergence approach in economic growth theory.

4. Time series based concepts of convergence

The question of gasoline price convergence is analysed in a pure time series framework - which in several important aspects differs from the cross-section convergence methodology - where especially Bernard and Durlauf (1995, 1996) have shown how to apply the econometric techniques concerning non-stationary variables to the question of convergence. Convergence between e.g. country *i* and a group average of all countries is now defined as, BD (1996):

$$\lim_{k \to \infty} \mathrm{E}\left(p_{i,t+k} - \overline{p}_{t+k} \left| I_t \right.\right) = 0 \tag{2}$$

I_t is the information set available at time *t*, and convergence requires equality of long-term forecasts. In an empirical testing strategy it is essential to assess whether $\left(p_i - \overline{p}\right)$ contains either a non-zero mean or a unit root because this implies that there cannot be convergence, and the series will diverge over time. This methodology of testing for convergence relative to the sample average has also been applied concerning income convergence, e.g. Carlino and Mills (1993), Loewy and Papell (1996), Li and Papell (1999).

The empirical application of this definition of convergence therefore relies on a Dickey-Fuller type of test for a unit root in the difference of the (log) values of gasoline prices, with *t* indicating a time trend:

$$\Delta\left(p_{i,t} - \overline{p}_t\right) = \alpha + \beta t + \mu\left(p_{i,t-1} - \overline{p}_{t-1}\right) + \text{lags of } \Delta\left(p_{i,t} - \overline{p}_t\right) + \varepsilon_t \tag{3}$$

In case a unit root is found, the country-specific gasoline price and the group average price will be driven by separate stochastic trends and, hence, diverge over time. Furthermore, assuming *no unit root* is present in (3), the intercept term and the deterministic trend parameter may be insignificant and thus indicate long-run convergence. Finally, when the deterministic trend parameter differs significantly from zero, a catching-up process is likely to take place assuming that the initial values of the gasoline prices differ in levels.

Thus, a necessary condition for convergence is that the cointegration vector between a given set of prices is (1, -1).[2] One difficulty involved in the time series approach is that these tests are sensitive to whether transitional processes are taking place in the economy, i.e. if the gasoline price in one or more of the countries initially starts from some (low) value and has not yet reached a level close to steady-state conditions as defined via the group average price level, then a null hypothesis of 'no convergence' tends to be accepted, even when it is false.

The Bernard-Durlauf methodology as presented in (3) is applied to the data - with results reported in the following section five - but more recently, a time series test procedure that is less restrictive with regard to the question stationarity versus non-stationarity of price differences concerning convergence has been introduced. Nahar and Inder (2002) point out that also non-stationary processes may convergence and present a new test methodology that allow for non-stationary but converging processes. When testing for convergence in respect to a group average - as in the present case for gasoline prices - the procedure starts (see Nahar and Inder for further details) as formerly given by (2), where differences in prices diminish over time. The squared price differences are then considered:

$$w_{it} = \left(p_{it} - \overline{p}_t\right)^2 \qquad (4)$$

When convergence takes place, $w_{i,t}$ gets closer to zero which implies:

$$\lim_{k \to \infty} E_t\left(w_{i,t+k}\right) = 0 \qquad (5)$$

Since $w_{i,t}$ is the squared price difference and therefore always positive, the following holds:

$$\left(\partial / \partial t\right) w_{i,t} < 0 : \quad w_{i,t+k} \to 0 \text{ as } k \to \infty \qquad (6)$$

The basic idea is then to evaluate convergence from the sign of (6), where a negative sign will indicate convergence as $w_{i,t}$ will head towards zero when the (average) slope of the positively-valued $w_{i,t}$ is negative. For the empirical application $w_{i,t}$ is defined as a function of time:

[2] Still, when cointegration is detected but the cointegration vector is deviating from (1, -1), the development in gasoline prices is driven by the same stochastic trend, but the level of these prices will not converge; see Bernard and Durlauf (1995).

$$w_{i,t} = \Theta_0 + \Theta_1 t + \Theta_2 t^2 + ... + \Theta_{n-1} t^{n-1} + \Theta_n t^n + \varepsilon_{i,t} \qquad (7)$$

The slope function is easily derived as the first derivative of (7) and convergence now corresponds to a negative value of the *average* of the slope functions, as not every slope can be expected to be negative:

$$\frac{1}{T}\sum_{t=1}^{T}\frac{\partial}{\partial t}w_{i,t} < 0 \qquad (8)$$

As $w_{i,t}$ is a function of time, the average slope function can be obtained - and in compact form given as:

$$\frac{1}{T}\sum_{t=1}^{T}\frac{\partial}{\partial t}w_{i,t} = \Theta_1 + \Theta_2 r_2 + ... + \Theta_n r_n \qquad (9)$$

where:

$$r_n = \frac{n}{T}\sum_{t=1}^{T} t^{n-1} \qquad (10)$$

When testing for convergence the null hypothesis of no-convergence is:

$$\begin{aligned} &H_0 : r'\Theta \geq 0 \\ &r = \left[0 \; 1 \; r_2 \; ... \; r_n\right] \\ &\Theta = \left[\Theta_o \; \Theta_1 \; ... \; \Theta_n\right] \end{aligned} \qquad (11)$$

The r-vector can easily be calculated from the trend values and the Θ parameters are estimated from (7). Finally, a t-test is performed concerning the restrictions on Θ as stated in the H_0 hypothesis with a rejection of the null hypothesis interpreted in favour of convergence. The empirical estimation is done in a two-step procedure as first the lag length of (7) is determined - by the Akaike Information Criterion (AIC) - and then the estimated parameters from (7) can be applied to test the restriction in (11).

5. Empirical evidence of gasoline price convergence

In order to carry out the tests described above, the data presented in section 2 are used in the analysis with all tests done concerning deviations from group averages as discussed in the former sections. The Bernard-Durlauf type of convergence test from (3) is performed for all twenty OECD-countries and Table 3a reports the results when measuring prices in US$ per litre.

Table 3a about here

In Group 1 the unit root hypothesis is rejected in four cases - as a condition for convergence in this methodology - but for Canada, Japan and Australia the intercept term differs significantly from zero indicating that price differences will not vanish over time as the time trend is most likely zero. For New Zealand there also is a significant intercept term, but as this is positive - and the time trend significantly negative - the conclusion in this case will be a catching-up process towards the group average. Only in one of the fifteen cases in Group 2 is the unit root hypothesis rejected - and like for New Zealand the evidence is in favour of a catching-up process. In Table 3b the results for the gasoline price variable in $ppp per litre is presented.

Table 3b about here

For the $ppp gasoline prices the evidence in favour of convergence is totally absent in Table 3b as only Belgium shows up with a catching-up hypothesis and for Italy the gasoline price is diverting from the group average due to the significant time trend parameter and zero intercept term. Therefore, the conclusion from Table 3a and Table 3b is only evidence of catching-up in a very few cases and no convergence in gasoline prices in the OECD countries. Applying the less restrictive methodology by Nahar and Inder the conclusion will be somewhat different which is evident from the results reported in Table 4a and Table 4b.

Table 4a about here

For Australia and twelve of the fifteen European countries the average slope was estimated to be negative and significantly differing from zero (at least the ten per cent level of significance) and thus favouring a convergence hypothesis according to the Nahar/Inder interpretation of time series convergence. As the gasoline prices are measured in US$ - cf. section 2 about the interpretation of prices in relation to convergence - one of the main reasons behind the narrowing of especially European prices might be convergence in gasoline taxation as variation in gasoline excises is usually the most important factor behind differences in national gasoline prices. In Table 4b for the gasoline prices in $ppp per litre only a few cases of convergence is revealed.

Table 4b about here

When applying the $ppp-prices in Table 4b the convergence interpretation as far as national gasoline prices are concerned is measured in relation to the general national price levels. The empirical evidence is only seven cases in Table 4b in favour of convergence concerning the relative prices between OECD countries, and the importance of this kind of convergence seems less than the previous discussion about prices in US$. When applying the Nahar/Inder convergence procedure the conclusion is generally more in favour of convergence than found in the unit root methodology and the main conclusion derived is, that among European countries the development in gasoline taxes is tested positive in relation to price convergence.

6. Conclusion

As the world prices of crude oil heavily influence the final prices of many energy products and services, national energy prices of especially oil products might be expected to be converging in periods of relative price stability. Two decades have passed since the dramatic oil price shocks of the 1970s and since then energy prices have evolved relatively smoothly in the industrialized countries, although shorter periods of instability of oil prices have also heavily influenced consumer prices of e.g. gasoline. Of course, energy taxes in many countries differ greatly and thereby also cause differences in final energy prices, but as some tax harmonization is taking place or similar tax levels (excises) are becoming more common (e.g. in the European Union), at least among some subgroups of OECD countries similarity concerning energy prices might be expected to appear.

The Dickey-Fuller unit root tests indicate that there is very little or no support to the notion of absolute convergence in gasoline prices in the OECD countries when testing for convergence towards a geographical group-mean of gasoline prices. At most, some catching-up processes - i.e. diminishing differences in gasoline prices - seem to be a common feature in a few cases. When applying the less restrictive test procedures from Nahar and Inder evidence of convergence in especially OECD-Europe is found when measuring gasoline prices in US$ per litre. This indicates a process of tax harmonization as the main differences in gasoline prices - with the production cost side also given in dollars from world market oil prices - are national excises on gasoline. When using $ppp-prices of gasoline, which can be interpreted as gasoline prices relative to the general, national price levels, less evidence is found in favour of convergence.

These results correspond well to the developments within the European Union, where a process of indirect tax harmonization has taken place during recent years, especially concerning goods like beer, wine, gasoline etc. The main reason for levelling out indirect taxes has been increased intra-EU border trade and furthermore, the creation of a common European market has also facilitated the flow of goods. Consequently, these processes have probably induced some convergence in both price levels and consumption patterns - including gasoline - across Europe.

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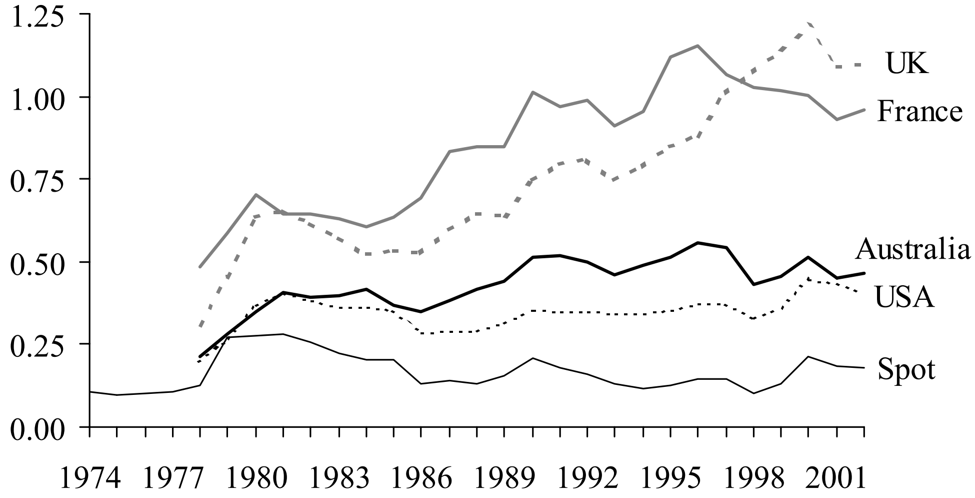
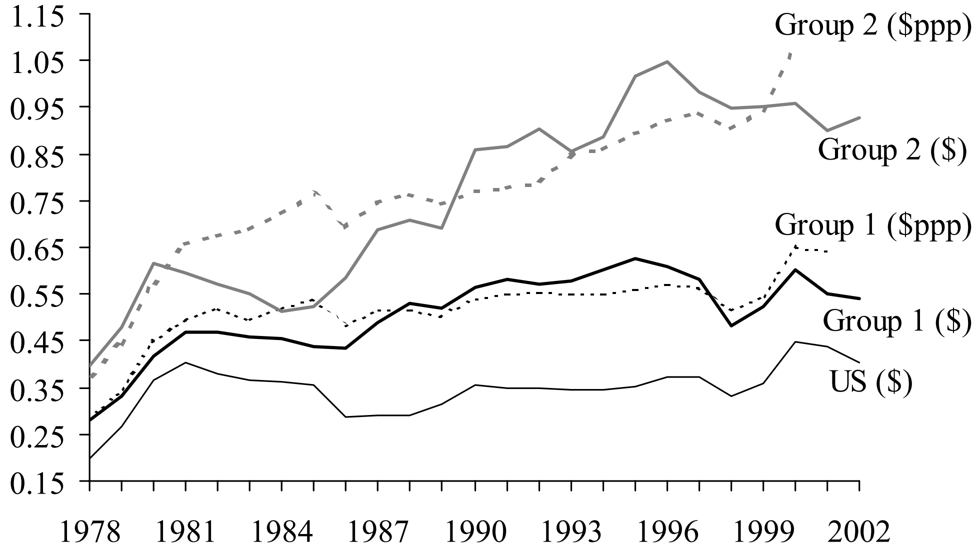
Figure 1. Gasoline prices in US$/litre, 1974-2002.



Note: Nominal premium gasoline prices, taxes included, and converted to US$ per litre. The spot price is the Rotterdam price of premium gasoline (usually given in US$/bl.)

Source: The World Energy Database, ENERDATA s.a. (France).

__Figure 2. Gasoline prices in US$/litre and $ppp/litre, 1978-2002.__



Note: $ppp-prices are nominal premium gasoline prices, taxes included, and converted to $ppp per litre from national prices in local currency and applying the $ppp-rates (international dollars) for these currencies. Also the prices in US$ per litre included for the USA and Group 1, which is the five non-European countries mentioned in the main text and Group 2 representing European OECD-countries. Source: The World Energy Database, ENERDATA s.a. (France).

Table 1. Unit root tests (DF/ADF).

Prices:	US$/litre	$ppp/litre
Group I		
USA	-4.32**{1}	-5.17**{1}
Canada	-3.70**{1}	-2.98{0}
Japan	-2.37{1}	-4.69**{1}
Australia	-3.27*{1}	-5.84**{0}
New Zealand	-2.77{0}	-3.48*{0}
Group II		
Austria	-2.20{0}	-3.13{1}
Belgium	-2.49{1}	-4.51**{1}
Denmark	-3.96**{1}	-4.42**{1}
Finland	-1.76{0}	-1.96{0}
France	-1.79{1}	-3.72**{0}
Greece	-1.26{1}	-1.95{0}
Ireland	-3.16{0}	-3.62*{0}
Italy	-1.62{0}	-3.01{0}
Netherlands	-2.61{0}	-5.17**{1}
Norway	-2.32{1}	-2.01{1}
Portugal	-1.43{0}	-2.59{2}
Spain	-2.39{0}	-2.37{0}
Sweden	-2.31{1}	-3.86**{0}
Switzerland	-2.78{1}	-2.72{1}
UK	-4.03**{2}	-1.97{1}

Note: The critical value is -3.63 at a 5% level of significance (indicated by ** in the table), and -3.25 at the 10% significance level (*), according to MacKinnon (1991). The test also includes a deterministic trend to allow for an alternative hypothesis of trend stationarity. The DF/ADF-test statistics have been derived from applying a suitable lag length {0, 1 or 2} in the unit root test in order to whiten the errors.

Table 2. Test statistics for β-convergence.

Price (p_t)	US$/litre	$ppp/litre
$\hat{\beta}$	0.654	0.693
Standard error	0.114	0.164

Note: The cross-section test of convergence is done for the time period 1978 to 2000 and includes all twenty OECD countries.

Table 3a. Test statistics for the convergence/catching up hypothesis. Prices in US$/litre.

Prices: US$/litre	DF/ADF	$\hat{\alpha}$	$\hat{\beta}$
Group I			
USA	-1.75{1}		
Canada	-4.77**{1}	-0.112**	0.002
Japan	-3.64**{1}	-0.195**	0.003
Australia	-4.87**{2}	-0.235*	0.002
New Zealand	-3.51*{1}	0.147*	-0.006**
Group II			
Austria	-2.26{1}		
Belgium	-1.79{0}		
Denmark	-2.59{1}		
Finland	-2.19{0}		
France	-2.46{1}		
Greece	-1.63{1}		
Ireland	-4.26**{1}	0.135**	-0.006**
Italy	-1.74{1}		
Netherlands	-1.73{2}		
Norway	-2.40{0}		
Portugal	-1.14{1}		
Spain	-3.15{1}		
Sweden	-2.56{1}		
Switzerland	-1.87{0}		
UK	-1.81{1}		

Note: The critical value is -3.63 at a 5% level of significance (indicated by ** in the table), and -3.25 at the 10% significance level (*), according to MacKinnon (1991). The DF/ADF-test statistics have been derived from applying a suitable lag length {0, 1 or 2} in order to whiten the errors.

Table 3b. Test statistics for the convergence/catching up-hypothesis. Prices in $ppp/litre.

Prices: $ppp/litre	DF/ADF	$\hat{\alpha}$	$\hat{\beta}$
Group I			
USA	-2.64{1}		
Canada	-2.14{0}		
Japan	-2.66{1}		
Australia	-2.93{1}		
New Zealand	-2.65{1}		
Group II			
Austria	-1.30{0}		
Belgium	-3.26*{1}	0.173**	-0.005*
Denmark	-2.58{1}		
Finland	-1.79{0}		
France	-2.70{1}		
Greece	-2.44{1}		
Ireland	-2.91{1}		
Italy	-3.42*{2}	0.009	0.007**
Netherlands	-2.67{0}		
Norway	-1.50{1}		
Portugal	-1.89{2}		
Spain	-2.23{1}		
Sweden	-1.89{0}		
Switzerland	-1.69{1}		
UK	-0.77{0}		

Note: The critical value is -3.63 at the 5% level of significance (indicated by ** in the table), and -3.25 at the 10% significance level (*), according to MacKinnon (1991). The DF/ADF-test statistics have been derived from applying a suitable lag length {0, 1 or 2} in order to whiten the errors.

Table 4a. Average slopes and test statistics for the convergence hypothesis. Prices in US$/litre.

Prices: US$/litre	Polynomial order	Average slope	t-statistic
Group I			
USA	4	-0.0037	-1.52
Canada	6	-0.0042	-1.29
Japan	4	-0.0060	-1.61
Australia	5	-0.0026*	-2.02
New Zealand	6	-0.0003	-0.50
Group II			
Austria	4	-0.0085**	-19.79
Belgium	5	-0.0009**	-3.36
Denmark	6	-0.0033*	-1.74
Finland	5	-0.0005	-0.86
France	5	-0.0029**	-5.50
Greece	4	-0.0843**	-10.13
Ireland	6	-0.0028**	-3.86
Italy	6	-0.0019**	-3.40
Netherlands	4	-0.0073**	-14.91
Norway	5	0.0007	0.81
Portugal	6	-0.0027**	-7.86
Spain	6	-0.0057**	-3.49
Sweden	6	0.0006	0.75
Switzerland	6	-0.0033**	-3.17
UK	5	-0.0017*	-1.95

Note: The polynomial order selected from the AIC-values varying the lag length from 1 to 6. An average slope value deviating from zero at the 5% level of significance indicated by ** - and * for the 10% significance level.

Table 4b. Average slopes and test statistics for the convergence hypothesis. Prices in $ppp/litre.

Prices: $ppp/litre	Polynomial order	Average slope	t-statistic
Group I			
USA	6	-0.0024	-0.59
Canada	6	-0.0070	-1.60
Japan	6	-0.0060**	-2.67
Australia	4	-0.0075**	-5.11
New Zealand	6	-0.0015	-0.57
Group II			
Austria	5	-0.0066**	-1.94
Belgium	6	0.0100	1.76
Denmark	5	0.0003	0.12
Finland	6	-0.0243**	-2.65
France	4	0.0004	0.98
Greece	6	0.0259	0.52
Ireland	6	-0.0085**	-3.13
Italy	6	0.0035	0.48
Netherlands	6	-0.0023	-0.61
Norway	6	0.0021	0.52
Portugal	6	-0.0477**	-3.29
Spain	6	-0.0058	-1.06
Sweden	5	-0.0157**	-3.92
Switzerland	6	-0.0104	-1.27
UK	6	-0.0001	-0.08

Note: The polynomial order selected from the AIC-values varying the lag length from 1 to 6. An average slope value deviating from zero at the 5% level of significance indicated by ** - and * for the 10% significance level.

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