*Bank i Kredyt 40 (2), 2009, 37-60*

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# Price convergence in the European Union and in the New Member States

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Submitted: 14 December 2008. Accepted: 1 April 2009.

## Abstract

This paper examines price dispersion in the European Union (EU15) and in three New Member States (Poland, Hungary and the Czech Republic) between 1995 and 2006. The research is motivated by the fact that the price convergence problem is at the top of the public agenda in many New Member States (NMS). The analysis utilizes both disaggregate and aggregate price data, including the prices of 157 products and two indices constructed using two different weighting procedures. For each category of goods the price dispersion is lower in EU15 than EU15 plus 3 NMS. Sigma convergence measured as a decline in the standard deviation over time is rejected. Unit root tests reject the validity of the Law of One Price (LOOP) for most of the estimations of indices but confirm the LOOP for individual goods. The half-lives are shorter for NMS than for the EU15.

**Keywords**: price convergence, international price dispersion, law of one price

**JEL**: E31, F36, F41

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## 1. Introduction

The Law of One Price (LOOP) states that when there are no impediments to international trade and no transport costs, prices of the same product should be equal when converted to a common currency regardless of the location. More formally, if the LOOP holds then

$$P_A^i - P_B^i \times E_{A/B} = 0 \tag{1}$$

with:

$P_A^i$ – the price of good $i$ sold in country $A$ in currency $A$,

$P_B^i$ – the price of the same good $i$ sold in country $B$ in currency $B$,

$E_{A/B}$ – the exchange rate between countries $A$ and $B$.

If a homogenous good has different prices in two locations it would be profitable to buy it where it is cheaper, and after transportation to sell it on the more expensive market. As a consequence, there is a flow of products from cheaper regions to more expensive ones. This process will continue until the price is equalized in both markets, leaving no further incentive for arbitrage transactions. Since equation (1) should hold for all goods, it should be true for the whole aggregate of goods. In this form it is known as the Purchasing Power Parity (PPP) hypothesis. Both LOOP and PPP hold only under strict circumstances: perfect competition, no transport costs and the absence of trade barriers. Understandably, all of these are violated in the real world.

On the other hand, there are also factors that in theory should speed spatial price convergence. The most basic is market integration. As far as the European Union is concerned, the removal of trade barriers and the realization of the four freedoms (the freedom of movement of goods, labour, capital and services) should cause more competition between firms, better allocation of capital, and higher production efficiency, and these will lead prices to converge.

As far as New Member States are concerned, price convergence can be viewed as an indicator of their successful integration with the EU and of the progress of the transition process. As our main hypothesis is that market integration lowers price differentials between countries, the integration of the NMS into the EU is certainly a good natural experiment to test this.

On the other hand, NMS as relatively low-price countries undergoing price convergence towards the EU average would experience a rise in their inflation rates and would have problems in fulfilling the nominal convergence criteria. They are afraid that their prices will increase due to integration, while Old Member States are afraid that they will have to drop prices if they want to be competitive. To our knowledge, our study is one of the first to analyze price convergence after the European enlargement in 2004.[1]

The main conclusions from the earlier empirical studies on the LOOP are as follows:

– the absolute version of the LOOP does not hold either within or across countries at a given point in time (Haskel, Wolf 2001);

– the price convergence over time takes place, but the convergence parameter (half-life) differs across studies (e.g. Cheung at al. (2001) reports half-life of price shock of 2.8 months, Gajewski and Kowalski (2004) – 282 months); consensus is that half-life of deviation is about three to five years.

– the price differentials are bigger for non-tradable goods than for tradables (Rogers 2007; Crucini, Shintani 2006);

[1] Dreger et al. (2007) analysed price dispersion at EU27 but not on the basis of individual prices.

– the price differentials are usually explained by: product and market specific factors: difference in wages, exchange rate volatility, differences in taxes, "border effect" (Wolszczak-Derlacz 2008);

– the data utilised to test the LOOP either take the form of price indices or the actual prices of different products (Engel, Rogers 2004 versus Allington et al. 2004).

For the extensive review of the LOOP literature see e.g. Rogoff (1996) and Allington et al. (2004).

We obtained our data from the Economist Intelligence Unit (EIU) on the actual prices of 157 individual products sold across European capital cities. Firstly, we perform the analysis on an item-by-item basis. Then we construct indices from the individual prices using two different weighting procedures: "equal-weighting" and "product specific weighting". For each dataset we conduct a complex analysis of price convergence employing the concept of sigma and beta convergence.

Sigma convergence occurs when the dispersion of the levels of a given variable between different economies tends to decrease over time. The concept is derived from the literature of real convergence (Barro, Sala-i-Martin 1992) and originally concerned the cross-sectional dispersion of income. In our context, sigma convergence occurs if the dispersion or standard deviation ($\sigma$) of prices declines over time.

When considering beta convergence, absolute and relative versions can be distinguished. Absolute (unconditional) beta convergence occurs when economies with different levels of a given variable approach an identical point. Conditional (weak) beta convergence is the process where economies with different levels of a given variable approach each other but the identical point is not reached. We follow the classical approach to measuring beta convergence: we estimate the so-called Barro's regression, which we adapt for our purpose by replacing income levels with price differentials. We want to check the relation between the price gap and that of the previous period. We test beta convergence with unit root tests. If cross-country price differences are mean-reverting, either to zero or to some non-zero stationary mean, the absolute or relative LOOP holds, rather than there being a unit root. The estimated coefficient on the lagged gap is the indicator of the convergence process. A De Blander-Dhaene (2006) unit root test is employed. It extends the fixed $T$ approach of Harris and Tzavalis (1999) to first order autoregressive errors and is based on a bias-corrected LS estimator of the autoregressive parameter. Since in this case there is a large cross-sectional dimension (bilateral pairs) and a limited time series dimension, the DD test seems suitable.

In our empirical analysis we compare estimates based on individual goods (disaggregate data), with those utilizing constructed indices. Nowadays, the vivid discussion whether indices or actual prices are more suitable for testing the LOOP is observed. Indices are used in studies of, for example, Isard (1977), Beck and Weber (2001), Cecchetti et al. (2002), Sosvilla-Rivero and Gil-Pareja (2002). While others (Crucini et al. 2005; Crucini, Shintani 2006; Imbs et al. 2005) show that aggregating the goods into price indices causes bias in estimates of the speed of adjustment of the real exchange rate, if the individual goods adjust at different speeds.

The paper is organized in the following way. In section 2 we describe the data. Section 3 estimates sigma convergence both for the disaggregate level of 157 individual goods and for the aggregate level based on price indices. In section 4 the tests of beta convergence are performed again for disaggregate and aggregate data. This is followed by the conclusion and suggestions for future studies.

## 2. Data

The data used in this study are obtained from the Economist Intelligence Unit (EIU). The original dataset is composed of annual observations of the actual prices for 173 products in 122 cities in 78 countries. To our knowledge this is the most extensive database of international retail prices. The data were primarily collected for the information of multinational corporations, which move employees around the world. The product list consists of tightly specified items such as: “bread”, “coca-cola” and a variety of services such as “laundry one shirt”, “cost of developing 36 colour pictures” etc.

The prices are expressed in Euros with purchasing power parity exchange rates used in calculations. In the pre-1999 period, ECU exchange rates were used. In the original database, the surveyed prices are listed for three types of store: supermarkets, medium-price retailers and expensive specialist shops. We only utilise the prices for supermarkets, which provide items of standard quality and are likely to be more compatible across international cities.

Data availability restricts our sample to the 15 capital cities of the Old Member States, plus only three NMS cities: Warsaw, Prague and Budapest. We restrict our dataset to the period from 1995 to 2006, following the suggestion that the period prior to 1995 was very volatile in terms of macroeconomic variables for the vast majority of transition economies, which might distort results. Part of this volatility stems from the various stabilization programmes (liberalization etc.), making pre-1995 price data unreliable. For example, Poland underwent a currency reform in 1994. In addition, the beginning of the 90s was for most NMS a period of hyperinflation, leading to anomalous observations.[2] In the case of missing observations, the CPI was used to provide an extrapolation. Some items were excluded from the data as difficult to be compared across cities, for example a taxi ride from the airport to the city centre. After these exclusions and adjustments, the final sample of goods was reduced to 157 products (for a product list, see Tables 6 and 7 in Appendix 1).

Using Engel and Rogers (2004) classification, we distinguish all goods to be either tradeable (107 items) or non-tradeable (50 items), a common sense distinction reflecting a compromise between theoretical considerations, the practice of international trade, and data availability. The division is not based on any universally accepted formal method, such as calculating the tradability of a good as the ratio of the total trade among the countries in a particular industry divided by total output of the industry across the same countries. It should be pointed out that there exists no purely tradeable or non-tradeable item because each one is a composition of tradeable and non-tradeable inputs, for example the production of bread involves the services of baking and selling; while laundry cannot be provided without washing powder. Moreover, the tradeable goods are grouped into 8 categories following the EIU categorisation: food perishable (34 items), food nonperishable (16 items), alcoholic beverages and tobacco (12 items), clothing and footwear (16 items), household supplies (6 items), personal care (8 items), recreation (7 items), cars and petrol (8 items).

The EIU dataset does have certain shortcomings (see Engel and Rogers 2004), which can be summarized as:

– the data are collected from a small number of outlets compared with surveys conducted by national statistical agencies;

[2] E.g. the price of white bread (1 kg) in Warsaw in 1990 was 5.91 USD – which is certainly unreliable despite the fact that EIU staff confirm the correctness of the underling price and exchange data as recorded at that time.

– the data come only from big agglomerations, which are not representative of whole countries;

– it is not clear whether the EIU methodology adequately accounts for packaging differences;

– it is not clear that the EIU methodology accounts for quality differences;

– the product list does not represent a complete consumption basket.

On the other hand, Rogers (2007) presents extensive evidence on the reliability of the EIU data. He shows a high correlation between the EIU price changes and annual CPI inflation, and also between PPP rates calculated on the basis of EIU data and the PPP reported by the OECD.

To check the reliability of the EIU data we construct an index from the raw individual prices. We compare our index with the more standard Comparative Price Levels (CPL) reported by Eurostat. The idea is to see if the prices of the individual goods are informative of the CPL, or alternatively are too unique and narrow to be useful. The procedure for index construction together with the correlation coefficients between the EIU index and the CPL are reported in Appendix 2. The overall impression is that there are generally high correlations between the EIU-based index and the CPL. The correlation coefficient for all pooled countries is 0.77. Of course, a perfect correlation cannot be expected because the sample of items in the EIU survey differs from the contents of the CPL basket.

## 3. Sigma convergence

### 3.1. Disaggregate data

Since we are in possession of a rich set of data on actual prices, we are able to investigate the validity of the Law of One Price for a particular year. To assess deviation from the LOOP, our basic measure of price dispersion is the standard deviation of prices (expressed in logs) for each item across cities:

$$\sigma_t^m = \sqrt{\frac{\sum_{i=1}^{N}(\ln p_{it}^m - \frac{1}{N}\sum_{i=1}^{N}\ln p_{it}^m)^2}{(N-1)}} \tag{2}$$

This measures the deviation of the price of good *m* from its geometric average price across all cities, where *N* is the number of cities. To provide a first impression of the price dispersion in the data, Table 1 presents the goods and services with the highest and lowest price dispersion in 2006.

The maximum standard deviation (σ) of prices is observed for “One X-ray at doctor’s office or hospital” reaching 72.5%. This product reaches the enormous value of 333 Euros in Copenhagen, while only costing 5 Euros in Stockholm. The lowest σ – 6.1% – is for Lipstick. Not surprisingly, eight of the ten goods with the lowest price dispersion are tradeable, while six out of ten with the highest dispersion are non-tradeable. Price dispersion for all products, measured as the mean standard deviation, is 38%; 36% for tradeables and 43% for non-tradeables.

Using this data set it might be possible to answer the question ‘where should I go to pay less?’ In Table 2 we present the most expensive and least expensive cities. In the first column we have the

Table 1
Price comparison across goods, 2006

| Lowest price dispersion | $\sigma_{2006}$ | Highest price dispersion | $\sigma_{2006}$ |
|---|---|---|---|
| Lipstick (deluxe type) (supermarket) | 0.145 | One X-ray at doctor's office or hospital, average | 0.725 |
| Compact disc album (average) | 0.159 | Mineral water (1l) (supermarket) | 0.667 |
| Regular unleaded petrol (1l) (average) | 0.180 | Hourly rate for domestic cleaning help (average) | 0.665 |
| International weekly news magazine (Time) (average) | 0.186 | Routine checkup at family doctor (average) | 0.644 |
| Low priced car (900-1299 cc) (low) | 0.20 | Women's cardigan sweater (chain store) | 0.603 |
| Fast food snack: hamburger, fries and drink | 0.203 | Potatoes (2 kg) (supermarket) | 0.589 |
| International foreign daily newspaper (average) | 0.204 | Entrance fee to a public swimming pool (average) | 0.573 |
| Business trip, typical daily cost | 0.206 | Maid's monthly wages (full time) (average) | 0.570 |
| Shampoo & conditioner in one (400 ml) (supermarket) | 0.207 | Flour, white (1 kg) (supermarket) | 0.565 |
| Compact car (1300-1799 cc) (low) | 0.208 | Electricity, monthly bill (average) | 0.565 |

Source: EIU and own calculations.

number of products in which a given city has the highest price among all cities, and in the second the lowest. Budapest is the least expensive city in the sample with 67 out of 157 products being the cheapest. For Warsaw and Prague the evidence is mixed. While both being the cheapest city for a considerable number of products, at the same time these cities appear as most expensive for some other products. There is no country which is uniformly expensive, although Copenhagen, London and Vienna tend to be at the high level for a number of products.

In the next subsection we will be able to draw a more general conclusion about ranking the cities according to the price paid for a basket of goods. When we look more closely at each individual good, we note that 113 out of 157 goods underwent price convergence (a drop in standard deviation) during the twelve years studied. Figure 1 shows the differences in price dispersion between 1995 and 2006: $\sigma_{1996}$ - $\sigma_{2006}$. The positive bar in the chart reports a decline in price dispersion and a negative bar represents an increase.

To assess the extent to which there was price convergence across EU countries, we calculated the unweighted cross-country standard deviation. Weighted standard deviation, defended on the basis that larger member states have a more significant impact on price convergence than smaller ones due to their bigger share of transactions within the EU, is, in our opinion, an inferior measure of overall price convergence because it reshapes price dispersion. In addition, it is not straightforward which type of weights should be used. A first proposition is to weight prices by GDP per capita, but prices in, for example, Luxembourg, which has extremely high GDP, do not have any extreme influence on prices in the overall Union market. Other choices as the weighting variable could be population, or openness of the economy, but each of them is open to similar criticisms.

Table 2
The most expensive and least expensive cities

| | **min** | **max** |
|---|---|---|
| Amsterdam | 7 | 0 |
| Athens | 5 | 5 |
| Berlin | 2 | 7 |
| Brussels | 0 | 7 |
| Budapest | 67 | 0 |
| Copenhagen | 1 | 26 |
| Dublin | 7 | 5 |
| Helsinki | 5 | 7 |
| Lisbon | 8 | 3 |
| London | 2 | 29 |
| Luxembourg | 6 | 6 |
| Madrid | 2 | 5 |
| Paris | 1 | 14 |
| Prague | 12 | 7 |
| Rome | 10 | 7 |
| Stockholm | 4 | 11 |
| Vienna | 5 | 14 |
| Warsaw | 13 | 4 |

Source: EIU and own calculations.

We check the sigma convergence hypothesis by testing whether the variance of prices (expressed in logs) across countries decreases over time. The null hypothesis of no convergence is equivalent to $H_0 : \sigma^2_{m,1} = \sigma^2_{m,t}$, where $\sigma^2_{m,t}$ is the variance of $p^m_{it} = \ln(P^m_{it})$, the log price of product *m* at time *t*. We test the hypothesis using the Likelihood Ratio Test ($T_2$) proposed by Carre and Klomb (1997) with the following test statistic:

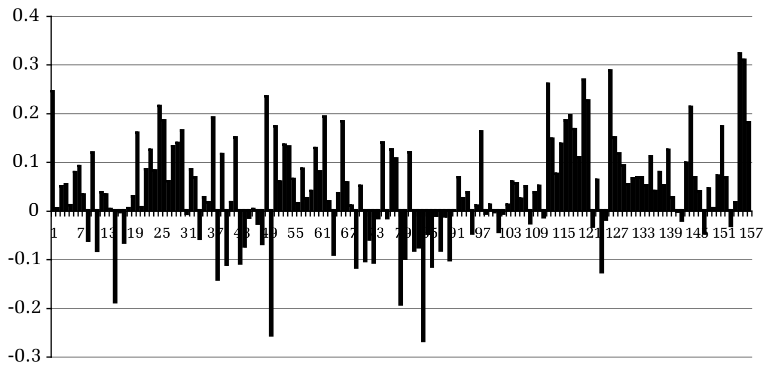
$$T_2 = (N - 2.5)\ln\left[1 + \frac{1}{4}\frac{(\hat{\sigma}_1^2 - \hat{\sigma}_T^2)^2}{\hat{\sigma}_1^2\hat{\sigma}_T^2 - \hat{\sigma}_{1,T}}\right] \qquad (3)$$

with $\hat{\sigma}_{1,T}$ the covariance between prices in the first and last period.

This statistic has a limiting $\chi^2(1)$ – distribution. Carre and Klomb proved in their simulation experiment that the $T_2$ statistic performs better than the traditional Lichtenberg (1994) test of the ratio between the variances in the first period and the last period. The procedure proposed by Lichtenberg leads to a low probability of accepting the hypothesis of convergence (because of a high probability of committing a type II error, especially for short time periods and a small sample).[3] We computed $T_2$ statistics for each of the items in our sample, and the hypothesis of convergence was confirmed for only 31 out of 113. We also performed the analysis for the same period of time, but separately for the sub-group of 15 member states. Here the situation is different. Figure 2

[3] In the literature we find more statistics concerning sigma convergence such as: $T_3 = \frac{\sqrt{N}(\hat{\sigma}_1^2 / \hat{\sigma}_{T-1}^2)}{2\sqrt{1-\hat{\pi}^2}}$, where $\pi$ is estimated from the equation: $p_{iT} = \pi p_{i1} + \mu_i$, which has asymptotically a standard normal distribution. Another procedure is to regress the yearly variance of the log prices against a trend and intercept.

Figure 1
Price dispersion 1995 versus 2006 in EU18 – all goods




* The difference between the standard deviation from 1995 and 2006, the positive value means convergence.

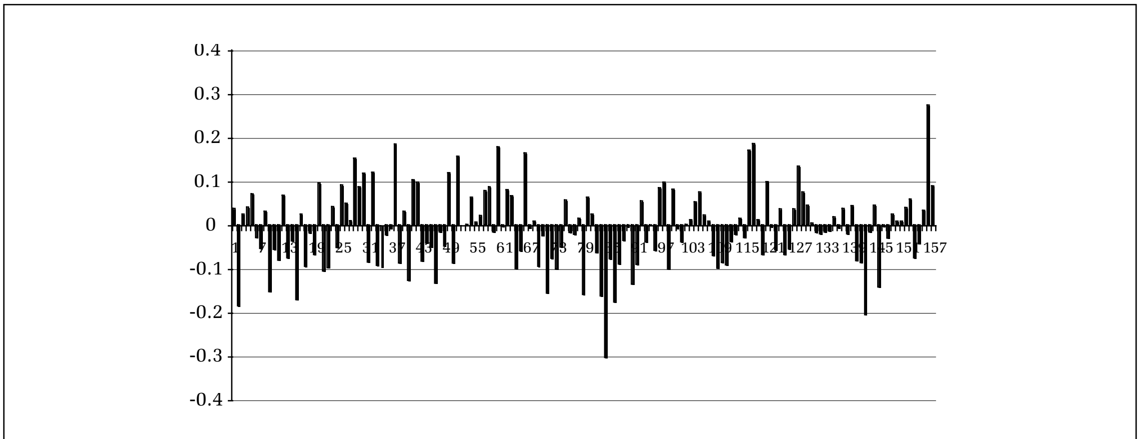
shows the difference in standard deviation between 1995 and 2006, but computed across EU15. For OMS, 75 goods underwent divergence (36 statistically significant); of the rest that underwent convergence, marked as a positive bar on the figure, none was statistically significant.

We are especially interested in potential changes in price dispersion over time. We investigate whether the prices for individual items in our sample show convergence trends. To save space we report here only the results for average dispersion and for the 8 sub-groups. Figure 3 plots average price dispersion (mean standard deviation) for each year between 1990 and 2005. In calculating the mean standard deviation we do not use any weights for different products; our measure is just a simple arithmetic mean. There are three lines representing mean standard deviation of all goods, tradeable and non-tradeable.

Prices are less dispersed for tradeable goods. Over the whole period, price convergence results in a fall in the deviation by 10% for all goods, by 6% for tradeable, and by 16.9% for non-tradeables. The decline in dispersion for each of the groups of products was not statistically significant so the hypothesis of sigma convergence is again rejected. Figure 4 presents the changes in price dispersion for the 8 categories of tradeable goods. Alcoholic beverages is the category with the sharpest decrease in dispersion, i.e. 19%, next in the ranking we have two groups: Recreation, and Food and Beverages, perishable, for which the decline amounts to 11%. For Household supplies and Car there was only a modest reduction of 9%. The prices for the remaining groups diverged over time: dispersion increased by 10% for Personal care and Clothing and by 1% for Food nonperishable. Again the differences in variances were statistically insignificant.

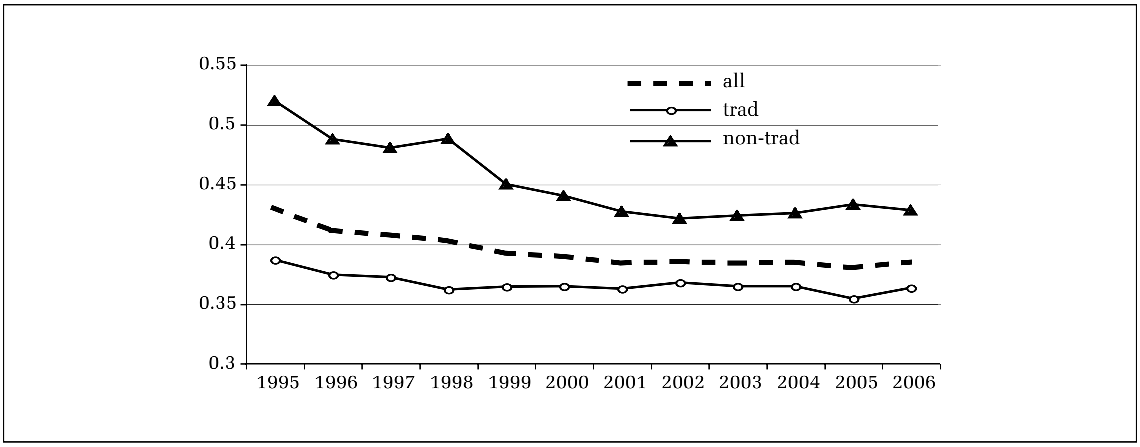
We computed the standard deviation of prices across EU15 and then compared it to the pattern of price convergence of the whole sample. In Figure 5 two lines are plotted: the upper represents the mean dispersion across 18 countries for all products, and the lower across EU15. In Appendix 2 we present a comparison of price convergence between EU15 and EU18 for each of the sub groups. In each case, price dispersion is lower in the E15 countries than in EU18.

Figure 2
Price dispersion 1995 versus 2006 in EU15 – all goods




* The difference between the standard deviation from 1995 and 2006, the positive value means convergence.

Figure 3
Price dispersion, 1995–2006 for all, tradeable and non-tradeable goods




* The mean standard deviation for each of the product group.

Figure 4
Change in price dispersion by product categories

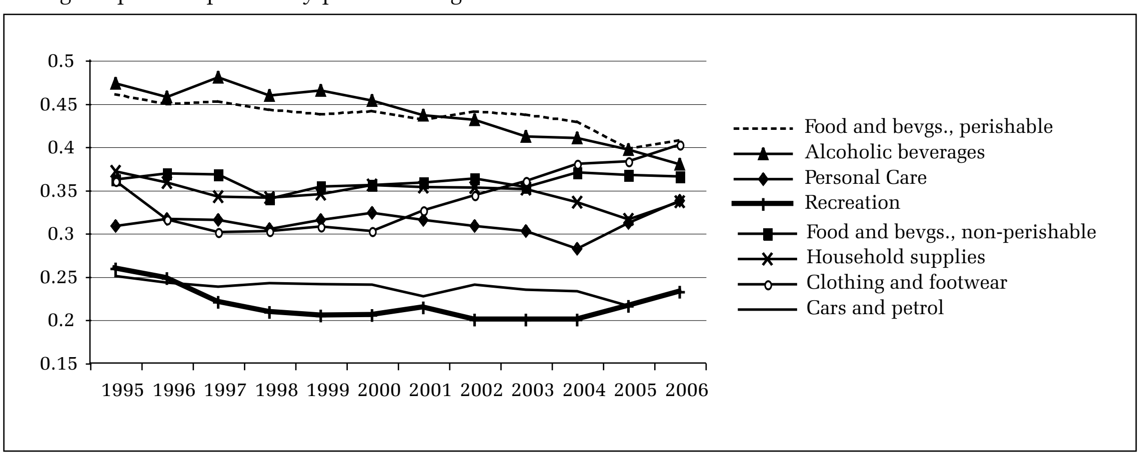
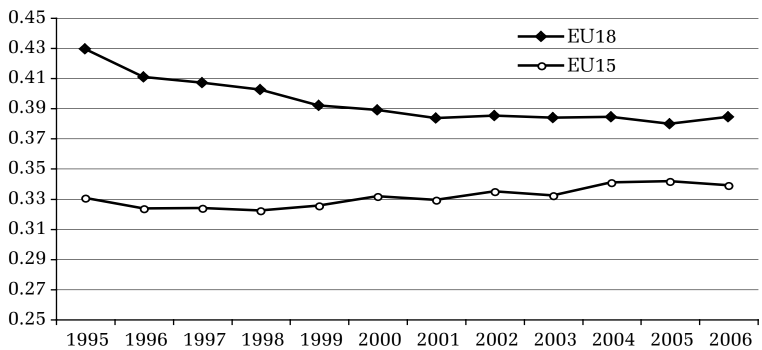


Figure 5
Price dispersion in EU18 versus EU15 – all products




## 3.2. Sigma convergence – aggregate data

To obtain aggregated data, we construct indices from the individual prices using two different weighting procedures: equal weights and good-specific weights. The good-specific weights, in contrast to CPI weights, use cross-country averages of country-specific expenditure to ensure a common basket of goods (Crucini and Shintini 2006).

The construction of the indices was preceded by de-meaning the prices: the price of each of the 157 products was divided by the average price of that particular item across all cities. The de-meaned prices were then weighted equally, or according to the weights used for the categories of the European Harmonized Index of Consumer Prices, using good-specific weights. The formula for the index is:

$$p_i = \sum_{m=1}^{157} \alpha_{mi} \left( \frac{p_{mi}}{\frac{1}{18}\sum_{i=1}^{18} p_{mi}} \right)$$

where:

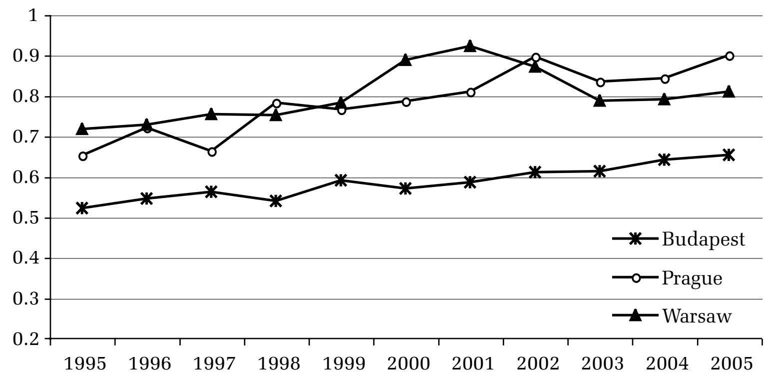
$i$ – the country/city,

$m$ – the product,

$\alpha_{mi}$ – the weight, which can either be equal for all *i,m* or CPI derived and for which $\sum_{m=1}^{157} \alpha_{mi} = 1$.

Under the second regime each item from the sample was first assigned to a subcategory of CPI countries. The resulting indices were normalized to the EU18 average (cross-city mean) set at 1.0. The indices make it possible to compare prices in relation to the EU average. An index higher than 1.0 means that the country is relatively expensive in comparison with the EU average; an index lower than 1.0 means that the country is relatively cheap. For example, in 2006 the price index for London was 1.18 meaning that prices were 18% above the EU average, while in Warsaw with price index 0.83 they were 17% below average.

Figure 6
Price indices (products equally weighted) for Budapest, Prague and Warsaw




Now we can clearly see that prices in the three NMS are well below the EU average, although in the analysed period they go up.

Figure 8 depicts the standard deviation across cities for three different sets of products: all, tradeable, and non-tradeable price indices. There are several noteworthy results. First of all, the price dispersion measured according to the indices is considerably lower than the results obtained from the average standard deviation for individual goods (0.2 as against 0.4). Secondly, price dispersion for non-tradeable goods is higher than for all goods and for tradeable ones.

We performed the formal convergence hypothesis test, and this time we obtained statistical significance for non-tradeable goods, but at the 90% confidence level. No differences emerge from the alternative weighting.

Figure 7
Price indices (products equally weighted) for 1995 and 2006

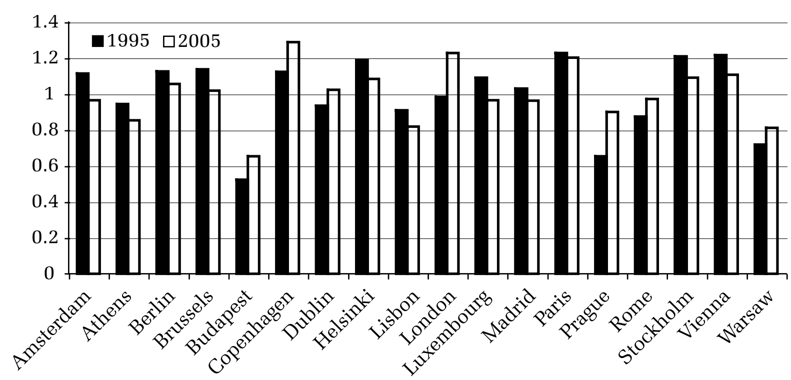
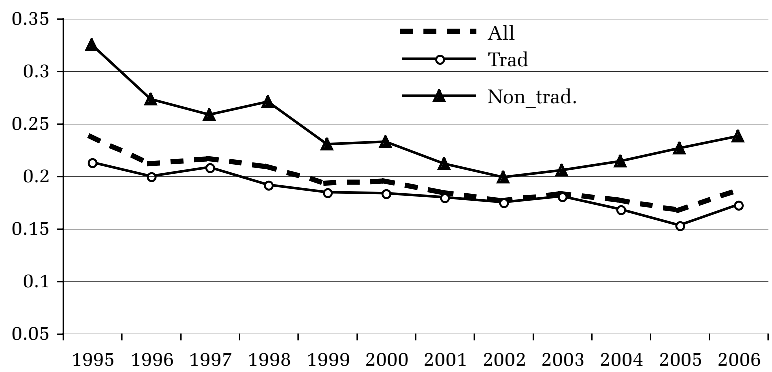


Figure 8
Price dispersion according to price indexes, 1995–2006, for all, tradeable and non-tradeable goods




## 4. Beta convergence

In this section we analyze the concept of beta convergence, which measures the persistence of deviations from the LOOP. We define bilateral relative prices by computing them as price differences expressed in logs:

$$q^m_{i,j,t} = \ln p^m_{i,t} - \ln p^m_{j,t} \tag{5}$$

where $p_{i,t}$ is the price of product $m$ in country $i$ at time $t$ and $p_{j,t}$ is the price of product $m$ in country $j$ at time $t$.

Relative prices cannot be computed for all possible pairs of cities because of the problem of linear correlation of observations. In order to test the LOOP hypothesis, we fit the following *ADF*(1) – like panel regressions:

$$q^m_{ij,t} = \alpha^m_{ij} + \beta q^m_{ij,t-1} + \rho\Delta q^m_{ij,t-1} + \varepsilon^m_{ij,t} \tag{6}$$

where $q^m_{ij,t}$ is the relative price, and the $\varepsilon^m_{ij,t}$ are assumed to be *IID* across *m*, city pairs *ij* and *t*.

We test only the relative version of the LOOP with the inclusion of a country pair/good-specific effect $\alpha^m_{ij}$. An individual effect allows each price difference to converge to a unique, country pair value. The term $\rho\Delta q^m_{ij,t-1}$ accounts for *AR*(1) serial correlation in the errors. The speed of convergence is calculated as: $\lambda = -\ln(|\beta|)$ and the half-life of price shocks according to the formula: $t^* = \frac{\ln(2)}{\lambda}$. The half-life indicates the number of periods needed to halve the distance from the mean. The specification (6) is estimated by the De Blander and Dhaene (2006) unit root test. Their test can be viewed as a pooled *ADF*(1) test of the null hypothesis that the series are *I*(1) implying that the LOOP does not hold. The test statistics are based on least-squares estimates from which the Nickell (1981) bias is removed. The limiting distributions of the test statistics (for an increasing number of independent cross-section units, $N$, and fixed $T$) are standard normal. The test differs from most other unit root tests in that it is designed to work well also when $T$ is small. More about the construction of the test can be found in De Blander, Dhaene (2006).

### 4.1. Beta convergence – disaggregated data

We test the LOOP for three sets of countries: all countries (EU18), Old Members States, and New Member States. Different versions with respect to goods cover were tested: all goods, tradeable goods, and non-tradeable. We perform the estimation item by item obtaining a good-specific persistence parameter. We subsequently calculate the average persistence over all goods. Table 3 reports the average values of bias-corrected LS estimates of the $\beta$ and ρ parameters together with standard errors in brackets.

The null hypothesis of unit root is rejected for all cases at standard levels of confidence.

It is noteworthy that the half-lives for the NMS are the lowest, while for the OMS they are the highest, with the estimation for the all-country sample in between. The different categories of goods have the same ranking for different sets of countries: the half-lives for tradeables is the lowest, then for all goods, and finally for non-tradeable items it is the highest. Generally, in comparison to earlier price studies with estimated half-lives in the range of 3–5 years (Crucini and Shintani (2006)), our results indicate low levels of mean persistence both for NMS and OMS.

Table 3
Relative LOOP, individual products – mean values

| **Countries** | **Goods** | **N** | | **Bias-corrected LS estimates** | **Half life** |
|---|---|---|---|---|---|
| All | All | 26 690 | β | 0.5994 (0.0052) | 1.67 |
| | | | ρ | 0.0712 (0.0061) | |
| | Tradable | 18 190 | β | 0.5650 (0.0067) | 1.49 |
| | | | ρ | 0.0660 (0.0075) | |
| | Non-tradable | 8 500 | β | 0.6731 (0.0076) | 2.07 |
| | | | ρ | 0.0822 (0.0101) | |
| NMS | All | 3 140 | β | 0.3848 (0.0189) | 0.92 |
| | | | ρ | 0.0597 (0.0175) | |
| | Tradable | 2 140 | β | 0.3663 (0.0231) | 0.74 |
| | | | ρ | 0.0426 (0.0210) | |
| | Non-tradable | 1 000 | β | 0.4243 (0.0326) | 1.31 |
| | | | ρ | 0.0963 (0.0315) | |
| OMS | All | 21 980 | β | 0.6161 (0.0057) | 1.81 |
| | | | ρ | 0.0945 (0.0068) | |
| | Tradable | 14 980 | β | 0.5871 (0.0073) | 1.63 |
| | | | ρ | 0.0909 (0.0085) | |
| | Non-tradable | 7 000 | β | 0.6780 (0.0087) | 2.17 |
| | | | ρ | 0.1023 (0.0114) | |

## 4.2. Beta convergence – aggregate approach

Now we turn to the aggregated data. First we perform the estimation based on the pooled data. As shown in Imbs et al. (2005) the aggregation bias is present in the pool specifications. Again we test the LOOP for three sets of countries: all countries (EU18), Old Members States and New Member States. The results are presented in table 4. The null hypothesis of unit root is rejected for all cases at standard levels of confidence but the half-lives are considerably higher than obtained in the previous section. Additionally, the half-life of non-tradeable goods for NMS is substantially lower than for the same good category both for OMS and all countries.

The same procedure applying to the two kinds of indices constructed from the individual prices was implemented. The results are presented in table 5.

This time, the null hypothesis of non-compliance with the relative LOOP cannot be rejected for most cases. For all three sets of countries, the LOOP does not hold when the index based on specific good weights is considered. For the sample of all countries, the LOOP is not rejected for non-tradeable equal weight implying a half-life of 4.23, lower than for the pool specification.

Comparing the half-lives of LOOP deviation obtained from individual products (the mean values) to the pooled specification and to results obtained for the indices we constructed, we see that the mean good do not provide a very reliable estimate of any aggregate persistence. In summary, aggregation bias appears to be an important feature of the data, a finding in line with Imbs et al. (2005).

Table 4
Relative LOOP, individual products – pooled specification

| Countries | Goods | N | | Bias-corrected LS estimates | Half life |
|---|---|---|---|---|---|
| All | All | 26 690 | $\beta$ | 0.8399 (0.0116) | 3.97 |
| | | | ρ | -0.1477 (0.0097) | |
| | Tradable | 18 190 | $\beta$ | 0.7564 (0.0157) | 2.48 |
| | | | ρ | -0.1424 (0.0108) | |
| | Non-tradable | 8 500 | $\beta$ | 0.9548 (0.0134) | 14.98 |
| | | | ρ | 0.0258 (0.0239) | |
| NMS | All | 4 710 | $\beta$ | 0.8104 (0.0247) | 3.30 |
| | | | ρ | -0.1448 (0.0226) | |
| | Tradable | 3 210 | $\beta$ | 0.6843 (0.0363) | 1.83 |
| | | | ρ | -0.1211 (0.0242) | |
| | Non-tradable | 1 500 | $\beta$ | 0.9332 (0.0282) | 10.02 |
| | | | ρ | 0.0047 (0.0692) | |
| OMS | All | 21 980 | $\beta$ | 0.8493 (0.0131) | 4.24 |
| | | | ρ | -0.1491 (0.0106) | |
| | Tradable | 14 980 | $\beta$ | 0.7751 (0.0174) | 2.72 |
| | | | ρ | -0.1476 (0.0121) | |
| | Non-tradable | 7 000 | $\beta$ | 0.9643 (0.0147) | 19.05 |
| | | | | 0.0331(0.0177) | |

Table 5
Relative LOOP, indices

| Countries | Indices | NT | | Bias-corrected LS estimates | Half life |
|---|---|---|---|---|---|
| All | All, equal weight | 170 | $\beta$ | 0.87245 (0.0833) | / |
| | | | $\rho$ | -0.1091 (0.1146) | |
| | Tradeables, equal weight | | $\beta$ | 0.8773 (0.0796) | / |
| | | | $\rho$ | -0.0191 (0.1325) | |
| | Non-tradeables, equal weight | | $\beta$ | 0.8489 (0.0700) | 4.23 |
| | | | $\rho$ | -0.1428 (0.1131) | |
| | All, CPI weight | | $\beta$ | 0.8826 (0.0868) | / |
| | | | $\rho$ | -0.1589 (0.1130) | |
| NMS | All, equal weight | 20 | $\beta$ | 0.8568 (0.0630) | 4.46 |
| | | | $\rho$ | -0.3730 (0.0995) | |
| | Tradeables, equal weight | | $\beta$ | 0.5076 (0.0431) | 1.022 |
| | | | $\rho$ | -0.1298 (0.1077) | |
| | Non-tradeables, equal weight | | $\beta$ | 0.8633 (0.4790) | / |
| | | | $\rho$ | -0.2920 (0.1617) | |
| | All, CPI weight | | $\beta$ | 0.7426 (0.2084) | / |
| | | | $\rho$ | -0.3289 (0.0294) | |
| OMS | All, equal weight | 140 | $\beta$ | 0.8409 (0.0917) | 4.00 |
| | | | $\rho$ | 0.0749 (0.0676) | |
| | Tradeables, equal weight | | $\beta$ | 0.8682 (0.0805) | / |
| | | | $\rho$ | 0.1179 (0.0791) | |
| | Non-tradeables, equal weight | | $\beta$ | 0.7793 (0.1109) | 2.78 |
| | | | $\rho$ | -0.0258 (0.0619) | |
| | All, CPI weight | | $\beta$ | 0.8761 (0.1056) | / |
| | | | $\rho$ | 0.0494 (0.0818) | |

## 5. Conclusions

This paper has investigated price dispersion in the EU15 and in three New Member States (Poland, Hungary and the Czech Republic) between 1995 and 2006. Prices in NMS in 2006 were still considerably lower than in the core EU countries. Budapest is the least expensive city in the sample with 67 out of 157 products being the cheapest. For Warsaw and Prague the situation is mixed, they both have a considerable number of products which are the cheapest across all cities but at the same time we can find the highest prices too. There is no country which is uniformly expensive, although Copenhagen, London and Vienna tend to be at a high level for a number of products.

In contrast to most of the previous studies that either utilized indices or actual prices, in our analysis we employed both aggregate and disaggregate price data.

For each category of goods, price dispersion is lower in OMS than in the sample of all countries analyzed. The magnitude of price dispersion is higher when the disaggregated data, rather than the aggregate data, are considered. Sigma convergence measured as decline in the standard deviation over time is statistically significant for 31 individual products for NMS and none for EU15.

For individual products we found strong evidence for mean-reversion in the time series of price differences across countries. For NMS the half-lives are the lowest. Pooling the data or construction of indices changes the picture. The half-lives are longer or even, in most cases for indices, we cannot reject the hypothesis of price divergence. This is probably connected with the aggregation bias.

The analysis attempts to evaluate the effect of the EU enlargement on price dispersion. The results indicate that there was no sudden drop in price differentials between NMS and OMS in 2004. However, due to the restriction of our data (the last covered year is 2006) we cannot provide very detailed insights into the particular impact of 2004 entry into the EU on price dispersion in NMS (especially that our analysis is based heavily on time series properties). If we consider the EU enlargement not as a particular point in time but as the process of integration that started in mid 90s we can draw further policy implications. Our results indicate that the process of integration of three NMS is accompanied by the decreasing of their price differentials toward the EU levels as envisage by the theory of economic integration. Bearing in mind that NMS have had relatively lower price levels, convergence towards EU levels entails a rise of their prices. However, if we treat as unbiased results the ones obtained by individual prices, the speed of convergence is relatively high (half-lives around one year) and the impact of EU enlargement in 2004 is over now. On the other hand, if half lives are longer, prices adjust more gradually, so the risk of inflation is lower.

From the policy perspective especially important is the issue of the difference in half-lives between tradable and non-tradable goods. Wages, considered as the "price of labor", fall within the category of non-tradables. Whatever aggregation approach we employed, the speed of convergence for non-tradable products was lower. This relatively slow wage convergence contrasts with the original hopes of quick wage convergence among the population after accession to the EU. Of course, we must be aware that a sudden increase in wages across NMS would imply an increase in prices, which neither would meet the expectations of ordinary citizens. In this example we see that the policy is a difficult exercise in balancing needs and desires of different agents.

Additionally, the aggregation bias was shown to be significant, that is why we argue that further studies should go in the direction of analyses of prices of individual products, as traders do not compare indices but make a decision on buying and selling on the basis of concrete price differences, and through their activities the LOOP works.

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## Acknowledgements

Joanna Wolszczak-Derlacz acknowledges financial support from the CERGE-EI Foundation under a program of the Global Development Network. The views expressed in the article do not necessarily represent those of CERGE-EI or the GDN.

## Appendix 1. Product list

Table 6
Tradeable goods

**Food and bevgs., perishable (34)**

1 White bread, 1 kg
2 Butter, 500 g
3 Margarine, 500g
4 Spaghetti (1 kg)
5 Flour, white
6 Sugar, white (1 kg)
7 Cheese, imported (500 g)
8 Cornflakes (375 g)
9 Yoghurt, natural (150 g)
10 Milk, pasteurised (1 l)
11 Potatoes (2 kg)
12 Onions (1 kg)
13 Mushrooms (1 kg)
14 Tomatoes (1 kg)
15 Carrots (1 kg)
16 Oranges (1 kg)
17 Apples (1 kg)
18 Lemons (1 kg)
19 Bananas (1 kg)
20 Lettuce (one)
21 Eggs (12)
22 Beef: steak, entrecote (1 kg)
23 Beef: stewing, shoulder (1 kg)
24 Beef: roast (1 kg)
25 Beef: ground or minced (1 kg)
26 Lamb: chops (1 kg)
27 Lamb: Stewing (1 kg)
28 Pork: chops (1 kg)
29 Pork: loin (1 kg)
30 Ham: whole (1 kg)
31 Bacon (1 kg)
32 Chicken: fresh (1 kg)
33 Fresh fish (1 kg)
34 Orange juice (1 l)

**Food and bevgs.,**

**non-perishable (16)**

35 White rice (91 kg)
36 Olive oil (1 l)
37 Peanut or corn oil (1 l)
38 Peas, canned (250 g)
39 Tomatoes, canned (250 g)
40 Peaches, canned (500 g)
41 Sliced pineapples, canned (500 g)
42 Frozen fish fingers (1 kg)
43 Instant coffee (125 g)
44 Ground coffee (500 g)
45 Tea bags (25 bags)
46 Cocoa (250 g)
47 Drinking chocolate (500 g)
48 Coca-Cola (1 l)
49 Tonic water (200 ml)
50 Mineral water (1 l)

**Alcoholic beverages and tobacco (12)**

51 Wine, common table (1 l)
52 Wine, superior quality (700 ml)
53 Wine, fine quality (700 ml)
54 Beer, local brand (1 l)
55 Beer, top quality (330 ml)
56 Scotch whisky, six years old (700 ml)
57 Gin, Gilbey's or equivalent (700 ml)
58 Vermouth, Martini &Rossi (1 l)
59 Cognac, French VSOP (700 ml)
60 Liqueur, Cointreau (700 ml)
61 Cigarettes, Marlboro (pack of 20)
62 Cigarettes, local brand (pack of 20)

**Household supplies (6)**

63 Laundry detergent (3 l)

64 Dishwashing liquid (750 ml)

65 Light bulbs (two, 60 watts)

66 Batteries (two, size D/LR20)

67 Frying pan (Teflon or good equivalent)

68 Electric toaster (for two slices)

**Personal Care (8)**

69 Soap (100 g)

70 Toilet tissue (two rolls)

71 Razor blades (five pieces)

72 Toothpaste with fluoride (120 g)

73 Facial tissues (box of 100)

74 Hand lotion (125 ml)

75 Shampoo

76 Lipstick (deluxe type)

**Clothing and footwear (16)**

77 Business suit, two piece, medium weight

78 Business shirt, white

79 Men's shoes, business wear

80 Mens raincoat, Burberry type

81 Socks, wool mixture

82 Dress, ready to wear, daytime

83 Women's shoes, town

84 Women's cardigan sweater

85 Women's raincoat, Burberry type

86 Tights, panty hose

87 Child's jeans

88 Child's shoes, dresswear

89 Child's shoes, sportswear

90 Girl's dress

91 Boy's jacket, smart

92 Boy's dress trousers

**Recreation (7)**

93 Compact disc album (average)

94 Television, colour (66 cm) (average)

95 Kodak colour film (36 exposures)

96 International foreign daily newspaper

97 International weekly news magazine

98 Paperback novel (at bookstore)

99 Cost of six tennis balls eg Dunlop

**Cars and petrol (8)**

100 Low priced car (900-1299 cc) (low)

101 Low priced car (900-1299 cc) (high)

102 Compact car (1300-1799 cc) (low)

103 Compact car (1300-1799 cc) (high)

104 Family car (1800-2499 cc) (low)

105 Family car (1800-2499 cc) (high)

106 Deluxe car (2500 cc upwards) (low)

107 Regular unleaded petrol (1 l)

Table 7
Non-tradeable goods

| | | | |
|---|---|---|---|
| 108 | Laundry (one shirt) (standard high-street outlet) | 134 | Unfurnished residential apartment: 3 bedrooms (moderate) |
| 109 | Dry cleaning, man's suit (standard high-street outlet) | 135 | Unfurnished residential apartment: 3 bedrooms (high) |
| 110 | Dry cleaning, woman's dress | 136 | Unfurnished residential apartment: 4 bedrooms (moderate) |
| 111 | Dry cleaning, trousers (standard high-street outlet) | 137 | Unfurnished residential house: 3 bedrooms (moderate) |
| 112 | Man's haircut (tips included) (average) | 138 | Unfurnished residential house: 3 bedrooms (high) |
| 113 | Woman's cut | 139 | Unfurnished residential house: 4 bedrooms (moderate) |
| 114 | Hourly rate for domestic cleaning help (average) | 140 | Unfurnished residential house: 4 bedrooms (high) |
| 115 | Maid's monthly wages (full time) (average) | 141 | Routine checkup at family doctor (average) |
| 116 | Babysitter's rate per hour (average) | 142 | One X-ray at doctor's office or hospital |
| 117 | Cost of developing 36 colour pictures (average) | 143 | Visit to dentist (one X-ray and one filling) |
| 118 | Daily local newspaper (average) | 144 | Hire of tennis court for one hour (average) |
| 119 | Three course dinner for four people (average) | 145 | Entrance fee to a public swimming pool (average) |
| 120 | Four best seats at theatre or concert (average) | 146 | Business trip, typical daily cost |
| 121 | Four best seats at cinema (average) | 147 | Hilton-type hotel, single room, one night including breakfast (average) |
| 122 | Cost of a tune up (but no major repairs) (low) | 148 | Moderate hotel, single room, one night including breakfast (average) |
| 123 | Cost of a tune up (but no major repairs) (high) | 149 | One drink at bar of first class hotel |
| 124 | Annual premium for car insurance (low) | 150 | Two-course meal for two people (average) |
| 125 | Annual premium for car insurance (high) | 151 | Simple meal for one person (average) |
| 126 | Taxi: initial meter charge (average) | 152 | Fast food snack: hamburger, fries and drink (average) |
| 127 | Taxi rate per additional kilometre (average) | 153 | Hire car, weekly rate for lowest price classification (average) |
| 128 | Furnished residential apartment: 1 bedroom (moderate) | 154 | Hire car, weekly rate for moderate price classification (average) |
| 129 | Furnished residential apartment: 1 bedroom (high) | 155 | Telephone and line, monthly rental |
| 130 | Furnished residential apartment: 2 bedroom (moderate) | 156 | Telephone, charge per local call from home (3 mins) |
| 131 | Furnished residential apartment: 2 bedroom (high) | 157 | Electricity, monthly bill (average) |

Source: EIU, CityData.

## Appendix 2. Do EIU data correspond to CPL?

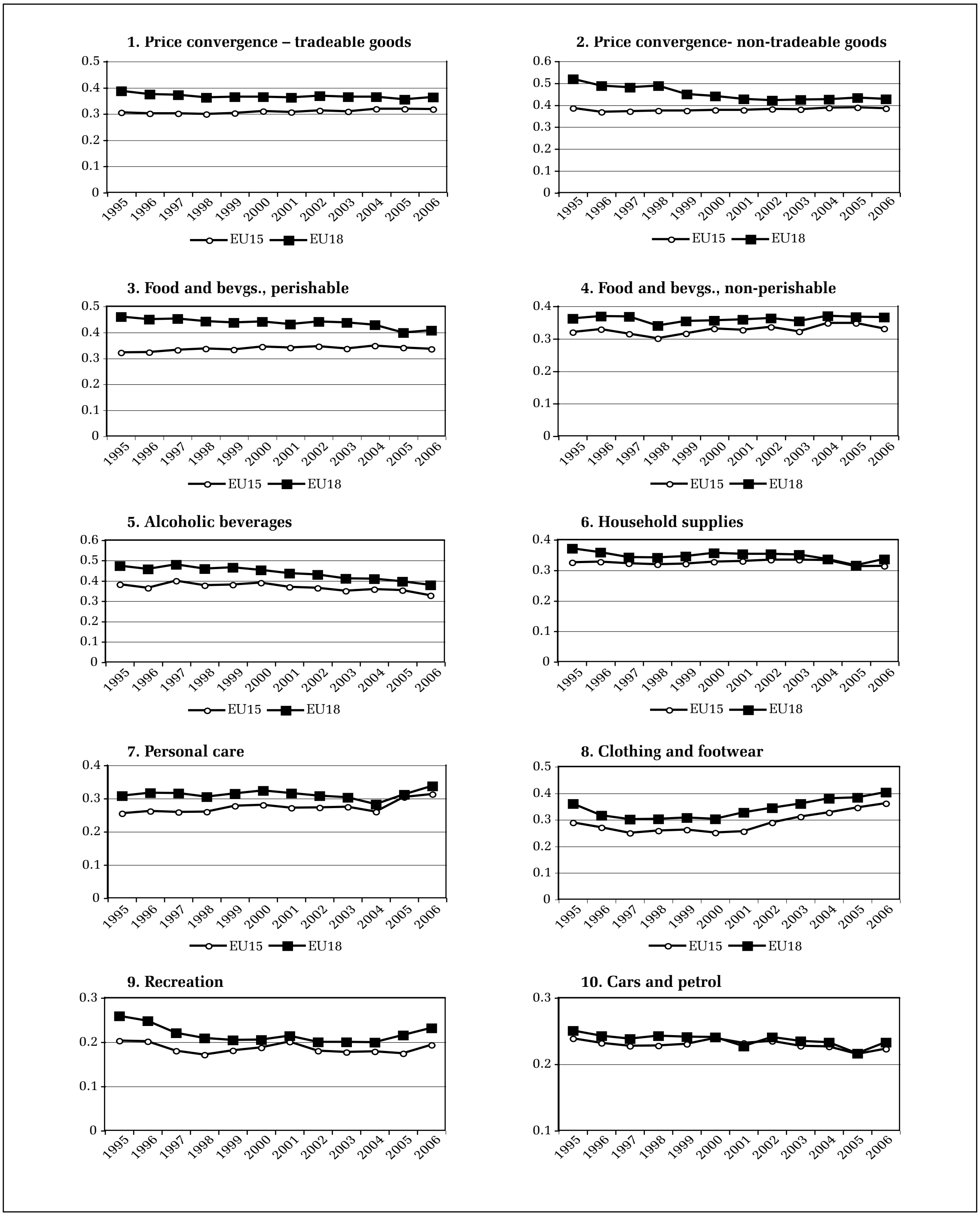
To check the reliability of EIU data we construct the index from the raw individual prices. We construct index using goodspecific weights. The goodspecific weights in contrary to HICP weights use cross-country averages (EU 18 average) of country specific expenditure to ensure the common basket of goods (Crucini, Shintani 2006). The construction of the index was prefaced with de-meaning the prices: the price of each of the 157 products was divided by the average price of that particular item across all cities. Then the de-meaned price of each item from the sample was first assigned to a subcategory of each HICP weight according to the representative year 2000. The formula of the index is as (4) in the main text. Now $\alpha_{ni}$ stand for the weights, which are HICP derived and for which $\sum_{n=1}^{157}\alpha_{ni}=1$. The resulting index was normalized to German average equaled to 1.0. An index higher than 1.0 means that the country is relatively expensive in comparison with Germany, an index lower than 1.0 means that the country is relatively cheap. Comparative Price Levels (CPL) were also expressed in relation to Germany. The correlation coefficients between the EIU index and CPL are reported in Table 8.

Table 8
Correlation of EIU based index and CPL (1995–2006)

| | **Correlation coeff.** | **Rank coeff.** |
|---|---|---|
| All (pooled) | 0.77 | 0.74 |
| Amsterdam | 0.37 | 0.83 |
| Athens | 0.08 | 0.13 |
| Brussels | 0.28 | 0.41 |
| Budapest | 0.88 | 0.87 |
| Copenhagen | 0.96 | 0.90 |
| Dublin | 0.80 | 0.58 |
| Helsinki | 0.39 | 0.54 |
| Lisbon | 0.54 | 0.75 |
| London | 0.95 | 0.90 |
| Luxembourg | 0.37 | 0.31 |
| Madrid | 0.53 | 0.44 |
| Paris | 0.62 | 0.64 |
| Prague | 0.94 | 0.97 |
| Rome | 0.96 | 0.89 |
| Stockholm | 0.72 | 0.85 |
| Vienna | 0.49 | 0.57 |
| Warsaw | 0.83 | 0.88 |

# Appendix 3

Figure 9
Sigma convergence accross EU15 and EU18 for different sub-groups




Source: calculation based on the EIU data.