Price convergence after the Eastern EU enlargement? Evidence from European Retail Food Prices

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Abstract

This paper studies price convergence within the European Union after the enlargement in 2004 until 2009. Using comprehensive Eurostat data, it is the first study able to look at price convergence of retail food prices at a disaggregate level, both for the old member states (EU15) and the eight new Central and Eastern European member states (EU8). Applying a test for σ-convergence, we find that prices within the European Union as a whole as well as within EU8 converge significantly in the periods after the accession. In contrast, there is no convergence within EU15 and since 1998 prices even have diverged slightly. We decompose price convergence and conclude that price convergence within the EU as a whole is partly driven by the dynamics within EU8, but the main effect is that EU8's and EU15's prices move towards each other.

Keywords:
Price convergence · International Price Dispersion · Law of one Price · European Union · Economic Integration · EU enlargement · Central Eastern European Countries

JEL Classification:
F0 · F15 · E31 · L81

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1 Introduction

Almost 20 years after the European internal market started and more than ten years after the Euro was introduced, there are substantial price differences for identical products within the EU. Such price differences also exist within the EU15, and in particular between the EU15 and the new Central and Eastern European member states. They can only partly be explained by cost differences or by differing overall price levels. From a theoretical point of view, it is not clear if these differences should diminish over time. Especially in the retail sector, price differences might be completely feasible even in competitive markets. If retailing gives a value-adding service to consumers, arbitrage will not take place and there is no reason to assume that prices have to converge over time.

Nevertheless, after an external shock like the Eastern enlargement of the EU in 2004, it is a relevant question whether these price differences decline over time. In this context, the food market is particularly interesting. While in most sectors trade liberalization took place gradually over the whole decade before the accession, the agricultural sector was only liberalized with the actual access of the new member countries.

To the best of our knowledge, this paper is the first study that analyses retail price convergence within the European Union at a disaggregate level including all Central and Eastern European states which accessed the EU in 2004 (EU8).
As part of the Eurostat-OECD PPP Programme, retail food prices for more than 400 narrowly defined items are collected. For the period 2003 - 2009, individual product prices are available. In addition, Eurostat has provided us with price indices for 34 food product groups for the period 2001 - 2009. The data allows us to look at price convergence for a time period that includes more than just the initial effects right after the EU enlargement.

To analyse price convergence, two different approaches are used. The concept of β-convergence refers to mean reversion measuring the forces that make deviations from a uniform price fade out over time. In contrast, σ-convergence means that the variance of prices within a group of countries becomes smaller. Note that β-convergence is not sufficient for σ-convergence, as due to random shocks on prices, it is possible to simultaneously observe significant mean reversion and a rising variance of prices. Hence, σ-convergence is only ensured if the mean reversion is sufficiently large. To test for convergence, we apply a test proposed by Egger & Pfaffermayr (2009). The advantage of this test is that it needs neither long time-spans nor high frequency data.

In line with the existing literature, we find that price convergence within the EU15 has reached a limit. Due to data restrictions the literature until now was only able to look at EU15. When including some selected new member states, no significant price convergence was found. Being able to look at food prices for all Eastern European member states, we find a significant decrease in the variance of prices (σ-convergence) within EU23. In addition, some price convergence within the new member states is observed for the periods after the accession. Moreover, we decompose the convergence dynamics within EU23 and find that the decrease of the variance mainly comes from the EU8 and the EU15 average prices moving towards each other.

The paper is organized as follows. Section 2 gives a short overview of the literature. In sections 3 and 4, we present the data and the method used. Section 5 estimates β-convergence and section 6 σ-convergence at different levels of aggregation. Section 7 concludes.

2 Retailing, the EU and price convergence

According to the law of one price (LOOP), on a perfectly integrated market a good would only have one price. Hence, when the European Single Market was introduced in 1992, it was widely expected that prices would converge within the European Union and that price differences between member countries would merely reflect cost differences, such as transport costs or differing value added taxes (Cecchini et al., 1988). Similar expectations emerged when the European Monetary Union started (European Commission, 1990).
It has, however, become quite clear that the LOOP and its aggregate version, the purchasing power parity (PPP), do not hold within the European Union. Large price differences for identical products are observed, which are not explained by cost differences. Early studies on this issue include Cumby (1996), who studies prices of Big Mac Hamburgers, or Haskel & Wolf (2001) who analyse the prices of IKEA, a furniture retailer. It is also well-documented that car producers set different prices in different EU member countries (Goldberg & Verboven, 2004).

Price differences for identical products are feasible as long as they do not exceed arbitrage costs (which may well be higher than mere transportation costs). Taking into account that retailing gives a value-adding service to consumers, arbitrage will hardly take place at the level of retailing and price differences may persist over time. The price of a retail product does not only include the raw product's cost, but also costs of retailing, as e.g. labour costs, and product specific profit margins. Bliss (1988) develops a theory of retail pricing and suggests that mark-ups to cover

overhead-costs will be set according to Ramsey-taxation rules, leading to higher mark-ups for goods with a lower elasticity of demand. It follows directly from this reasoning that even in competitive markets, retail prices will vary within a group of countries as long as demand patterns differ.
Nevertheless, an obvious question is whether prices converge over time. The early empirical studies seemed to confirm the expectation of declining price differences between countries. Until the 1990s, price convergence was thought of as β-convergence, which refers to mean reversion of price differences between countries, meaning that a given deviation from the law of one price fades out over time.
Significant β-convergence was found in all studies mentioned above, and the same is true for virtually all studies on European prices. In the recent literature it has been widely discussed, that β-convergence is not sufficient for price convergence in the sense of a decreasing price dispersion between countries. It is possible to observe significant mean reversion, but at the same time the variance of prices increases due to random shocks on prices (for a further discussion see section 4). Hence to interpret β-coefficients correctly, it is also necessary to examine σ-convergence, which is defined as a decrease of the variance over time (Barro & Sala i Martin, 1995; Carree & Klomp, 1997).

Consequently several studies consider σ-convergence of prices in addition to β-convergence within the European Union. Egger et al. (2009) find significant σ-convergence for tradeable, but not for non-tradable goods within EU15 in the time period when the internal market was introduced (1990 - 1996). Wolszczak-Derlacz & De Blander (2009) reject price convergence within EU15 and three selected new member-states in the following ten years from 1995 - 2005, and Parsley & Wei (2008) do not find price convergence for Big Macs during the time of the Euro changeover. For the same time period (1995 - 2005), Fischer (2009) finds large variation of the prices of washing machines and even price divergence within EU 15. The only study with data available for all new member states of the European Union uses data until march 2005. However it only looks at mean reversion and not at σ-convergence (Funke & Koske, 2008).

3 The data

This paper analyses European retail food prices. In the framework of the Eurostat-OECD Purchasing Power Parity Program (PPP), retail prices for more than 400 narrowly defined food products are collected every three years to calculate PPP figures. Meanwhile the program includes 37 countries. For the years 1995 - 2009 (EU15) and 2001 - 2009 (EU25), the data set has been provided by Eurostat at an aggregate level (the price level index "food and non alcoholic beverages" - PLI-food)

and a semi-aggregate level (34 product group indices, such as "pasta products", "beef and veal" or "fresh milk" - also called basic headings).

For 2003 to 2009, prices are also available at the individual items level (e.g. "milk fresh, unskimmed, 1 liter, well known brand", more on the structure of our data can be found in appendix A). Prices including VAT and other taxes are collected in supermarkets. The observed daily offer prices are adjusted for seasonal effects (e.g. for fruit, fish, etc.), reported in their national currencies and then converted into euro with the official Eurostat exchange rate for the given year. As prices for individual products are reported by the national statistical bureaus only if they are considered relevant, there are several missing observations at the single items level (European Commission, 2006).

The advantage of using data on the items level is that this is the data originally collected and that it refers to well-defined individual products which on a perfectly integrated market would have a single price. Nevertheless, there are also good reasons to use data at the product group level. First, it is available for a longer time period. Furthermore, price indices are reported for all countries and all product groups at all observed times. In contrast, some items for which prices are collected have been replaced by others and cannot be traced in the course of time, and not every price is reported in each country. Requiring that a product is observed at all three dates (2003, 2006, 2009) and that its price is reported in 50% of both the old member countries EU15 as well as the new member countries EU8 leaves us with only 147 products out of more than 400 for the estimations on the items level in sections 5 and 6.2.

In the following analysis, we distinguish between three groups of countries. (i) the group of the old member countries EU15, (ii) the Central and Eastern European countries EU8, which accessed the EU in 2004, and (iii) these two groups together as EU23. Since Bulgaria and Romania joined the EU only in 2007 and data is not available before 2006, these two countries are left out. Moreover we exclude the two small island-states Malta and Cyprus. They are also new EU member states, but their situation is hardly comparable with the EU8.

Starting at the highest level of aggregation – the PLI-food – large price index differences within EU23 are observed(Figure 1). With Poland as the cheapest country within EU23 (64% of the EU27 average) and Denmark as the most expensive one (138%), the difference in price level indices is more than 100%. One might suppose that it is unlikely to find equal price level indices within the European Union of 23, as the new members just recently joined the EU. But even when we only consider EU15 countries, the price level indices differ from 84% of the EU15 average

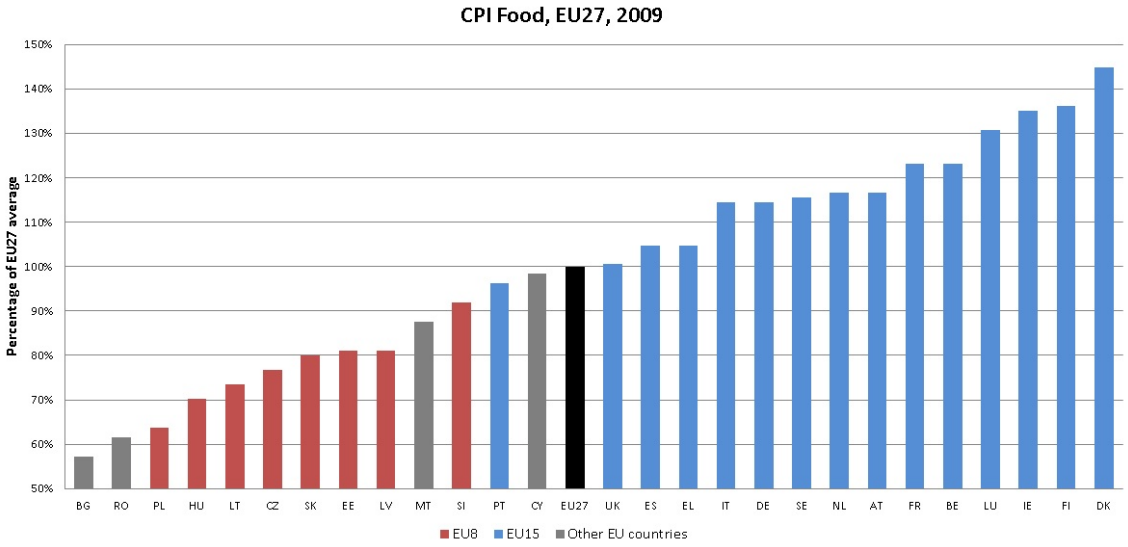

Figure 1: PLI-food and non alcoholic beverages 2009, EU27 = 100%

in Portugal to 122% in Denmark. However, although Denmark on the whole has the highest prices for food, there are also some food products that cost less than the EU15 average in Denmark. The Danish price indices of the 34 product groups range from 81% for rice to 216% for mineral waters (EU15=100%). Moreover, even when taking such country-product group specific effects (one product group being expensive in a country but another one being cheap) into account, considerable unexplained price differences remain[1]. Thus price patterns are much more complex than just countries being expensive or cheap on the whole and price convergence must be considered at a disaggregate level.

4 Methodology

4.1 Measuring convergence

In the literature, two different approaches to measure price convergence are used. The concept of β-convergence refers to mean reversion. It measures the forces that make deviations from a uniform price – caused by a one-time initial shock – fade out over time. In contrast, σ-convergence means that the variance of prices within a group of countries becomes smaller (Barro & Sala i Martin, 1995). In addition to β-convergence, this concept also takes into account that random shocks occur after the initial one. Hence β-convergence is necessary, but not sufficient for σ-convergence. Due to random shocks on prices, it is possible to simultaneously observe significant mean reversion and a rising variance of prices. Price convergence is only ensured if the mean reversion is strong enough to dominate the disperion induced by the

[1] In appendix B we look at so called "double relative prices (DRP)" to illustrate this observation.

ongoing random shocks. To analyse σ-convergence, we apply a Wald-test proposed by Egger & Pfaffermayr (2009). The advantage of this test is that it needs neither long time-spans nor high frequency data. The test uses results of the standard β-convergence regression, which can be viewed as a simple AR(1) process[2]:

$$p^i(t) = \alpha + \pi * p^i(t-1) + u_{it}$$

The natural logarithm $p^i(t)$ of the price of a given product or product group in country i in period t is regressed on $p^i(t-1)$, the log price in period $t-1$. When the data is demeaned (i.e. $\bar{p}(t) = \frac{1}{n}\sum_{i=1}^{n} p^i(t) = 0$ and $\bar{p}(t-1) = 0$), $p^i(t)$ is actually the deviation of the product's price in country i from the country group's average (e.g. the deviation of the price for butter in Germany from the average price for butter in the EU23). The coefficient π can then be interpreted as the remainder of period $t-1$'s price deviation in period t and $\pi < 1$ denotes mean reversion. The smaller is π, the larger is the mean reversion. Moreover, for demeaned data, the constant α will always be zero.

Price indices in logs are in general demeaned by definition. Note however that for considering the different groups of countries (EU8, EU15, EU23), also price indices have to be renormalized such that the mean of the respective country group is equal to zero.

In addition to the mean reversion, there are random shocks captured in the error terms u_{it}, which increase the variation of prices. Hence β-convergence does not necessarily imply that the variance of prices falls over time. For the Wald-test whether the variance has declined[3] over time (H_1) against the null that variance has not changed (H_0),

$$H_1 : \sigma^2_{t-1} > \sigma^2_t \text{ vs. } H_0 : \sigma^2_{t-1} = \sigma^2_t \ ,$$

Egger & Pfaffermayr (2009) derive the following test statistic, which is $\chi^2(1)$ distributed:

$$W_0 = \frac{N(\hat{\sigma}^2_{t-1}(\hat{\pi}^2 - 1) + \hat{\sigma}^2_u)^2}{4\hat{\sigma}^4_{t-1}\hat{\sigma}^2_u} \sim \chi^2(1)$$

To calculate this one-sided test, the variance of the regression's residuals $\hat{\sigma}^2_u$ and the corresponding coefficient $\hat{\pi}$ as well as the number of observations N are taken from

[2]In the literature, one can also find an alternative formulation of the regression above (hence the name β-convergence):

$$\Delta p^i(t) = \alpha + \beta * p^i(t-1) + u_{it}$$

The two formulations are equivalent by substracting $p^i(t-1)$ on both sides of the β-regression. Then $\pi - 1 = \beta < 0$ corresponds to mean reversion.

[3]The same test can be used to test for significant divergence:

$$H_1 : \sigma^2_{t-1} < \sigma^2_t \text{ vs. } H_0 : \sigma^2_{t-1} = \sigma^2_t$$

the β-convergence regression above. In addition we need $\hat{\sigma}^2_{t-1}$, the variance of prices in $t-1$.

The test can be applied to pooled data (more than one product or product group) provided that the data is properly demeaned[4] such that the prices of all products k converge towards zero (ln(1)). This can either be achieved by using a product-fixed effect – both for the β-regression and the calculation of the variances – or by normalizing the data before running the mean reversion regression. We choose the second possibility and normalize the mean of the prices (price indices) of each product (product group) k to zero, i.e. $\bar{p}_k(t) = \frac{1}{n}\sum_{i=1}^{n} p_k^i(t) = 0$.

4.2 Convergence decomposition

With the test introduced above, one can tell if there is significant price convergence or divergence within a given country group. However, convergence within EU23 can come from different sources: prices may converge within subgroups (e.g. EU8, EU15), prices of the subgroups may move towards each other or both developments may happen at the same time. To be able to distinguish the different reasons for convergence, we decompose the variance using the standard textbook notation of the variance[5]:

$$\sigma^2 = E(X^2) - (E(X))^2$$

With prices normalized to $\bar{p}_{EU23} = 0$, and $\bar{p}_{EU15}$ and $\bar{p}_{EU8}$ denoting the averages of the subgroups, we get

$$\begin{aligned}\sigma^2_{EU23} &= \frac{1}{23}\sum_{i=1}^{23} p_i^2 - \underbrace{(\bar{p}_{EU23})^2}_{=0} \\ &= \frac{15}{23}\cdot\sigma^2_{EU15} + \frac{8}{23}\cdot\sigma^2_{EU8} + \frac{15}{23}\cdot(\bar{p}_{EU15})^2 + \frac{8}{23}\cdot(\bar{p}_{EU8})^2.\end{aligned}$$

The variance of the EU23 price indices consists of the two subgroups' weighted variances and their weighted quadratic means. Since the two subgroups average prices are linked to each other by $\bar{p}_{EU23} = 15\cdot\bar{p}_{EU15} + 8\cdot\bar{p}_{EU8} = 0$, either both means are moving towards zero or both are moving away from it. Thus we can further simplify the decomposition and substract the variance in period $t-1$ to get

$$\Delta\sigma^2_{EU23} = \frac{15}{23}\Delta\sigma^2_{15} + \frac{8}{23}\Delta\sigma^2_{8} + \frac{8}{15}(\bar{p}_{EU8})^2. \tag{1}$$

[4]See Egger et al. (2009). In the test statistics W_0, we deviate from their original notation, as it imposes unintended restrictions on the data: The number of observations for every product would have to be the same. This is the case for product groups, but not for items. The test itself remains unchanged.

[5]For the complete deduction of the decomposition, see appendix C

The change of the variance of prices within EU23 consists of the weighted change of the variances within EU15 and within EU8, as well as the weighted effect of the two subgroups moving towards each other. In the following section on price convergence we use this decomposition of the price variance for the interpretation of the results.

5 β-convergence

In this section, we pool all product groups as well as all single items and look into β-convergence. While product groups are reported at every observed period and for every country, there are missing values on the items level. To avoid effects induced by a change of the sample, we drop items for which prices were not reported at every point of time (2003, 2006, 2009). Furthermore we drop products with less than 50% of the observations in either EU15 or EU8, which leaves us 147 products[6]. This ensures, that we really measure convergence towards the average of country groups EU8/15 and especially EU23 and not the average of yet another subgroup of these.

Product groups

	2001 - 2003			2003 - 2006			2006 - 2009		
	EU8	EU15	EU23	EU8	EU15	EU23	EU8	EU15	EU23
$\hat{\pi}$	0.62***	0.79***	0.93***	0.54***	0.82***	0.76***	0.72***	0.81***	0.78***
	(0.048)	(0.027)	(0.015)	(0.034)	(0.029)	(0.015)	(0.050)	(0.024)	(0.016)
N	272	510	782	272	510	782	272	510	782
$Adj.R^2$	0.381	0.630	0.767	0.470	0.612	0.767	0.433	0.683	0.758

Items

	2001 - 2003			2003 - 2006			2006 - 2009		
	EU8	EU15	EU23	EU8	EU15	EU23	EU8	EU15	EU23
$\hat{\pi}$				0.51***	0.74***	0.73***	0.57***	0.87***	0.76***
				(0.022)	(0.015)	(0.010)	(0.025)	(0.020)	(0.013)
N				993	1824	2817	993	1824	2817
$Adj.R^2$				0.342	0.566	0.661	0.344	0.498	0.564

Standard deviations in brackets. *** significantly different from 1 on the 1% level.
Country groups set to $\bar{p}_{EUX} = 0$

Table 1: β-convergence results for pooled data

Table 1 shows the results of the OLS-regressions. Both for the product groups and the individual items all estimated $\hat{\pi}$ are significantly smaller than 1. Thus there is mean reversion in every subgroup of countries and every time-period[7]. Within EU15, for the product groups the estimated $\hat{\pi}$ stays roughly constant over time (0.79, 0.82 and 0.81) and rises slightly for the items from 0.74 to 0.87. Within EU23, the product groups' $\hat{\pi}$ is quite large (0.93) in the pre-accession period, meaning that mean reversion is weak, and then drops roughly to the EU15 level of 0.76 (0.78)

[6] We choose the limit to be set at 50%, but choosing anything between 25% and 80% does not change the results.

[7] Only when running the regressions for the PLI-Food the estimates are not always significantly different from 1. This is due to the small number of observations. The results can be found in appendix D.

in the period until 2006 (2009). On the items level, results are roughly the same as for the product groups (0.73 – 0.76). Mean reversion for product groups within EU8 is already quite strong in the period from 2001 to 2003 (0.62), but with 0.54 it is strongest (i.e. $\hat{\pi}$ is smallest) from 2003 to 2006, only to rise in the following period to a level of 0.72, slightly below EU15's and EU23's level. On the items level both periods show strong mean reversion with a parameter $\hat{\pi}$ of 0.51 and 0.57. In a nutshell, only within EU8 and EU23 mean reversion gets stronger in the period after the Eastern EU enlargement. However as discussed above, β-convergence is only a necessary but not a sufficient condition for price convergence. The next section therefore considers σ-convergence.

6 σ-convergence

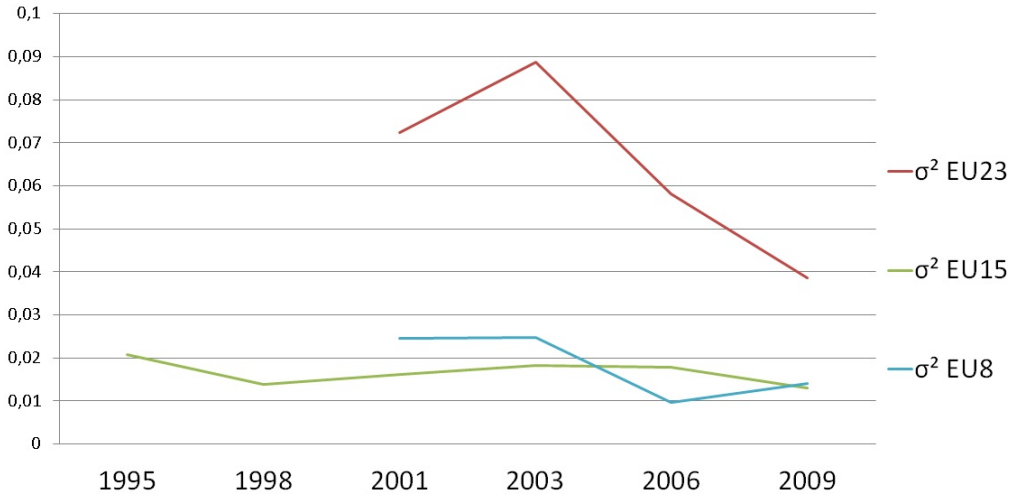

Figure 2: Variance of the PLI-food within selected countrygroups

To get a first impression of price dispersion within the EU, figure 2 shows the development of the PLI food's variance over time. As expected, the variance[8] is lower within EU15 than within EU23, which means food price indices are more homogeneous in the old member states. Within EU15 the variance of the food price indices initially falls from 1995 to 1998 (the period just after the accession of three new members), but stays roughly constant over the following years ($\sigma^2_{98} \approx \sigma^2_{09}$). Price convergence seems to have reached a limit within EU15. In contrast, if we look at EU 23, in the pre-accession period the variance of the PLI-food rose[9], but in the periods from 2003 to 2009 it fell sharply. In the subgroup EU8, price indices converged towards each other after these countries joined the EU and somewhat

[8]Normally to compare the dispersion of different samples the coefficient of variation (CV) is used. Unlike the variance, the CV is normalized with the mean of the sample. However, using log-values has the same normalizing effect on the variance. The variance of log-values, is approximately the CV of non log values.

[9]Aggregate data for the new member states is only available from 2001 to 2009

diverged in the following period. The comparison of the three countrygroups give a first hint that the dynamics within EU23 are actually due to the two sub-groups moving towards each other and not by convergence within the two subgroups.

6.1 σ-convergence at a semi-aggregate level - product groups

For a more detailed analysis, this subsection looks at the product groups level. Table 2 gives the exact changes of the variance and the results of the Wald-test[10] for the pooled product groups.

		$\Delta\hat{\sigma}^2 = \hat{\sigma}_t^2 - \hat{\sigma}_{t-1}^2$						
	N	**95-98**	**98-01**	**01-03**	**03-06**	**06-09**	**95-09**	**03-09**
EU23	782			0.0115***	-0.0250***	-0.0163***		-0.0413***
				(132.35)	(604.04)	(537.50)		(1301.21)
EU15	510	-0.0092***	0.0028***	-0.0004	0.0042***	-0.0018***	-0.0045***	0.0024***
		(333.02)	(41.07)	(0.70)	(86.88)	(15.59)	(42.46)	(24.32)
EU8	272			0.0007	-0.0144***	0.0046***		-0.0098***
				(1.59)	(753.11)	(166.78)		(227.76)

Test statistics in brackets, *** significant at 1% level

Table 2: σ-convergence results for product groups

Within EU15 we only find significant σ-convergence in the period from 1995 to 1998 (the period right after Finland, Sweden and Austria joined the EU) and in 2006 - 2009 (roughly returning to the 1998 level). In the other periods, the food price indices diverge or results are not significant. Again, this indicates that since 1998, in the EU15 prices do not converge any more. The price indices for some product groups diverge and for others they converge, but the overall price dispersion stays roughly the same. If we look at EU 23 in the period before the EU enlargement, the product groups' price indices significantly diverge, but they converge strongly in the periods after the accession. In our last subgroup (EU8), price dispersion fell after these countries joined the EU and slightly rose again in the following period. Looking at the longer period from 2003 to 2009 we find that price indices converged within EU23 and EU8, but diverged within EU15. Within the EU15, we find significant convergence only when including the time right after the accession of Finland, Sweden and Austria (1995 to 2009). The results for the product groups show that the strong convergence within EU23 must be caused by EU15 and EU8 moving towards each other and not mainly by convergence within these two subgroups. To further investigate this point, we look at the variance decomposition (Equation 1 on page 7). Table 3 gives a summary of the results.

In the period before the accession (01-03) convergence within EU8 and EU15 is not significant. Price divergence within EU23 could be explained by EU15 and EU8 moving away from each other, but the value of $\bar{p}_{EU8}$ is not statistically significant[11]. In the period directly after the EU enlargement shock, the convergence of the two

[10] For this one-sided test the critical value of the $\chi^2(1)$ test statistic at the 1% significance level is 6.63. All coefficients are either significant at the 1%-level or not significant.

[11] Confidence Intervalls for $\bar{p}_{EU8}$ can be found in appendix C.

		$\Delta\sigma^2 = \hat{\sigma}_t^2 - \hat{\sigma}_{t-1}^2$			
	N	**01-03**	**03-06**	**06-09**	**03-09**
$\Delta\hat{\sigma}^2_{EU23}$	782	0.0115***	-0.0250***	-0.0163***	-0.0413***
$\frac{15}{23}\Delta\hat{\sigma}^2_{EU15}$	510	-0.0003	0.0027***	-0.0012***	0.0016***
$\frac{8}{23}\Delta\hat{\sigma}^2_{EU8}$	272	0.0005	-0.0094***	0.0030***	-0.0064***
$\frac{8}{15}\Delta(\bar{p}_{EU8})^2$	272	0.0113	-0.0183***	-0.0181***	-0.0365***

*** significant at 1%-level

Table 3: σ-convergence decomposition, product groups

groups towards each other makes up for roughly two thirds of the total convergence and is statistically significant. In the last period considered (2006-2009), there would not be any convergence in EU23 without the old and new member states moving towards each other. This effect is even higher than the overall convergence within EU23, as it has to offset divergence within EU8. Hence the driving force behind the strong convergence within EU23 after the EU enlargement in 2004 is that the old and the new member states' price indices are moving towards each other.

Finding price convergence on a pooled level does not imply though that price indices of every product group do converge. Figure 3 shows the change of the variance between 2003 and 2009 for every product group, where dark bars denote significant changes. For comparison, in the first column the change of the variance of the pooled product groups is given. Since the variance of natural-log price-indices is approximately the coefficient of variation of normal price indices, the magnitude of the changes can actually be compared.
Figure 3 confirms the results of the pooled test. Since the enlargement in 2004, most price-indices within the EU23 have converged significantly, with the product groups "bread" and "beef and veal" having the highest convergence rate (-16% and -14% respectively). While within EU8 still more product groups converge than diverge, the opposite is the case within EU15. More product groups diverge than converge, with "edible ice, ice-cream and sorbet" diverging the most. Interestingly, this product group converges significantly within EU23 and insignificantly within EU8. To look at the disaggregate level in more detail, the next chapter deals with the items level.

6.2 σ-convergence at a disaggregate level - products

In the last subsection it has become clear that overall price convergence within the EU23 is quite strong. It is mainly driven by EU15 and EU8 converging towards each other. Since there is already heterogeneity in the convergence of the individual semi-aggregate product groups, it is worth to look into price convergence at the most disaggregate level, the individual products. As mentioned above, we drop products whose prices are not reported in every time period and product groups for which

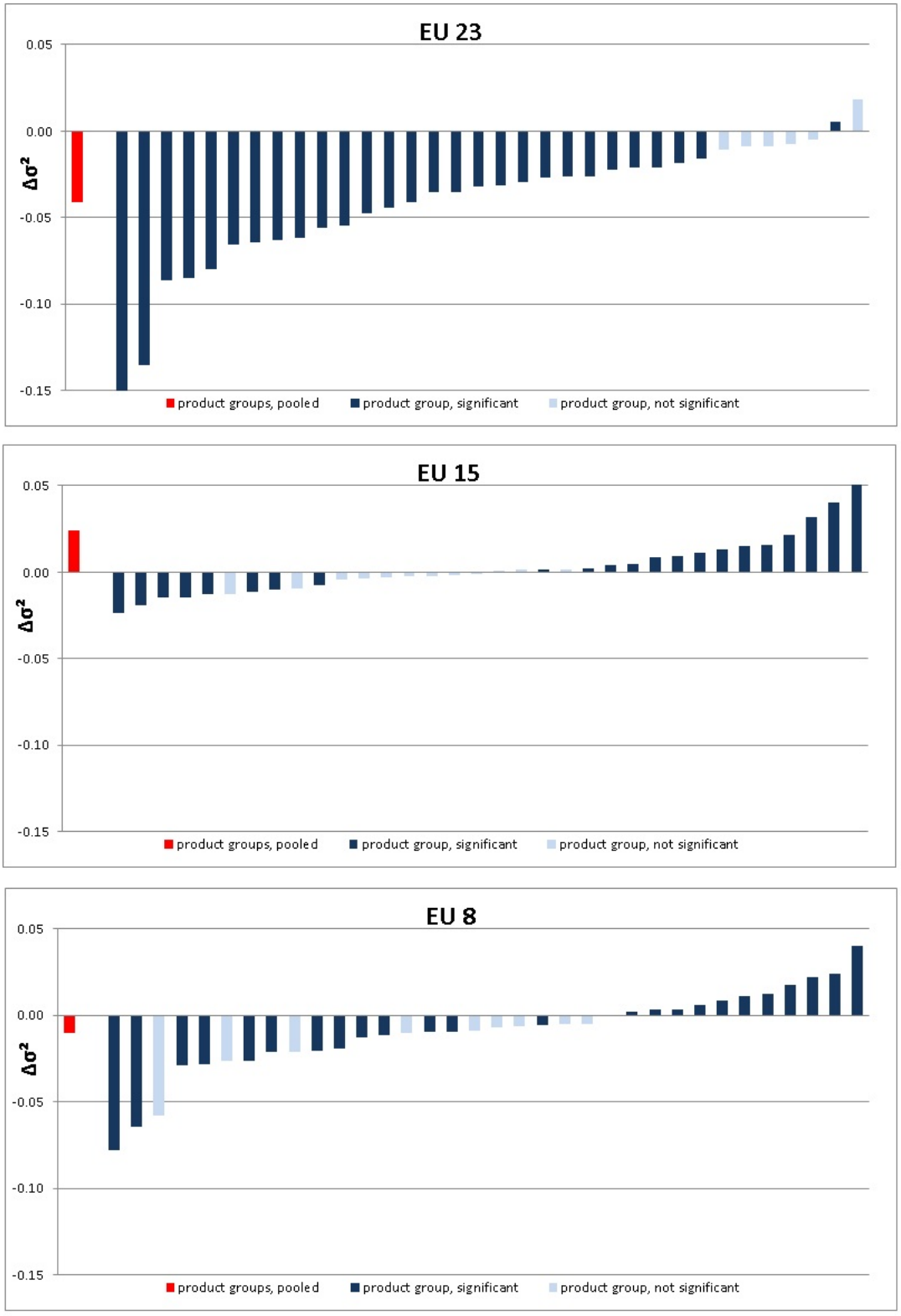

Figure 3: σ-convergence ($\Delta\sigma^2$) by product groups, 2003 - 2009

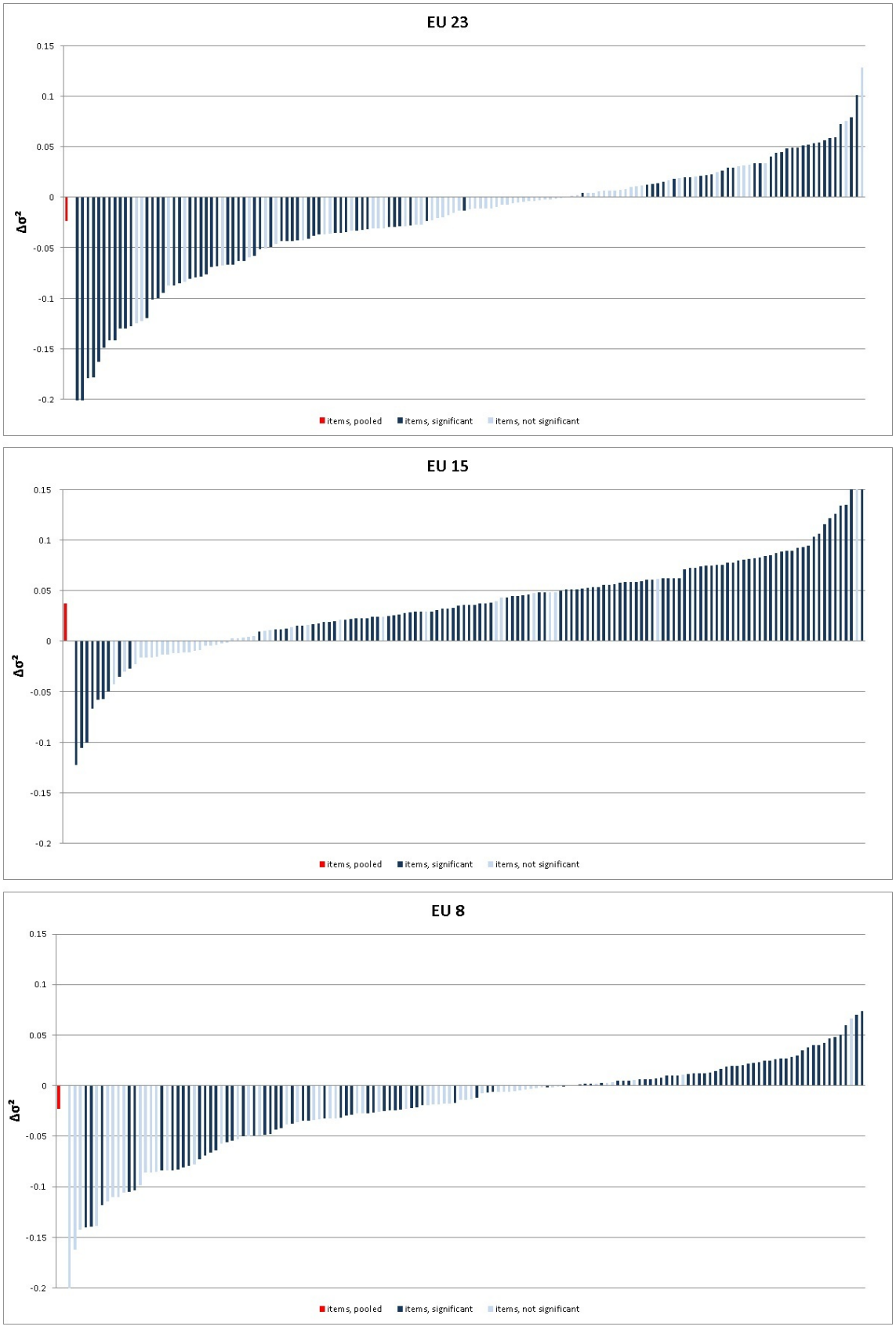

Figure 4: σ-convergence ($\Delta\sigma^2$) by items, 2003 - 2009

there are less than 50% of observations available within EU8 or EU15. This ensures that for every product we indeed measure convergence towards EU8/15/23 averages and not yet another subgroup of these. As noted above, prices at the level of individual items could only be provided by Eurostat for the dates 2003, 2006 and 2009.

The σ-convergence results are shown in table 4. The results for the single item prices are somewhat different from the product groups level, but the overall picture is robust. Within the old member states EU15, prices converged significantly from 2003 to 2006 (diverging at product groups level) and diverged significantly from 2006 to 2009 (converging at product groups level). Nevertheless the result is the same for the long period from 2003 to 2009. Pooled item prices as well as pooled product group indices diverged within EU15 in that period. Within EU23 there is significant divergence in the second sub-period 2006-2009, which is not the case at the product group level, and which can be explained by the divergence within EU15. However, convergence remains strongly significant in the first and in the long period in EU23. Finally looking at prices within EU8, we find that prices converge in all three periods considered, while price divergence was found for the second subperiod 2006 - 2009 for product groups. But also for the EU8, the results coincide for the whole period 2003 - 2009 since EU enlargement.

The differences between the results for pooled product groups and pooled indivudual products may have several reasons. First the EU15 are already quite integrated and overall food price dispersion is roughly constant over time. Some products still converge but others diverge, making results depended on the exact choice of products analysed. Second, due to our restrictions on the data we loose some products' observations, which are used to compute the product groups' indices. Furthermore looking at price indices and looking at product prices are two different approaches. It is not clear which one is the more relevant. Nevertheless the strong convergence within EU23 in the longer period after the EU accession (2003-2009) is robust and can be found at both the single item and the product group level.

			$\Delta\sigma^2$		
	k	N	**03-06**	**06-09**	**03-09**
EU23	147	2817	-0.0282***	0.0043***	-0.0239***
			(585.50)	(16.04)	(273.55)
EU15	147	1824	-0.0025***	0.0393***	0.0369***
			(12.00)	(1949.50)	(1426.90)
EU8	147	993	-0.0189***	-0.0038***	-0.0227***
			(386.40)	(28.55)	(553.16)

Test statistics in brackets, *** significant at 1% level

Table 4: σ-convergence at the items level, 50% cutoff

If we look at the decomposition of the EU23 variance, we find that in both the subperiods and the long period prices in EU8 and EU15 are strongly moving towards

each other[12]. This effect overcompensates the divergence within EU15 in the long period 2003 - 2009. It is also strong in the period 2006 - 2009, in which prices within EU23 diverge, as price divergence within EU15 dominates. Hence again it becomes obvious that the main driving force of price convergence within EU23 is convergence between the two subgroups, and not convergence within the two subgroups EU15 and EU8.

			$\Delta\sigma^2$		
	k	N	**03-06**	**06-09**	**03-09**
$\Delta\hat{\sigma}^2_{EU23}$	147	2817	-0.0282***	0.0043***	-0.0239***
$\frac{15}{23}\Delta\hat{\sigma}^2_{EU15}$	147	1824	-0.0016***	0.0256***	0.0240***
$\frac{8}{23}\Delta\hat{\sigma}^2_{EU8}$	147	993	-0.0123***	-0.0025***	-0.0148***
$\frac{8}{15}\Delta(\bar{p}_{EU8})^2$	147	993	-0.0143***	-0.0188***	-0.0331***

Test statistics in brackets, *** significant at 1% level

Table 5: σ-convergence at the items level - decomposition, 50% cutoff

In a last step we look at the price dispersion of individual products. Figure 4 shows the change of the variance for each product between 2003 and 2009. Again dark bars denote statistically significant changes of the variance, and the first column gives the respective change of the variance of the pooled products as a comparison. As mentioned above, the magnitude of the changes can be compared. At large, more products' prices within EU8 and EU23 converge significantly than diverge in the period after the Eastern enlargement of the European Union. This result is in line with the findings of our product groups analysis. Nevertheless, there are also many products that diverge significantly in this period. The fact that more changes are insignificant for EU8 is partly due to the fewer number of observations per product. In contrast, there are hardly any products for which prices converged within EU15. Here 113 of the 147 products diverged and only 14 converged significantly.

7 Conclusion

Using a unique data set on retail food prices from the EUROSTAT-OECD PPP Programme, we analyse price convergence within the European Union, with a particular focus on the period since the EU enlargement in 2004. We are able to look into price convergence of all 15 old memberstates EU15 as well as the 8 new Eastern European ones EU8 . Employing a test introduced by Egger & Pfaffermayr (2009), we find that in the lead-up to accession (2001-2003), food prices diverged within the group of these 23 countries. In contrast, price convergence within the European Union as a whole is significant after 2003, indicating that the enlargement had a vital effect on food price dispersion.

In line with the results of previous studies, we find no price convergence within EU15. In the old member states, price convergence has reached a limit after 1998, and food

[12]See footnote 11.

prices even have started to diverge again. In contrast, prices converged within the subgroup of new member states EU8 after the accession in 2004. However, this effect is not sufficient to explain the magnitude of price convergence within EU23. When decomposing EU23's variance of food prices, we find that the driving force behind price convergence in the European Union is convergence between the two groups of countries EU8 and EU15, with average prices for food products of these two groups moving towards each other.

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A Data

	EU15	**EU23**
PLI Food	1995-2009	2001-2009
product groups	1995-2009	2001-2009
items	2003-2009	2003-2009

Table 6: Data availability

PLI food	34 product groups		378 items	
	1	Rice	1	Long-grain rice, parboiled, SB A
			2	Long-grain rice, parboiled, WKB
			3	Long-grain rice, parboiled, in cooking bags, WKB
			4	Long-grain rice, not parboiled, BL
			5	Round-grain rice, WKB
			6	Basmati rice, WKB
	2	Other cereals, flour and other cereal products	7	Wheat flour, WKB
			8	Wheat flour, BL
			9	Wheat semolina, WKB
			10	Wheat "couscous" / WKB
			11	Cornflakes, SB B
			12	Cornflakes, BL
			13	Breakfast cereal, SB C
			14	Breakfast cereal, SB D
			15	Flaked oats for cooking, WKB
			16	Muesli, crunchy, WKB
	3	Bread	17	Baguette
			18	Roll
			19	Roll, multicorn
			20	Pre-baked baguettes/rolls, WKB
			21	Bread, white, small loaf
			22	Bread, white, large loaf
			23	Bread, white, small pack, WKB
			24	Bread, white, large pack, WKB
			25	Bread, grey
			26	Bread, whole meal, wheat
			27	Bread, mixed
			28	Bread, rye
			29	Bread, whole meal, wheat, WKB
			30	Bread, multicorn
			31	Bread, whole meal, rye, WKB
			32	Bread, rye, WKB
			33	Breadcrumbs, WKB
	4	Other bakery products	34	. . .
			35	. . .
	5	Pasta products		
	6	Beef and Veal		
	7	Pork		
	8	Lamb, mutton and goat		
	9	Poultry		
	10	Other meats and edible offal		
	11	Delicatessen & other meat		
	12	Fish and seafood		
	13	Preserved fish and seafood		
	14	Fresh milk		
	15	Preserved milk and other milk products		
	16	Cheese		
	17	Eggs and egg-based products		
	18	Butter		
	19	Margarine		
	20	Other edible oils and fats		
	21	Fresh or chilled fruit		
	22	Frozen, preserved or processed fruit and fruit-based products		
	23	Fresh or chilled vegetables		
	24	Fresh or chilled potatoes		
	25	Frozen, preserved or processed vegetables and vegetable-based products		
	26	Sugar		
	27	Jams, marmalades and honey		
	28	Confectionery, chocolate and other cocoa preparations		
	29	Edible ice, ice cream and sorbet		
	30	Food products n.e.c.		
	31	Coffee, tea and cocoa		
	32	Mineral waters		
	33	Soft drinks and concentrates		
	34	Fruit and vegetable juices		

SB = Specified Brand, WKB = Well known brand, BL = Budget label

Table 7: Data structure

B Double relative prices

It is conceivable that price differences mainly reflect country-product-group-specific effects, which are briefly discussed in section 3. To analyse whether this is the case, we compare relative prices between single items of the same product group, leading to "double relative prices (DRP)" (Haskel & Wolf, 2001):

$$DRP_{kl}^{ij} = \frac{R_{kl}^{i}}{R_{kl}^{j}} = \frac{P_k^i / P_l^i}{P_k^j / P_l^j}$$

Here the relative price R_{kl}^{i} (R_{kl}^{j}) is defined as the relative price of two goods k and l within the same product group in country i (j) (e.g. skimmed and unskimmed milk within the product group "fresh milk" in country i). The two item prices P_k^i and P_l^i both include the same country-sector specific effects (e.g. labour costs, taxes), which cancel out in the relative price. For an easier interpretation we always divide the larger relative price by the smaller one, thus creating percentage deviations (with $DRP_{kl}^{ij} = 1$ representing equal relative prices). Figure 5 shows, the deviation of the median and the 90%-percentile DRP within selected product groups. Looking at all product groups, on average, still half of the double relative prices within each product group differ by more than 24% (p90=1,73). Hence there is substantial variation in relative food prices that is not explained by country-sector specific effects.

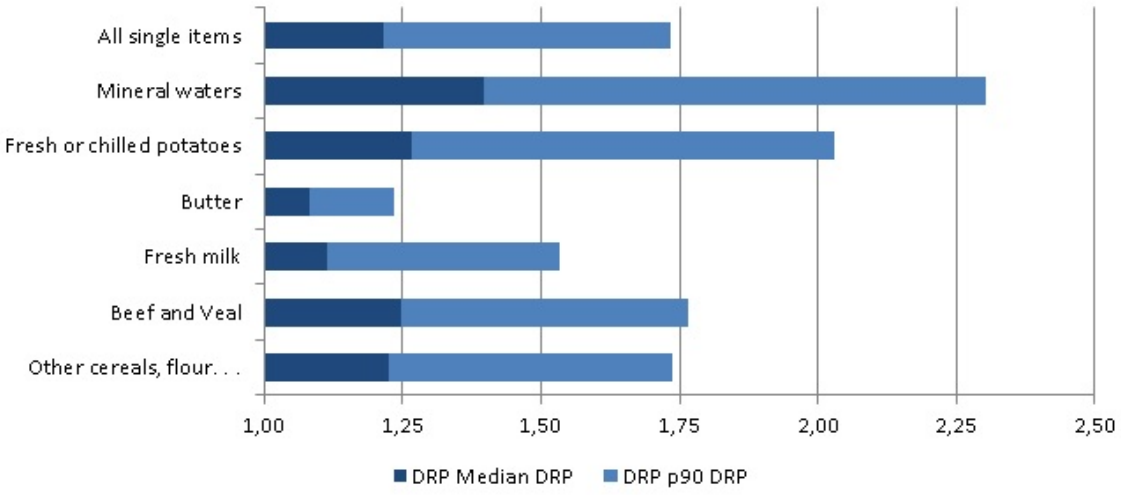

Figure 5: Double relative prices within product groups, EU15, 2009

C Convergence decomposition

C.1 Deduction

Price indices are in natural logs. There are $m+n$ countries in two subgroups of size m and n, and prices are normalized to $\bar{p}_{m+n} = 0$.

$$\underbrace{p_1, ..., p_m}_{m}, \underbrace{p_{m+1}, ..., p_{m+n}}_{n}$$

$$\bar{p}_{m+n} = \frac{1}{m+n}\sum_{i=1}^{m+n} p_i = 0 \quad ; \quad \bar{p}_m = \frac{1}{m}\sum_{i=1}^{m} p_i \quad ; \quad \bar{p}_n = \frac{1}{n}\sum_{i=m+1}^{m+n} p_i$$

We use the standard textbook equation of the variance:

$$\begin{aligned}
\sigma^2 &= E(X^2) - (E(X))^2 \\
\sigma^2_{m+n} &= \frac{1}{m+n}\sum_{i=1}^{m+n} p_i^2 - \underbrace{(\bar{p}_{m+n})^2}_{=0} \\
&= \frac{1}{m+n}\sum_{i=1}^{m+n} p_i^2 \\
\sigma^2_m &= \frac{1}{m}\sum_{i=1}^{m} p_i^2 - (\bar{p}_m)^2 \\
\sigma^2_n &= \frac{1}{n}\sum_{i=m+1}^{m+n} p_i^2 - (\bar{p}_n)^2 \\
m\cdot\sigma^2_m + n\cdot\sigma^2_n &= \sum_{i=1}^{m+n} p_i^2 - m\cdot(\bar{p}_m)^2 - n\cdot(\bar{p}_n)^2 \\
&= (m+n)\cdot\sigma_{m+n} - m\cdot(\bar{p}_m)^2 - n\cdot(\bar{p}_n)^2
\end{aligned}$$

Hence:

$$\boldsymbol{\sigma^2_{m+n} = \frac{m}{m+n}\cdot\sigma^2_m + \frac{n}{m+n}\cdot\sigma^2_n + \frac{m}{m+n}\cdot(\bar{p}_m)^2 + \frac{n}{m+n}\cdot(\bar{p}_n)^2}$$

The variance of the whole sample consists of the subgroups' weighted variances and their weighted quadratic means.

As $m\cdot\bar{p}_m + n\cdot\bar{p}_n = 0$, and hence either both means are moving towards zero or both are moving away from it, we can further simplify using $\bar{p}_m = -\frac{n}{m}\cdot\bar{p}_n$:

$$\frac{m}{m+n}\cdot(\bar{p}_m)^2 + \frac{n}{m+n}\cdot(\bar{p}_n)^2 = \frac{m}{m+n}\cdot(-\frac{n}{m}\cdot\bar{p}_n)^2 + \frac{n}{m+n}\cdot(\bar{p}_n)^2$$

$$
\begin{aligned}
&= (\frac{m}{m+n} \cdot \frac{n^2}{m^2} + \frac{m}{m+n})(\bar{p}_n)^2 \\
&= \frac{mn^2 + m^2 n}{(m+n)m^2}(\bar{p}_n)^2 \\
&= \frac{(m+n)mn}{(m+n)m^2}(\bar{p}_n)^2 \\
&= \frac{n}{m}(\bar{p}_n)^2
\end{aligned}
$$

Thus:

$$\sigma^2_{m+n} = \frac{m}{m+n}\sigma^2_m + \frac{n}{m+n}\sigma^2_n + \frac{n}{m}(\bar{p}_n)^2,$$

or equivalently

$$\sigma^2_{m+n} = \frac{m}{m+n}\sigma^2_m + \frac{n}{m+n}\sigma^2_n + \frac{m}{n}(\bar{p}_m)^2.$$

In the EU-23 case:

$$\sigma^2_{EU23} = \frac{15}{23}\sigma^2_{15} + \frac{8}{23}\sigma^2_8 + \frac{8}{15}(\bar{P}_{EU8})^2$$

In changes:

$$\Delta\sigma^2_{EU23} = \frac{15}{23}\Delta\sigma^2_{15} + \frac{8}{23}\Delta\sigma^2_8 + \frac{8}{15}\Delta(\bar{P}_{EU8})^2$$

C.2 Estimated Confidence Intervalls

$\bar{p}_{EU8}$	N	Mean	Std. Err	[90% C.I.]		[95% C.I.]		[99% C.I.]	
products 2003	993	-0.3105	0.0106	-0.328	-0.293	-0.331	-0.290	-0.338	-0.283
products 2006	993	-0.2441	0.0097	-0.260	-0.228	-0.263	-0.225	-0.269	-0.219
products 2009	993	-0.1727	0.0091	-0.188	-0.158	-0.191	-0.155	-0.196	-0.149
product groups 2001	272	-0.3377	0.0145	-0.362	-0.314	-0.366	-0.309	-0.375	-0.300
product groups 2003	272	-0.3803	0.0143	-0.404	-0.357	-0.409	-0.352	-0.417	-0.343
product groups 2006	272	-0.2870	0.0131	-0.309	-0.265	-0.313	-0.261	-0.321	-0.253
product groups 2009	272	-0.2157	0.0131	-0.237	-0.194	-0.241	-0.190	-0.250	-0.182
PLI-food 2001	8	-0.3449	0.0553	-0.450	-0.240	-0.476	-0.214	-0.538	-0.151
PLI-food 2003	8	-0.3929	0.0555	-0.498	-0.288	-0.524	-0.262	-0.587	-0.199
PLI-food 2006	8	-0.3071	0.0348	-0.373	-0.241	-0.389	-0.225	-0.429	-0.185
PLI-food 2009	8	-0.2329	0.0418	-0.312	-0.154	-0.332	-0.134	-0.379	-0.087

Table 8: Confidence intervalls of $\bar{p}_{EU8}$

D PLI level

PLI Food

	2001 - 2003			2003 - 2006			2006 - 2009		
	EU8	EU15	EU23	EU8	EU15	EU23	EU8	EU15	EU23
$\hat{\pi}$	0.85	1.01	1.08	0.61	0.87	0.79	0.91	0.71	0.76
	(0.221)	(0.098)	(0.052)	(0.060)	(0.133)	(0.041)	(0.321)	(0.131)	(0.061)
N	8	15	23	8	15	23	8	15	23
$Adj.R^2$	0.662	0.881	0.951	0.945	0.766	0.943	0.500	0.672	0.877

Standard deviations in brackets. Country groups set to EU X = 1

Table 9: β-convergence results for the PLI

PLI Food

		$\Delta\hat{\sigma}^2 = \hat{\sigma}_t^2 - \hat{\sigma}_{t-1}^2$						
	N	**95-98**	**98-01**	**01-03**	**03-06**	**06-09**	**95-09**	**03-09**
EU23	23			0,0158***	-0,0293***	-0,0188***		-0,0481***
				(64,21)	(179,90)	(117,75)		(367,88)
EU15	15	-0,0064***	0,0020***	0,0021***	-0,0003	-0,0045***	-0,0072***	-0,0049***
		(88,54)	(46,02)	(35,32)	(0,16)	(40,67)	(40,58)	(39,82)
EU8	8			0,0002	-0,0131***	0,0038***		-0,0093***
				(1,81)	(798,89)	(82,83)		(41,14)

Test statistics in brackets, *** significant at 1% level

Table 10: σ-convergence results, PLI-Food

		$\Delta\sigma^2$			
	N	**01-03**	**03-06**	**06-09**	**03-09**
$\Delta\hat{\sigma}^2_{EU23}$	23	0.0158***	-0.0293***	-0.0188***	-0.0481***
$\frac{15}{23}\Delta\hat{\sigma}^2_{EU15}$	15	0.0013***	-0.0002	-0.0029***	-0.0032***
$\frac{8}{23}\Delta\hat{\sigma}^2_{EU8}$	8	0.0001	-0.0085***	0.0025***	-0.0061***
$\frac{8}{15}(\bar{p}_8)^2$	8	0.0144	-0.0206	-0.0183	-0.0389

*** significant at 1%-level

Table 11: σ-convergence decomposition, PLI-Food