Price Convergence after the Eastern Enlargement of the EU: Evidence from Retail Food Prices

October 8, 2014

Andreas Lindenblatt*, Switgard Feuerstein†

Abstract

Using detailed micro data on European retail food prices for EU15 and all eight Central and Eastern European accession countries, we analyse price convergence within the European Union after the enlargement shock in 2004. Testing for σ-convergence, we find strong price convergence within EU23, which is mainly explained by convergence between and not within the two subgroups of the old and the new member states.

Keywords:
Price convergence · Sigma convergence · International price dispersion · Law of one price · European Union · EU enlargement · Central and Eastern European Countries

JEL Classification:
F0 · F15 · E31 · L81

Acknowledgements:
We are grateful to Paul Konijn of Eurostat for providing us with the data for our research. Moreover, we thank Peter Egger, Michael Pfaffermayr as well as participants and discussants of the ETSG in Copenhagen, the Annual Meeting of the Committee for International Economics of the 'Verein für Socialpolitik' in Kiel, the 11th annual GEP postgraduate conference in Nottingham and EARIE in Rome for helpful comments.
Switgard Feuerstein gratefully acknowledges financial support from the Marie Curie Programme of the European Union (Project No. 25679) for the research visit at GEP, University of Nottingham.

*Department of Economics, University of Heidelberg, Bergheimerstr. 58, D-69115 Heidelberg, Germany, Phone: +49-6221-542909, Fax: +49-6221-543176, E-Mail: Andreas.Lindenblatt@awi.uni-heidelberg.de (Corresponding Author)

†Department of Economics, University of Heidelberg, Bergheimerstr. 58, D-69115 Heidelberg, Germany, Phone: +49-6221-543170, Fax: +49-6221-543176, E-Mail: Switgard.Feuerstein@awi.uni-heidelberg.de and GEP, University of Nottingham

1 Introduction

This paper studies the effect of the EU enlargement in 2004 on food price convergence. Using comprehensive Eurostat data[1], it is the first study looking at price convergence of retail prices at a disaggregate level, both for the old member states (EU15) and the eight new Central and Eastern European member states (EU8). 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.

Within the single market of the European Union, large price differences for identical products are well documented, which can only partly be explained by cost differences or by differing overall price levels. In general, it was expected that these price differences decrease over time, as ongoing market integration amounts to convergence of prices. There are, however, also reasons why price differences may persist and need not disappear. Especially in the retail sector, price differences for individual products are feasible even in competitive markets. If retailing gives a value-adding service to consumers, arbitrage will not take place. After some adjustment, a constant level of price dispersion may be reached. Price convergence will only be observed if this steady state is not yet reached or if there is a new steady state due to an external shock. It is hence an empirical question, to what extent prices converge after an external shock like the Eastern enlargement of the EU in 2004. The results are of political relevance, as Dreger et al. (2008) point out that, "price convergence facilitates the working of common economic policies". 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 in 2004.

Until the 1990s, price convergence was thought of as *β-convergence* (mean reversion), which is found in virtually all studies on European prices. However, 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, while the variance of prices increases due to ongoing random shocks on prices. Hence, it is necessary to examine *σ-convergence*, which is defined as a decrease of the variance over time (Barro & Sala i Martin, 1995; Carree & Klomp, 1997). This point is further discussed in section 4. Applying a test for σ-convergence by Egger & Pfaffermayr (2009), we find *price divergence* within the European Union as a whole in the lead-up to accession, but *price convergence* thereafter. Furthermore, we decompose the variance of prices and conclude that price convergence within the EU as a whole is partly driven by the dynamics within EU8, but the main effect is convergence between EU8's and EU15's prices.

The paper is organized as follows. Section 2 gives a short overview of the literature.

[1] We thank Paul Konijn of Eurostat for providing us with the data.

In sections 3 and 4, we present the data and the method used. Section 5 looks at σ-convergence as well as its decomposition and section 6 concludes.

2 Retailing, the EU and price convergence

According to the law of one price (LOOP), on a perfectly integrated market a good will only have one price. When the European Single Market was introduced in 1992, it was therefore widely expected that prices would converge within the European Union and that price differences between member countries would merely reflect remaining cost differences, such as transport costs or differing value added taxes (Cecchini et al., 1988). Similar expectations emerged when the European Monetary Union (EMU) started (European Commission, 1990).

There are, however, also reasons why price differences are observed and may persist over time. Retail prices do not only include production costs or import prices, but also retailing costs, which to a large extent reflect labour costs, and profit margins. 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 even when all trade barriers have been removed.

Price levels are in general lower in countries with a low per capita income. The accession of the Central and Eastern European transition countries, which have low price levels, has increased price dispersion within the EU. Dreger et al. (2008) emphasize two countervailing effects on the price indices of these countries. The integration into the internal market will increase competition and thereby lower prices, while the process of catching up increases prices due to the Balassa-Samuelson effect, i.e. due to rising wages. When the second effect dominates, rising labour costs lead to rising prices. Price differences within the EU become smaller and thus price convergence is observed.

However, price patterns are much more complex than just some countries having high prices and other countries having low prices. Relative prices of pairs of goods also vary a lot among the member states of the EU, with individual products being relatively expensive in some countries and relatively cheep in others (see section 3). Such price differences may reflect different mark-ups for the same product in different countries, thus they might emerge from price setting behaviour in the retail sector. 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. Consequently, retail prices for individual products will vary within a group of countries as long as demand patterns – and therefore elasticities of demand – differ, even in competitive

markets. Such differences in product-specific profit margins can explain long-run price differences for individual products. MacDonald & Ricci (2005) discuss the effect of the distribution sector in the context of PPP, albeit at a highly aggregate level.

There are thus forces reducing price differences in integrated markets, but also reasons for long-run price differences. These countervailing effects eventually balance, and a constant level of price dispersion will be reached. Price convergence is observed when this state is not reached yet, or when an external shock has changed the steady state. It is thus an empirical question whether in a given situation prices converge.

Empirical studies show that the law of one price does not hold within the European Union. Large price differences for identical products are observed, which cannot be explained by cost differences (see e.g. Cumby (1996) for Big Mac Hamburgers, Haskel & Wolf (2001) for prices of IKEA, a furniture retailer, and Goldberg & Verboven (2004) for cars). In view of these price differences, several studies looked at σ-convergence of retail prices within the European Union. Egger et al. (2009) find some significant σ-convergence for tradeable but not for non-tradeable goods for EU12 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 within the countries of the European Monetary Union (EMU). For the same time period (1995 - 2005), Fischer (2012) finds large variation of the prices of washing machines and even price divergence within EU15. Moreover, EMU seems to have had no effect on price convergence. Only two studies have data available for all new member states of the European Union, both using data until 2005. While Funke & Koske (2008) only look at mean reversion and not at σ-convergence, Dreger et al. (2008) find small (initial) effects of the EU enlargement on convergence.

On the whole, there is hardly any evidence for price convergence within the EU. Our paper expands the existing literature in several dimensions. By covering the EU15 and *all* Central and Eastern European countries, which acceded the EU in 2004, as well as extending the period considered until 2009, it accounts for the full magnitude of the enlargement shock. It includes not only initial, but also medium-term effects on prices. Moreover, the analysis uses disaggregate data. We can thus study comprehensively, whether or not after the external shock of Eastern enlargement, retail food price convergence has taken place within the new EU. Moreover, we decompose convergence into within and between subgroups convergence.

3 The data

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 (e.g. "fresh milk, unskimmed, 1 liter, well known brand"). For every product, employees of the respective national statistical bureau collect prices at 15-20 different outlets ignoring short term price reductions such as promotional offers.[2] Prices are then adjusted for spatial and seasonal effects (e.g. for fruit, fish, etc.) and weighted such that for the given product the average price reflects the national shopping pattern (with regard to the different types of outlets). As prices are reported in their national currencies, they are converted into euro with the official Eurostat exchange rate for the given year. The data is available for the three waves 2003, 2006 and 2009 and shows that there are large price differences for identical products within the EU, and also within EU15 (Eurostat, 2010). Unfortunately, not all products can be traced over time, as the set of products has somewhat changed. Moreover, countries only collect prices that they consider relevant, meaning that not all countries report all prices, which results in missing data. Matching the products of these three waves, we have compiled a data set of 147 products. For a more detailed description of the data see European Commission (2006).

Eurostat also provides the data at a semi-aggregate level of 34 product group price indices (also called "basic headings", e.g. fresh milk, pasta), and there are good reasons to analyse data at this level as well. In contrast to the individual products, there are observations for all countries for every product group and problems of missing data do not occur. Moreover, the price indices are available for a longer time period (1995-2009 for EU15 and 2001-2009 for EU25), allowing us to consider price dispersion also in the period before accession. Hence, in section 5 the analysis of price convergence is conducted both at the level of individual products and at the level of the product groups.[3]

In the following analysis, we distinguish between three groups of countries. (i) 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.[4] Since Bulgaria and Romania only joined in 2007 and data is not available before 2006, these two countries are left out. Moreover, we omit Malta and Cyprus. Their situation as small island states is hardly comparable to the EU8.

Starting at the highest level of aggregation – the consumer price index food and non-alcoholic beverages (CPI-food) – large price index differences within EU23 are

[2] For specified brands, the price is collected in 5-10 outlets.

[3] Other papers on price convergence, which are based on data from the Eurostat OECD PPP program, look at the product group level (e.g. Egger et al., 2009) or an even more aggregate level (e.g. Dreger et al., 2008). They do not use individual product prices.

[4] One other group that comes directly to mind are the EMU countries. We do not report results for this subgroup as these do not differ from EU15.

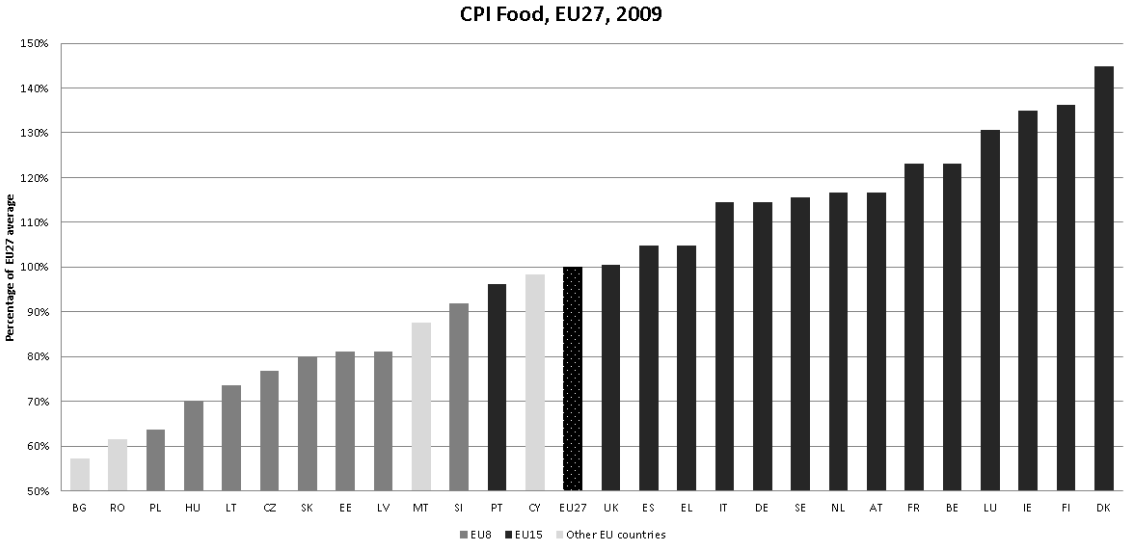

Figure 1: CPI food and non alcoholic beverages 2009, EU27 = 100%

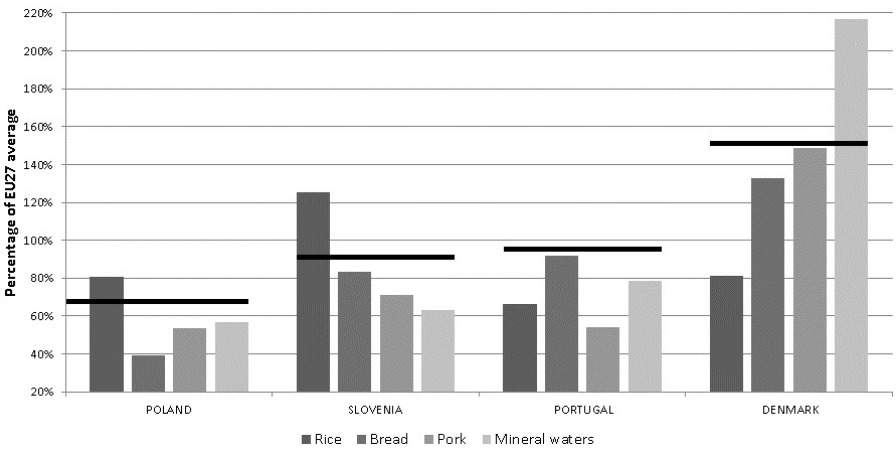

Figure 2: Selected product groups and countries, 2009, EU27 = 100%. The black bar depicts the CPI-food of the respective country

observed (Figure 1). With Poland as the cheapest country within EU23 (64% of the EU27 average) and Denmark as the most expensive one (145%), the difference in price level indices is more than 100%. It may be no surprise that price level indices vary substantially 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 96% of the EU27 average in Portugal to 145% in Denmark.

Although Denmark on the whole has the highest prices for food, there are also some food products that cost less than the EU27 average in Denmark and the Danish price indices of the 34 product groups range from 81% for rice to 216% for mineral waters (EU27=100%). In Poland, the cheapest country, rice costs as much as in Denmark, i.e. 81% of the EU27 average. In contrast, rice costs 125 % of the EU27 average in Slovenia, where the CPI-food is below 100%. Figure 2 illustrates this variety showing the price indices of some selected product groups and countries as well as their CPI-food.

Similar patterns arise when individual products within a product group are considered. Even when taking country-product group specific effects into account, considerable unexplained price differences remain at the individual product level. For many individual products, prices (measured relatively to the European average of this product) are well above or well below the price index of the respective product group in that country. Within the product group "rice" individual prices vary for example from 74% - 84% of the EU27 average in Poland, 99% - 147% in Slovenia and 71 - 121 % in Denmark. Thus retail price differences are much more complex than just countries being expensive or cheap on the whole, and price convergence must be considered at a disaggregate level. Moreover, these price patterns imply that price convergence may depend on the level of aggregation. It is possible that prices converge at the level of individual products but diverge at the aggregate level of product groups (and vice versa). As mentioned above, the Danish prices for the different kinds of rice vary from 71% to 121% of the EU27 average, with a product group index for rice of 81%. If the 121%-price falls, this contributes to convergence at the product level but to divergence for the product group rice.

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). Price convergence

is only ensured if the mean reversion is strong enough to dominate the dispersion induced by ongoing additional random shocks. To analyse σ-convergence, we apply a Wald-test proposed by Egger & Pfaffermayr (2009), which tests whether the variance has declined between two points in time, t_0 and t_1.[5] The advantage of this test is that it neither needs long time-spans or high frequency data nor it is biased by pooling over several points in time. The test is based on the β-convergence regression[6]:

$$p_k^i(t_1) = \alpha_k + \pi \cdot p_k^i(t_0) + u_{kt_1}^i \tag{1}$$

$p_k^i(t_1) = ln(P_k^i(t_1))$ is the natural logarithm of price P of product (or product group) k in country i in period t_1. It is regressed on $p_k^i(t_0)$, the log price in period t_0. As the mean – i.e. the average of the log prices – towards which reversion is measured might be product specific, a product fixed effects α_k is employed. Mean reversion measures the decrease of deviations of prices from the (product k specific) country groups average. The coefficient π can then be interpreted as the remainder of period t_0's price deviation in period t_1 and $\pi < 1$ implies mean reversion. The smaller is π, the stronger is the mean reversion.

In addition to the mean reversion, there are random shocks captured in the error terms u_{kt}^i. Hence β-convergence does not necessarily imply that price dispersion actually decreases.

For the Wald-test whether the variance σ_t^2 declined over time against the null hypothesis that the variance remained constant ($H_0 : \sigma_{t_0}^2 = \sigma_{t_1}^2$ vs. $H_1 : \sigma_{t_0}^2 > \sigma_{t_1}^2$), Egger & Pfaffermayr (2009) derive the following test statistic, which is $\chi^2(1)$ distributed[7] :

$$W_0 = \frac{N(\hat{\sigma}_{t_0}^2(\hat{\pi}^2 - 1) + \hat{\sigma}_u^2)^2}{4\hat{\sigma}_{t_0}^4 \hat{\sigma}_u^2} \sim \chi^2(1) \tag{2}$$

To calculate this one-sided test, the estimated variance of the regression's residuals $\hat{\sigma}_u^2$ and the corresponding coefficient $\hat{\pi}$ as well as the number of observations N are taken from the β-convergence regression above. In addition, we need $\hat{\sigma}_{t_0}^2$, the

[5] Another approach would be to look at non-parametric methods as in Quah (1996), who shows that even without σ-convergence, "convergence clubs" may evolve. In our research we follow the parametric σ-convergence literature, as we look at how exogenously given groups evolve.

[6] In the literature, an equivalent formulation of the regression above exists (hence the name β-convergence):

$$\Delta p_k^i(t_1) = \alpha + \beta \cdot p_k^i(t_0) + u_{kt_1}^i$$

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

$$H_0 : \sigma_{t_0}^2 = \sigma_{t_1}^2 \text{ vs. } H_1 : \sigma_{t_0}^2 < \sigma_{t_1}^2$$

estimated variance of prices at the initial date t_0, which is defined as:

$$\hat{\sigma}^2_{t_0} = \frac{1}{N} \sum_{k=1}^{K} \sum_{i=1}^{I_k} (p^i_k(t_0) - \bar{p}_k(t_0))^2 \tag{3}$$

Here K is the total number of products (or product groups), I_k is the number of reporting countries for product (or product group) k and $N = \sum_{k=1}^{K} I_k$ is the total number of observations. For the 34 product groups, I_k always equals 8, 15 or 23 respectively. For the individual products, I_k varies.[8] Note that price convergence is conditional on the product (but not on the country), since when calculating the variance in equation (3), the deviation of each price p^i_k from $\bar{p}_k$ is used for each product (or product group) k. Alternatively, the price data can be demeaned, i.e. normalized such that $\bar{p}_k(t) = \frac{1}{I_k} \sum_{i=1}^{I_k} p^i_k(t) = 0$ for $t = t_0, t_1$ and each k (Egger & Pfaffermayr, 2009, p. 460, footnote 5). $p^i_k(t)$ is then actually the deviation of country i's price from the average price across countries (e.g. across EU15 countries). Price indices in logs are generally demeaned by definition, however, 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. With properly demeaned data, the product fixed effects α_k in equation (1) will equal zero.

The considered time period covers the years of the hike and the subsequent fall in world market food prices in the years 2007 and 2008 and also the recession year 2009. Insofar as these shocks affect prices in the countries considered equally, the effects are captured in the averages $\bar{p}_k$ and price convergence is unchanged. However, these shocks may affect prices differently or at different speed in different countries, which could then be interpreted as shocks u^i_k counteracting price convergence.

4.2 Convergence decomposition

For the interpretation of the results on price convergence or divergence, we decompose the variance of a single product group k into within-groups and between-groups variances:[9]

$$\sigma^2_{k,EU23} = \frac{15}{23} \cdot \sigma^2_{k,EU15} + \frac{8}{23} \cdot \sigma^2_{k,EU8} + \frac{15}{23} \cdot \bar{p}^2_{k,EU15} + \frac{8}{23} \cdot \bar{p}^2_{k,EU8}$$

In Appendix A.1, we show that for the special case of price indices, where $\bar{p}_{EU23} = 0$, the decomposition can be further simplified, aggregated over products groups k and

[8] This expression is more general than in Egger & Pfaffermayr (2009), as it does not restrict its use to cases with the same number of reported observations for every observed entity (e.g. I firms in each of K industries).

[9] The basis of this decomposition is the same as in the one-way analysis of variance (ANOVA). While ANOVA then uses this decomposition to test if the subgroups' population means are the same, we want to know to what extent the variance between or within subgroups has changed For the special case of only two subgroups, ANOVA is actually identical to the t-test (Rabe-Hesketh & Skrondal, 2008).

extended to changes ($\Delta\sigma^2_{EU23} = \sigma^2_{EU23,t} - \sigma^2_{EU23,t-1}$):

$$\Delta\sigma^2_{EU23} = \frac{15}{23}\Delta\sigma^2_{EU15} + \frac{8}{23}\Delta\sigma^2_{EU8} + \frac{8}{15}\frac{1}{34}\sum_{k=1}^{34}\Delta\bar{p}^2_{k,EU8} \tag{4}$$

The estimated change of the variance within EU23 equals the weighted sum of variance changes within the subgroups EU15 and EU8, plus a term measuring the change of the dispersion between the two subgroups (between-groups variance). To estimate the significances of the first two terms, the Wald-Test proposed above is used. The latter term's significance can be estimated with a simple paired t-test or a Wilcoxon matched-pairs signed-ranks test. Note however, that this equation only refers to the semi-aggregate data at the product group level, as due to the missing data at the level of individual products, the weights would differ for the individual products.

5 σ-convergence

In this section, we analyse σ-convergence both at the level of individual products and of the product groups. Significant β-convergence is found in all cases, i.e. both for products and for product groups and for all time periods considered.

5.1 Convergence within country groups at a disaggregate level - products

As mentioned in section 3, the set of prices observed has somewhat changed over time and not all prices are reported in all countries. We only include those products, for which prices are reported at all three dates (2003, 2006 and 2009) and for which more than 50% of the observations are available in both EU8 and EU15, which leaves us with 147 products[10]. This ensures that for every product we indeed measure convergence towards EU8/15/23 averages and not yet another subgroup of these.

	K	N	**03-06**	**06-09**	**03-09**
$\Delta\hat{\sigma}^2_{EU23}$	147	2817	-0.0282***	-0.0168***	-0.0450***
			(585.50)	(373.71)	(1370.23)
$\Delta\hat{\sigma}^2_{EU15}$	147	1824	-0.0025***	-0.0033***	-0.0058***
			(12.00)	(28.52)	(56.25)
$\Delta\hat{\sigma}^2_{EU8}$	147	993	-0.0189***	-0.0038***	-0.0227***
			(386.40)	(28.55)	(553.16)

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

Table 1: σ-convergence at the products level - 50% cutoff

[10] Varying the cut-off level between 25% and 80% does not change the qualitative results.

Table 5 shows the changes of the estimated variances and the results of the Wald-test[11]. Prices have significantly converged in all country groups EU8/15/23 in both subperiods 2003-2006 and 2006-2009, and thus in the entire period 2003-2009. The decrease in the variance of prices within EU8 is much stronger in the sub-period 2003-2006 right after accession than in 2006-2009. In EU15, the effect is rather small.

As described in section 4, these results are obtained when the estimation is run with pooled data and thus refer to the question, if overall, food prices have converged when considered at the disaggregate level of prices for narrowly defined individual products. A further question that might be of interest is how price dispersion for individual products has evolved over time. Convergence results for the single products, that can be found in Figure 4 in Appendix B, support the results for the pooled data: Between 2003 and 2009 prices have converged for a majority of products within EU23, EU15 and EU8, and this effect is least pronounced in EU15.

5.2 Convergence within country groups at a semi-aggregate level - product groups

In this subsection, price convergence at the level of product group price indices is considered. These price indices are available since 1995 for EU15 and since 2001 for EU8 (whereas prices for individual products are only available since 2003). The σ-convergence results are shown in Table 6.

	N	**95-98**	**98-01**	**01-03**	**03-06**	**06-09**	**95-09**	**03-09**
$\Delta\hat{\sigma}^2_{EU23}$	782			0.0115***	-0.0249***	-0.0162***		-0.0411***
				(136.59)	(609.01)	(538.64)		(1309.90)
$\Delta\hat{\sigma}^2_{EU15}$	510	-0.0092***	0.0027***	-0.0004	0.0042***	-0.0018***	-0.0045***	0.0024***
		(334.68)	(39.76)	(0.52)	(87.16)	(15.72)	(42.95)	(24.28)
$\Delta\hat{\sigma}^2_{EU8}$	272			0.0007	-0.0143***	0.0046***		-0.0097***
				(1.56)	(748.82)	(168.14)		(224.07)

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

Table 2: σ-convergence at the product groups level

Within EU15, we only find significant σ-convergence in the period from 1995 to 1998 (the period right after Finland, Sweden and Austria had joined the EU) and in 2006-2009, but price dispersion is still higher in 2009 than in 1998. In the other periods, the food price indices diverge or the results are not significant. Hence since 1998, within the old member countries EU15, prices do not converge any more. Looking at EU23 in the period 2001-2003 right 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 2006-2009. Figure 5 in Appendix B, shows the results for individual product groups

[11]For this one-sided test, the critical values of the $\chi^2(1)$ test statistic at the 10%/5%/1% significance level are 2.71/3.84/6.63.

for the period 2003-2009. In EU23, only two product groups diverge, whereas price dispersion falls for all other product groups. Price indices also converged for most product groups in EU8. In EU15, the picture is mixed, and on the whole, price divergence dominates.

Comparing results for individual products and for product groups

Comparing table 1 and table 2 shows, that the results for the disaggregate level of individual products and the semi-aggregate level of product groups differ in some cases. Results are sensitive to the level of aggregation. While at the level of invidual products, prices converge in all cases considered, this does not hold for the product group indices. For EU15, product group price indices diverge in the period 2003-2006, and this effect is so strong, that there is also divergence for the longer period of 2003-2009. In the EU8, price indices diverged between 2006 and 2009, but in the longer period of 2003-2009, this divergence is dominated by the strong convergence in the earlier period of 2003-2006.

However, the differing results are not inconsistent with each other. There are several explanations why convergence at the level of individual products may differ from convergence for the product groups. First, we restrict our dataset to products that are sufficiently common (50% of EU8 as well as 50% of EU15 countries reporting prices), which most likely differs from the products used in each country for product group aggregation. These most common products might converge faster than the other ones. Second, the products in a given basket might enter with different weights. Thirdly, when aggregating the prices from products to product groups, relatively cheap and relatively expensive products average out. As discussed in section 3, it is possible that a price change contributes to convergence at the product level but to divergence at the level of product groups (and vice versa).

Note however that the result of price convergence in EU23 both in the periods 2003-2006 and 2006-2009 is robust. When considering the long period 2003-2009 after accession, the result of price convergence within the EU8 also holds both at the disaggregate level of products and of product groups. In contrast, within the group of the old member countries EU15, prices converged between 2003 and 2009 when considered for individual products, but diverged at the product group level.

Thus it may indeed be relevant whether price convergence is considered based on disaggregate or on semi-aggregate data. Prices for narrowly defined products, that are widespread in Europe, converged in EU15 on the whole, but this is not reflected at the level of price indices for the product groups.

5.3 Convergence between country groups

The σ-convergence results within country groups suggest, that the strong convergence within EU23 could be caused by convergence between EU15 and EU8 and not mainly by convergence within these two subgroups. To further investigate this point, we look at the variance decomposition at the product group level (see section 4.2). Table 3 summarizes the results.[12]

	N	**01-03**	**03-06**	**06-09**	**03-09**
$\Delta\hat{\sigma}^2_{EU23}$	782	0.0115***	-0.0249***	-0.0162***	-0.0411***
$\frac{15}{23}\Delta\hat{\sigma}^2_{EU15}$	510	-0.0002	0.0027***	-0.0012***	0.0015***
$\frac{8}{23}\Delta\hat{\sigma}^2_{EU8}$	272	0.0002	-0.0050***	0.0016***	-0.0034***
$\frac{8}{15}\frac{1}{K}\sum_{k=1}^{K}\Delta\bar{p}^2_{k,EU8}$	272	0.0115***	-0.0227***	-0.0166***	-0.0394***

*** significant at 1%-level

Table 3: σ-convergence decomposition at the product groups level

In the period before the accession (2001-2003), price dispersion both within EU8 and EU15 remained virtually unchanged. Price divergence within EU23 can be explained by the fact that price differences between EU15 and EU8 increased. In the period 2003-2009, i.e. after the enlargement shock, the decline in between-groups variance amounts to more than 90% of the total convergence. In the last sub-period considered (2006-2009), there would not be any convergence in EU23 without convergence between the old and new member states. Hence the driving force behind the strong convergence within EU23 after the EU enlargement in 2004 is not convergence within these two subgroups, but between them. In 2003, $\bar{p}_{EU8}$ (the average of price indices of all product groups in all EU8 countries) was 33% lower than the EU23 average while it was only 18% lower in 2009. Figure 3 illustrates the variance decomposition graphically.

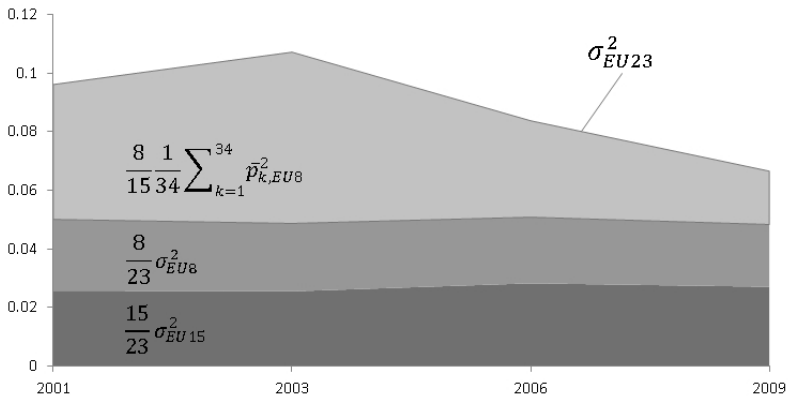

Figure 3: Variance decomposition on the product groups level.
$\frac{15}{23}\hat{\sigma}^2_{EU15}$, $\frac{8}{23}\hat{\sigma}^2_{EU8}$ and $\frac{8}{15}\frac{1}{34}\sum_{k=1}^{34}\Delta\bar{p}^2_{k,EU8}$ add up to $\hat{\sigma}^2_{EU23}$

One question that comes to mind is whether only the EU8's prices rose or if prices actually moved towards each other. This cannot be distinguished when using price

[12] The results of the paired t-test and the Wilcoxon test, whether $\frac{8}{15}\frac{1}{34}\sum_{k=1}^{34}\bar{p}^2_{k,EU8}$ has changed between two given points in time, can be found in appendix A.2 .

indices. By construction, if one subgroup becomes relatively more expensive, the mean of the whole sample changes and hence the other subgroup has to become relatively less expensive. However, if we look at food prices at the individual product level, we find that the average price increase per year between 2003 and 2009 within EU15 was only 0.9%. In real terms prices then have actually moved towards each other.

6 Conclusion

As on a perfectly integrated market, a good can only have one price, it is widely expected that ongoing market integration leads to price convergence, thereby enhancing efficiency. However, from a theoretical point of view, prices need not necessarily converge, as for instance retailing services are non-tradable and arbitrage will be reluctant to react to retail price differences. Nevertheless, if price convergence occurs, this can be interpreted as an indicator of market integration, showing that the internal market project, which aims at increasing welfare, works well. This idea can be applied to the new Central and Eastern European member states: price convergence may indicate that these countries successfully integrate into the markets of the European Union.

Using a unique micro level data set on retail food prices from the Eurostat-OECD PPP Program, we find that in the lead-up to accession (2001-2003), food prices diverged within EU23. In contrast, price convergence has occured after 2003, indicating that the enlargement had a vital effect on food price dispersion. Given that price convergence is found, the underlying dynamics and subgroup behavior is of interest. The driving force behind price convergence in the European Union is convergence between the two groups of countries EU8 and EU15, with the difference of average prices for food products of these two groups becoming smaller. A subsequent research question could be whether convergence clubs as described in Quah (1996) will endogeneously emerge. The possibly evolving clubs would not necessarily have to coincide with the exogeneously determined country groups EU8 and EU15. We leave this question to further research.

References

Barro, R. J., & Sala i Martin, X. (1995). Economic growth. McGraw-Hill advanced series in economics. New York, NY [u.a.]: McGraw-Hill.

Bliss, C. (1988). A theory of retail pricing. Journal of Industrial Economics, 36(4), 375 – 391.

Carree, M., & Klomp, L. (1997). Testing the convergence hypothesis: A comment. Review of Economics and Statistics, 79(4), 683–686.

Cecchini, P., Catinat, M., & Jacquemin, A. (1988). The European challenge, 1992: the benefits of a single market. The European Challenge. Gower Publishing Co., Brookfield, Vermont.

Cumby, R. (1996). Forecasting exchange rates and relative prices with the Hamburger Standard. NBER Working paper, (no. 5878).

Dreger, C., Kholodilin, K., Lommatzsch, K., Slačálek, J., & Wozniak, P. (2008). Price convergence in an enlarged internal market. Eastern European Economics, 46(5), 57–68.

Egger, P., Gruber, S., & Pfaffermayr, M. (2009). The law of one price: A new econometric approach and evidence from disaggregated data. Applied Economics, 41(26), 3345–3357.

Egger, P., & Pfaffermayr, M. (2009). On testing conditional sigma-convergence. Oxford Bulletin of Economics and Statistics, 71(4), 453–473.

European Commission (1990). One market, one money: An evaluation of the potential benefits and costs of forming an economic and monetary union. European Economy, (44).

European Commission (2006). Eurostat-OECD methodological manual on purchasing power parities. European Commission / OECD.

Eurostat (2010). Price levels for food, beverages and tobacco across the European market differ significantly . Statistics in Focus, (30).

Fischer, C. (2012). Price convergence in the EMU? Evidence from micro data. European Economic Review, 56(4), 757 – 776.

Funke, K., & Koske, I. (2008). Does the Law of One Price Hold within the EU? A Panel Analysis. International Advances in Economic Research, 14(1), 11–24.

Goldberg, P. K., & Verboven, F. (2004). Cross-country price dispersion in the euro era: A case study of the European car market. Economic Policy 40.

Haskel, J., & Wolf, H. (2001). The law of one price – a case study. Scandinavian Journal of Economics, 103(4), 545 – 558.

MacDonald, R., & Ricci, L. A. (2005). The real exchange rate and the Balassa–Samuelson effect: The role of the distribution sector. Pacific Economic Review, 10(1), 29–48.

Parsley, D., & Wei, S.-J. (2008). In search of a euro effect: Big lessons from a Big Mac meal? Journal of International Money and Finance, 27(2), 260 – 276.

Quah, D. T. (1996). Empirics for economic growth and convergence. European economic review, 40(6), 1353–1375.

Rabe-Hesketh, S., & Skrondal, A. (2008). Multilevel and longitudinal modelling using Stata. STATA press.

Wolszczak-Derlacz, J., & De Blander, R. (2009). Price convergence in the European Union and in the new member states. Bank i Kredyt, 40(2), 37–59.

A Convergence decomposition

A.1 Deduction

Price indices are in natural logs. There are $m+n$ countries in two subgroups of size m and n, and prices of a specific product group are normalized such that $\bar{p}_{m+n} = 0$. For better readability we first omit the product group index k.

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

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

We use the standard textbook equation of the variance:

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

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.

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

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

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

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

Expressed in changes and adding the product group index k, we get:

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

Finally, we aggregate over all product groups k:

$$\Delta\sigma^2_{m+n} = \frac{1}{K}\sum_{k=1}^{K}\sigma^2_{k,m+n} = \frac{m}{m+n}\Delta\sigma^2_m + \frac{n}{m+n}\Delta\sigma^2_n + \frac{n}{m}\frac{1}{K}\sum_{k=1}^{K}\Delta(\bar{p}_{k,n})^2$$

In the EU23 case with $K = 34$ product groups:

$$\Delta\sigma^2_{k,EU23} = \frac{15}{23}\Delta\sigma^2_{k,EU15} + \frac{8}{23}\Delta\sigma^2_{k,EU8} + \frac{8}{15}\Delta(\bar{p}_{k,EU8})^2$$

$$\Delta\sigma^2_{EU23} = \frac{15}{23}\Delta\sigma^2_{EU15} + \frac{8}{23}\Delta\sigma^2_{EU8} + \frac{8}{15}\frac{1}{34}\sum_{k=1}^{34}\Delta(\bar{p}_{k,EU8})^2$$

A.2 Estimated Confidence Intervalls for $\frac{8}{15}\frac{1}{34}\sum_{k=1}^{34}\Delta\bar{p}^2_{k,EU8}$

For better readability, here we use $\mathfrak{p}_t = \frac{1}{34}\sum_{k=1}^{34}\Delta\bar{p}^2_{k,EU8,t}$

Period	N	$\mathfrak{p}_{t-1}$	$\mathfrak{p}_t$	$\Delta\mathfrak{p}_t$	$\frac{8}{15}\Delta\mathfrak{p}_t$	t	[99% C.I.] of $\Delta\mathfrak{p}_t$		z
2001-2003	34	0.1001	0.1217	0.0216	0.0115	-3.4388	- 0.0388	- 0.0044	- 3.1200
2003-2006	34	0.1217	0.0792	- 0.0425	- 0.0227	7.656	- 0.0273	- 0.0577	4.8640
2006-2009	34	0.0792	0.0481	- 0.0311	- 0.0166	5.5055	- 0.0157	- 0.0466	4.9150
2003-2009	34	0.1217	0.0481	- 0.0736	- 0.0394	8.6095	- 0.0503	- 0.0970	5.0860

*** Both tests show significance at the 99% level, t is the t statistic of the paired t-test
z is the z statistic of the Wilcoxon matched-pairs signed-ranks test.
The confidence interval of $\mathfrak{p}_t$ has been calculated based on the paired t-test.

Table 4: Paired t-test and Wilcoxon matched-pairs signed-ranks test for $\mathfrak{p}_t = \frac{1}{34}\sum_{k=1}^{34}\Delta\bar{p}^2_{k,EU8,t}$

B Individual product / product group convergence

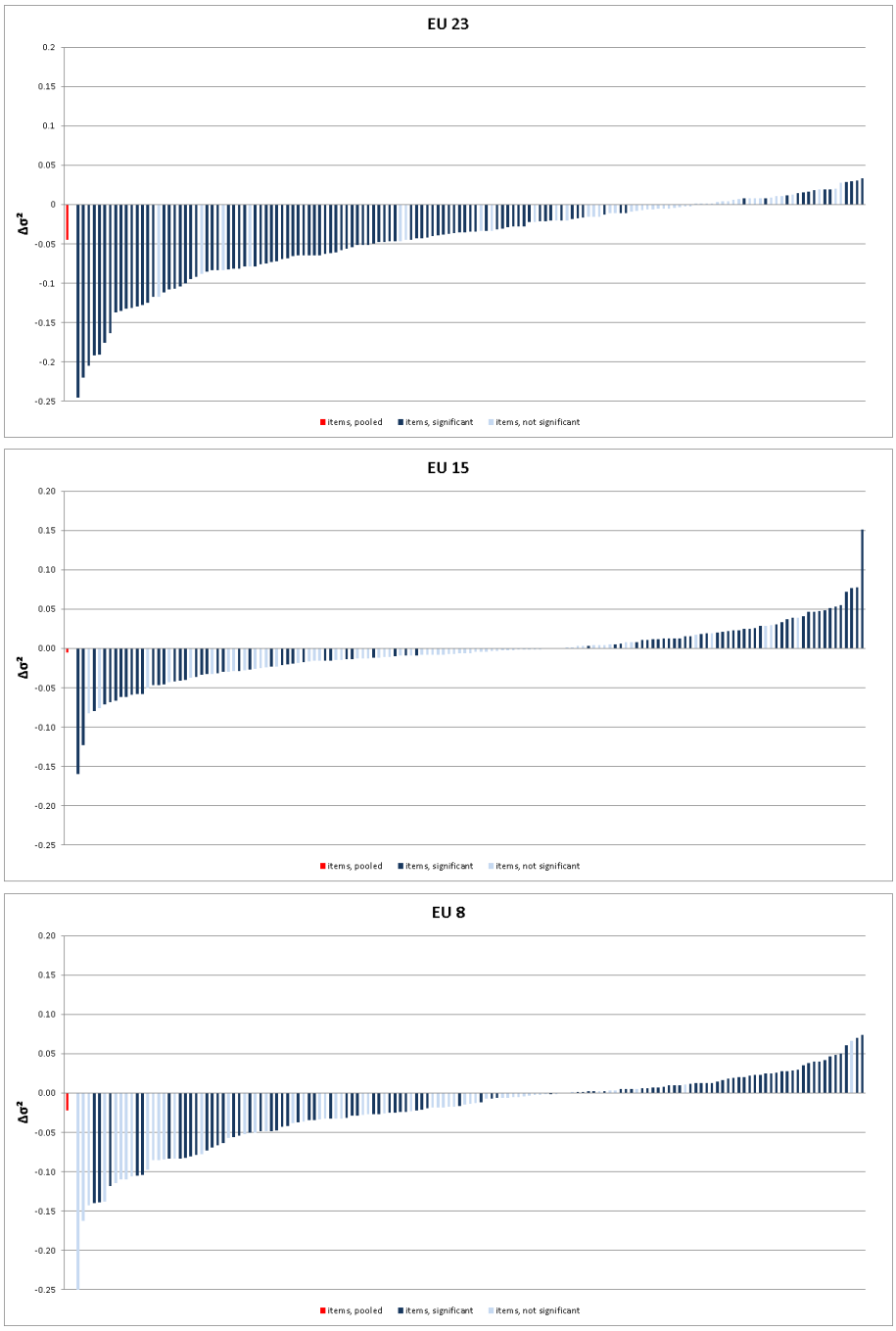

Figure 4: σ-convergence ($\Delta\sigma^2$) by products, 2003 - 2009. The first bar depicts the pooled convergence result. Light grey bars are not statistically significant.

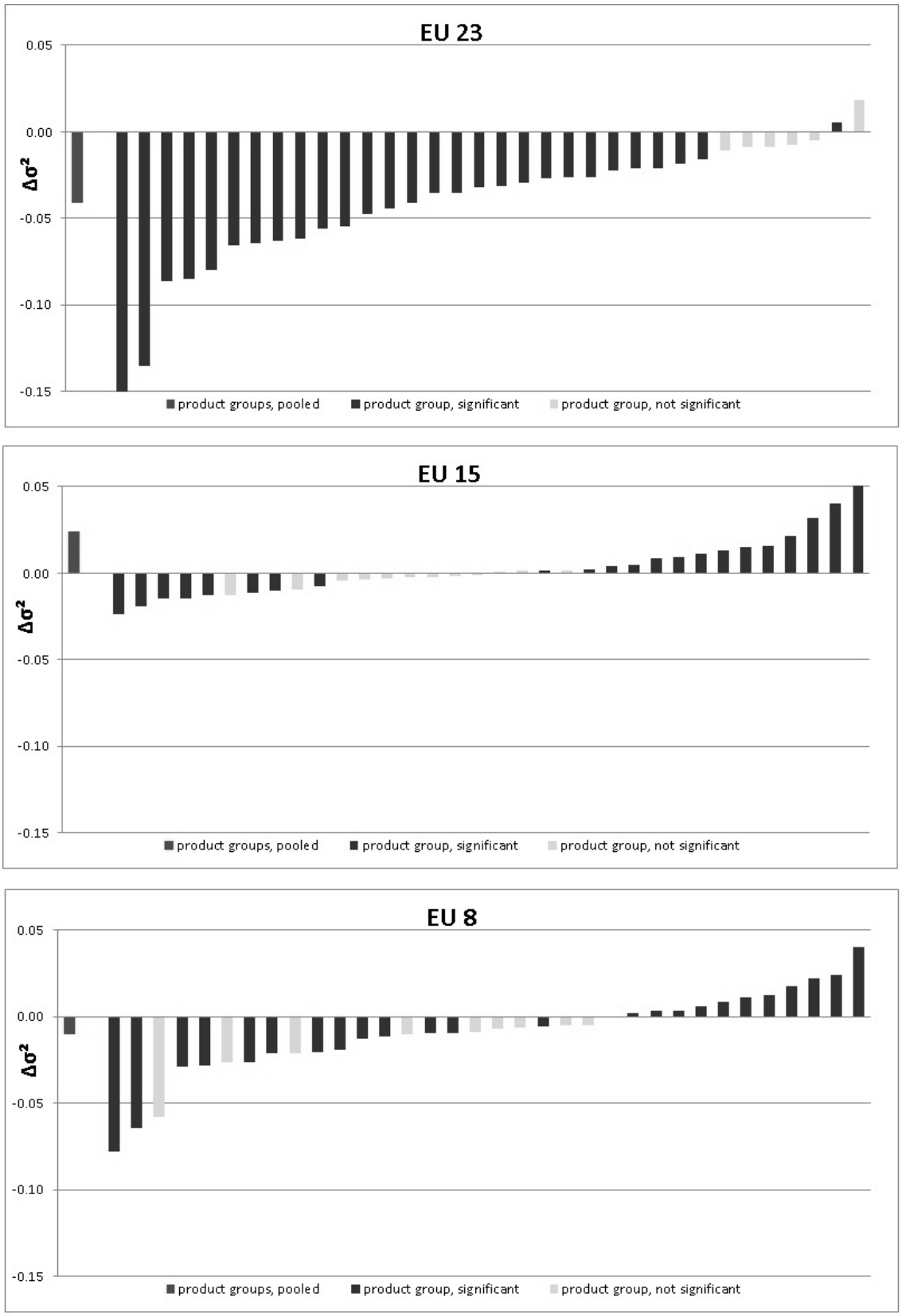

Figure 5: σ-convergence ($\Delta\sigma^2$) by product groups, 2003 - 2009. The first bar depicts the pooled convergence result. Light grey bars are not statistically significant.

C For Referee - Fixed effects vs. no fixed effects

No country fixed effect

	K	N	**03-06**	**06-09**	**03-09**
$\Delta\hat{\sigma}^2_{EU23}$	147	2817	-0.0282***	-0.0168***	-0.0450***
			(585.50)	(373.71)	(1370.23)
$\Delta\hat{\sigma}^2_{EU15}$	147	1824	-0.0025***	-0.0033***	-0.0058***
			(12.00)	(28.52)	(56.25)
$\Delta\hat{\sigma}^2_{EU8}$	147	993	-0.0189***	-0.0038***	-0.0227***
			(386.40)	(28.55)	(553.16)

With country fixed effect

	K	N	**03-06**	**06-09**	**03-09**
$\Delta\hat{\sigma}^2_{EU23}$	147	2817	-0.0030***	-0.0066***	-0.0096***
			(18.76)	(146.53)	(212.97)
$\Delta\hat{\sigma}^2_{EU15}$	147	1824	-0.0006	-0.0011*	-0.0017**
			(0.35)	(3.19)	(5.20)
$\Delta\hat{\sigma}^2_{EU8}$	147	993	-0.0079***	-0.0078***	-0.0157***
			(107.05)	(174.83)	(478.52)

Test statistics in brackets, */**/*** significant at 10%/5%/1% level

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

No country fixed effect

	N	**95-98**	**98-01**	**01-03**	**03-06**	**06-09**	**95-09**	**03-09**
$\Delta\hat{\sigma}^2_{EU23}$	782			0.0115***	-0.0249***	-0.0162***		-0.0411***
				(136.59)	(609.01)	(538.64)		(1309.90)
$\Delta\hat{\sigma}^2_{EU15}$	510	-0.0092***	0.0027***	-0.0004	0.0042***	-0.0018***	-0.0045***	0.0024***
		(334.68)	(39.76)	(0.52)	(87.16)	(15.72)	(42.95)	(24.28)
$\Delta\hat{\sigma}^2_{EU8}$	272			0.0007	-0.0143***	0.0046***		-0.0097***
				(1.56)	(748.82)	(168.14)		(224.07)

With country fixed effect

	N	**95-98**	**98-01**	**01-03**	**03-06**	**06-09**	**95-09**	**03-09**
$\Delta\hat{\sigma}^2_{EU23}$	782			-0.0021***	0.0026***	-0.0002		0.0023***
				(28.21)	(119.94)	(0.15)		(89.84)
$\Delta\hat{\sigma}^2_{EU15}$	510	-0.0046***	0.0023***	-0.0022***	0.0020***	0.0021***	-0.0004	0.0040***
		(180.87)	(87.19)	(37.30)	(77.58)	(90.36)	(0.43)	(235.09)
$\Delta\hat{\sigma}^2_{EU8}$	272			0.0006***	-0.0044***	0.0009***		-0.0035***
				(13.52)	(200.39)	(35.05)		(93.83)

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

Table 6: σ-convergence at the product groups level

D For Referee only - Example of the data structure

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