E C O N O M I C S   B U L L E T I N

Price Convergence in the EU Poultry and Eggs Markets

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Abstract

This paper uses the notions of convergence in ratio and of convergence in difference to investigate price convergence for poultry and eggs in geographically separated EU markets. According to the empirical results, there is global and strong convergence of prices in the poultry markets but not in the egg markets. The latter appear to be fragmented into a number of price convergence clubs.

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1. Introduction

Since the early 1990s, the efforts by the European Commission to achieve integration of national markets have been intensified. The completion of the Single Market has facilitated the free movement of people, goods, and capital, while the EMU reduced the exchange rate volatility and the risks of cross-border activities, and increased transparency thanks to prices expressed in a common currently. In addition, initiatives have been undertaken towards tax harmonization and other structural reforms in product markets to enhance competition and to reduce distortions caused by different forms of government intervention. It has been generally recognized, however, that cross-country price dispersion (a key indicator of the degree of market integration) in the EU has been persistent, and rather stable over time (e.g. European Commission, 2001a, 2001b, and 2004; Borchert and Reineke, 2007). The large and persistent price differences for virtually identical products even in neighboring or comparable countries has been an issue of great concern. Starting from 2008, the European Commission will chart basic consumer goods across the EU members in an effort to identify areas where prices may be unfairly high.

Despite the public interest, formal research on price convergence in the EU is scarce. In the most recent years, there has been a handful of studies which investigated empirically the validity of the Law of One Price (LOP) for certain commodities in the EU markets using time series techniques (unit root or cointegration tests). Notable examples are the studies by Goldberg and Verboren (2005) on the car market, by Sanjuan and Gil (2001) on the pork and the lamb markets, and by Fousekis (2007) on the pork and the poultry markets.

Several researchers have pointed out that the unit root or the cointegration tests are not well suited for investigating convergence (e.g. Phillips and Sul, 2007; Nahar and Inder, 2002; Bernard and Durlauf, 1996). The reason is that they rely on the implicit assumption that the data are characterized by steady-state dynamics and, thus, they possess well defined population moments; inferences are invalid when the data are characterized by transition dynamics (meaning they are far from a limiting distribution). Moreover, the finding that the difference between two prices is level stationary - something which is often reported in empirical studies of the LOP - does not imply that the two prices are converging to each other.[1] As a matter of fact, that finding implies that the difference between the two prices remains (on average) constant over time. A behavior of this type, however, is consistent with what Quah (1993 and 1996) termed as *persistence* rather than with *convergence* (or *divergence*).

The objective of the present paper is to investigate price convergence in the EU national (localized/geographically separated) poultry and egg markets. The empirical analysis utilizes recently proposed notions of convergence (Webber et al., 2005; Webber and White, 2004) which allow for transition dynamics. The paper examines both global convergence (meaning that prices in all markets in the sample convergence to each other) as well as club convergence (meaning that prices in a subset of markets convergence to each other and divergence from prices in markets which do not belong to that subset). In what follows, section 2 contains the analytical framework (convergence in ratio and convergence in difference); section 3 discusses the tests statistic and the clustering algorithm employed for the endogenous selection of potential price convergence clubs; section 4 presents the data and the empirical results, while section 5 offers conclusions and suggestions for future research.

[1] Level stationarity (stationarity around zero) of a price difference is sufficient condition for the weak (strong) version of the LOP to hold (e.g. Asche et al., 1999; Goldberg and Verboren, 2005).

2. Analytical Framework

Let the prices in markets *i* and *j* in period *t* be P_{it} and P_{jt}, respectively, and in period *t+k* (k being a positive integer) be P_{it+k} and P_{jt+k}, respectively. Let also, without loss of generality, $P_{it} > P_{jt}$ and define θ to be the solution of the equation

$$\left(\frac{P_{it}}{P_{jt}}\right)^{\theta} = \left(\frac{P_{it+k}}{P_{jt+k}}\right) \qquad (1).$$

If $|\theta| < 1$, the prices in the two markets exhibit convergence in ratio, while if $|\theta| > 1$, they exhibit divergence in ratio.

Similarly, define ϕ to be the solution of the equation

$$(P_{it} - P_{jt}) = \phi(P_{it+k} - P_{jt+k}) \qquad (2).$$

If $|\phi| > 1$, the prices in the two markets exhibit convergence in difference; while if $|\phi| < 1$, the prices in the two markets exhibit divergence in difference.[2]

Convergence (divergence) in ratio is neither a necessary nor a sufficient condition for convergence (divergence) in difference, and convergence (divergence) in difference is a neither necessary nor a sufficient condition for convergence (divergence) in ratio. Because of this, Webber and White (2004) distinguish between strong convergence (both in ratio and in difference) and weak convergence (either in ratio or in difference, but not in both). The complete characterization of a convergence process requires investigation of both convergence in ratio and convergence in difference.

In empirical applications the researcher has typically panel data from N>2 geographically separated markets and T time periods. For the study of convergence in ratio she(he) needs an aggregator function which depends on price ratios but not on possible switches in the relative positions (changes in rank) of the markets in the cross-section distribution of prices over time. Such an aggregator function can be any homogeneous of degree zero in its arguments index of inequality (I^R) that is, a measure with the property

$$I_t^R = I_t^R(P_{1t}, \ldots, P_{it}, \ldots, P_{Nt}) = I_t^R(\frac{P_{1t}}{P_{it}}, \ldots, 1, \ldots, \frac{P_{Nt}}{P_{it}}) = I_t^R(\frac{P_{1t}}{\bar{P}_t}, \ldots, \frac{P_{it}}{\bar{P}_t}, \ldots, \frac{P_{Nt}}{\bar{P}_t}) \qquad (3),$$

where *i*= 1,2, …, N, *t*=1, 2, …, T, and $\bar{P}_t$ stands for the average of the cross-section distribution of prices at *t*. A homogenous of degree zero index of inequality decreases (increases) when one of the price ratios moves closer to (far away from) unity, ceteris paribus. In the literature of inequality a number of degree zero measures are available, including the Standard Deviation of Natural Logarithms, the Gini Coefficient, the Entropy Measure, and the Coefficient of Variation. In most empirical investigations of convergence in ratio the Standard Deviation of Natural Logarithms (SDL) is employed and this choice is made here as well (e.g. Barro et al., 1991; Bernard and Johnson, 1996a and 1996b).

For the study of convergence in difference the researcher needs an aggregator function which depends on the price differences but not on possible changes in the rank of markets in the cross-section price distribution over time. Such an aggregator function can be any linearly homogenous in its arguments inequality index (I^D) that is, a measure with the property

[2] Further elaboration on price ratio and price difference dynamics is possible. For example, $0 < \theta < 1$ implies convergence in ratio without switching or $0 > \phi > -1$ implies divergence in difference with switching (Webber et al. 2005; Webber and White, 2004). Issues of preservation (or of switching) of relative positions, however, are beyond the scope of the present study.

$$I_t^D(\lambda P_{1t}, \ldots, \lambda P_{it}, \ldots, \lambda P_{Nt}) = \lambda I_t^D(P_{1t}, \ldots, P_{it}, \ldots, P_{Nt}) =$$

$$I_t^D(\lambda(P_{1t} - \bar{P}_t), \ldots, \lambda(P_{it} - \bar{P}_t), \ldots, \lambda(P_{Nt} - \bar{P}_t)) = \lambda I_t^D(P_{1t} - \bar{P}_t, \ldots, P_{it} - \bar{P}_t, \ldots, P_{Nt} - \bar{P}_t) \quad (4),$$

with $\lambda > 0$. A homogenous of degree one index of inequality decreases (increases) when one of the price differences moves closer to (far away from) zero, ceteris paribus. Again, a number of such indexes are available in the literature including the Range, the Sum of Absolute Deviations from the Mean, and the Standard Deviation. Here, the Standard Deviation (SD) is employed because of its superior theoretical properties relative to the other indexes (e.g. Sen, 1997).

The use of the SDL and the SD as aggregator functions renders the search for convergence in ratio and convergence in difference to a search of the so-called σ-convergence (e.g. Barro et al., 1991; Quah, 1993; Friedman, 1994). With the SDL one investigates relative σ-convergence, while with SD she(he) investigates absolute σ-convergence. [3]

3. The Test Statistic and the Clustering Algorithm

A test for σ-convergence is a test for a downward trend in an appropriate inequality index. A number of tests are available in the literature (e.g. Lichtenberg, 1994; Carree and Klomp, 1997) which are based on the difference or on the ratio of the inequality estimates at beginning and the end of a sample. Statistics of that type, however, take into account only two time points and their results are likely to be highly dependent on their choice which is typically imposed by the available data. Alternatively, one may adopt Brillinger's (1989) approach that involves weighting the data by a linear combination that induces a strong temporal contrast between the initial and the final levels of the inequality measure. In Brillinger's test procedure it is assumed that the inequality series (call it S_t) can be expressed in the "signal plus noise" form

$$S_t = \eta_t + \varepsilon_t \quad (5),$$

where η_t is a monotonic trend component (the level of S_t) and ε_t is a stationary and zero-mean process. In testing for convergence, the null hypothesis is $n_t = \eta$ for every t, while the alternative is $\eta_{t+1} \leq \eta_t$ (t=1, 2, …, T) with a strict inequality for some t. The relevant test statistic is

$$\tau = \frac{\sum_{t=1}^{T} w_t S_t}{(V_L \sum_{t=1}^{T} w_t^2)^{0.5}} \quad (6),$$

which under the null follows asymptotically the standard normal. In (6), w_t are weights which are calculated as $w_t = [(t-1)(1-\frac{t-1}{T})]^{0.5} - [t(1-\frac{1}{T})]^{0.5}$ so that $w_{T-j} = -w_{j+1}$ (hence $\sum_t w_t = 0$), and V_L is an estimate of the long-run variance of the residuals, ε_t, from the regression of S_t on a linear trend fitted by OLS .[4] V_L can be estimated as

[3] As pointed out by Kolm (1976), notions of inequality can be classified into those which attach inequality to difference (absolute inequality) and those which attach inequality to ratio (relative inequality). Therefore, the terms relative σ-convergence and absolute σ-convergence employed here are perfectly consistent with earlier literature

[4] The long-run variance is $2\pi f(0)$, with f(0) being the power spectrum of ε_t at frequency zero.

$V_L(l) = \hat{\gamma}(0) + 2\sum_{\tau=1}^{m}(1 - \frac{l}{m+1})\hat{\gamma}(l)$, where l is a truncation parameter and $\hat{\gamma}(l)$ is the autocovariance of the residuals at lag l (Newey and West, 1987). Brillinger's test is one-sided with critical value at the 5 percent level equal to -1.65.

In this paper we test first for global convergence in ratio (with SDL) and for global convergence in difference (with SD) for each commodity. When the empirical evidence is against of global convergence we search for convergence clubs by applying the hierarchical agglomerative clustering algorithm proposed by Proietti (2005):

at the initial stage each national market represents a separate price convergence club. Thus, initially, there are N clubs, $C_i, i = 1, 2, ..., N$;

(1) compute the inequality measure for every *t* and for every pair of clubs *[i, j]*;
(2) compute the statistic $\tau^{[i,j]}$ for each pair;
(3) if the minimum $\{\tau^{[i,j]}\}$ is above the critical value at the 5 percent level then stop; otherwise, choose the pair for which $\tau^{[i,j]}$ is minimum;
(4) combine clubs C_i and C_j;
(5) iterate steps (1) to (4) until $\{\tau^{[i,j]}\}$ is not significant at the 5 percent level.

4. The Data and the Empirical Results

The empirical analysis utilizes prices of poultry and eggs from 14 EU countries (localized markets) over the period 1995:1 to 2006:6. That means, the analysis relies on 138 time series observations from each of the 14 localized markets. The countries included are Austria (AT), Belgium (BE), Germany (DE), Denmark (DK), Spain (ES), Finland (FI), France (FR), Greece (GR), Ireland (IR), Italy (IT), the Netherlands (NE), Portugal (PT), Sweden (SE), and the United Kingdom (UK). The price of poultry is expressed in Euro per 100 kg, while that of eggs in Euro per 100 items. Both prices have been obtained from the European Commission (2007).

Figure 1 presents the evolution of the measures of global inequality in ratio. The global SDL for poultry prices appears to be generally decreasing during 1995, 1996, 2000, 2001, 2003, 2004, 2005, and 2006 and to be generally increasing during 1997, 1998, 1999, and 2002. Its average value in the first half of the sample is 0.21, while in the second half of the sample it is 0.18. Overall, the respective graph indicates that relative inequality in poultry prices has not been increasing over the sample period. The global SDL for eggs appears to be generally decreasing during 1995, 1996, 1997, 2000, 2003, 2004, and 2005, and to be generally increasing during 1998, 1999, 2001, 2002, and 2006. Its average value in the first half of the sample is 0.2, while in the second half of the sample is 0.24. Overall, the respective graph indicates that relative inequality in egg prices has not been decreasing over the sample period.

Figure 2 presents the evolution of the measures of global inequality in difference. The value of the global SD for poultry prices in the first half of the sample is 30, while in the second half it is 26.9. Overall, the respective graph indicates that the absolute inequality in poultry prices has not been increasing over the sample period. The value of the global SD for egg prices in the first half of the sample is 20.7, while in the second it is 24.6. Overall, the respective graph indicates that the absolute inequality in egg prices has not been decreasing over the sample period.

Table 1 presents the empirical values of the test statistics for global convergence in ratio and in difference.[5] For poultry prices, the null of no global convergence has been

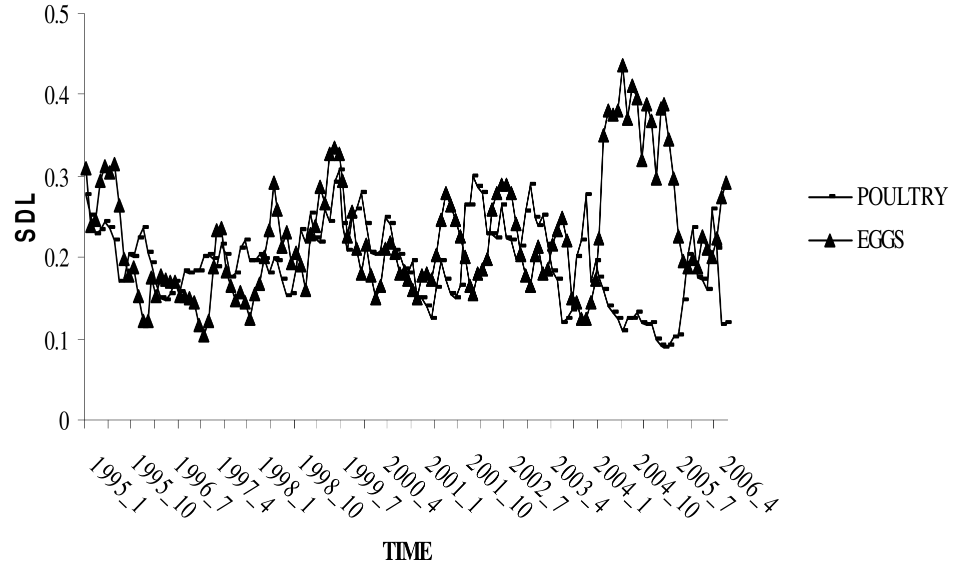

Figure 1. The Measures of Global Inequality in Price Ratios

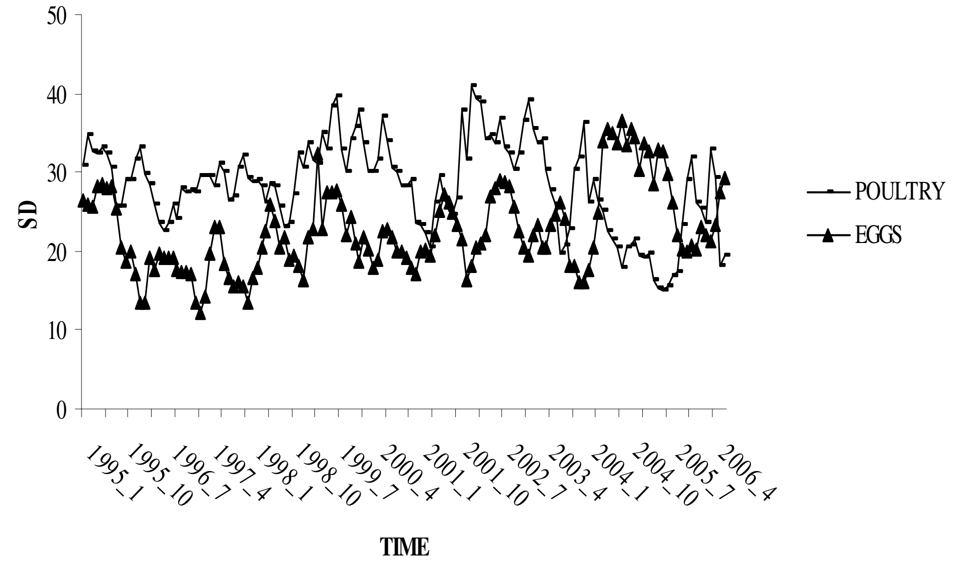

Figure 2. The Measures of Global Inequality in Price Differences

rejected at any reasonable level of significance suggesting that in the period under consideration inequality of poultry prices in the 14 EU members has decreased. Since the null has been rejected both for ratios as well for differences, convergence in poultry prices has

[5] The truncation parameter for calculating V_L has been selected optimally. In particular, m has been set equal to the integer part of $4(T/100)^{0.25}$ (e.g. Newey and West, 1994; Kwiatkowski et al., 1992). All computations have been carried out in Ox and they are available from the author upon request.

been a strong one. For egg prices, the null of no global convergence cannot be rejected. For both convergence in ratio and convergence in difference the empirical values of the respective test statistics are positive but not statistically significant, indicating that, for egg prices, inequality in ratio and inequality in difference have remained fairly constant.

Table 1. Tests for Global Convergence

	In Ratio	In Difference
Poultry	-2.23	-1.92
Eggs	0.85	1.27

Table 2 presents the aggregation history of the clustering algorithm in the search for egg price convergence clubs in ratio. In square brackets the clusters that are formed at each iteration are reported; C_k refers to the club formed in the kth iteration (for instance, at iteration 4 DE joined the club comprising FR, PT, and NE). There are three such clubs. The first consists of seven members (FR, PT, NE, DE, ES, BE, AT), the second consists of six members (DK, IT, SE, IR, GR, and UK), while the third consists of only one member (FI). Table 3 presents the aggregation history of the clustering algorithm in search for egg price convergence clubs in difference. There are three such clubs. The first consists of six members (FR, PT, NE, DE, ES, BE), the second consists of four members (GR, UK, AT, FI), and the third consists of again four members (DK, IT, SE, IR).

Table 2. Search for Convergence Clubs in Ratio (Egg Prices): Aggregation History of the Algorithm

Iteration	Clubs C_k	$\tau^{[i,j]}$ *
1	[GR][UK]	-6.13
2	[FR][PT]	-4.91
3	[C_2][NE]	-5.09
4	[C_3][DE]	-4.83
5	[DK][IT]	-4.72
6	[C_5][SE]	-5.07
7	[C_6][IR]	-4.76
8	[C_7][[C_1]	-3.38
9	[C_4][ES]	-3.27
10	[C_9][BE]	-2.49
11	[C_{10}][AT]	-1.66

*, the values do not have to be monotonic

Among the markets considered, the prices in FR, PT, NE, DE, ES, and BE converge strongly to each other. The same holds for the prices in DK, IT, SE, and IR as well as for the prices in GR and UK. In contrast, the prices in FI and in AT converge only weakly (the former in difference and the latter in ratio) to prices in other EU member countries. FR has common borders with ES, NE, BE, and DE, while ES has a common border with PT. This is an indication that proximity of localized markets may facilitate the price convergence process.

Table 3. Search for Convergence Clubs in Difference (Egg Prices): Aggregation History of the Algorithm

Iteration	Clubs C_k	$\tau^{[i,j]}$ *
1	[GR][UK]	-6.05
2	[FR][PT]	-5.22
3	[C_2][NE]	-4.57
4	[C_3][DE]	-4.26
5	[DK][IT]	-4.24
6	[C_5][SE]	-4.71
7	[C_6][IR]	-4.36
8	[C_4][ES]	-3.14
9	[C_1][AT]	-2.99
10	[C_8][BE]	-2.71
11	[C_9][FI]	-2.08

*, the values do not have to be monotonic

The evidence, however, is by no means uniform. For example, egg prices have converged strongly in GR and UK (or in IT and SE) which are national markets located far away from each other. Also, egg prices in FI and SE (which have a common border) have not converged to each other either in ratio or in difference.

5. Conclusions

Price dispersion in the EU is considered as a potential threat to market integration policies and it has been an issue of great concern and the focus of intense public debate. It is not accidental, therefore, that the European Commission has reinforced the monitoring and benchmarking of price differences in the context of the Internal Market Strategy. Despite the strong interest of policy makers, however, empirical economic research on price convergence in the EU is scarce.

This paper relies on recently proposed notions of convergence and an econometric test for the presence of a monotonic trend in a time series in order to investigate price convergence of two agricultural commodities (poultry and eggs) in 14 localized/geographically separated EU markets. According to the empirical results, there is global and strong convergence of prices in the poultry markets but not in the egg markets. The latter appear to be fragmented into a number of price convergence clubs.

The present study covered a period characterized by intensified efforts of the European Commission to reduce price differentials of the national markets in general (e.g. completion of the Single Market, establishment of the EMU, introduction of a number of structural reforms) and of the agricultural markets in particular (e.g. elimination of the Monetary Compensatory Amounts which acted as taxes/subsidies in intra-Community trade; enactment of the ‘mutual recognition principle” whereby commodities accepted for sale in one member country must be accepted in another as well). The empirical evidence from this paper suggests that the horizontal measures (meaning measures applying to all markets), may not be sufficient to deal with persistent price differentials. Future research, therefore, should concentrate on factors (such as distances, differences in market structures, differences in competitive pressures or per capita incomes and tastes) that are likely to influence price dynamics in geographically separated commodity markets. It appears that there are two possible avenues. One involves the estimation of multinomial logit models to determine factors affecting the probability of a market to become a member of a given price convergence club. Another, involves the estimation of hedonic models in price differentials. Both, however, require much more detailed information (e.g. from regional level) on prices and factors of interest which is not currently available.

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