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Are current EU cereal prices correlated?[1]

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ABSTRACT: This paper evaluates the correlations between European cereal prices in up to 87 markets of 24 Member States. History and geography play a role: The highest correlations are observed between closely located internal markets of the "old" Union; prices are more correlated along transport routes, in particular rivers. We observe that 10 years after the Accession (8 in the case of Rumania and Bulgaria) we do not have a complete integration between the "old" and the "new" Member States. We advance several possible explanations: Weaker producers' organisations, lack of storage facilities, less efficient transport facilities.

KEYWORDS: Cereals, Common Agricultural Policy, Europe.

JEL classification: C49, P22, P28, Q11, Q17.

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¿Existen correlaciones entre los precios actuales de los cereales en Europa?

RESUMEN: El artículo analiza las correlaciones de precios de los cereales, en 87 mercados de 24 Estados miembros de la Unión. La historia y la geografía desempeñan su papel: Por un lado, las mayores correlaciones se observan entre los mercados de la "vieja" Europa y, por otro, también siguen las rutas de trasporte, en particular fluvial. Los Alpes siguen siendo una barrera. No tenemos aún una integración completa entre los «antiguos» y los «nuevos» Estados miembros. Adelantamos algunas explicaciones posibles, en particular, la escasa organización de los productores y las deficiencias en las redes de transporte que todavía requieren inversiones.

PALABRAS CLAVE: Cereales, Europa, Política Agraria Común.

Clasificación JEL: C49, P22, P28, Q11, Q17.

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1. Introduction

The extent to which EU agricultural markets are integrated is highly relevant for European Union policy makers. As explained by Sanjuán and Gil (2001), “a weak degree of integration indicates that, despite the institutional efforts to achieve a unified market, prices are not perfectly transmitted and, therefore, misallocation of resources and distortions of production and distribution might occur. The greater the degree of integration, the more efficient is the interacting markets”.

Are current EU cereal prices correlated? As European civil servants, we would like to answer positively to this question. The Common Market Organisation for Cereals was the first CMO to be put in place, in 1962. Since then, the single market has been implemented and the free circulation of goods has become a basic principle of the European Union.

This was, for instance, the conclusion of Sanjuán and Gil (2001) for the EU pork and lamb markets in the period 1988-1995 and of Serra *et al*. (2006) in the case of the EU pork market in the period 1994-2004;

Tangermann (1992) analysed price relationships across Member States in the period 1974-89. He found that differences between prices and price variation in years 1987-89 increased in comparison with years 1974-76 which he interpreted as a sign of market deterioration.

The smallest price differences for wheat were between Belgium and UK, Germany and Belgium, France and Belgium while the biggest were between Italy and France. For barley the lowest gaps were between Germany and UK, UK and France and the highest between France and Italy. He found stronger correlation for wheat between neighbouring countries such as Belgium and Germany and weaker for Italy. For barley price trends were more similar across Member States than for wheat but transmission of price changes was weaker.

In a more recent study of the cereal market, Zanias (1999) found integration between France and Italy and between Belgium, Germany and UK.

We should expect that prices from closely located markets should tend to be more similar. In addition, Europe has a well-developed transport network and recent developments in communication technologies allow market operators to quickly find out about European and global prices and physical factors like weather, harvest etc.

Market price transmission amongst EU Member States (and along the food chain) is particularly relevant today. In the last decade, and particularly since the 2007/08 food crises, food price volatility in world markets has seen an increasing trend (Assefa *et al.,* 2014). Even more, the successive CAP reforms, the reduction of EU border protection after the Uruguay Round and some bilateral Free Trade Agreements, have connected EU and world prices for some important commodities such as cereals, sugar and milk with world prices. In addition, the last EU enlargements have significantly changed the face of the EU cereal market, with some “in land” countries such as Hungary and some “Black sea” exporters such as Bulgaria and Romania.

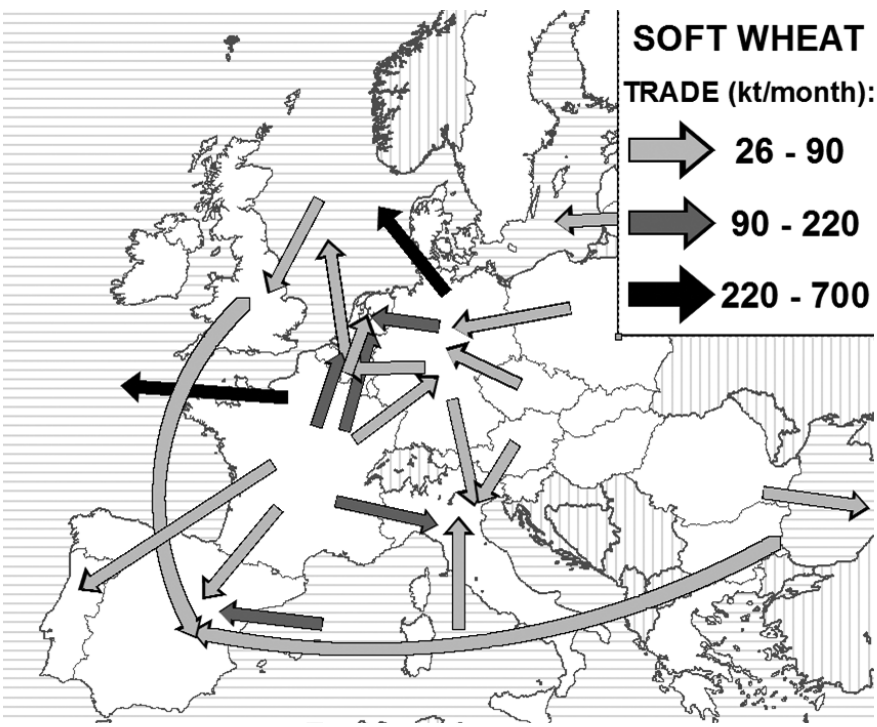
The present article is organised as follows. Section 2 provides with some basic information on the European cereal market. Section 3 includes a short literature review. Section 4 presents our data sources and the methodology followed in this analysis. In Section 5 we present our results and in Section 6 our concluding remarks.

2. Background analysis: EU cereal trade

Wheat is the most important cereal produced and trade in the European Union. The main flows, based on years 2004-2013[2] are indicated on the Map 1 based on Eurostat data presented in Table 1. COMEXT data do not allow making the difference between feed and milling wheat.

MAP 1

Soft wheat trade in the European Union (2004-2013)



Source: Authors' elaboration from Table 1.

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[2] On 1st May 2004, the European Union integrated 10 new Member States.

TABLE 1

Monthly average soft wheat trade

From	To	Average (kt/month)[3]
FR	Outside EU	691.640
DE	Outside EU	222.882
FR	NL	168.313
FR	BE	151.785
FR	IT	140.685
DE	NL	131.384
Outside EU	ES	111.435
Outside EU	IT	88.035
FR	ES	81.774
DE	BE	70.600
UK	ES	67.005
CZ	DE	61.151
BG	ES	52.514
FR	PT	51.127
BE	NL	50.429
RO	Outside EU	47.013
DE	IT	41.255
FR	DE	39.403
Outside EU	UK	38.675
LT	Outside EU	33.618
AT	IT	33.078
BE	Outside EU	31.208
PL	DE	26.413

Source: Own calculations based on Eurostat.

France, Romania, Austria and Lithuania are the main exporters; Portugal, Spain, The Nederland and Italy the major importers and Belgium, United Kingdom and Germany were both importing and exporting. The highest flows were exports to partners outside the EU from France and Germany. Imports from outside the European Union were a key component of the market in United Kingdom, Spain and Italy.

[3] Monthly average.

We have done similar analysis for corn and barley. For the former, France and Hungary were exporters to neighbouring countries. France was the biggest exporter in terms of volumes and number of trade partners. Portugal and Spain were importers importing from France and outside the EU. Italy, Germany and The Nederland were both importing and exporting from neighbouring countries and outside the EU. Romania was exporting outside the EU. As for wheat, imports from outside the European Union were a key component of the market in United Kingdom, Spain and Italy.

For barley also France is the biggest exporter. The other exporters were United Kingdom, the Czech Republic and Romania. Spain, Italy and The Nederland were importers and Belgium and Germany were both importing and exporting.

3. Literature review

There is an abundant scientific literature on the issue of price transmission. Outside the agricultural markets, in recent years the transmission of financial crisis and the concept of contagion (for instance Rigobon, 2003; Bekaert *et al.,* 2005; Dungey *el al.,* 2005 and 2007; Ahlgren and Antell 2010) have received particular attention.

A number of analyses conducted on spatial price transmission have focused also their attention on agricultural and food markets. For instance, Goodwin and Piggott (2001) on corn and soya in North Carolina; Serra *et al.* (2006) looked to the US egg market; Ben-Kaabia and Gil (2007) have analysed price transmission in the Spanish lamb sector; Balcombe *et al.* (2007) looked at Brazilian wheat, maize and soya prices; Brümmer *et al.* (2009) at wheat and flour market in Ukraine; Hassouneh *et al.* (2010) at Spanish bovine market and the BSE effect; Abdulai (2000) and Ankamah-Yeboah (2012) to the maize market in Ghana.

Fackler and Goodwin (2001) indicated correlation coefficient as an “initial descriptive device” for studies on market integration. The basic assumption is that prices of the same crop in spatially linked markets should be highly correlated. Matrix of pairwise correlations between markets was the first method in the economic literature used to find the most and the least correlated markets. In the research of Mohendru (1937) on fortnight prices in Punjab pairwise correlation coefficients ranged from 0.43 to 0.86. The majority of analyses of correlation were conducted in the developing countries (see a list in Fackler and Goodwin, 2001). Amongst the analyses for Europe concerning historical market integration, Ejrnæs and Persson (2000) analysed the market integration and transport costs in France from 1825 to 1903 and Federico (2012) covers works within Europe or involving European cities from the thirteenth century to the Second World War.

As far as European agricultural markets are concerned, in addition to the studies already quoted in the introduction, Gaetano Santerano and Cioffi (2012) have looked to the price transmission during market crisis, taking as case study the European vegetable sector.

It should be underlined that physical trade between two markets is the relevant evidence of market integration and not correlations as such (Heytens, 1986). Low correlation coefficient may arise in a situation of seasonal change in the direction of commodity flow (Heytens, 1986 after Timmer, 1984). Two markets may not have direct trade with each other but be highly correlated if, for instance, they share the same destination market (Harris, 1979). High correlations may also appear not only on efficiently integrated market system but also in the situation of monopoly or price fixing (Heytens, 1986). Common price trends (like general inflation); common seasonality (especially likely in agriculture); different agents located in spatially different markets selling into a third, common, market (Serra *et al.,* 2006) or any other synchronous common factor, may produce parallel but unrelated price co-movements on different markets (Heytens, 1986). The exogenous trends coming from general inflation and seasonality can be adjusted for by de-trending the data.

On the other hand low correlations may appear where due to storage and delays in arranging sales or in delivery, the co-movement of prices is not synchronous (Fackler and Goodwin, 2001).

4. Material and methods

4.1. Data sources

The analysis has been conducted for maize, feed barley, milling and feed wheat. Trade data are from COMEXT. The dataset on prices consisted of time series of prices for each crop reported once a week by the EU Member States and stored in a database of the Directorate General of Agriculture of the European Commission (DG AGRI).

Our results have to be interpreted with care. Despite significant progress on data harmonisation, prices are not completely uniform for the reported stage. In particular, depending of the country and the market, prices can be in silo, Free on Board (FOB), delivered, truck or unknown. Some time series are not continuous throughout the period of the analysis (May 2004 – June 2013). Nevertheless, it is a unique source of market information, today not publicly available.

US prices were taken from the database of the International Grain Council (IGC) and transformed to Euro by using exchange rates of the European Central Bank.

4.2. Analysis

As Sanjuán and Gil (2001) underlined, applying one method of analysis may not be flexible enough to account for the complex interactions of prices in separated markets. Nevertheless, our methodology can be seen as a first step in an ongoing analysis. We focused on the spatial aspect of crops trade and prices. As far as we are aware, no published study has addressed until now EU spatial agricultural price relationships after the 2004 enlargement and we have been able to draw some conclusions which, we believe, presented some interest.

Analysis of physical trade of cereals has been conducted to provide a background for price correlation analysis in view of all price correlations limitations presented in the introduction. In the analysis monthly volumes of soft wheat, barley and maize traded between EU Member States and external partners in period 2004 – 2013 have been extracted from the COMEXT database. To identify the highest and most continuous in time flows a trimmed average have been calculated for all the period for each pair of importer – exporter (20 % of highest and lowest values was excluded from the average calculation to avoid the impact of exceptionally high and low values).To limit the dataset size all non-EU countries have been treated as one external partner. For each cereal the trimmed averages[4] have been arranged in decreasing order to identify pairs importer-exporter with the highest volume. These pairs have been presented with arrows on maps. To avoid congestion on maps and present the biggest trade flows only the highest volumes which together make up around 65 % percent of sum of all trade have been presented. The threshold of 65 % was selected empirically.

The analysis was conducted for maize, feed barley, milling and feed wheat. It was, in particular, important to make the difference between milling and feed wheat as they are 2 different markets responding to 2 different logics. The exporting Member States are different so are the clients and the degree of potential substitution with competing crops.

In order to include the potential correlations with external markets the dataset was expanded with the series with weekly average FOB prices of Soft Red Winter wheat, 3 Yellow Corn maize from US and feed maize, feed and milling wheat from Ukraine.

To account for spurious correlation due to inflation prices were detrended as described by Lentz *et al.* (2012). Prices from time series for each single market were divided by corresponding value of the Consumer Production Index (CPI) for given country and month.

Next, to minimise the impact of the seasonality prices have been also divided by the seasonality index. The seasonality index was calculated for each month in the following way. First for each country, for each crop and month a monthly average price was calculated. This average was divided by the corresponding monthly value of CPI. Finally the averages divided by the CPI were averaged for the same month in order to obtain an index for each month.

Finally a coefficient of correlation was calculated between all markets for the same crop. Correlation coefficients were calculated only if there were at least 100 observations in the time series and 50 pairs to calculate the correlation coefficient between 2 time series. To account for lower correlations due to a possible delay in price co-movement we applied a simple technique of shifting one of time series before calculating correlation coefficient: For each pair of markets time series of prices of the second market was shifted forward and backwards by 3, 2 and 1 week (e.g. quotation of day 21 became 14 and 7 of the month). If the correlation coefficient calculated with the use of shifted series was higher than the initial correlation the shift and correlation were recorded. As a result a table with pairs of time series, correlation between them with and without shift and shift value were obtained. The table was sorted by the decreasing correlation in order to find the most highly correlated time series.

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[4] Average of the last 5 years removing the highest and the lowest.

To detect the spatial patterns, especially due to time lags, a set of maps was created by plotting correlations as lines between markets with arrows showing the shift when correlations after shifting a time series was higher than the initial correlation without time shift.

For each crop we created a set of maps showing from 1 to 20 percent of highest correlations.

5. Results

Before presenting results spatially we give a summary of correlation analysis for all crops. We have selected 6 indicators listed in a Table 2.

TABLE 2

Summary of correlation analysis

Crop	Maize	Feed Barley	Feed Wheat	Milling wheat
Number of EU markets (Member States)	65 (17)	85 (24)	54 (18)	87 (22)
Number of pairs for correlation analysis (EU)	2,064	3,493	1,400	3,667
Average correlation after shift within EU (without shift)	0.9217 (0.9123)	0.9295 (0.9191)	0.9289 (0.9174)	0.9338 (0.9261)
Coefficient of variance of correlation within EU (%)	7.6	5.3	5.6	6.4
Average value of trans-border correlations	0.9162	0.9268	0.9254	0.9305
Position of first trans-border correlation as % of number of pairs	3.2	0.6	1.4	1.6

Source: Authors' calculation from Eurostat, DG AGRI, International Grain Council and European Central Bank.

The number of markets with time series meeting the earlier described requirements was different for each crop. This directly impacted the number of pairs of markets for correlation analysis. The biggest number of markets, and thus markets pairs, was for milling wheat and the lowest for feed wheat.

Even after compensating for the impact of seasonality in inflation, the average correlation between prices for all crops was in general high, at level of 0.9 and more. This had an impact on the way in which we present further correlations between single markets on maps. Shifting time series to compensate for time lags further increases the average correlation.

Moreover the assumed time lags between price markets presented spatially later in the article are consistent between markets and in line with crop trade directions. This can be an evidence of validity time series shifting technique applied in the current analysis.

Maize is the most diversified in terms of correlation strength variability and feed barley has the lowest variability. Milling wheat has the highest average of trans-border correlations while maize the lowest. Correlations between markets located across national borders are lower than correlations markets inside the same EU Member State. This is confirmed by the position of the first trans-border correlations on the list of all correlations

Below we describe the spatial distribution of the highest correlations between the markets for each crop starting from the highest. We also describe trends in time lags in price development based on sets of 20 maps created for each crop. Due to space limits and for clarity we present only maps which best illustrate tendencies described in the text.

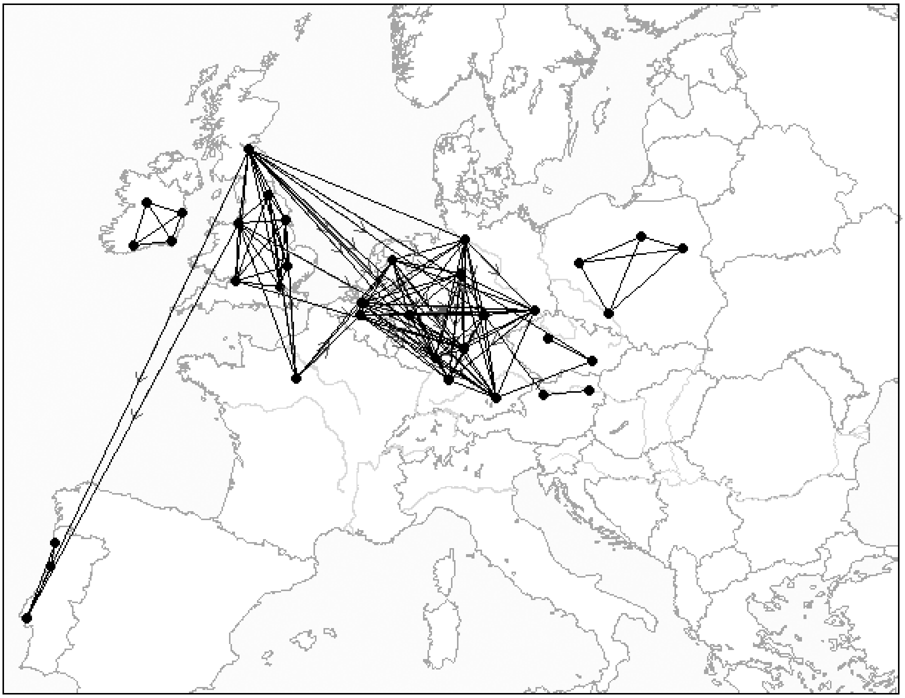
5.1. Feed Wheat

In the case of feed wheat trans-border correlations Belgium – Netherlands and Belgium – Germany are within the 2 % of the highest correlations. In this subset there are internal correlations in the UK, Ireland, Portugal and Germany. Most of the 6 % of highest correlations is concentrated between Belgium, The Netherlands and Germany. The delay in price formation has an inland direction from the Northern areas and ports. Markets from the UK and France also precede the markets in Belgium, Netherlands and Germany.

For France and UK, the result is consistent with the trade flows we have presented in Section 2. Ireland appears correlated with Northern Europe ports rather than UK. Correlations appear between Polish and Czech markets. The correlation between UK and Portugal appears in the 8 % of highest correlation, on line with the deep historical trading links between those 2 Member States.

MAP 2

Feed wheat. 8 % of highest correlations



Source: Own calculations based on DG AGRI.

5.2. Milling wheat

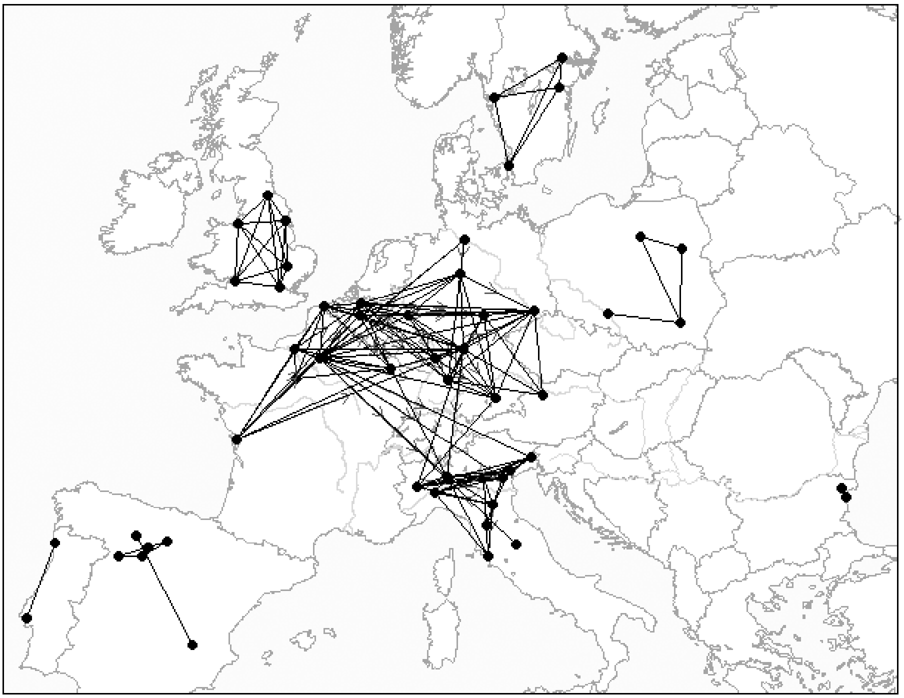
Similar to feed wheat, first trans-border trade correlations between France, Belgium and Germany are amongst the highest 2 %, jointly with the correlations inside the internal markets of Portugal, Spain, France, UK, Italy, Germany, Sweden and Bulgaria.

When we move to 4 %, we found trans-Alps correlations, despite the fact that it is a transport barrier. This could be due to the non-substitutability of milling wheat as compared to feed cereals.

Distribution of 7 % highest correlations shows separate areas: Portugal, Spain, United Kingdom, highly correlated area of France, Belgium, The Netherlands, Germany, Italy, Austria and Czech Republic.

MAP 3

Milling wheat. 4 % of the highest correlations



Source: Own calculations based on DG AGRI.

5.3. Feed maize

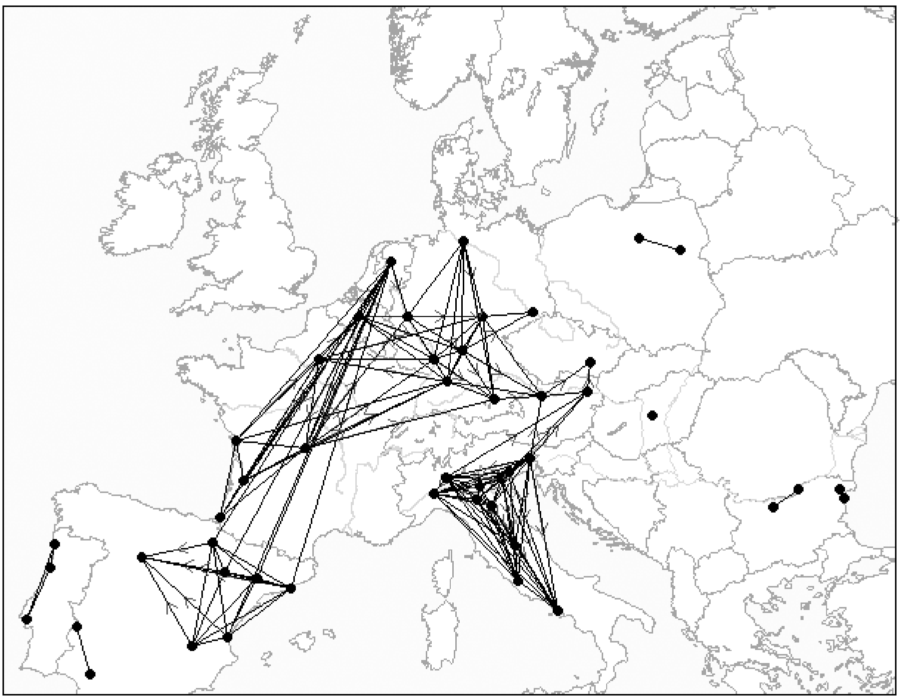
3 % of the highest prices correlations concern the internal markets of Spain, France, Italy, Germany and Austria. In Italy, price transmission moves from the North (main producing region) to the South.

In Germany the most highly correlated markets are located in South-Western Germany. The links overlap with the river shipping route of Rhine, Main and Danube. In France the most correlated markets are located in the South-Western part - maize producing region. In Spain the strongest correlations are between ports and inland markets, as a logic consequence of the special provisions foreseen in the Spanish Act of Accession which guarantees preferential access to third country (originally US) corn.

The correlations follow the valleys. The first trans-border correlations appear among 4 % of the highest correlations (Central France, Belgium and Southern Germany) and increase on the 5 % (France with The Netherlands, Belgium with Germany and Germany with Austria along Danube).

MAP 4

Maize. 7 % of the highest correlations



Source: Own calculations based on DG AGRI.

With threshold of 6 % appear correlations between local markets in Portugal and trans-border correlations between the Netherlands and Germany, Austria and Italy – linking North and South of Europe and between the Netherlands and Belgium and Spanish ports which can reflect the impact of imports from outside the EU on prices. Observation of time lags for a higher number of correlations allows identifying that the delay goes inland from ports.

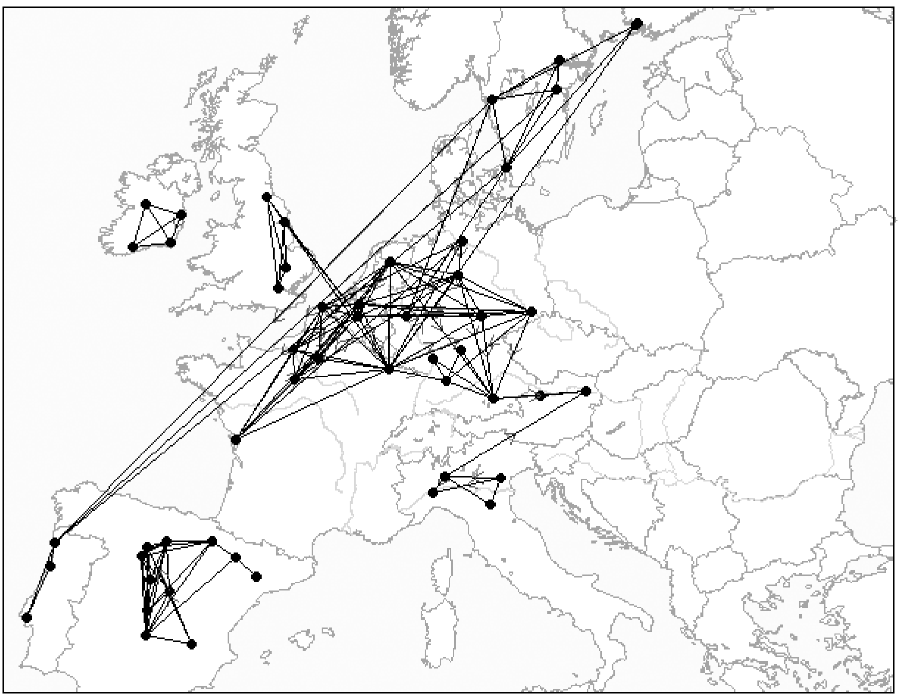
The first correlation with a "new" Member State (between Austria and the Czech Republic) appears after threshold of 7 %. The correlations between local markets in the new EU Member States are lower than within and between markets of the "old" Union. This cannot be explained only on the basis of the exchange rate barrier. Hungary highest trans-border correlation appears first with Czech Republic and not as one may expect with Austria along the Danube.

5.4. Barley

Contrary to maize, first trans-border correlation between France and Belgium belongs to 1 % of the highest correlations. The remaining correlations concern closely the located internal markets of Portugal, Spain, France, United Kingdom, Ireland, Germany and Sweden.

MAP 5

Barley. 4 % of the highest correlations



Source: Own calculations based on DG AGRI .

Extension to 2 % adds to the picture correlations: France – Germany, France – The Netherlands and The Netherlands – Belgium, as well as internal market correlations in Spain, Italy, Germany and Austria. Majority of new correlations appears in a form of a bow which goes first along Northern Germany and descends to the South in the Eastern Germany. This pattern may reflect the river transport network.

Extending the threshold to 4 % reveals more complete picture. As in case of maize, Austrian markets are correlated both with Germany and Italy linking Northern and Southern Europe. There are also correlations between UK - France and Portugal – Sweden – Finland. This may reflect the fact that Portugal may import barley from these countries. Metz in France seems to be a central point correlated to markets in France, UK, Belgium, Germany, Scandinavia and even Bulgaria.

Spain and Poland are more isolated and belong to the 20 % of the highest correlations.

6. Concluding remarks

This paper evaluates the correlations between European cereal prices in up to 87 markets of 24 Member States, trying to answer to our original question: Are current EU cereal prices correlated?

Our main findings could be summarizing in the following points:

- Correlations between prices for all crops are in general high, at level of 0.9 and more.
- Maize is the most diversified in terms of correlation strength variability and feed barley has the lowest variability.
- Milling wheat has the highest average of trans-border correlations while maize the lowest.
- The highest correlations are observed between closely located internal markets of the "old" union.
- Prices are more correlated along transport routes, in particular rivers. Alps continues to be a transport barrier, as it was when Tangermann (1992) made his study.
- Inclusion of time lags in the analysis increased correlation between time series. The delays observed on maps have directions which are consistent with the trade flows we have observed.

  Despite this globally positive picture, we observe that 10 years after the Accession (8 in the case of Bulgaria and Romania) to the European Union, we do not have a complete integration between the "old" and the "new" Member States. Correlations between local markets of the new EU Member States are lower than within and between markets of the "old" Union.

  Obviously, this issue deserves further research. Nevertheless, we can advance some possible explanations, partly correlated amongst them:

- Weaker cooperatives and producers' organisations. "The socialist-experience has until today a major influence in Central and Eastern Europe" even if the situation is significantly different from one country to another, in particular due to way the transition processes after 1989 have worked out (Bijman *et al.,* 2012).

- Lack of storage facilities on farm which force farmers to sell once the cereals are harvested. They are generally owned by the traders. This is why a standard balance sheet analysis can allow to anticipate the net annual surplus (or deficit) of one of those Member State (in particular Rumania and Bulgaria) but not the total volumes available for export at the beginning of the marketing year and the volumes of imports which could take place at the end of the campaign.
- Less efficient transport facilities. Local markets (for instance Hungary or the Czech Republic) are more isolated and consume first locally produced grain and only after other more costly grains.
- The reduction of the EU border protection, and in particular the 155 % rule[5] imposed by the US to the EU in the context of the renegotiation of the Blair House agreement, implies that it can be cheaper in some West-European countries to import cereals from Canada, the United States or the Black Sea than to trade it from Eastern Member States.

But our main conclusion is that this analysis is just a first step. Further analysis is required. We have access to powerful European price database which should deserve to be analyse with more sophisticated tools as those used in the most recent literature. In addition, the Directorate general for Agriculture of the European Commission has access to different transport costs which would allow deeper price convergence analysis.

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[5] The revised Blair House agreement has capped the EU import duty at a maximum of 55 % of the cereal intervention price.

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