CHANGES IN SELECTED POLISH AGRICULTURAL PRICE VOLATILITY

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Abstract
There is a growing concern about issues related to high agricultural commodities price volatility since the food crisis in 2007/08. In this contribution the development of Polish agricultural price volatility is analyzed. Polish wheat, pork and beef prices volatilities were quantified and compare to volatilities of prices on European and international markets. There is an increase in wheat price volatility in 2005-2014 comparing to years 1993-2003, while pork and beef prices became more stable. Relative growth of Polish agricultural price volatility is present on all three analyzed markets. To identify changes in volatility transmission patters Granger causality tests were also performed. Change in wheat price volatility transmission was revealed.
Keywords
agricultural prices, volatility, agricultural policy, Polish agricultural markets

Introduction

The issue of agricultural commodities price volatilities has always attracted considerable attention of farmers, policymakers and agricultural economists. There is a vast literature that deals with the problem of unstable prices in agri-food sector. Since food crisis in 2007/08 there is observed even growing number of studies on price volatility (Kornher, Kalkuhl 2013).

In this paper the problem of agricultural price volatility from farmers perspective is taken into consideration. The question is whether the price volatility after joining the European Union (EU) decreased or opposite. Operating on the EU Single Market should stabilise agricultural prices since impact of weather conditions on total production is more heterogeneous. On the other side since Luxembourg reforms in 2003 Common Agricultural Policy (CAP) became more market-oriented and price risk in agriculture is quite high. Trade liberalization also matters since price shocks from international markets are quickly transmitted to domestic markets in last decades. Wheat, pork, and beef prices on Polish, European, and International market covering the period 1993-2014 are used to find the answer to question whether EU accession helped Polish farmers with price risk. The annualized standard deviation of logarithmic price ratios is used as a volatility measures. Prices from International markets are used as a benchmark. Then the assessment of Granger causality between analyzed time-series is tested to help to understand the nature of price volatility transmission.

1. Literature review

As it was mentioned above there is wide scientific literature dealing with problems of price volatility in agriculture. It should not be a surprise since high price risk can cause loss of economic efficiency, retard economic growth and has significant negative impact on farmers' welfare (World Bank, 2005). Higher price volatility can also increase food insecurity,

especially in developing countries (Sarris 2013). Haile and Kalkhul (2013) also proved that output price volatility discourages agricultural investment in terms of cropland expansion.
Significant upward shift in agricultural price volatility since the beginning of food crisis in 2007/08 drove intensified attention on topic of price volatility. However Chand (2010) shown that even before food prices are more volatile than any other commodity. Since there is a wide consensus that there was real growth in prices volatility, the biggest effort was put to identify causes of that growth.
Growing global biofuel sector and increased strength of linkage between prices of energy and agricultural products is one of the most important factor (Saghaian 2010; Serra Zilberman 2011, Tyner 2010). Patton et all (2012) give more details about transmission of price volatility from energy markets to agricultural markets. Another explanation for increased agricultural prices volatility is development of food commodity futures markets (von Braun, Tadesse 2012; Gilbert 2010). This close connection of agricultural and financial markets raises the question about the role of speculation in food price changes. However the debate is still far from being settled. Results of studies confirmed in this field are ambiguous (Haile, Kalkhul 2013). Among other factors of observed price volatility growth supply shocks due to unfavourable weather conditions and growing demand for food caused by rapid economic growth in China and throughout Asia (Gilbert 2010) and volatile exchange rates (Balcombe 2009) are the most often mentioned. Figiel et al (2012) presented the complete list of factors influencing volatility of agricultural commodity prices.
Although there are many studies concerning issues of price volatility in agriculture, the majority of papers refers to price changes in highly developed or developing countries. As Bakucs and Jambor (2014) noticed the analysis of food price volatility in New Member States (NMS) of UE is actually missing. In their study Bakucs and Jambor (2014) using the Eurostat monthly food price indices for years 2005-13 found that food price volatility differs significantly among NMS and different products. During the 1st decade in EU Hungary experienced the highest volatility, while Slovakia and Slovenia the lowest. It also turned out that volatility of NMS food prices exceeded EU27 levels. In another study concerning the agricultural price volatility in selected East European countries authors evaluated levels and components of wheat price volatility in years 2004-2011 and examined the sensitivity of volatility to spatial aggregation of the price data (Figiel et al. 2012). Despite fact, that on EU single market price levels follow similar trends differences in volatility of national prices were demonstrated. Smaller countries like Lithuania, Slovakia or Hungary experience higher volatility, while prices in France or Germany are more stable. Polish wheat prices volatility was close to the EU average. Agricultural price volatility on the German markets were analyzed by von Ledebur and Schmitz (2012). They focused on an agricultural policies impact on price volatility and showed that after Mid-term-Review of CAP, historical volatility increased significantly in Germany.

2. Data and Methods

In this paper monthly Polish prices of wheat, pork and beef prices are used to assess the level of volatility in period from January 1993 to December 2014. The data source was Central Statistical Office (CSO) of Poland. German prices from all three analysed markets are also used as a proxy for European prices. Those data are taken from Agricultural and Rural Development European Union (ARDEU) commission database. Although time series for average EU price are available as well there is suspicion that such an aggregated prices are less volatile than those from any single member state. As a benchmark International prices are used. For wheat it is American soft red winter wheat export price delivered at the US Gulf port for prompt or 30 days shipment; for pork – American Swine (pork), 51-52% lean Hogs,

U.S. price; for beef – Australian and New Zealand beef 85% lean fores, CIF U.S. import price. All three time series are from International Monetary Fund (IMF) database.
Consumer Price Indices for analyzed countries from Federal Reserve Bank of St. Louis Database are used to convert nominal to real prices. The analyzed time series of real prices were decomposed through multiplicative model into following components: trend, seasonal changes and random fluctuations. Seasonality effect was identified with seasonal dummy variables and then time series were deseasonalized since this part of volatility should not be considered as a real price risks for farmers.
There are different methods to measure volatility. From relatively simple ones like counting observations outside some specified thresholds around trend [Bakucs, Jambor 2014] to more sophisticated various class of Generalized Autoregressive Conditional Heteroscedasticity models (Yang et al 2001). Review of different volatility measures can be found at (Figiel, Hamulczuk 2012). In this paper annualized standard deviation (SD) of logarithmic price ratio is employed to measure price volatility. It is defined as follows:

$$\sigma_t = \left[T * \left({}^{1}/_{n-2}\right) \sum_{t=2}^{n} (r_t - \bar{r})^2 \right]^{1/2}$$

where r_t is rate of return in moment *t* defined as $r_t = ln\left({}^{Y_t}/_{Y_{t-1}}\right)$, $\bar{r}$ is the average rate of return in the period from 1 to n (number of observations) and T is the number of periods in year (12).
To identify whether there is volatility transmission between analyzed time series and in which direction, Toda and Yamamoto procedure to test for Granger causality is employed (Toda Yamamoto 1995).
The Augmented Dickey-Fuller (ADF) test were used to determine order of integration. If null hypothesis is not rejcted it means that there is a non-stationarity. T-statistic of coefficient φ in the following formula is the base for ADF test statistic (Lütkepohl, Krätzig 2007):

$$\Delta y_t = \alpha_t + \varphi y_{t-1} + \sum_{i=1}^{p} \delta_i \Delta y_{t-i} + \varepsilon_t$$

where: y_t – observation in time *t*, α_t – deterministic term, p – the lag order (as suggested by Akaike's Information Criterion - AIC) δ_i, ε_t – coefficients describing the short-run persistence of Δy_t.
Formula of Vector Autoregression (VAR) model that will be set up is presented below (Tsay 2010):

$$Y_t = \psi D_t + A_1 Y_{t-1} + \ldots + A_p Y_{t-p} + u_t$$

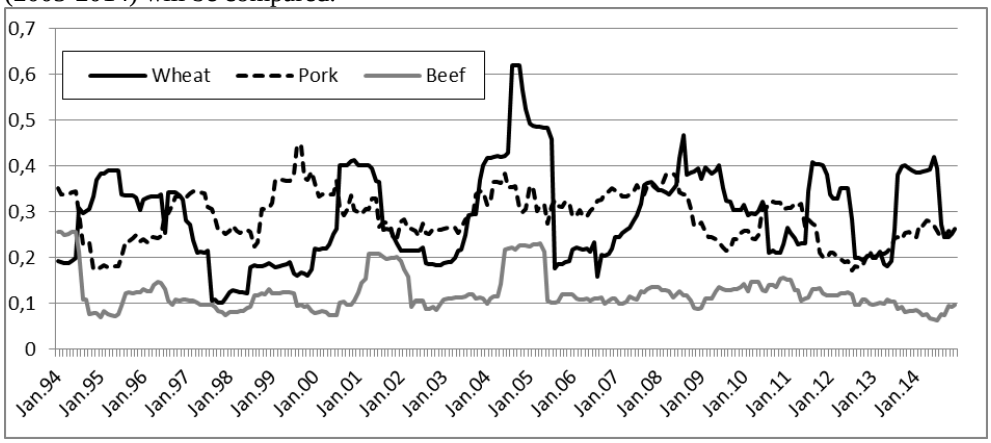
where: Y_t – stochastic process, D_t – vector of deterministic variables, Ψ – matrix of deterministic variable parameters, A_i – coefficient matrices, p – order of VAR model. In Toda-Yamamoto (T-Y) procedure data in VAR model are not differentiated. Maximum lag length p is sum of number suggested by AIC (q) and maximum order of integration (m) of analyzed time series. If there is serial correlation in the residuals, p can be increased to resolve this problem.
We say that there is Granger causality if forecasts of *y* variable are better when values of *x* are used than without them (Lütkepohl, Krätzig 2007). Granger causality test is based on following formula:

$$y_t = a + \sum_{j=1}^{k} \alpha_j y_{t-j} + \sum_{j=1}^{k} \beta_j x_{t-j} + \varepsilon_t$$

where: a, α, $ß_j$ – model parameters, k – maximum lag length, ε_t – random component. Null hypothesis states that $ß_1=\ldots=ß_k=0$, what means that there is no Granger causality. Testing Granger causality using T-Y procedure it is essential to test the hypothesis that only first q lagged values (number obtained by using AIC) of x equals 0.

3. Results

As it can be seen on Fig. 1 it is hard to answer the question whether volatility of Polish agricultural prices measured by the annualized SD of logarithmic price ratios increased after joining the EU on basis of the graphical interpretation. However it is easily perceived that prices of every three analyzed products were highly unstable during 2004, when price adjustment processes took place. This is the reason why in following part of this study this period will be excluded from analysis, and two pre- (1993-2003) and post-accession periods (2005-2014) will be compared.



Source: Own calculations based on GUS

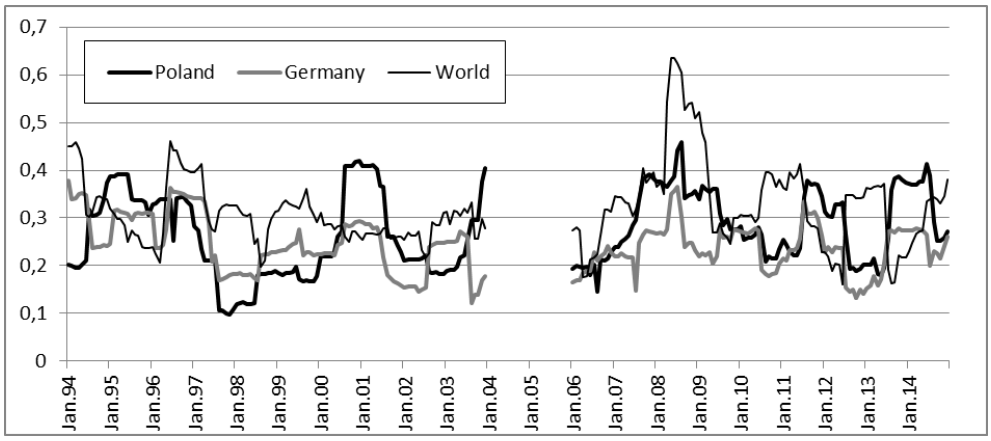
Fig. 1 Volatility of wheat, pork, and beef prices in Poland in 1993-2014

It should be noticed, that although prices from period 1993-2014 are analyzed, time series of annualized SD must be shorter due to requirements of calculation. In order to assure the transparency of presented graphs, the results of price volatility analysis of each agricultural product will be presented in separate subsections.

3.1. Wheat prices volatility

As it was seen in Fig. 1 it is difficult to assess whether Polish wheat price volatility changed after joining the EU. The same is the case when Polish prices volatility is compared to the German and World price volatilities, as it was presented in Fig. 2.

Although wheat market in Poland and EU was far from being fully open to international trade during analyzed periods some similarities in volatility changes are easily visible. Due to price transmission from international market there are growths of price volatility that were results of dynamic increase in wheat prices in the 1st half of 1996, during food crisis 2007/08, then in 2010/11 and 2012/13 years on all of three markets.



Source: Own calculations based on GUS, ARDEU, and IMF.

Fig. 1 Volatility of Polish, German, and World wheat prices in 1993-2003 and 2005-2014.

Table 1 Basic statistical measures of the annualized SD of logarithmic Polish, German and World wheat price ratio

Measure	Poland pre 2004	Poland post 2004	Germany pre 2004	Germany post 2004	World pre 2004	World post 2004
Mean	0,222	0,282	0,243	0,237	0,297	0,337
Median	0,257	0,292	0,249	0,236	0,305	0,333
SD	0,090	0,073	0,062	0,048	0,057	0,100
Lower quartile	0,186	0,221	0,211	0,206	0,266	0,270
Upper quartile	0,338	0,368	0,294	0,271	0,327	0,371

Source: Own calculations based on GUS, ARDEU, and IMF.

Descriptive statistics of price volatility time series presented in Tab 1. indicate that volatility prices of German and Polish wheat were quite equal during 1993-2003 period and both were significantly lower than world wheat price volatility. This is probably the result of agricultural policy in Poland and UE before 2004. The aim of the Polish agricultural policy before joining the EU was to keep cereals (wheat and rye) prices stable. It was achieved by setting minimum price for wheat at relatively high level, intervention purchasing and high import tariffs. For instance during marketing year 1995/95 Agricultural Market Agency (AMA) purchased nearly 70% of all registered purchasing. Similarly in the EU wheat prices in this period were most often directly dependent on fixed intervention price, and there were serious trade barriers on the borders. Considerable part of German wheat price volatility before 2004 is caused by changes of intervention prices.

After year 2004 volatility of Polish and World wheat prices increased significantly. CAP is more market-oriented policy that previous Polish national agricultural policy. There were also few serious shock prices on international cereal markets that was transmitted to European market. It is worth to mention that 2004 is used as a threshold year in studies concerning effect of biofuel productions to agricultural prices volatility [da Silveira, Mattos 2015]. Surprisingly after 2004 German wheat prices volatility decreased a little bit comparing to period before 2004.

When comparing Polish and German and World wheat prices volatility changes growth of volatility of Polish producer wheat prices should be noticed. On average (measured by mean value) volatility of Polish prices before 2004 equaled 97% of recorded on German market, but after 2004 rose to 122%. When comparing to World prices Polish wheat price volatility increased from 81% to 84%.

Table 2 Granger causality test results for wheat prices volatility

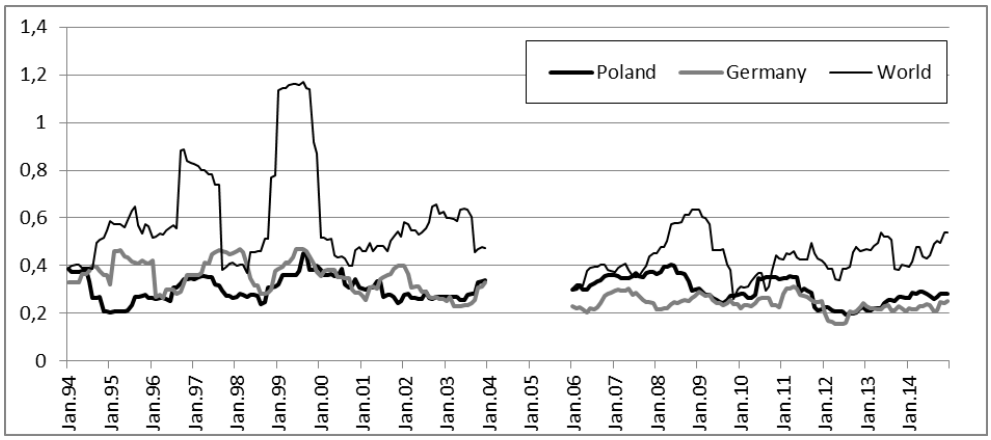
		1993-2003		2005-2014	
Cause	Effect	F Statistics	p value	F Statistics	p value
Germany	Poland	0,90334	0,553266	**2,64472**	**0,003754**
World	Poland	**2,99286**	**0,054243**	1,58542	0,112487
Poland	Germany	1,20116	0,294894	0,79572	0,683890
Poland	World	1,43667	0,242142	1,53650	0,128394

Source: Own calculations.

Results of Granger causality tests are presented on Tab. 2. Every analyzed time series was integrated of order 1. It should be noted, that since null hypothesis states that there is no Granger causality, low p values indicate presence of Granger causality. As it is noted in Tab. 2, in the first analyzed period we can say that volatility of World prices Granger caused volatility of Polish wheat prices. It has changed after joining the EU. After 2004 volatility of Polish wheat prices was Granger caused by volatility of German prices.

3.2. Pork prices volatility

Pork cycles are well known phenomena that exist all around the world on hog markets. As a consequence of cyclical fluctuations of livestock supply there is high price volatility on pork market. The levels of price volatility on pork market are much higher than those observed on wheat markets, what can be seen when Fig. 1 and Fig. 3 are compared.



Source: Own calculations based on GUS, ARDEU, and IMF.

Fig. 3 Volatility of Polish, German, and World pork prices in 1993-2003 and 2005-2014.

However spikes of volatility are relatively less frequent than on wheat market. Pork price cycles are common, but somehow stable. The only exceptions are spikes observed on American market that was a consequence of unexpected growth of prices in 1996 and sudden drop in 1998. Since there was no rapid changes of pork prices during food crisis in 2007/08 and afterwards, as it was observed on cereals or butter and cheese markets, The level of volatility did not increase after 2004.

Table 3 Basic statistical measures of the annualized SD of logarithmic Polish, German and World pork price ratio

Measure	Poland pre 2004	Poland post 2004	Germany pre 2004	Germany post 2004	World pre 2004	World post 2004
Mean	0,282	0,289	0,359	0,239	0,545	0,428
Median	0,302	0,296	0,355	0,241	0,603	0,436
SD	0,052	0,056	0,068	0,033	0,207	0,083
Lower quartile	0,266	0,254	0,299	0,221	0,462	0,382
Upper quartile	0,345	0,351	0,410	0,263	0,639	0,477

Source: Own calculations based on GUS, ARDEU, and IMF.

As it is shown in Tab. 2 before 2004, volatility of pork prices in Poland was much lower than in EU or in international market. The same as in the case of wheat, low volatility can be tied to high level of government intervention in the market processes. The aim of agricultural policy towards pork was to stabilize prices and farmers' income. The most important tool was intervention purchasing. In general AMA purchased pork in the times of oversupply and sell its own reserves when prices were high. When prices were low the export was subsidized. There was no such a support for pork producers in the EU.
Since Polish pork prices volatility remained almost unchanged after 2004 and volatility decreased in markets that are set as a benchmark, it can be concluded that pork producers in Poland face relatively higher price risk after joining the EU. Mean value of price series constructed as relation of pork price volatility in Poland and in Germany rose from 97% before 2004 to 122% after 2004. When comparing to world prices there is also a growth from 81% to 84%.

Table 4 Granger causality test results for pork prices volatility

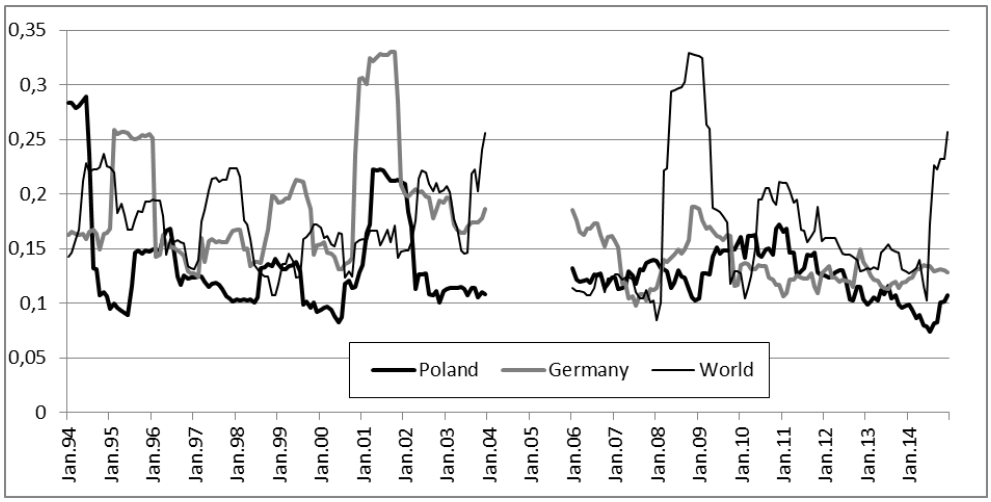
		1993-2003		2005-2014	
Cause	Effect	F Statistics	p value	F Statistics	p value
Germany	Poland	1,95596	0,125211	**2,59820**	**0,014354**
World	Poland	1,20992	0,289706	0,30439	0,582399
Poland	Germany	**2,01700**	**0,097454**	**4,85836**	**0,000007**
Poland	World	0,75680	0,701626	0,08434	0,772108

Source: Own calculations.

Granger causality tests results indicate that there are no causation between American and Polish pork price. Quite surprising are results for Polish and German pork prices, where two dimensional causality were revealed in two analyzed periods, since there are no economical explanation for causality from Polish to German market. This is probably the result of cointegration of analyzed time series.

3.3. Beef prices volatility

Among 3 analyzed markets beef prices volatility is the lowest. Nominal prices of beef are relatively stable. However there were some periods when beef prices changed significantly. For instance, price movements due to mad cow disease (BSE) shifted price volatility upwards. High level of World price volatility in 2008/09 is caused by sudden, however short-term change of beef price in March and April 2008. The levels of price volatility on beef markets are presented in Fig. 4.



Source: Own calculations based on GUS, ARDEU, and IMF.

Fig. 4 Volatility of Polish, German, and World beef prices in 1993-2003 and 2005-2014.

Basic statistics of analyzed price volatility time series are presented in Tab. 5. Polish beef price volatilities are the lowest in both periods. The reason for low relatively volatility before accession to EU is government intervention similar to that on pork market. Although mean value increased after 2004, median and upper quartile indicates that there is no apparent growth. The only change is the drop of SD if this time series, since there were no serious supply shocks after 2004. On the other sides volatility of beef prices set as benchmarks decreased significantly.

Table 5 Basic statistical measures of the annualized SD of logarithmic Polish, German and World beef price ratio

Measure	Poland pre 2004	Poland post 2004	Germany pre 2004	Germany post 2004	World pre 2004	World post 2004
Mean	0,120	0,125	0,168	0,130	0,167	0,147
Median	0,137	0,124	0,191	0,135	0,174	0,167
SD	0,048	0,021	0,054	0,022	0,034	0,061
Lower quartile	0,106	0,108	0,154	0,119	0,148	0,125
Upper quartile	0,148	0,141	0,206	0,150	0,203	0,195

Source: Own calculations based on GUS, ARDEU, and IMF.

As a result it can be stated that comparing to changes in World beef price volatility, price risk for Polish beef producer increased slightly. From the other side a significant growth of beef price level fully compensate it.

Table 6 Granger causality test results for pork prices volatility

		1993-2003		2005-2014	
Cause	Effect	F Statistics	p value	F Statistics	p value
Germany	Poland	**2,02819**	**0,026683**	1,26009	0,268681
World	Poland	0,01876	0,891310	0,71610	0,399427
Poland	Germany	1,16280	0,321525	1,52460	0,133362
Poland	World	2,69992	0,103133	0,10257	0,749428

Source: Own calculations.

Results of Granger causality tests are presented on Tab. 6. Only one Granger causality relation was found. During the first analyzed period German beef price volatility Granger cause changes in Polish beef price volatility. No such a relation were discovered among other pairs of time series.

Conclusions

Agricultural prices volatility plays important role in the variety of economic processes. It directly impacts stability of farmers' income and has impact on economic efficiency of agricultural production. So it is very important to quantify price volatility of agricultural products. The question whether and in what manner price volatility changed after Polish accession with EU is of great relevance. For instance, the answer to that question can be helpful hint in discussion about the effectiveness of different agricultural policies.

In this paper relatively simple measures were used to show changes in selected agricultural products price volatility. Analysis results indicate that comparing to World or European, Polish prices became more volatile after joining the EU.

Another interesting conclusion is that shift in price volatilities differ among markets. Pork and beef prices were more stable during last decade that at the turn of the century. On the other side, wheat prices become more volatile. As other authors state, growing biofuels production can be one of the reason of this growth [Gilbert 2010; Tyner 2010].

The change in the pattern of price volatility transmission was found on wheat market. Before 2004 wheat prices volatility was transmitted from American market, while after joining the EU, European price volatility started to determine Polish wheat price volatility. On pork and beef market no such change was caught.

In this paper prices of only three agricultural products were analyzed. There can be also chosen different prices as a proxy for European and especially World prices. Finally, different periods can reveal some interesting facts about changes in agricultural price volatility in last decades.

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