Market Integration in the EU Pork Market – Evidence from Panel ESTAR Models

Mariusz Hamulczuk
Warsaw University of Life Sciences (WULS-SGGW) – Poland
E-mail: mariusz_hamulczuk@sggw.edu.pl

Citation: Hamulczuk, M. (2020). Market Integration in the EU Pork Market – Evidence from Panel ESTAR Models. *Ikonomika i upravlenie na selskoto stopanstvo,* 65(4), 91-98 (Bg).

Abstract

Market integration is a key pre-condition for the efficient allocation of production factors and the maximization of economic welfare. Within this framework the aim of this research is to assess horizontal integration of the UE pork markets over time using panel models and weekly price series data. According to the spatial equilibrium model, market agents make trade decisions only when price differences exceed trade costs. Thus panel STAR models were used in this study. The obtained results confirmed nonlinear price adjustment in the EU pork markets. Price adjustments in central EU countries are stronger than in the peripheral countries and the strength of price convergence varies over time.

Key words: spatial market integration; pork market; European Union; panel STAR models

Пазарна интеграция на пазара на свинско месо в ЕС – доказателства от панелните модели ESTAR

Мариус Хамулчук
Варшавски университет за науки за живота (WULS-SGGW) – Полша
E-mail: mariusz_hamulczuk@sggw.edu.pl

Резюме

Пазарната интеграция е ключова предпоставка за ефективно разпределение на производствените фактори и максимизиране на икономическото благосъстояние. В тази рамка целта на това изследване е да се оцени хоризонталната интеграция на пазарите на свинско месо в ЕС във времето, като се използват панелни модели и седмични данни за ценови серии. Според модела на пространственото равновесие пазарните агенти взимат търговски решения само, когато ценовите разлики надвишават търговските разходи. По този начин в това проучване са използвани панелни STAR модели. Получените резултати потвърдиха нелинейна корекция на цените на пазарите на свинско месо в ЕС. Корекциите на цените в страните от централния ЕС са по-силни от тези в периферните страни и силата на конвергенцията на цените варира във времето.

Ключови думи: интеграция на пространствения пазар; пазар на свинско месо; Европейски съюз; панелни STAR модели

Introduction

Spatial integration of agricultural commodity markets is significant from an economic point of view. Without spatial market integration, no signals would be transmitted between the surplus and deficit regions, prices would be more volatile, specialization would not take place according to the comparative advantage theory, while no potential benefits of trade would be gained (Fackler and Goodwin, 2001; Donaldson, 2015). The theoretical background for assessing this phenomenon is provided by a spatial equilibrium model and spatial arbitrage, where trade is determined by price differences and trade costs. Arbitrage refers to the purchase and sale of commodities in two or more markets in order to profit from their price differences. The spatial arbitrage determines the behavior of prices in accordance with the relative version of the law of one price (LOP). This means that there is a relatively constant relationship or difference between prices over time, resulting, inter alia, from the trade cost.

Increased spatial market integration is evidenced by the intensification of trade, a reduction in trade costs and an increase in price co-movement (Barrett and Li, 2001). The price co-movement is the most frequently used approach to assess spatial market integration. Price transmission and price convergence are regarded as manifestations of the extent, to which supply and demand shocks are transmitted between locations (McNew and Fackler, 1997; Fackler and Goodwin, 2001; Goldberg and Verboven, 2005). Different regions do not have to trade directly, it is enough if they are part of the same exchange network. It is generally accepted that the greater the price co-movement in different locations, the stronger the degree of integration of the analyzed markets. Dynamic econometric models are usually applied to study the spatial integration of commodity markets. These can be single-equation, multivariate or panel models. When specifying the model an important role is also played by the assumed nature of price adjustments: linear vs. nonlinear (van Dijk et al., 2002; Ghoshray, 2010).

Pig and pork markets are some of the most important commodity markets in the EU and in the world. The EU pig population in December of 2019 was nearly 148 million (Eurostat, 2020). The EU is the world's second biggest producer of pork after China and the biggest exporter of pork and pork products in the world. However, in 2019 around 19% of the total EU swine meat export value (fresh, chilled and frozen) constituted intra-EU trade (Eurostat, 2020), which indicates a significant trade aspect of the EU pork market integration. Under specialization of production and the spread of ASF, intra-EU trade should play an even greater role in the future. According to the OECD-FAO Agricultural Outlook, average consumption of pork meat per capita in the EU countries in 2019 was over 33 kg. To stress the importance to pork consumption in the EU it is worth stressing that in 2019 it constituted 48% of the total meat consumption (OECD/FAO 2020).

Empirical research on spatial integration of the pork market in the EU has mainly focused on the assessment of price co-movements and their mutual adjustments. Serra and Gil (2005) studied price transmission processes within selected EU pork markets after the implementation of the EU single market in 1993. Using the local linear regression (LLR) technique and the threshold autoregressive model (TAR) they proved existence of nonlinear price transmission between major EU players. Physical distance, trade volume and flow of information were the main factors explaining the strength and nature of price adjustments. Liu (2011) using threshold error correction models proved symmetric cointegration of the Finish pork price with Danish and German prices. He concluded that the speed of price transmission is still slow compared to that between the Danish and German markets. In turn, Grigoriadis et al. (2016) used the R-vine copula approach to explain market integration in the EU pork markets. Their findings suggest regionalization of pork markets in the EU and asymmetric price adjustments. Holst and von Cramon-Taubadel (2013) using vector error correction models (VECMs) analyzed the effects of EU eastern enlargement on the integration of pork markets in the EU. They showed that the speed of price transmission is positively related to the volume of pork trade between countries; however, physical trade is not a necessary condition for cointegration and price transmission. Fousekis and Grigoriadis (2019) confirmed that the strength of price co-movement is closely related to the physical distance between national markets. Holst and von Cramon-Taubadel (2013) also indicated that pork prices in the new EU member states adjust more rapidly to price changes in the EU–15 rather than vice versa. Hamulczuk and Stańko (2013) using the Granger causality test and the VAR model confirmed that pig prices in Poland are determined mostly by the situation on foreign markets. Impulse response functions show that in the long-run only around 30% of the Polish pig price variation depends on domestic conditions.

The aim of this study was to assess the nature of spatial integration on the pork market in the EU countries in 2005–2020. For this purpose nonlinear panel smooth transition autoregressive (STAR) models were used, which until now had not been used in this type of research.

Material and methods

To assess spatial integration of the pork market in the EU, weekly time series of prices for pig carcasses in class E (which is the most representative class of pork meat) in 21 EU countries were used (Figure 1). The series covered the period from January 2005 to May 2020 (803 observations). Due to the incompleteness of price data, the study did not include a few countries. For example, Bulgaria, Romania and Croatia were omitted as their quotes are only available from 2007 or 2013. On the other hand, the quotations of pork prices in class E for Italy (which is one of the key producer and consumer of pork in the EU) unavailable since 2017.

Panel models based on logarithmic variables were used to provide an empirical evaluation of spatial integration in the EU pork market. This approach facilitates a simultaneous analysis of the strength and nature of mutual price adjustments in a large number of countries. The linear panel model used for assessment of price convergence can be written as follows (Levin et al., 2002):

$$\Delta P_{it} = \alpha_i + \theta_t + \delta_i t + \rho(P_{it-1}) + \sum_{j=1}^{p} \varphi_j \Delta y P_{it-j} + \varepsilon_{it}, \quad (1)$$

where P_{it} is a price in country $i = 1, \ldots, N$ in time $t = 1, \ldots, T$, α_i are specific effects for countries resulting from the impact of factors not included in the model, θ_t are common time effects, δ_i are the individual trends, and φ_j are the coefficients for a lagged dependent variables add-

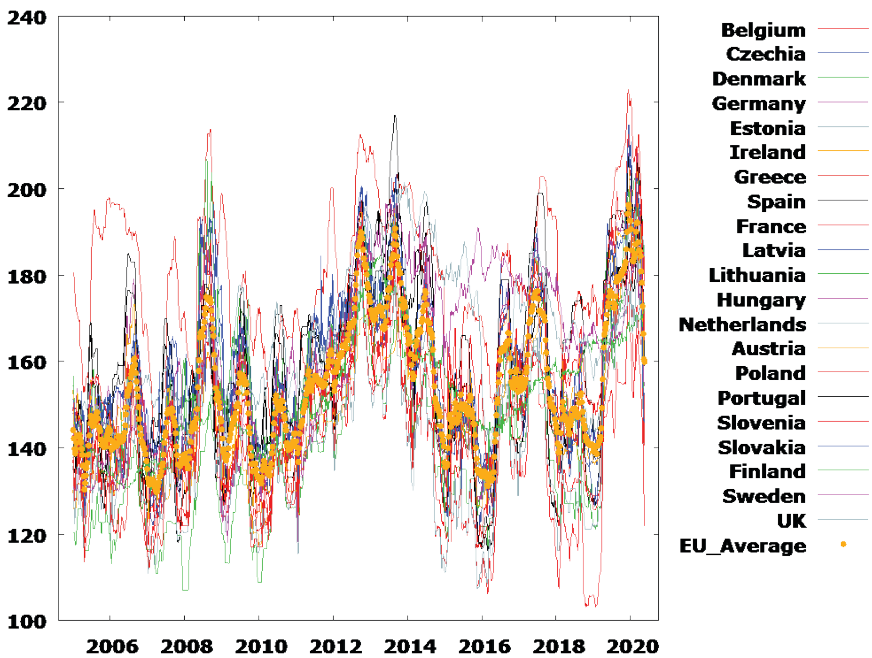

Fig. 1. Weekly prices of pork in the EU countries (Euro/100 kg)
Source: The author's study based on European Commission data.

ed for the elimination of autocorrelation of a random component (for lag j = 1, …, p), ε_{it} is a random term. Parameter ρ determines the speed of price convergence and thus strength of market integration.

For the sake of simplicity, this model can also be written in terms of price series deviations from average prices in the EU (this role is played by specific effects adjusted for common and individual time effects): $R_{it} = P_{it} - \alpha_i - \theta_t - \delta_i t$. Variable R_{it} can be regarded as an approximation of deviations of prices in country i from their long-run equilibrium. Then the model 1 can be transformed to the following equation:

$$\Delta R_{it} = \rho(R_{it-1}) + \sum_{j=1}^{p} \varphi_j \Delta R_{it-j} + \varepsilon_{it}. \quad (2)$$

Coefficient ρ shows the pace of price convergence to the long-run equilibrium state. However, in line with the price arbitrage theory and the spatial partial equilibrium model (Samuelson, 1952), price adjustments are expected to depend on the size of the deviations from the long-run equilibrium state. That is, with small price deviations, there are no incentives for arbitration or they are weaker than with large deviations. This suggests the use of three-regime non-linear TAR or STAR models (van Dijk et al., 2002). Due to the fact that the TAR model is one of the special cases of the quadratic or exponential STAR model, only the latter ones were considered for use in the study. The panel STAR model can be written as follows:

$$\Delta R_{it} = \rho_1(R_{it-1})\big(F(S_t,\gamma,\mathbf{c})\big) + \rho_2(R_{it-1})\big(1 - F(S_t,\gamma,\mathbf{c})\big) + \sum_{j=1}^{p} \varphi_j \Delta R_{it-j} + \varepsilon_{it} \quad (3)$$

where: ρ_1, ρ_2 are parameters determining the price adjustment speed, and $F(S_t;\lambda,\mathbf{c})$ is a transition function from interval (0,1). The price adjustments are non-linear and are represented by the weighted average of the parameters and the estimated transition function $\rho_1 F + (1 - \rho_2)F$. This function depends on parameter λ controlling smoothness of transition between regimes, vector **c** containing the threshold parameters and transition variable S_t (in our case it is R_{it-1}). In this study the exponential STAR model (ESTAR) was used, which is equivalent to the use of the exponential transition function $F(S_t;\lambda,c) = 1 - e^{-\lambda(S_t - c)^2}$.

It is worth noting that the prices deviations of R_{it} in individual countries may be characterized by a different variance, e.g. depending on the location of the country. In order to eliminate this influence, before the final estimation of panel ESTAR models, the R_{it} variables for individual countries were standardized. Overall, the study followed a two-step approach. In the first step R_{it} was calculated as the residuals from the linear panel model with only deterministic variables (fixed effects, time effects, individual trends). In the next step these residuals were standardized and then panel ESTAR models were estimated on their basis using optimization procedures.

Results

The price adjustment studies were conducted for four-year sub-periods. This separation can be justified by the fact that over time, the costs of trade or the export position of individual countries (a net exporter may become a net importer) may change over time. This division facilitates the analysis and enables the assessment of changes in the strength of market integration over time. For this purpose R_{it} values were calculated for each sub-sample, which was standardized in the next step.

The standard deviations of the raw R_{it} vary considerably between countries (Figure 2). The highest deviations of prices from the long-run equilibrium state are observed in the peripheral countries, which results from the increase in trade costs along with the distance from the benchmark (the average EU price). In addition, the deviations differ between sub-periods in each country, which further justifies the division of data into sub-samples.

In the next step, the linear panel and non-linear panel ESTAR models were estimated for individual sub-periods according to formulas 2 and 3. In the latter case, optimization procedures were used. The results of the research are presented in Figures 3–5. The horizontal axis shows the price deviations from the equilibrium state, while the vertical axis shows the rate of price adjustments to the long-run equilibrium state (coefficient ρ and component $\rho_1 F + (1 - \rho_2)F$).

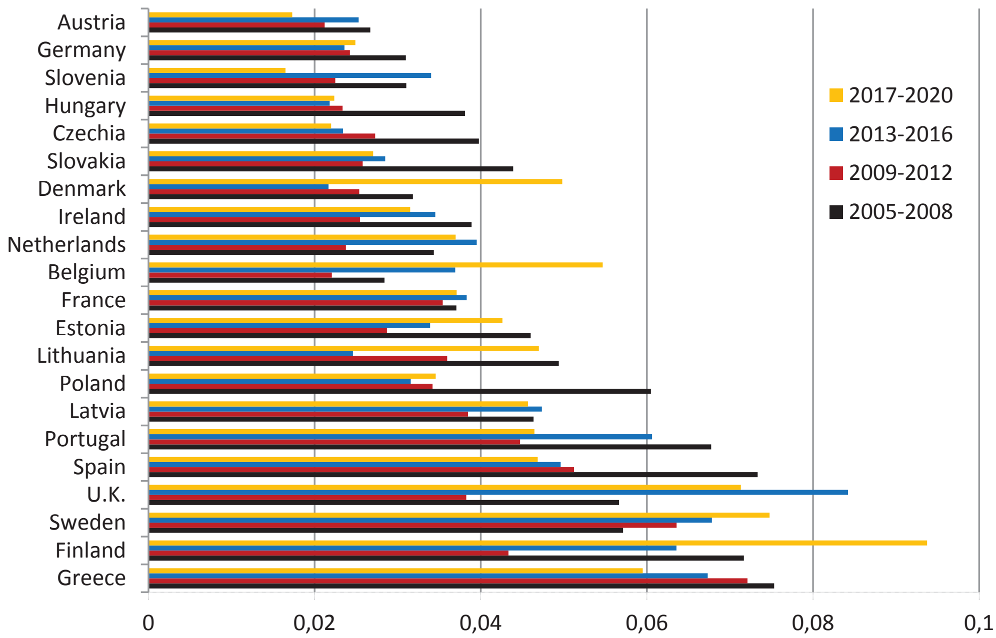

Fig. 2. Standard deviations for raw R_{it} in 21 EU countries

Source: The author's study.

Figure 3 shows coefficient ρ for the linear model (horizontal line) and component (ρ_1F + (1 - ρ_2)F) for the ESTAR model. Both show the rate of price adjustments depending on the distance from the long-run equilibrium state R_{it}. It is worth noting that the estimates presented there were obtained for standardized data. Therefore estimates are common for all the countries. It can be noted that the fastest price convergence according to the linear model took place in 2009–2012 (ρ = 0.141), while it was the weakest in 2017–2020 (ρ = 0.064). The reasons for the decline in market integration in recent years include uncertainty related to the outbreak of the ASF epidemic in Europe and in the world (Jongeneel et al., 2020).

This figure, however, suggests that the pace of price convergence depends on the size of the shock causing the price disequilibrium. When deviations from the equilibrium state are small enough (close to zero), price adjustments are 2–3 times weaker than for large price deviations. It can be noticed here that as we move away from the long-run equilibrium state, the strength of price convergence increases, which on theoretical grounds is justified by the growing possibilities of arbitration. The shape of the price adjustments revealed in component ρ_1F + (1 - ρ_2)F in the ESTAR model confirms the functioning of the EU pig market in accordance with the theoretical foundations of arbitration and the spatial equilibrium model. The occurrence of price adjustments with very small deviations from the equilibrium might be due to imperfect data and the method used, or market linkage resulting from information flows.

The non-linear adjustments being a function of disequilibrium levels presented in Figure 3 may be treated as average paths of price convergence in all the analyzed countries. In order to calculate the adjustments in individual countries, the standardized deviations were re-standardized by multiplying the standardized R_{it} by the standard deviations contained in Figure 2. After such adjustment, it can be seen that the pace of adjustments of domestic prices to the average prices in the EU differs significantly between countries (Figure 4). This is evidenced by the large dispersion in the position of the ρ_1F + (1 - ρ_2)F component for the same level of price deviation observed in different countries. The weakest price adjustments (see external points) are observed in such countries as Greece, Finland, Sweden and

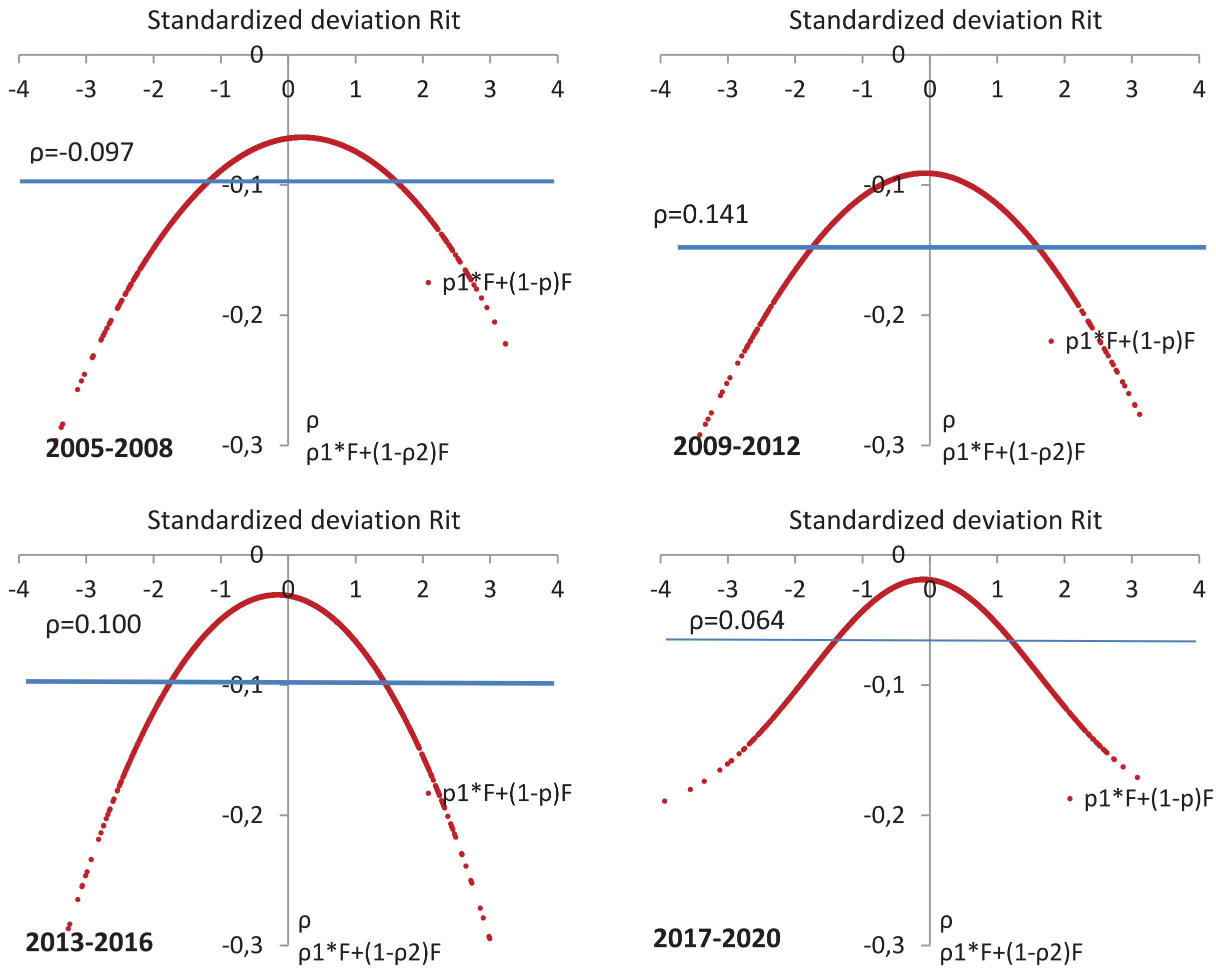

Fig. 3. Linear and non-linear adjustments of prices to the long-run market equilibrium in the EU
Source: The author's study.

the UK. The strongest price adjustments (internal points) are found in the centrally located countries, e.g. Austria and Germany. Overall, the countries with the weakest price adjustments are those where standard deviations (see Figure 2) are greatest, while the strongest price adjustments are seen in those countries with the lowest standard deviations.

In order to more accurately depict the essence of price adjustments depending on the disequilibrium magnitude, only a few countries for 2017–2018 were included in Figure 5. It can be seen that the same pace of price convergence ($\rho_1 F$ + (1 - ρ_2)F)) to the long-run relationship is observed at a different level of deviations (one could also compare the convergence coefficients in different countries for the same deviation from equilibrium). For example, the 10% adjustment rate per week (($\rho_1 F$ + (1 - ρ_2)F) = 0.10) in the case of Finland occurs when deviations from the long-run equilibrium is 16% (R_{it} = 0.16). For Austria the same speed of price adjustment is noticeable only for the 3% disequilibrium (R_{it} = 0.03). Thus, it can be concluded that price adjustments differ significantly between countries and the main factor influencing market integration seems to be related with the physical distance between the countries studied. Hence, the outcomes of this study confirm results obtained by Serra and Gil (2005) as well as Fousekis and Grigoriadis (2019).

Conclusions

Research based on panel models has shown that the strength of price adjustments varies over time. The strongest price adjustments were ob-

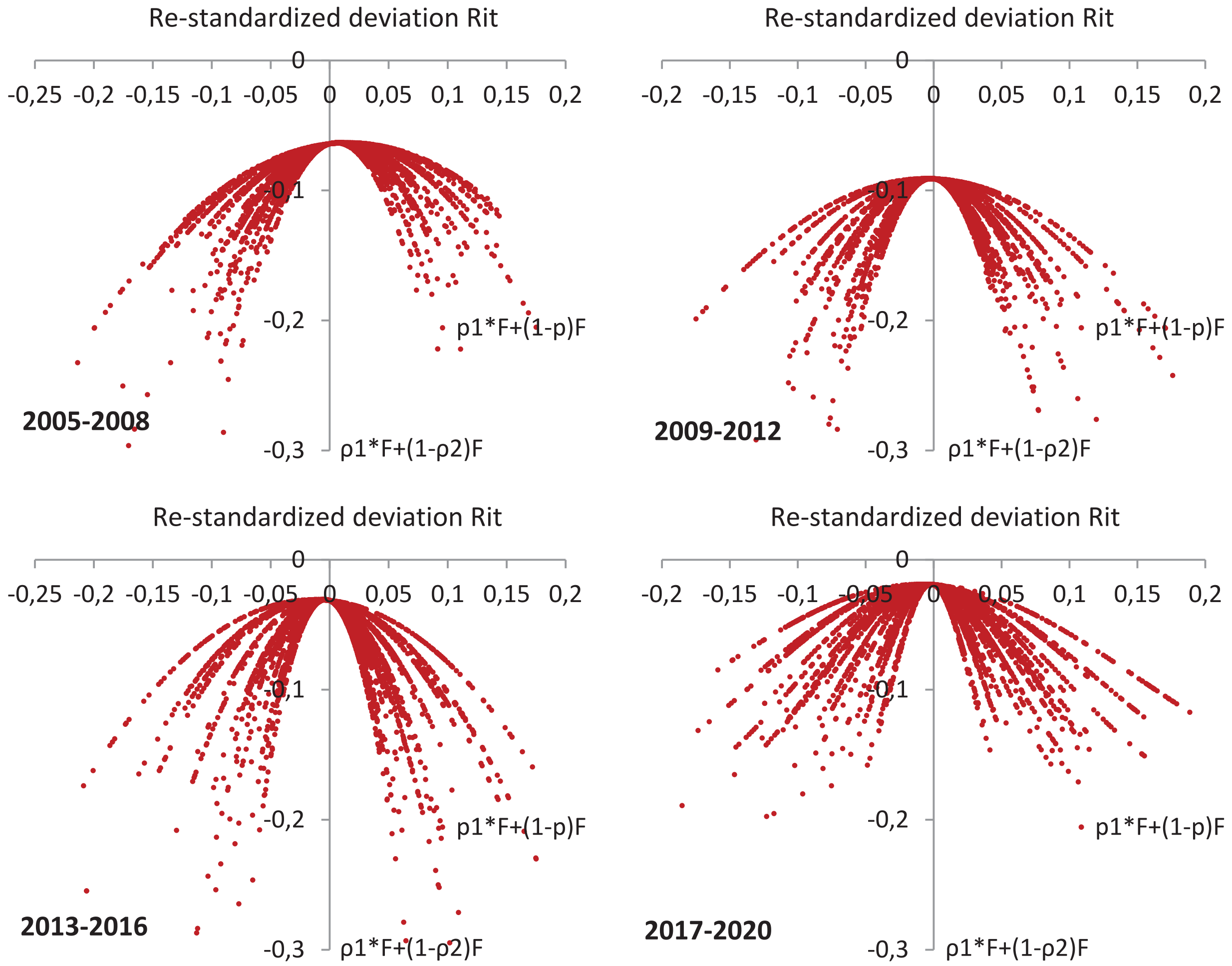

Fig. 4. Nonlinear price adjustment to the long-run market equilibrium in individual countries

Source: The author's study.

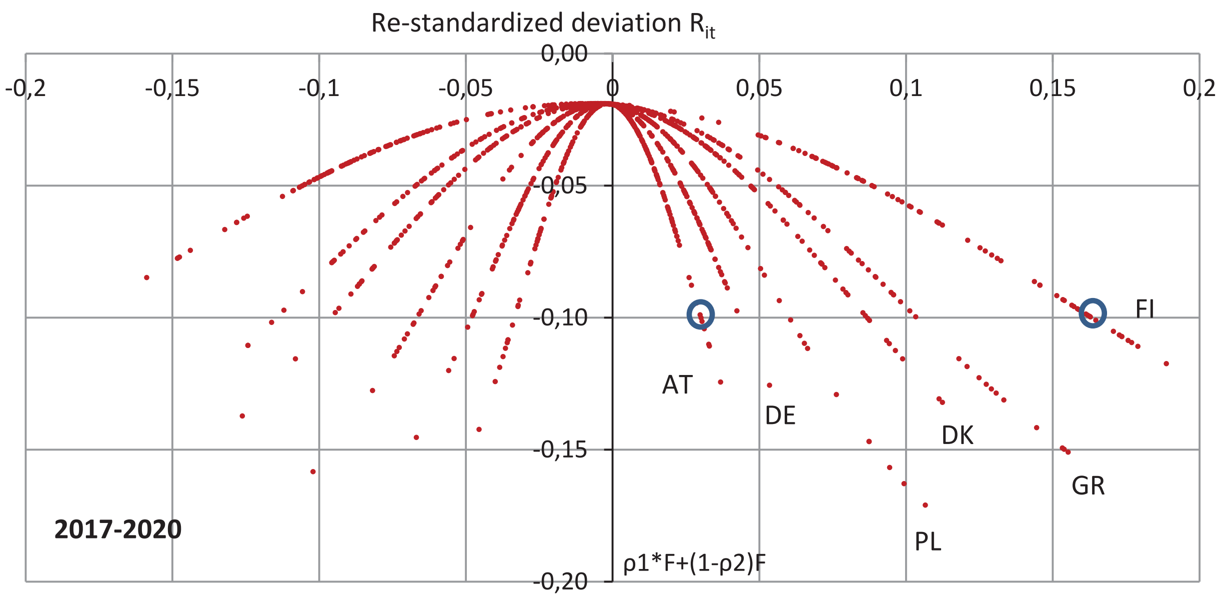

Fig. 5. Nonlinear price adjustment to the long-run market equilibrium in selected countries in 2017–2020

Source: The author's study.

served in 2009–2012 while the lowest in 2017–2020. The decline in the strength of the EU pork market integration in 2017–2020 may have been caused by the outbreak and spread of ASF worldwide.

The results obtained from panel ESTAR models indicate a non-linear pork price convergence. Along with the increase in price deviations from the long-run equilibrium state, the rate of price adjustments increases, which is consistent with the theoretical premises of the spatial equilibrium model. The approach adopted in the research has shown that in fact price convergence in individual countries depends on their physical distance relative to the benchmark market. The price adjustments in the central countries were stronger than in the peripheral countries for the same price deviations from their long-run equilibrium. This confirms that the distance between locations and the related arbitration opportunities play a key role in the spatial integration of EU pork markets.

However, the conducted research has some weaknesses. First of all, it is a simple and two-step estimation method of the panel ESTAR model based on optimization algorithms. Secondly, the performed standardization of data in individual countries was based on price deviations from the long-run equilibrium state. In subsequent studies it is worth considering other standardization algorithms, e.g. based on those used in the LLC test (see Levin et al., 2002).

References

Barrett, C. B., Li, J. R. (2002). Distinguishing between Equilibrium and Integration in Spatial Price Analysis. *American Journal of Agricultural Economics*, 84(2), 292-307.

Dijk, D. V., Teräsvirta, T., & Franses, P. H. (2002). Smooth transition autoregressive models – a survey of recent developments. *Econometric reviews*, *21*(1), 1-47.

Donaldson, D. (2015). The gains from market integration. *Annual Review of Economics,* 7, 617-647.

Fousekis, P., & V. Grigoriadis. (2019). Integration and Hierarchy of Pork Markets in the EU: An Analysis from the Vantage of Graph Theory. *German Journal of Agricultural Economics*, 68(2), 118-134.

Ghoshray, A. (2010). Smooth transition effects in price transmission: The case of international wheat export prices. *Economics Letters*, No. 106, 169-171.

Goldberg, P. K., Verboven, F. (2005). Market integration and convergence to the Law of One Price: evidence from the European car market. *Journal of International Economics*, Vol. 65(1), 49-73.

Grigoriadis, V., C. Emmanouilides, & P. Fousekis. The Integration of Pigmeat Markets in the EU. Evidence from a Regular Mixed Vine Copula. *Review of Agricultural and Applied Economics,* 19, 1(2016), 3-12.

Hamulczuk, M., Stańko, S. (2014). Factors affecting changes in prices and farmers' incomes on the Polish pig market. *Problems of Agricultural Economics*, 341 (4), 135-157.

Holst, C., & von Cramon-Taubadel, S. (2013). *Trade, Market Integration and Spatial Price Transmission on EU Pork Markets Following Eastern Enlargement. Georg-August University of Göttingen* (No. 1307). Göttingen Discussion paper.

Jongeneel, R., Gonzalez-Martinez, A. & Hoste, R. (2020). An Uncertain Fate for the EU Pig Sector: Potential Consequences of the 2019 African Swine Fever Outbreak in East Asia. *EuroChoices*, doi:10.1111/1746-692X.12274.

Levin, A., Lin, C. F., & Chu, C. S. J. (2002). Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of econometrics*, *108*(1), 1-24.

Liu, X. (2011). Horizontal price transmission of the Finnish meat sector with major EU players. *MTT Discussion Paper 1/2011*, Helsinki, Finland: MTT Economic Research.

McNew, K., Fackler, P. (1997). Testing Market Equilibrium: Is Cointegration Informative? *Journal of Agricultural and Resource Economics*, 22(2), 191-207.

Samuelson, P. (1952). Spatial Price Equilibrium and Linear Programming. *American Economic Review*, 42, 283-303.

Serra, T., Gil, J. M. & Goodwin, B. K. (2006). Local Polynomial Fitting and Spatial Price Relationships: Price Transmission in EU Pork Markets. *European Review of Agricultural Economics*, 33, 3(2006), 415-436.

Eurostat. (2020). Eurostat Database: https://ec.europa.eu/eurostat/data/database

OECD/FAO. (2020). *OECD-FAO Agricultural Outlook 2020-2029*, FAO, Rome/OECD Publishing, Paris, https://stats.oecd.org/Index.aspx?DataSetCode=HIGH_AGLINK_2020