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SPATIAL INTEGRATION OF AGRICULTURAL COMMODITY MARKETS – METHODOLOGICAL PROBLEMS

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Abstract

The degree of integration of spatial markets is one of the most important determinants of economic welfare. However, the proper definition of this concept and the selection of appropriate methods of its analysis are important. Hence, the purpose of this study is to compare and evaluate methodical concepts for measuring the phenomenon of spatial integration of agricultural commodity markets. Based on the literature review, the theoretical premises and definitions of the integration of commodity markets were presented in the paper, followed by the most important methods for assessing the market spatial integration. When discussing them, attention was drawn to their characteristics in relation to theoretical concepts and to the possibility of their practical application on commodity agricultural markets in the light of available statistical information. The assessment of spatial integration can be based on price information, trade costs and trade flows. In the light of the studies conducted, it can be concluded that not all approaches used by researchers are justified in the theoretical foundations of spatial integration of markets. The main barriers to the practical verification of the occurrence, strength and changes in the spatial integration of agricultural commodity markets include the lack of full homogeneity of goods and difficulties in estimating the costs of trade.

Keywords: spatial integration, agricultural commodity markets, methods.

JEL codes: C01, F11, Q17.

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Introduction

In view of climatic and soil limitations, the production of agricultural products is not evenly distributed in geographical terms, hence there is a need to conduct trade among regions with surpluses and those characterised by deficits. The transfer of demand and supply shocks among locations, which allows to balance surpluses with deficits, is called the spatial integration of markets (Fackler and Goodwin, 2001). As a result of the increased population and consumer income in the last several decades, trade in agri-food products has been significantly intensified all over the world. This trade is determined by changes in trade costs. On the one hand, we witness processes reducing barriers to trade as a result of development of information technologies, reduction in customs rates or bilateral agreements. On the other hand, we are dealing with a number of new non-tariff restrictions and concentration processes which are barriers to the optimal allocation of production factors or general welfare (Hamulczuk, 2018). Therefore, questions about the nature of links among agri-food markets in various countries or regions, the strength of these links or directions of changes are still up-to-date.

The issue of links among spatially identified commodity markets occupies one of key positions in the theory of economics. The studies on the degree of and changes in the spatial integration of markets are important from both the cognitive and utilitarian point of valuation. The results of empirical studies on the spatial integration may form a basis for verifying some hypotheses and assumptions accompanying various theories and economic laws. The knowledge of the degree of integration of commodity markets and the strength of transmitting price signals among markets is important from the viewpoint of policy-makers and creators of economic policies. Any changes in the policy will be manifested by the modified strength of price transmission from global markets and third country markets, and, consequently, will influence the trade balance. A positive aspect of spatial integration of markets is the stabilisation of market prices and a reduction in the price risk thanks to flows of surpluses to regions characterised by deficits. The opening of markets may be deemed an alternative to governmental programmes aimed at stabilising producer and consumer prices. In this context, the spatial integration is a key condition for the region's food security, as it reduces the exposure of producers and consumers to unexpected fluctuations of local supply of raw materials and processed products. It is worth adding that effective arbitrage as part of spatial integration of markets is a tool to weaken local monopolies. The possibility of entering a given market weakens the position of local companies and makes them adjust prices and costs to prices in other locations. The integration with external markets is also an opportunity for the increased production and consumption, without a need to influence prices in the local market. Without the spatial integration, there would be no specialisation in line with the theory of comparative advantages. To sum up, the absence of spatial integration of markets is a barrier to maximising general welfare from the economic viewpoint (Fackler and Goodwin, 2001; Donaldson, 2015).

The applied research methodology is of key importance in the studies on the strength of and changes in the spatial integration of agricultural commodity markets. In the last thirty years, there has been a huge progress in the development of quantitative methods. Therefore, research hypotheses are often verified anew and researchers, using modern research methods, reach completely different conclusions than their predecessors. In this context, the objective of this paper is to present and critically assess methodical concepts of measuring the spatial integration of agricultural commodity markets. The point is not only to present research methods, but also to assess the possibility of their practical application in the light of available empirical data. Equally important is the interpretation of obtained results and their compliance with theoretical assumptions.

Spatial integration of markets in definitional terms

At the beginning, we will try to explain the notion of spatial integration of markets in a clearer manner. In economics, we commonly use the notion of "integration" which means all phenomena leading to strengthening links under a given economy or among economies in such a way that the result is the harmonised whole (Balassa, 1961; Ropke, 1959). His commonly believed that due to the constant development of technology and science, the integration is a process (Kamecki, 1967) geared towards the creation of a uniform economic structure as a result of changes in both real and regulatory spheres. The integration in the regulatory sphere involves the adjustment of market institutions and structures and legal regulations applicable in individual markets. The integration in the real sphere is associated with a free flow of production factors, goods and services as well as information. The essence of integration processes is determined by phenomena in the real sphere where economic benefits of integration itself are visible and put into practice. The integration in the regulatory sphere is not sufficient to recognise the integration in the real sphere. However, it is difficult to imagine a free flow of production factors and trade without lifting administrative and legal barriers.

Quite often, the notion of integration is reduced to some units, e.g. commodity markets, sections and sectors, regions or whole economies which are treated as separate wholes. This paper is dedicated to the spatial integration of commodity markets. Cournot (1938) defined the "market" as a territory covered by unlimited trade where prices easily and immediately assume the same level. This gives rise to the first definition of integration of markets talking about the price convergence or the occurrence of this tendency due to spatial arbitrage. Otherwise, there must probably be limitations in the trade and information flows so these two locations cannot be defined as a single integrated market.

However, Roehner (1995) shows that the notion of "spatial integration of markets" is not precise and is multidimensional. The literature review shows that this is an empirical concept and many definitions refer to the concepts and methods of verification of this phenomenon. The first studies, due to calculation problems, referred to small price differences or a strong price linkage, as a characteristic of (strong) integration of markets. According to Ravallion (1986), integrated markets are locations where prices do not behave independently. In his opinion, the integration among spatially defined markets takes place when prices behave similarly in the long or short term. Thus, it is highlighted that in practice the integration of markets is associated with convergence processes, adaptation processes and time-distributed response to shocks coming from other markets. This type of integration is most often related to assessing the occurrence of the law of one price. The similar interpretation of price integration of markets has been adopted by Goldberg and Verboven (2005) who treat it more as the price convergence process under the law of one price.

Many definitions associate the integration of markets with the assessment of the extent to which demand and supply shocks are transmitted among locations (McNew and Fackler, 1997; Fackler and Goodwin, 2001). Most often, it is assumed that the basis for the transmission of shocks is trade. Yet, individual regions do not need to conduct trade directly; it is enough for them to be part of the same trade network. The verification of integration defined in this way is, however, often reduced to the assessment of convergence and correlation among prices in these locations. Adopting the hypothetical shock transferring the function of surplus demand in region A as ε_A, we can present the R_{AB} price transmission coefficient between regions A and B as the following equation:

$$R_{AB} = \frac{\partial P_B / \partial \varepsilon_A}{\partial P_A / \partial \varepsilon_A}, \tag{1}$$

where P_A and P_B mean prices in individual regions. As a result, the transmission coefficient, when assuming direct responses, may be reduced to the assessment of relative price changes in two locations $R_{AB} = \partial P_B / \partial P_A$. The closer is the value of this coefficient to one, the higher is the degree of integration of markets. It can be concluded that this is the most general definition of spatial integration of markets and a starting point for its measurement.

Gonzalez-Rivera and Helfand (2001), in their definition of integration of markets, refer to meeting both the condition of trade and exchange of information which results in the similar behaviour of prices in the long term. Barrett and Li (2002) associate the spatial integration with the concept of tradeability and market contestability. This means that the trade flow itself is a sufficient indicator informing of the market integration. Also, the absence of trade flow where price differences do not exceed trade costs does not attest to the absence of market integration. For this reason, Barrett (2001) points to a need to separate the concept of integration of markets and the concept of market efficiency. In their opinion, the market efficiency should be analysed in terms of the extent to which the market equilibrium is achieved. In turn, the integration should be assessed through the prism of real and potential trade flows.

To sum up, it can be assumed that the literature of the subject is dominated by two concepts underlying the definition of spatial integration of commodity markets. In the first one, the integration is referred to the process of interlinks among market participants, which are reflected by the trade flow. The second concept entails the assumption, as a criterion of spatial integration of markets, of the co-variability of prices in various locations which results both from the trade flow and information flow. Sometimes, it is referred to as the price integration of markets (Figiel, 2002).

Theoretical foundations of spatial integration of commodity markets

In the majority of empirical studies, their authors refer to such notions as spatial integration, spatial efficiency, spatial arbitrage or law of one price. Defining them and understanding their interlinks and differences is essential for adopting an appropriate research methodology. Market arbitrage is a key concept underlying decision-making by market participants, so-called market agents. Arbitrage refers to the purchase and sale of commodities (or assets in general) in two or more markets so as to make a profit on their price differences. If price differences among markets exceed trade costs (i.e. costs of arbitrage which include loading, unloading, transport, insurance, information search, costs of breaking down trade barriers, cost of capital and risk, etc.), then the agent purchases the product in the market where the price is lower and sells it where the price is higher, thus making a profit on this transaction. Therefore, trade in commodities as part of arbitrage includes a combination of complementary activities, from the collection of information, through the physical movement of commodities, to the settlement of the transaction (Pirrong, 2014). The condition of spatial arbitrage may be formally presented in a form of the following equation (Baulch, 1997):

$$\left|P_{At} - P_{Bt}\right| \leq \tau_{ABt}, \tag{2}$$

where: P_{At} – price of commodity i in location A (domestic market) in period t, P_{Bt} – price of commodity i in location B (foreign market) in period t, expressed in the currency of country A, τ_{ABt} is the cost of price arbitrage between location A and location B in period t.

This condition means that differences between prices in location A and location B should not exceed trade costs between these locations τ_{ABt}. Otherwise, possibilities of making above-average profits encourage arbitrageurs to intensify trade, which, consequently, leads to reducing price differences below trade costs. In the case of competitive markets, there may be a situation where differences exceed the level of trade costs in the short term price, whereas thanks to arbitrageurs, in the long term, price differences should seek to meet the condition expressed by formula 2.

Thus, spatial arbitrage determines price behaviour in accordance with the law of one price (LOP). However, we are not talking here about the absolute version of law of one price, which assumes the absence of trade costs, but the law of one price in a relative version. It means that there is a relatively constant relation or difference between prices over time, resulting, inter alia, from arbitrage costs, quality of commodities or different preferences. It is most often assumed that the law of one price is a concept appropriate for the long term, as many studies (e.g. Isard, 1977) show deviations from the LOP in the short term. Thus, here we have a reference to price convergence, not to the immediate adjustment of prices (Goldberg and Verboven, 2005). The reference in LOP definitions to costs of arbitrage, as pointed out by McChesney, Shugart and Haddock (2004), is a reason for which, paradoxically, the law of one price becomes the law of many prices.

One of conditions for efficient arbitrage is the homogeneity of commodities. Even in the case of commodities that seem to be homogeneous, there are differences in their quality. Erjnæs, Person and Rich (2008) propose to decompose differences between prices in two locations into components related to costs of arbitrage τ_{ABt} and the component illustrating differences in the quality of commodities *A* and *B* for which the Q_{ABt} designation has been adopted. Hence, the extension of formula 2 can be presented as follows:

$$\left|P_{At} - P_{Bt}\right| \le \tau_{ABt} + Q_{ABt}, \tag{3}$$

where Q_{ABt} is a time-variable bonus expressing differences in the quality of commodities, other designations are as in formula 2. By adopting this assumption, a modified condition of arbitrage for similar products has been obtained. It is worth adding that Broda and Weinstein (2008) proposed a modification in the relative law of one price to the form of approximate relative law of one price, where the study concerns similar but not identical products.

There are a number of theoretical models describing the spatial formation of prices and trade (Fackler and Goodwin, 2001). The most commonly used are spatial market equilibrium models[1]. They assume that intraregional trade costs amount to zero, which means that buyers and sellers in individual local markets are located at the same point. Therefore, trade within the local market is ignored, with a focus on interactions with other locations (points). Therefore, it is assumed that local markets are perfectly competitive and there is no distinction between a decision to sell in the local market and a decision to sell in neighbouring markets. An example of this model is the spatial partial equilibrium model proposed by Enke (1951) and Samuelson (1952), and later developed by Takayama and Judge (1964).

The idea of this model has been contained in Fig. 1. It has been assumed there that there are two regions (*A* and *B*), which trade in one homogeneous good. D_A and D_B mean demand functions in individual markets while S_A and S_B are cor-

[1] The other group of models used to assess the integration is called agents-on-links models or basis point models. These models refer to location models (Haddock, 1982) assuming the existence of internal interlinks within regions which are treated as points in market equilibrium models.

responding supply functions. If regions are permanently separated from each other and do not form a single market, then P_{0A} and P_{0B} represent unit market prices resulting from the condition of autarky equilibrium in each market. Assuming perfect competition and the absence of trade costs in the conditions of free trade, the price in both countries would be at the level of P_1 and the level of trade being the intersection of the surplus supply line ES_A and the deficit demand line ED_B would be Q_1. In fact, such situation is not possible due to trade costs τ_{ABt}. These costs form a wedge between the export price and the import price, thus unit prices in markets *A* and *B* being in the state of market equilibrium will not be fully equalised. The price in the import region will then be equal to: $P_{2B}=P_{2A}+\tau_{AB}$, which means that the unit level of trade costs in the conditions of market equilibrium is equal to $\tau_{AB}=P_{2B}-P_{2A}$. It can be noticed that as trade costs appear, the quantity of traded commodities is reduced from Q_1 to Q_2.

This model in the basic version refers to the assumptions of a perfectly competitive market (there are also its extensions to the olygopolistic form) and the full substitutability of commodities. The lack of homogeneity of commodities is a reason for which price differences are not equal to trade costs and purchasers are not indifferent to the place of origin of commodities. Therefore, in the practice of trade modelling, it is assumed that there is no full substitution of commodities between regions. Thus, the heterogeneity of goods within a single commodity market (sector) may result in the simultaneous export of the same good in two directions (cross-hauling).

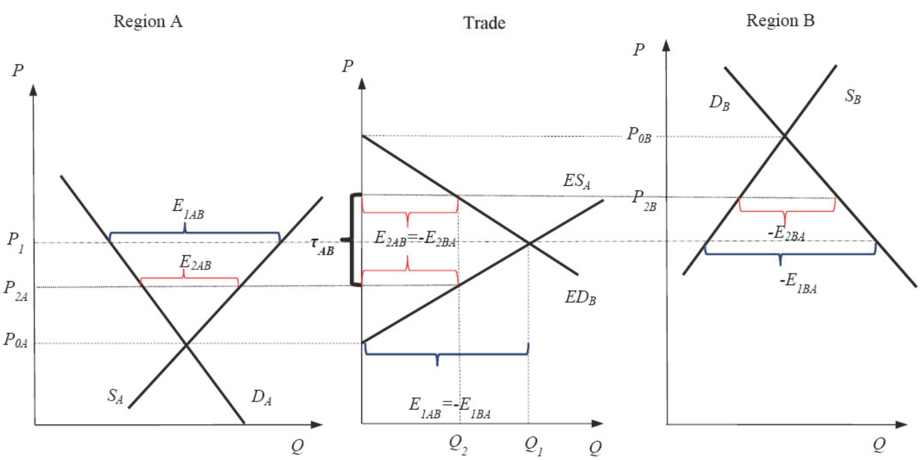

Fig. 1. Spatial equilibrium model.

Source: own study based on: Samuelson (1952).

According to Fig. 1, there may be three situations. Firstly, prices may be the same after taking trade costs into account. Then, there is the integration of markets *A* and *B* and, at the same time, there is market equilibrium (markets are efficient). Secondly, when price differences exceed the level of trade costs, this encourages arbitrageurs to act and transfer commodities from the surplus region to the region with deficits. If this happens, markets are integrated, but, at the same time, they are not in the state of spatial equilibrium, so they are not efficient. Therefore, we can see that the concept of integration involves trade also where markets are not in equilibrium[2]. Thirdly, price differences may be lower than the level of unit trade costs. Then, there are no grounds for arbitrageurs to act and there is no transmission of demand and supply shocks. Therefore, paradoxically, the decrease in price differences below trade costs increases the probability of the absence of spatial integration of markets. Thus, it is worth stressing that the decrease in trade costs increases the probability of integration of markets while their increase increases the probability of the absence of trade. This means that reducing trade costs should also be a manifestation of the progressive process of integration of markets.

Assessing the degree of spatial integration of markets based on price information

Most studies on the spatial integration of commodity markets are based on price information, which results from the high availability of such data. Prices are often the only observable market parameter expressing the impact of countless factors. It is generally assumed that the higher is the co-variability of prices in various locations (or the so-called price transmission), the stronger is the degree of integration of analysed markets. However, not everyone remembers that, according to the theoretical assumptions, the starting point for studying the integration in markets A and B should be the following equation:

$$P_{At} = \gamma_0 + \gamma_1 P_{Bt} + \gamma_2 T_t + u_t , \qquad (4)$$

where P_{At}, P_{Bt} are prices in time t, T_t means trade costs or a variable explaining them, u_t is a random component characterised by the identical independent distribution with zero expected value. The structural parameters of the model γ_0, γ_1, γ_2 determine the level of price integration of analysed markets and the impact of trade costs on the price level. The closer is the value of the γ_1 coefficient to one, the stronger is the assumed degree of integration of markets *A* and *B*. In practice, the T_t variable is usually ignored, which may have serious consequences for the results obtained.

[2] Early equilibrium models allowed for trade only at equilibrium prices (tâtonnement), while not taking into account the process of achieving the state of equilibrium by the economy (market). Over time, a new class of models has been developed which describes real-time trade, also when prices are distant from or are getting close to equilibrium prices (non-tâtonnement models) (e.g. Fisher, 1976).

Equation 4 is an example of a static approach in which we adopt an unrealistic assumption about an immediate price response in one location to price changes in another. For this reason, and for statistical reasons (non-stationarity of variables or problems with autocorrelation), dynamic models are most often used in the practice of studying price transmission in spatial terms. In general, when choosing the model and its specification, the researcher must decide whether to select the following models:

- parametric or non-parametric;
- one-equation, multi-equation or panel;
- static or dynamic;
- linear or non-linear;
- based on the long-term relation or not.

As a rule, one should also decide on the majority of the above-mentioned points. For example, studies can be based on a dynamic, parametric, multi-equation model in which we adopt non-linear price adjustments to the long-term relation. The choice of the model is determined by the objective of studies, data availability, statistical characteristics of series, or the researcher's knowledge. Most studies are based on parametric models. An alternative to parametric models, as tools to assess price transmission and integration of markets, may be non-parametric or semi-parametric solutions, which use, for example, estimators of local polynomial regression. The result of these analyses is a graphical picture of price adjustments between markets depending on the size of price differences (e.g. Serra, Goodwin, Gil and Mancuso, 2006; Rosales and von Cramon-Taubadel, 2015).

In one-equation dynamic models (when simplifying considerations to two markets, which also takes place in practice), it is assumed that the price level in market *A* in time t is a function of past (or possibly also current) prices in market *B* and past prices in market *A*:

$$P_{At} = \sum_{i=1}^{p} \alpha_{Ai} P_{At-i} + \sum_{j=1}^{q} \beta_{Aj} P_{Bt-j} + \varepsilon_t, \qquad (5)$$

where: α, β are parameters of the model, p and q is the maximum series of delays, εt is a random component, other designations as in equation 4. This model can be extended by additional deterministic variables (absolute term, trend, seasonal variables, variables describing structural changes) as well as by additional control variables (e.g. for grasping trade costs). In multi-equation models (e.g. vector autoregression models), we take into account from 2 to about 5 markets, achieving as many equations as endogenous variables. In models of this type, prices in the analysed market are a function of past prices in a given market and past prices in all other markets (just like in equation 5). The advantage of these models is the fact of avoiding the problem of endogeneity of variables. In turn, in panel models, we describe price adjustments in more objects in the form of one equation. In the latter, the price adjustment process is most often analysed in the context of the so-called beta price convergence (more in e.g. Wolszczak-Derlacz, 2007).

The above-mentioned models may take into account the existence of the so-called co-integration (long-term relation) or not. It is assumed that, in the case of non-stationary variables, mutual price adjustments in the long term are presented e.g. as equation 5 (the so-called co-integrating relation). If the remainders of the long-term relation are stationary, then a model similar to model 5 is constructed, only on the first differences, and is additionally extended by the delayed remainders from the long-term equation:

$$\Delta P_{At} = \sum_{i=1}^{p} \alpha_i \Delta P_{At-i} + \sum_{j=1}^{q} \beta_j \Delta P_{Bt-j} + \rho u_{t-1} + \varepsilon_t \,, \tag{6}$$

where the designations are as above. The ρ parameter expresses the rate of return to long-term equilibrium determined by the cointegrating equation. The closer is ρ to -1, the faster is the return to the state of spatial equilibrium, and thus the stronger is the spatial integration of these markets. An alternative to the above-mentioned model is a dynamic specification based on the approach by the London School of Economics (the so-called ARDL-ECM model). Multi-equation and even panel models can be constructed on a similar basis.

All the models discussed so far have been linear, which is not in line with the theoretical assumptions. As it results from Fig. 1, the level of trade costs determines limits within which price arbitrage is profitable and where price adjustments occur or is not profitable and prices behave independently. Therefore, linear models do not take into account the lack of continuity of trade. This factor and a failure to include the variable illustrating trade costs in the specifications of models is a reason for which the application of linear models and co-integration tests in studies on the integration of markets faces some criticism (e.g. Barrett, 1996; McNew and Fackler, 1997).

Fig. 2 shows several types of price adjustments to the long-term relation depending on the deviation from the long-term relation (cf. formulas 6 and 7). The linear model assumes that price adjustments are identical, regardless of the size of shocks (causing deviations from equilibrium), and take place until prices are equalised, as presented in a form of a horizontal line. In fact, the trend towards price equalisation is limited by the condition of price arbitrage (cf. formula 2, Fig. 1). If price differences exceed the level of trade costs, then mutual price adjustments should take place and if not, prices may behave independently. This type of adjustments is included in the TAR threshold autoregressive model (Balke and Fomby, 1997; Hamulczuk, 2018), which can have two forms. In the bandTAR model, adjustments take place only outside the middle range determined by trade costs τ, and in the EquationTAR model some adjustments (weaker) are also within the middle range (in Fig. 2 we have an example of the latter). By extending formula 6, such a model can be presented as follows:

$$\Delta P_{At} = \begin{cases} \mu_1 + \sum_{i=1}^{p-1} \alpha_{1i} \Delta P_{At-i} + \sum_{j=1}^{q-1} \beta_{1j} \Delta P_{Bt-j} + \rho_1 (u_{t-1}) + \varepsilon_{1t} & for \quad -\infty < u_{t-1} < -\tau_1 \\ \mu_2 + \sum_{i=1}^{p-1} \alpha_{2i} \Delta P_{At-i} + \sum_{j=1}^{q-1} \beta_{2j} \Delta P_{Bt-j} + \rho_2 (u_{t-1}) + \varepsilon_{2t} & for \quad -\tau_1 \le u_{t-1} \le \tau_2 \\ \mu_3 + \sum_{i=1}^{p-1} \alpha_{3i} \Delta P_{At-i} + \sum_{j=1}^{q-1} \beta_{3j} \Delta P_{Bt-j} + \rho_3 (u_{t-1}) + \varepsilon_{3t} & for \quad \tau_2 < u_{t-1} < \infty \end{cases} \tag{7}$$

where the designations are as above.

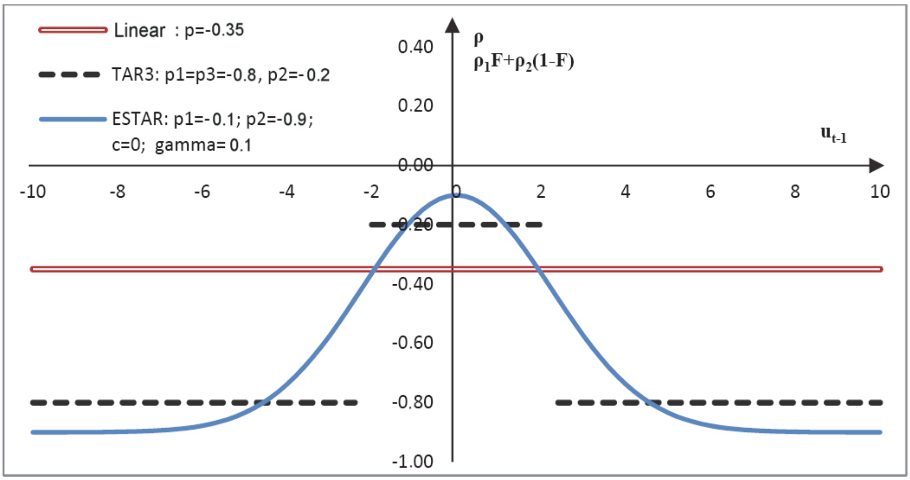

Fig. 2. Exemplary price adjustments to the long-term relation in linear and non-linear models.
Source: own study.

Instead of a step function of transition among regimes, we may use continuous second-order exponential or logistic functions (F), which will allow to express three-regime dynamics in the form of a smooth transition autoregressive model (STAR). We can find more on this, inter alia, in van Dijk, Teräsvirta and Franses (2002) or Ghoshray (2010). Fig. 2 shows price adjustments to the long-term equilibrium of the ESTAR exponential model with certain parameters assumed, where adjustments are non-linear and represent the weighted average of error correction parameters and the estimated exponential transition function $\rho_1 F + \rho_2(1\text{-}F)$. It can be noticed that when going away from long-term equilibrium, the strength of price adjustments increases, which is theoretically justified by growing possibilities of arbitrage. When comparing all price adjustments, we can notice that parameters of linear models in a sense represent "averaged" values for these different regimes. This results in the more frequent rejection of the zero hypothesis about the integration of markets in favour of the hypothesis promoting their segmentation. The TAR or STAR models can also be estimated as part of multi-equation or panel models, which entails further problems. The most important obstacle to the efficient use of non-linear models in practice in agricultural markets is the relatively low frequency of most available price information (usually monthly), which does not allow to grasp non-linear adjustments. There are also problems in estimating threshold parameters, which are basically expressed in a constant form τ (Hamulczuk, 2018). As we know, trade costs change over time, they are not identical in different countries.

The question is how reliable it is to conclude on the spatial integration of markets based on models based on prices only. This largely depends on the quality of price information. It is most often assumed that agricultural commodities are homogeneous goods, which can be compared with each other without any obstacles and traded worldwide at fixed prices. In fact, commodities are not homogeneous and there are quite large differences in parameters among them. They result from a source of origin or commodities, type of its use, variety or breed and widely understood quality. The incomplete substitutability of apparently homogeneous commodities, together with a failure to include information on trade costs, significantly reduces the estimated price transmission power. As already mentioned, the co-variability of prices results from trade and information flows. The latter factor (functioning of countries or regions in a larger network of links) is a reason for which the strength of mutual price adjustments in periods with and without trade does not need to differ significantly (e.g. Stephens, Mabaya, von Cramon-Taubadel and Barrett, 2012).

Assessing the degree of integration taking into account trade costs and trade flows

The natural manifestation of spatial integration of agricultural commodity markets is the decrease in barriers to trade or more broadly – trade costs. The reduction in trade costs over time is attributed to the increase in the integration of markets, while the increase in these costs – with the decrease in this integration. In general, the increase in trade costs reduces the probability of spatial integration of markets (cf. Fig. 1). This aspect of integration may be assessed either directly or indirectly. The direct assessment consists in measuring individual types of trade costs: transport, trade barriers, costs of obtaining information, market risk, etc. The precise estimation of full trade costs is virtually impossible even for a single period, let alone the measurement of these costs over time. Also, it is difficult to quantify the impact of non-tariff barriers to trade. It may be considered that inference on the integration based only on estimates of trade costs is encumbered with a large uncertainty. As a rule, such analyses are based on low frequency and most often annual data. To this end, both expert estimates and calculations made based on gravity models (e.g. Miao and Fortanier, 2017) are used. In this latter case, it is possible to extrapolate estimates beyond the sample of analysed countries as well as to other periods. However, it is not possible to determine uniform criteria, which would be used to assess the degree of integration as it is not fully known at what level of costs it is possible to regard markets as integrated and at what level it is not. Thus, this type of analysis is only relative and allows to make a comparative assessment of the integration process over time and space.

Indirect inference on the integration of markets in the context of trade costs may consist in analysing price differences or price relations among various locations. Here, it is assumed that price differences (relations) result from the impact of the unobservable level of trade costs. The higher the price differences are, the lower the integration of markets is. The increased distance, membership in various economic groupings as well as introduction of tariff and non-tariff barriers should result in the increase in price differences. Such studies may be conducted both for pairs of countries and for a certain group of countries. Inference can be based on both graphic and statistical analysis of price differentiation in individual periods. A tendency to reduce price differences or to narrow down price relations will express the increased degree of integration of markets. In the case of the study on the integration within the larger number of markets, we may use one of measures illustrating the spatial price differentiation, e.g. variance, standard deviation or coefficient of variation. The assessment of integration in this case is identical with the assessment of sigma price convergence (Wolszczak-Derlacz, 2007).

Unfortunately, indirect inference on trade costs and thus on the spatial integration of markets, based on price differences, is encumbered with two serious risks. Firstly, the weakness of this approach is the fact that in commodity markets there may be changes in the direction of trade and, as a result, also changes in the sign in a number of price differences. Therefore, there may be short-term situations when there are differences close to zero, which, of course, do not reflect the level of trade costs. Secondly, it should be remembered that trade takes place within a network of links. For example, we have three countries A, B, C where country B is an importer located between exporting countries A and C. In this case, market prices of exporting countries may be identical, due to which price differences will not reflect trade costs. Therefore, it can be considered that only in the case of trade price differences can be treated as approximated trade costs. Thirdly, changes in the quality of the listed commodity, taking place over time, lead to price changes which may result in false conclusions (cf. formula 3).

Another criterion applied in assessing the integration of commodity markets is the physical trade flow. It is assumed that the integration is directly linked to the transfer of supply surpluses from one market to other markets. Thus, the mere fact of stating the trade flow (tradeability) between locations is considered a manifestation of integration of markets (Barrett and Li, 2002). The higher is the share of trade in production or consumption, the stronger is the degree of integration of analysed commodity markets. The integration of commodity markets, in the context of trade, is most often justified by specialisation and comparative advantages, as well as by economies of scale and product differentiation (Fontagné, Freudenberg and Peridy, 1997).

The simplest approach in the assessment of integration is based on the very fact of trade. If there is trade in any direction, it can be considered that in the light of trade flows markets are integrated. With two countries, we may be dealing with the absence of trade, with unilateral or bilateral trade. Based on this, Knetter and Slaughter (1999) as a measure of integration of commodity markets in multidimensional terms, proposed the market breadth index for trade flows, expressed by the following formula:

$$\theta_{it} = \frac{\sum_j \sum_{k \neq j} Z_{ijkt}}{(2 * N(N-1))_t} \tag{8}$$

where Z_{ijkt} is a variable with the value of 1 if country *j* exports commodity *i* to country *k* in time *t*, and zero if trade does not take place. In general, in a single period there may be $N(N\text{-}1)$ trade flows between countries. The value of the Θ_{it} index is from zero to one. The closer this index is to one, the stronger is the integration of markets in a given group of countries and in given time *t*.

The second type of measures for measuring the integration of markets in the context of trade takes into account the volume of this trade in absolute or relative terms. The higher the volume of this trade is, the stronger is the integration. It seems that the better solution is to determine the relative volume of trade (export or import) in relation to production or consumption. Fig. 3 shows the selected measures showing changes in the level of spatial integration in the group of EU-13 countries in the common wheat market. The left panel provides information on the level of trade among these countries and the right – on the share of this trade in production. In turn, on the right panel, there is the standard deviation of logarithms of common wheat prices and the market breadth index (formula 8) in the group of EU-13 countries. The figures presented clearly show the increase in the spatial integration of the common wheat market in the EU-13 countries. This is confirmed by a growing trend in trade and its share in production. At the same time, the number of countries involved in trade increased. In 2004, around 30% of potential international trade flows of wheat in the EU were implemented among the EU-13 countries, while in 2018 this percentage was about 50%. In addition, price differences decreased from around 10% to around 5% in the analysed period, which can be perceived as a reduction in trade costs.

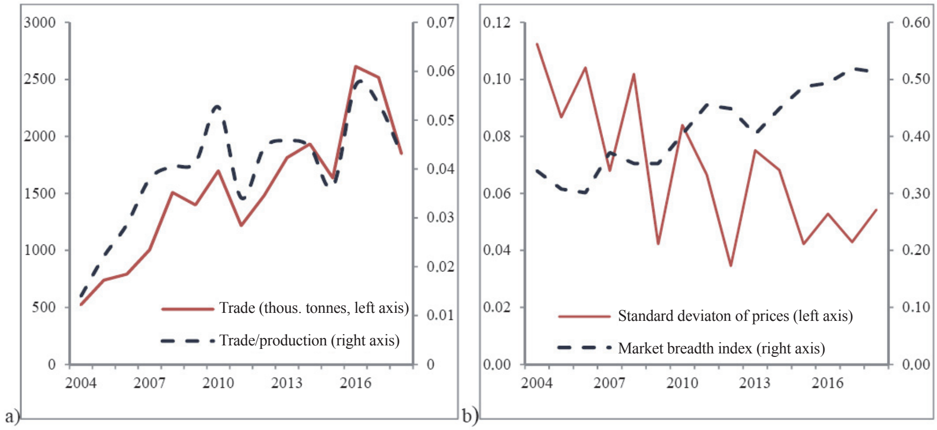

Fig. 3. Exemplary indices illustrating changes in the degree of integration of the common wheat market, in the current EU-13 countries in the years 2004-2018.

Source: own study based on the data from the Eurostat database.

Other proposals of studies on the integration of commodity markets may be found in anti-monopoly and antitrust policies. Significant factors limiting market power include the extent to which demand and supply can substitute a given good for other goods from the same geographical location or for the same good from a different geographical location. To this end, it is possible to determine the so-called geographic market delineation (Davis and Garces, 2010). One of methods used to analyse the geographic market delineation is the Elzinga-Hogarty test (1973). It is based on the assumption that regions trading with each other belong to the same market. This analysis is based on data covering the volume of production and consumption and quantities of exported and imported products. The disadvantages of this method include the fact that it is based on low frequency data (only annual data is available), which does not allow to analyse the issue of integration of markets in a more precise manner. Its advantages include relatively low requirements as regards necessary data and the simplicity of calculations.

Unfortunately, the above-mentioned approaches are limited to the aspect of direct integration only. Having surpluses of agricultural commodities does not need to entail a necessity to export them if it is possible to process them in the country concerned and to export semi-finished products or final products. Adopting such a perspective means that commodity markets in various regions or countries can be interlinked without a need for direct trade. For example, the integration in the pork market may take place as a result of parallel trade in piglets, fattening pigs, half-carcasses, various types of meat or processed products. Although in the milk market there is trade in butter, milk powder or cheese, buying-in prices of milk in EU countries whose trade is of little importance or does not exist at all are strongly correlated. Therefore, spatial relations in other links in the marketing chain should also be taken into account so as to fully illustrate the integration of markets.

Another solution used in studies consists in taking into account price information, flow volumes and trade costs at the same time. The best known are switching models based on the probability of transition among regimes. These models are also referred to as parity bounds models (PBM). They refer directly to the concept of price arbitrage and price arbitrage costs. The idea of this model was presented by Spiller and Huang (1986) and developed by Baulch (1997). The most famous modification by Barrett and Li (2002) extends the model from three to six regimes by including information on the trade flow. The idea of the latter model is presented in Table 1. The probability of classification into different market states (regimes) results from placing price differences against the background of trade costs (three situations in the first column) and the occurrence of trade or lack there of. It is assumed that in each regime price differences are equal to the sum of expected trade costs τ_t and stochastic cost components v_t, e_t and u_t. More information on the essence of the model and the procedure of its estimation can be found in Barrett and Li (2002).

Table 1

Market regimes and corresponding probabilities in the PBM model

Specification	Trade, A=1	No trade, A=0
$P_{Bt} - P_{At} = \tau_t + v_t$	Regime 1 – λ_1	Regime 2 – λ_2
$P_{Bt} - P_{At} = \tau_t + v_t + e_t$	Regime 3 – λ_3	Regime 4 – λ_4
$P_{Bt} - P_{At} = \tau_t + v_t - u_t$	Regime 5 – λ_5	Regime 6 – λ_6

Source: study based on: Barrett and Li (2002).

The implementation of these models results in estimating λ probabilities of being found in various regimes (Table 1). In general, PBM models assume that there are transitions among regimes over time, while the probability of being found in a given regime remains unchanged over time. In the first, third and fifth regimes, there is trade (A=1), while in the remaining ones there is no trade (A=0). The inclusion of trade information together with information on arbitrage rent allows to define and distinguish between two concepts: integration of market and spatial market equilibrium. According to Barrett and Li (2002), the integration involves tradeability or market contestability. This is manifested by the trade flow, information flow or both at the same time. The physical trade flow is sufficient, but not necessary for the integration of markets. These authors identify four basic market states. The competitive market equilibrium occurs when the zero-profit condition is met, i.e. it includes regimes 1, 2 and 6. The market disequilibrium takes place in the remaining regimes, i.e. 3, 4 and 5. The integration of markets takes place when there is the trade flow or there are no incentives for arbitrage (regimes: 1, 2, 3 and 5). The market segmentation, which is complementary to the integration of markets, includes regimes 4 and 6.

The main issue in PBM models is the way of determining trade costs τ_t. In general, three cases can be distinguished: determining directly from the model based on commodity prices only and information on trade flows; estimating costs outside the model or; combining these two methods (e.g. Baulch, 1997; Padilla-Bernal, Thilmany and Loureiro, 2003; Barrett and Li, 2002). The difficulty in the practical implementation of the model for analysing the integration of agricultural commodity markets is the lack of homogeneity. This makes it difficult to estimate the so-called arbitrage rent. Statistical data shows quite often that the export takes place even though prices in an exporting country are higher than those in an importing country (Hamulczuk, 2018).

Summary

The issue of spatial integration of agricultural commodity markets is important from the economic viewpoint. Without the spatial integration of markets, signals would not be transmitted among surplus and deficit regions, prices would be more variable, there would be no specialisation in line with the comparative advantage theory, and potential benefits of trade would not be put into practice. The theoretical starting point for assessing this phenomenon is the spatial partial equilibrium model and the idea of spatial arbitrage, where trade is determined by the level of prices and trade costs. The increase in the degree of spatial integration of markets is expressed by the increase in trade, reduction in trade costs and increase in the co-variability of prices.

A direct manifestation of spatial integration of markets are physical trade flows from locations with surpluses to locations with deficits. The higher is the share of trade in production or consumption and the higher is the number of trading partners, the stronger is the degree of spatial integration. In order to better grasp the aspect of spatial integration, flows of substitution commodities and processed products can be included in empirical studies. This approach is the least sensitive to the lack of homogeneity of commodities. Nevertheless, it does not allow to grasp the indirect integration, e.g. among countries, resulting from their functioning within a network of trade links. An alternative way to assess changes in the degree of spatial integration is to analyse trade costs. Costs can be estimated directly (problems with their estimation) or assume that trends in their changes are expressed by the evolution of price differences over time (here, in turn, the interpretation is not obvious). A more comprehensive approach is the simultaneous analysis of trade costs, price differences and trade flows (PBM models). This allows to assess whether market arbitrage opportunities are actually used. The third approach used in studies on the spatial integration of commodity markets is based on analysing the co-variability of prices and their mutual adjustments. The theoretical justification for studies on the spatial integration of commodity markets are non-linear TAR or STAR models assuming the differentiated rate of price adjustments depending on the level of profitability of market arbitrage. Nevertheless, this requires long data series with fairly high frequency.

The availability of data, its frequency, number of observations or reliability, comparability over time and space decide on a study approach to be used in the empirical assessment. In practice, studies based on price information from physical or forward markets with fairly different frequency are dominant. Difficulties in estimating trade costs and the lack of full homogeneity of agricultural commodities over time and space can be considered as major barriers to the practical implementation of most study approaches and models and the limited reliability of conclusions formulated on their basis.

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METODOLOGICZNE PROBLEMY OCENY PRZESTRZENNEJ INTEGRACJI TOWAROWYCH RYNKÓW ROLNYCH

Abstrakt

Stopień przestrzennej integracji rynków jest jedną z ważniejszych determinant dobrobytu ekonomicznego. Istotne znaczenie odgrywa jednak właściwe zdefiniowanie tego pojęcia oraz wyborów odpowiednich metod jego analizy. Stąd celem niniejszego opracowania jest porównanie i ocena metodycznych koncepcji pomiaru zjawiska przestrzennej integracji towarowych rynków rolnych. Bazując na przeglądzie literatury, w pracy przedstawiono teoretyczne przesłanki i definicje integracji rynków towarowych, a następnie omówiono najważniejsze metody oceny przestrzennej integracji rynków. Komentując je, zwrócono uwagę na ich charakterystykę w nawiązaniu do koncepcji teoretycznych oraz na możliwości ich zastosowania w praktyce na towarowych rynkach rolnych w świetle dostępnych informacji statystycznych. Generalnie ocena przestrzennej integracji rynków może być oparta na informacjach cenowych, kosztach wymiany handlowej oraz przepływach towarowych. W świetle przeprowadzonych badań można uznać, że nie wszystkie podejścia stosowane przez badaczy znajdują uzasadnienie w teoretycznych podstawach przestrzennej integracji rynków. Za główne bariery w praktycznej weryfikacji występowania, siły oraz zmian przestrzennej integracji towarowych rynków rolnych należy brak pełnej homogeniczności towarów oraz trudności z oszacowaniem kosztów wymiany handlowej.

Słowa kluczowe: integracja przestrzenna, towarowe rynki rolne, metody.

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