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THE CAUSAL RELATIONSHIPS BETWEEN THE WHEAT PRICES IN SELECTED EU COUNTRIES

ZWIĄZKI PRZYCZYNOWE POMIĘDZY CENAMI PSZENICY W WYBRANYCH KRAJACH UE

Key words: causal relationship, Granger test, wheat prices, VAR model

Słowa kluczowe: ceny pszenicy, modele VAR, test Grangera, związki przyczynowe

Abstract. Considering the situation in Polish agriculture the relationships between the Polish agricultural market and the EU agricultural markets should be taken into account. The aim of this study is to identify the links between the price of wheat in Poland and selected European Union countries (Spain, Denmark and Czech Republic). The Granger test is used to analyse the causal relationships between the considered variables.

Introduction

The cereals market in the European Union is a strategic markets. The first provisions of the CAP in the cereals sector have been introduced on the 1 of July 1967. The cereals: wheat and rye are very important for people and for their feeding, the prices of many products are depend on the cereals prices. Price adjustment processes between different national markets for agricultural products run quite slowly. It is important to describe the adjustment process which determine the integration and efficiency of the agricultural markets.

The aim of this study was to identify the causal relationships between the prices of wheat in Poland and selected European Union countries. For this purpose the Granger[1] causality test was used, the procedure is based on the vector autoregression – VAR.

Empirical material

In this study, the average monthly prices of wheat in euro per 100 kg from January 2006 to December 2010 as the empirical material were used, which is the 60 observations in the following countries: Poland, The Czech Republic, Spain and Denmark. Data were obtained from the Central Statistical Office[2].

In this study, the following symbols were used:

- v1 – average monthly prices of wheat in Poland in Euro per 100 kg,
- v2 – average monthly prices of wheat in Czech Republic in Euro per 100 kg,
- v3 – average monthly prices of wheat in Spain in Euro per 100 kg,
- v4 – average monthly prices of wheat in Denmark in Euro per 100 kg.

Table 1. The basic characteristic of the individual time series
Tabela 1. Podstawowe charakterystyki analizowanych szeregów czasowych

Specification/ ***Wyszczególnienie***	**v1**	**v2**	**v3**	**v4**
Mean/*Średnia*	224.49	212.85	188.23	219.35
Standard deviation/ *Odchylenie standardowe*	49.77	44.57	37.02	48.85
Coefficient of variation/ *Współczynnik zmienności [%]*	22	20	19	22
Min	143.48	145.53	136.10	149.46
Max	320.70	299.28	289.30	326.53

Source: own study
Źródło: opracowanie własne

[1] Granger Causality: x is simply granger causal to y if and only if the application of an optimal linear function leads to $\sigma^2\left(y_{t+1}\middle|I_t\right) < \sigma^2\left(y_{t+1}\middle|I_t - \overline{X}_t\right)$; i.e. if future values of y can be predicted better, i.e. with a smaller forecast error variance, if current and past values of x are used. Compare: W. Charemza, F. Deadman, Nowa ekonometria, M. Osińska, Ekonometria finansowa.

[2] http://www.stat.gov.pl/gus/5840_738_PLK_HTML.htm, http://www.statbank.dk/statbank5a/default.asp?w=1280, http://www.czso.cz/eng/redakce.nsf/i/agriculture_ekon, http://www.ine.es/en/inebmenu/mnu_agricultura_en.htm

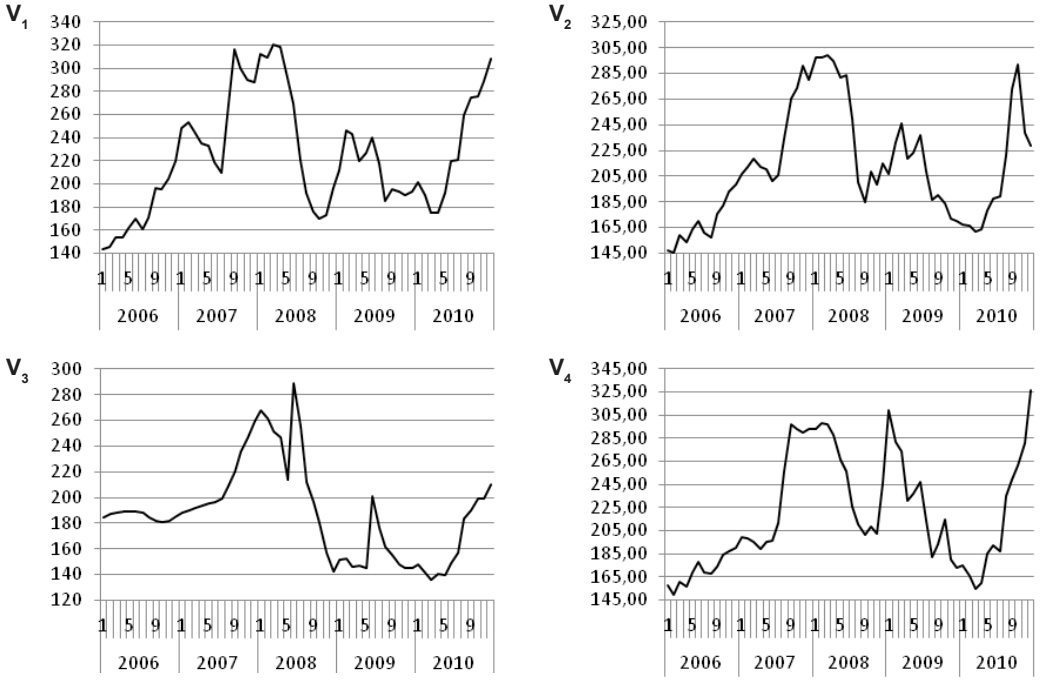

Figure 1. The monthly average values of the analyzed variables for the period 1.2006–12.2010
Rysunek 1. Kształtowanie się średniomiesięcznych wartości analizowanych zmiennych vi, i=1,2,3,4 w okresie 1.2006-12.2010 (euro/100kg)
Source: own study based on GUS data
Źródło: opracowanie własne na podstawie danych GUS

Basic characteristics of the individual time series are presented in Table 1. The lowest average price in the period was recorded in Spain – 188.23 euro/100 kg, while the highest average monthly price was recorded in Poland – 224.49 euro/100 kg. The prices of wheat in Poland and Denmark show the greatest differentiation – the variation coefficient was 22%. Comparing the prices of wheat in all analyzed countries it can be concluded that wheat prices are characterized by variability on a similar average level of about 20%.

Materials and methods

To verify the hypothesis about the causality between variables, the Granger test was used constructed on VAR models. VAR models are presented in econometric literature, therefore in this paper the general characteristics of this model are presented. The VAR model are presented in work Jusélius [2006], Cromwel et.al [1994] and Lutkepohl [2006].

The variables, which will be used in Granger test, should be stationary, therefore the rank of integration should be known. To test the stationarity of the variables augumented test Dickey-Fuller was used, it is presented in: Zivot, Wang [2006], Sarris, Hallam [2006]. Then the two-dimensional VAR model was estimated, which is presented by the formula:

$$Z_t = \sum_{i=1}^{p} A_i Z_{t-i} + \varepsilon_t$$

where:
Z_t – *is an observation vector,*
A_i *- matrix of parameters standing for the delayed variable vector* Z_{t-I},
ε_t – *is a disturbance term.*

The Schwarz criterion was used to identify the rank of delay. The BIC statistic is presented in work Ruppert [2010]. The use of VAR models requires a normal distribution and the lack of autocorrelation from the disturbance term. The LM test are presented in work Baltagi [2002], Cameron [2005].

The procedure of the Granger causality test begins with the estimation of model parameters:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + ... + \alpha_p y_{t-p} + \varepsilon_t \quad (1)$$

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + ... + \alpha_p y_{t-p} + \beta_1 x_{t-1} + \beta_2 x_{t-2} + ... + \beta_q x_{t-p} + \eta_t \quad (2)$$

where:
x_t – *empirical value of the variable X,*
y_t – *empirical value of the variable Y,*
p – *rank of delay of the variable,*
ε_t, η_t – *disturbance term of the models.*

The Granger test verifies the hypotheses:

$$H_0 : \sigma^2(\varepsilon_t) = \sigma^2(\eta_t)$$
$$H_0 : \sigma^2(\varepsilon_t) \neq \sigma^2(\eta_t) \quad (3)$$

and the test statistic is presented by the formula:

$$G = \frac{n \cdot \left(s^2(\varepsilon_t) - s^2(\eta_t)\right)}{s^2(\varepsilon_t)} \quad (4)$$

The F statistic has chi-square distribution – $\chi^2(q)$.

The results of the research

Examination of causal relationships between variables started from testing stationarity. The hypotheses of stationarity of variables were rejected on the basis of the ADF test (p-value 0,05). The correct specification of the VAR model requires stationarity of the variables. Therefore the first differences of the variables were taken under consideration Δvi, i=1,…,4. The decision was made that the first differences are stationary (Tab. 2 and 3).

The next step was to estimate the ranks of delays for the VAR models which was made by means of estimating eight models:

– Model 1 describes the relationship between first differences in wheat prices in Poland Δv1 and the first differences in wheat prices in Czech Republic Δv2,
– Model 2 describes the relationship between first differences in wheat prices in Poland Δv1 and the first differences in wheat prices in Spain Δv3,
– Model 3 describes the relationship between first differences in wheat prices in Poland Δv1 and the first differences in wheat prices in Denmark Δv4,
– Model 4 describes the relationship between first differences in wheat prices in Czech Republic Δv2 and the first differences in wheat prices in Spain Δv3,
– Model 5 describes the relationship between first differences in wheat prices in Czech Republic Δv2 and the first differences in wheat prices in Denmark Δv4,
– Model 6 describes the relationship between first differences in wheat prices in Spain Δv3 and the first differences in wheat prices in Denmark Δv4,

The rank of delays were chosen on the basis of the Schwarz criterion. Optimal rank of delay was chosen when the BIC statistic was the lowest (Tab. 4).

Table 2. The results of ADF test for variables v_i, i=1,…4
Tabela 2. Wyniki testu ADF dla zmiennych v_i, i=1,…4

Variable/ *Zmienna*	ADF	p-value
v_1	-1.64229	0.4608
v_2	-1.66035	0.4516
v_3	-1.79826	0.3819
v_4	-1.83542	0.3636

Source: own study
Źródło: obliczenia własne

Table 3. The results of ADF test for variables Δv_i, i=1,…4
Tabela 3. Wyniki testu ADF dla zmiennych Δv_i, i=1,…4

Variable/ *Zmienna*	ADF	p-value
Δv_1	-1.94017	0.0440
Δv_2	-2.08047	0.0360
Δv_3	-1.96684	0.0471
Δv_4	-2.01364	0.0422

Source: own study
Źródło: obliczenia własne

Table 4. The values of BIC statistics for chosen rank of delay models
Tabela 4. Wartości statystyki BIC dla wybranych opóźnień modeli

Model	Rank of delay (q)/*Pozycja opóźnienia (q)*	BIC
1	1	8.430
2	1	8.545
3	1	8.791
4	1	8.819
5	1	8.573
6	1	8.283

Source: own study
Źródło: obliczenia własne

The study of disturbance term properties allowed to adopt the hypotheses of normality and lack of autocorrelation. Next parameters of models (1) and (2) were estimated, which allowed to use the Granger test. The following conclusions have been drawn on the basis of the Granger test results (Tab. 5):
Δv1 is a cause of Δv2,
Δv2 is a cause of Δv1,
Δv3 is a cause of Δv1,
Δv4 is a cause of Δv1,
Δv4 is a cause of Δv2.

The obtained results allowed to identify one-way causal relationships between the analyzed variables. On the basis of the statistics G we can conclude that the variables Δv1, Δv2, Δv3, Δv4, which constitute first increment of wheat prices in Poland, Czech Republic, Spain and Denmark are the causes of variable Δv1, Δv2, i.e. the first increment of wheat prices in Poland and Czech Republic. In other cases, the differences between the models (1) and (2) are negligible, so there is no causality in Granger test sens.

Table 5. The values of Granger test statistic and critical value of χ^2
Tabela 5. Wartość statystyki G oraz wartości krytycznych χ^2

The value/*Zmienne*	**G**	**χ^2(p); α=0,05**
Δv_1 jest przyczyną Δv_2	7.964824	5.991465
Δv_2 jest przyczyną Δv_1	4.236891	3.841459
Δv_1 jest przyczyną Δv_3	1.031495	3.841459
Δv_3 jest przyczyną Δv_1	3.914439	3.841459
Δv_1 jest przyczyną Δv_4	1.610470	3.841459
Δv_4 jest przyczyną Δv_1	5.458506	3.841459
Δv_2 jest przyczyną Δv_3	1.381687	3.841459
Δv_3 jest przyczyną Δv_2	1.532691	3.841459
Δv_2 jest przyczyną Δv_4	1.739984	3.841459
Δv_4 jest przyczyną Δv_2	5.191852	3.841459
Δv_3 jest przyczyną Δv_4	0.518859	3.841459
Δv_4 jest przyczyną Δv_3	1.247717	3.841459

Source: own study
Źródło: obliczenia własne

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Streszczenie

Zważając na sytuację w polskim rolnictwie należy wziąść pod szczególną uwagę powiązania polskiego rynku rolnego z rynkami rolnymi krajów UE. Celem tego badania była identyfikacja powiązań pomiędzy ceną pszenicy w Polsce i wybranych krajach Unii Europejskiej (Hiszpanią, Danią i Czechami). Test Granger został wykorzystany do analizy przyczynowych relacji pomiędzy założonymi zmiennymi.

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