Linkage of grain prices in Ukraine with the world crude oil prices

Abstract
Over the past decade, we have observed an increased use of renewable energy sources based on agricultural commodities. It is stimulated by a wide range of political tools in developed countries and leads to the linkage of agricultural markets with energy markets even in the countries which do not have own peculiar policies regarding renewable energy. In this context, the purpose of the paper is to assess the linkage between corn and wheat prices in Ukraine and Brent crude oil prices. The price analysis was carried out on the basis of monthly data covering the period between January 2001 and December 2018 with the use of ARDL-ECM models and bound tests approach. The obtained results indicate time varying relationships between the Ukrainian grain prices and the world crude oil prices. The strongest price linkage was observed between 2008 and 2013, a period characterised by a substantial increase in bioethanol production, low grains inventory levels and high crude oil prices. It should be noted that reaching planned mandatory blending levels in most countries promoting biofuel policy and relatively low crude oil prices does not constitute a motivation to increase the use of cereals for biofuel production. The increase of stocks in the world grain markets also contributes to reducing the strength of price connections.

Keywords: Grains; Crude Oil; Biofuel; Price Transmission; ARDL-ECM

JEL Classification: Q13; Q18; Q28

DOI: https://doi.org/10.21003/ea.V175-07
prices of foods and crude oil, especially for those agrifood markets (Tyner, 2010; Wright, 2014). The general belief is that RES could be an opportunity for the development of agriculture and the increase of agricultural producers’ incomes (Makarchuk et al., 2007). Biofuel demand for biofuel production is one of the main factors underlying price linkage between agricultural and crude oil markets. The second channel linking both markets is via input costs (Potori & Stark, 2015). The dynamic growth of agricultural raw materials used for biofuels was reflected in the increase in the level and volatility of world agricultural commodity prices (Abbot, 2013; Galchynska et al., 2015; Wright, 2014). Due to globalisation, decisions of main world biofuel players have heavily affected agricultural and food prices in the countries that didn’t support biofuel production and consumption (Lagi et al., 2011; HLPE, 2013).

Ukraine is one of such countries, where biofuel production, in particular ethanol, doesn’t play any important role, despite the adoption in 2009 low promotion of the production and use of biofuels (Verkhovna Rada of Ukraine, 2009). Ukraine is one of the major producers and exporters of grains in the world and Ukrainian grain prices are significantly linked with world prices (Götz et al., 2012; Goychuk & Meyers, 2014). Therefore, we expect that the linkage between the grain prices and crude oil prices in Ukraine is also a very interesting question. The main objective of this study is to test their strength over time. We could not find any research assessing the impact of crude oil prices on Ukrainian grain prices. In this context, the study attempts to fill this gap and makes a contribution to the knowledge by providing evaluation of the linkage of corn and wheat prices in Ukraine with the world crude oil prices.

2. Brief Literature Review

Biofuel demand becomes more and more important part of the balance sheet of grains in the world (Schmitz & Meyers, 2015). Policy decisions in the biofuel era have led to the competition of grain and oilseeds demand for food, feed and energy purposes (McPhail & Babcock, 2012; Kretschmer et al., 2012). Involvement of biofuels, production of which is based on agricultural commodities, in the energy purposes (McPhail & Babcock, 2012; Kretschmer et al., 2012) have found that correlations between prices of grains and oil in the USA and Poland have changed from negative to positive along with biofuel introduction. D. Kumar (2017) points that existing volatility spillover from crude oil to agricultural commodities does not remain stable but exhibit multiple structural breaks.

3. Purpose

The paper aims at presenting an econometric analysis showing the nature of the linkage of the Ukrainian grain prices with the world crude oil prices. The empirical analysis of monthly price series is carried with the use of the ARDL-ECM framework attempted to solving time varying relationships between crude oil and grains prices.

4. Data and methods

To analyse the linkage between grain prices and crude oil prices, we used a monthly price series data covering the period between January 2001 and December 2018 (Figure 1). Wheat and corn price series express procurement prices in Ukraine, whereas oil price series is for Brent crude oil. All variables were expressed in USD. The source of data was the FAOSTAT (corn and wheat) and the World Bank (crude oil).

To test stationarity of time series, we applied the Augmented Dickey Fuller (ADF) test (see Enders, 2010). The empirical analysis of the price linkage was carried out with the use of the bound test and ARDL-ECM model (Pesaran et al., 2001). The applied procedure has several advantages over the conventional co-integration testing because it can be used regardless of whether the underlying series are I(0), I(1) or even fractionally integrated. An unrestricted ARDL-ECM model was specified:

$$
\Delta Y_t = \phi_0 + \sum_{i=1}^{p} \phi_i \Delta Y_{t-i} + \sum_{i=0}^{q} \gamma_i \Delta X_{t-i} + \tau Y_{t-1} + \pi_1 X_{t-1} + e_t. \quad (1)
$$

where:

- $Y$, $X$ are dependent and independent variables, respectively;
- $e_t$ is white noise errors;
- $\phi_0$ and $\gamma_i$ represent short run dynamics;
- $\pi_1$, and $\tau$ are long-run relationship.

The lag length of the model (p, q) was chosen according to AIC.

The existence of a long-run relationship among the variables was tested basing on F-test statistic. The null hypothesis of no cointegration (H0: $\pi = \tau = 0$) is tested against an alternative, assuming the presence of cointegration among the variables (H1: $\pi \neq \tau \neq 0$). The calculated F-test statistic values are compared with two sets of critical values according to Pesaran et al. (2001). If the F-statistic is below the lower bound critical value, then the null hypothesis of no co-integration cannot be rejected. If the F-statistics exceed the upper critical value, then the null hypothesis of no co-integration can be rejected. If the computed F-statistic
falls between the lower and upper bounds, then the results are inconclusive.

Bearing in mind that such relationships might be unstable over time, we tested the stability of the parameters using a CUSUM test. Moreover, to test the parameter instability and the structural change in the ARDL-ECM models, Bai-Perron multiple breakpoint test was applied (Bai & Perron, 1998). Three procedures were used to test structural breaks, each allowing heterogeneous error distributions across breaks. We tested: I+1 vs. I, sequentially determined breaks, I+1 vs. I globally determined breaks and 1 to M globally determined breaks. After assuming structural breaks, new ARDL-ECM models for each subsample were estimated. The whole analysis was summarised by computing dynamic multipliers which show the amount of information each exogenous variable contributes to the endogenous variables.

5. Results

The empirical analysis started with testing unit roots in the logarithmic price series. The null hypothesis for crude oil price series (assuming non-stationarity) cannot be rejected at the 5% and 10% significance levels (p = 0.268). The null hypotheses for the wheat price series (p = 0.087) and the corn price data (p = 0.058) can be rejected at the 10% significance level but not at the 5% level. The ADF test applied for first differences of all log price series allows us to reject the null hypothesis. The inconclusive results of the ADF test for the price levels justified the use of the ARDL-ECM framework, which is a robust for non-stationarity assumption, during testing long run relationships.

According to AIC, the most suitable models were ARDL (1.1) for the wheat-oil analysis and ARDL (2.1) for corn-oil modelling. However, the model for wheat-oil was subject to autocorrelation. Therefore, it was extended to ARDL (2.1). The estimated ARDL (2.1) models for the whole sample are presented in Table 1. Errors of these models are not serially correlated. Thus, we can use them for cointegration testing.

For further analysis, we determined two structural breaks (Table 3). It seems to be in line with our expectations and the fact that most procedures of the Bai-Perron test envisage such a solution. All the explanatory variables are regime variables. We assume that error distribution may vary over regimes.

The results of the application of three procedures are included in Table 2. The sequential procedure indicates three breakpoints for the wheat model and two structural breaks for the corn model. The remaining two procedures suggest two structural breakpoints in both models. According to the sequential, the procedure break dates for the wheat model are October 2010, June 2013 and February 2016. Global procedures indicate the break dates in October 2010 and December 2014. According to all procedures, the structural break dates for the corn model are September 2008 and September 2013.

F-statistic 5.23 for the first model and 5.08 for the second model. The lower and upper bounds for the F-test statistic at the 10% and 5% significance levels are (4.04, 4.78) and (4.94, 5.73), respectively. In both cases, the Wald-test statistics are over the upper bound critical value at the 10% significance level. At the 5% significance level, the bound test results are inconclusive. Therefore, we can conclude that there exist long-run relationships between the Brent crude oil series and the grain prices in Ukraine series, however only at the 10% significance level. Relaying on the ARDL-ECM models, we estimated the long-run relationships (Table 1). In the long run, a 1% increase in crude oil prices leads to 0.48% and 0.42% increase of wheat and corn prices, respectively. From Table 3, we can conclude that the adjustment to the long-run relationship is mainly from grain prices. Therefore, we can assume that crude oil prices are weekly exogeneity for the Ukrainian grain prices.

The CUSUM test (cumulative sum of residuals) indicates stability of the parameters of both the models which validates bound test results. However, the visual price analysis suggests time varying price co-movements. To verify this presumption, we applied three versions of the Bai-Perron multiple break point test for the models presented in Table 1. All explanatory variables were used as breakpoint variables. We assume that error distribution may vary over regimes.

To determine time varying price co-movements, we tested the stability of the parameters of both the models which validates bound test results. However, the visual price analysis suggests time varying price co-movements. To verify this presumption, we applied three versions of the Bai-Perron multiple break point test for the models presented in Table 1. All explanatory variables were used as breakpoint variables. We assume that error distribution may vary over regimes.

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For further analysis, we determined two structural breaks (Table 3). It seems to be in line with our expectations and the fact that most procedures of the Bai-Perron test envisage such a solution. All the explanatory variables are regime varying, therefore the models in each subsample can be treated as separate. In most of the subsamples, the null hypothesis
of no cointegration between the grains series and the crude oil series cannot be rejected.

The role of Brent crude oil prices in determining Ukrainian wheat and corn prices appears to be clear with regard to Figure 2, which portrays a cumulated response of grain prices on 1% shock in crude oil prices both for the whole period and particular subsamples. Two graphs represent impulse response functions calculated for the unconstrained models (Tables 1, 3). Constructing the model by removing insignificant variables in first differences doesn’t significantly modify the obtained results.

The estimated impulse response functions look pretty similar for both markets. In the whole analysed period (2001-2018), a 1% change in crude oil prices leads to a 0.41% change in wheat and corn prices in a 12-month span. The responses of grain prices on shocks from crude oil prices vary significantly between sub-periods.

In 2001-2008, the 1% increase/decrease in crude oil prices led to approximately a 0.4% increase/decrease in grain prices within 12 months. Such a shape of the function may indicate that the crude oil shock in this period was transmitted first into the cost of production and transportation and then into grain markets. We observe completely different price linkages in 2008-2013 (corn) and 2008-2014 (wheat) with a strong reaction of grain prices on crude oil price shocks. A 1% change in crude oil prices leads to a 0.85-0.87 change in wheat and corn prices within a 12-month span. In the short term, we can even observe over-reaction of corn prices due to a low level of corn stocks. Since 2013 (corn) and 2014 (wheat), a very limited impact of crude oil on grain prices has been observed.

6. Conclusions

The purpose of the research was to analyse the linkage of Ukrainian grain prices with Brent crude oil prices. The theoretical framework indicates a possible impact of world crude oil prices on grain prices in Ukraine via world grain prices. The crude oil-wheat and the crude oil-corn linkage in Ukraine might be especially evident due to a significant share of Ukrainian grain export on the world market.

The application of the cointegration bound test proves the existence of a long-run relationship between the crude oil prices and the grain prices in 2001-2018. The long run elasticity of corn prices, with respect to Brent crude oil price, is 0.022 whereas the long run elasticity in crude oil price is 0.48. The Bai-Perron multiple breakpoint test indicates possible structural breaks in 2008 and 2013-2014. The estimated ARDL-ECM models confirm the time varying relationship between the crude oil series and the grain price series.

In 2001-2008, the shocks in crude oil were slowly transmitted to the corn prices, confirming that cost of production and transportation are the main channel linking crude oil and grain markets. In 2008-2013, we could see evidence of strong co-movements of crude oil prices and grain prices, which was caused by a rapid increase in biofuel demand, depletion of grain stock and relatively high crude oil prices increasing profitability of biofuel production.

Since 2013-2014, the price linkages between crude oil and grain prices seem to have become insignificant. Reaching the planned mandatory blending levels in most countries promoting biofuel policy and, relatively, low crude oil prices does not constitute a motivation to increase the use of cereals for biofuel production. The increase in stocks of the world grain markets also contributes to the reducing strength of price connections.

The extension of this study may include the application of the threshold or other regime switching models, which can
be useful when assessing asymmetric and time varying relationships. Further study may be related to the inclusion of the world grain and bioethanol series into the models, which will enable us to assess the interconnection between the world crude oil prices and the Ukrainian cereal prices more accurately.

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Received 14.04.2019