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Coal Prices in Poland: Is the Domestic Market Separated from the International Market?

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ABSTRACT

The paper presents the relationships between coal prices on the domestic market in Poland and the prices of coal and natural gas on the international market. The analyses use the ARDL model. Long-term linkages were analysed with the bounds test, while short-term adjustments - with unconditional ECM models. The obtained results indicate a clear hierarchy of markets. Coal prices on the Polish market were not cointegrated with natural gas prices and they were relatively poorly integrated with coal prices on the international market. Coal prices exported from Poland and international prices were connected more strongly. The strongest relationships were stated between coal and gas prices on the international market. At that level, coal prices behaved in a manner characteristic to the global market.

Keywords: Coal, Prices, Integration, International Market, Domestic Market, Poland
JEL Classifications: C22, F14, Q41

1. INTRODUCTION

The energy market is highly diverse. Despite integration processes, it is difficult to speak about one energy market, common for various energy sources and particular regional and domestic markets. Oil, coal and natural gas have the largest share in the consumption of primary energy. Demand for these products is not shaped by the same factors and they do not constitute perfect substitutes. Transportation costs, domestic and transnational regulations, deviations from excellent competition result in separation of domestic and local markets. These factors cause an increase in price differences among particular markets and weaken linkages among price changes. Many studies indicated that the oil market is global. The market of coal and natural gas is more diversified. In many countries, after the oil crises in the 1970s, the use of coal in energy production has been increased, as it was treated as an element of the strategy of reducing the economic dependence on oil. In addition, the natural gas consumption has significantly increased. It becomes more and more popular among others due to the pursuit of reduced carbon emissions. As a consequence, global conditions for the market of coal and natural gas have become much more important.

Energy markets have their structure and hierarchy, just like other markets. Taking into account the spatial criteria, they can be divided into the international market, domestic, and local markets. At the international level, competition is usually much stronger. At the domestic level, in particular local, non-competitive structures become much more important. This differentiation may result in a different price behaviour. In the case of a more competitive international market, price impulses may transmit more quickly, leading to a stronger integration than at the level of domestic and local markets. In the paper, one attempted to verify the occurrence of such differences on the example of coal prices on the Polish and international market. In the conducted analyses, long-term relationships between markets and the rate of short-term price adjustments were tested. Based on that, differences in market integration were assessed.

Several arguments support selecting the Polish market for analyses. Firstly, Poland belongs to a group of important, but not largest coal producers. Its share in global production comes to 1.5%. As the output is decreasing, this share has declined almost 3 times since 1990. Secondly, coal is very significant in the Polish economy, in particular against other countries of the European Union. In 2018, 86% of production and 30% of consumption of hard coal in the entire EU fell to Poland. In addition, coal share in the power production is very high, approx. three-quarters. Thirdly, the Polish coal market is strongly connected with the international market through export and import. As the decline in production is faster than the decline in consumption, Poland has become a significant importer of hard coal. In the years 2015-2018, the coal import came to almost 20% of production, while export did not exceed 10% of production. A high share of international trade should constitute a factor positively affecting an integration of the domestic market with the international market. However, this linkage may be weakened by structural conditions of the coal and energy sector in Poland. The state constitutes the largest owner of mines, power plants and heat generating plants. This leads to strong, formal and informal agreements on the energy market, affecting coal prices. Long-term price contracts constitute the basic form of formal agreements. Also other, hidden forms of agreements, leading to preferring specific coal suppliers may be applied. In addition, an obligation of approving changes in electricity prices constitutes a part of the state impact on the market. A structure of the energy market in Poland, different from the competitive structure, constitutes the basis for asking a question presented in the paper's title.

2. LITERATURE REVIEW

Analyses based on testing price linkages among markets are commonly applied in the market integration studies. According to this approach, integrated markets shall mean the markets where prices do not behave independently (Barrett and Li, 2002; McNew, 1996). Accepting such an assumption leads to the conclusion that the smaller the differences and/or the stronger the price linkages, the more integrated the markets. Integration implies the price equalisation mechanism under the law of one price or an analogous market response to a specific shock (Engel and Rogers, 2004). The first interpretation concerns homogenous products, while the second one may concern various products less related to each other, e.g. via the market of final goods. Price equalisation among markets is connected with the activities of arbitragers, while integration requires their sufficient number and conditions allowing for their efficient operations on markets. The condition for a fully effective arbitrage is constituted, among others, by the homogeneity of products, a possibility of product resale and the lack of risk (Pippenger and Phillips, 2008). Perfect competitiveness constitutes another condition. Monopolistic structures may result in an increase in price differences among local markets (Takayama and Judge, 1971). Arbitrage possibilities are also limited by the costs of exchange, e.g. transportation costs, duties, etc.. However, differences in price levels among markets should not exceed the total arbitrage costs.

Analyses of energy commodity prices constitute a popular area of research. The research subject includes, among others, factors forming energy source prices, impact of these prices on particular sectors and entire economy, as well as relationships among particular markets. The most common subject of studies is constituted by the prices of oil, natural gas and coal.

The most common subjects of analyses of integration on the energy market include the correlations of prices of coal, natural gas and oil, as well as connections between prices of the same products on various markets. Research results indicate that these prices are subject to the mechanism that integrates markets, but also to the factors specific for particular markets, affecting the differentiation of price levels and their changes in the short and long term (Aruga and Managi, 2011; Nick and Thoens, 2014). Price linkage may result from substitutive relations and a similar response to exogenous demand shocks (Hartley and Medlock, 2014; Ramberg and Parsons, 2012). Oil, gas and coal are only partial substitutes, though, and the possibility of their mutual substitution is limited. As a consequence, due to diverse costs of output, transport and processing, price relations for particular energy commodities are different from relations of energy content (Brown and Yücel, 2007). Demand and supply conditions - specific for particular markets - result also in significant differences in price seasonality (Ramberg and Parsons, 2012).

In general, the results indicate that there is not one primary energy market, while price correlations among various commodities, if any, are usually long-term (Aruga and Managi, 2011; Bachmaier and Griffin, 2006; Mohammadi, 2011). This suggests a poor integration of markets of coal, gas and oil, as well as their low substitutability. Transportation costs of energy commodities, relatively high and being subject to fluctuations, increase the arbitration costs and as a result they weaken the price linkages between particular markets []. The global nature describes mainly the market of oil and petroleum products. Cointegrating relationships describe also the oil and gas prices, although in the short term the linkages may be weak and undergo changes in time (Ramberg and Parsons, 2012). Long-term contracts significantly affect the coal and gas prices. Their impact on the market integration is not unambiguous. On the one hand, contracts may stiffen prices, weakening, in particular, the short-term connections. However, on the other hand, they may be based on formulas connecting prices on one market with prices on the other market (Agerton, 2017).

Results of analyses concerning price linkages on the coal market are not unambiguous. In some papers, it has been said that this market is regional, less connected with prices of other energy sources (Bachmaeir and Griffin, 2006; Mohammadi, 2011). In other papers, though, bilateral linkages are declared among coal and oil prices, thus indicating their high level of substitutability (Zamani, 2016). It is the matter of controversial debate whether the coal market is global. Some papers declare that coal prices are formed mainly by regional and local conditions, as well as long-term contracts (Bachmaier and Griffin, 2006; Mohammadi, 2011). A weak connection of coal prices has been declared e.g. among the majority of US local markets (Bachmaeir and Griffin, 2006). In turn, the results obtained in other papers have indicated a strong connection of coal prices among the most important regional coal markets and an international nature of this market (Li et al., 2010; Xue and Huang, 2017; Zamani, 2016).

3. METHODOLOGY AND DATA

The research procedure adopted in the paper is based on the concept of market integration - popular in economic analyses. According to it, integrated markets shall mean the markets where prices do not behave independently. Integration testing was based on testing of relationships between coal prices on the Polish market and prices on foreign markets. Long-term linkages were interpreted as a result of market integration. The rate of short-term adjustments to the long-term balance was interpreted as a description of the power of market integration. Usually, various versions of VAR or ARDL models are applied in analyses of price correlations. Analyses conducted in the paper are based on the ARDL models due to their relative simplicity and a lower level of restrictions in reference to variables in the model. Contrary to the VAR models, the ARDL models do not require the integration of all variables at the same level.

The research procedure covered the following steps:

- Step 1 - Removal of seasonal components from price series of oil and gas prices. Markets of energy products are at risk of seasonal fluctuations (Ramberg and Parsons, 2012). According to the product and region, distribution of seasonal fluctuations may be different, which may disrupt analysis results. Prices were seasonally adjusted with use of the Census X13 procedure.
- Step 2 - Identification of breakpoints. Breakpoints constitute critical points in time series and are connected with trend changes. For their identification, the Bai-Perron multiple breakpoint test was conducted (Bai and Perron, 1998).
- Step 3 - Testing of a level of integration of variables. An option of applying the methodology adopted in the paper is limited to variables integrated at the level of zero or one. In the research, the ADF test was applied with modifications considering the occurrence of breakpoints (Perron and Ng, 1996).
- Step 4 - Development of basic ARDL models for particular price pairs. In the basic version, the ARDL regression model has the following form:

$$P_{y,t} = \alpha_0 + \alpha_1 P_{y,t-1} + \ldots\ldots + \alpha_i P_{y,t-i} + \beta_0 P_{x,t} + \beta_1 P_{x,t-1} + \ldots\ldots + \beta_j P_{x,t-j} + \varepsilon_t \quad (1)$$

In the model 1, the division into exogenous variable P_y and endogenous variable P_x was adopted based on theoretical criteria. As the Polish market of energy and coal is relatively small, prices on the Polish market have been treated as the endogenous variable and prices on the international market - as the exogenous variable. A number of delays in ARDL models was determined based on the Schwartz criterion. The LM test was applied to check whether residuals in the model were serially independent.

- Step 5 - Testing long-term correlations between natural gas prices and oil prices. The bounds test was applied for that purpose (Pesaran et al., 2001). The starting point in this test is constituted by the ARDL model converted into the form of unrestricted or conditional ECM:

$$\Delta P_{y,t} = \alpha_o + \sum_{i=1}^{k}\alpha_i \Delta P_{y,t-i} + \sum_{j=1}^{p}\beta_j \Delta P_{x,t-j} + \theta_1 P_{y,t-1} + \theta_2 P_{x,t-1} + \epsilon_t \quad (2)$$

Testing the long-term relationship between variables is based on testing the H_0 hypothesis that $\theta_1 = \theta_2 = 0$. Rejection of H_0 means the acceptance of the hypothesis about a long-term linkage between variables P_y and P_x. The test results were correlated with critical values for the upper and lower bound. The lower bound is based on the assumption that all variables are I(0), while the upper bound is based on the assumption that all variables are I(1). The bounds test may be applied when residuals from the ARDL model are serially independent. If the bounds test indicates the long-term correlation between variables, the ARDL long-run form is provided:

$$P_{y,t} = \alpha_0 + \alpha_1 P_{x,t} + z_t \quad (3)$$

where z (error-correction term EC) is the residuals series from the long-run regression (so-called cointegrating regression).

- Step 6 - For variables showing long-term relationships, an analysis of short-term linkages was conducted and the rate of achieving balance among markets as a result of exogenous price shock was defined. The ARDL model converted into the conventional restricted ECM was applied:

$$\Delta P_{y,t} = \alpha_0 + \sum_{i=1}^{k}\alpha_i \Delta P_{y,t-i} + \sum_{j=1}^{p}\beta_j \Delta P_{x,t-j} + \gamma z_{t-1} + \epsilon_t \quad (4)$$

The γ coefficient from the model (4) indicates the rate of short-term price adjustments P_y to the long-term balance between P_y and P_x prices. According to the theory, the γ coefficient should be negative.

In the paper, three price categories of the Polish coal were analysed:

- PLX - Average price in export from Poland to the European Union states, data according to Eurostat There were selected prices in the intra EU export, as Poland exports coal mainly to the EU states. Export outside the EU is much smaller and characterised with smaller stability.
- PLI - PSCMI1 index of thermal coal with calorific value 20-24 MJ/kg for coal power plants, data of the Industrial Development Agency in Poland
- PLII - PSCMI2 index of coal with calorific value 23-27 MJ/kg for heat generating plants and industrial customers, data of the Industrial Development Agency in Poland Prices from the Polish market were compared with the following prices from the international market:
- AUS - Prices of Australian coal from January 2015 FoB Newcastle with calorific value of 25.1 MJ/kg, and in the years 2011-2015 FoB Newcastle/Port Kembla with calorific value of 26.4 MJ/kg, data of the World Bank. Selection of the Australian coal price is justified with the fact that Australia is the largest coal exporter. Its share in the global export has come in the recent years to approx. 30%.
- ICE - Prices of Rotterdam Coal Futures contracts on the International Commodity Exchange. The analyses took into

account prices in forward contracts, as forward markets were very transparent and liquid. Forward prices are dominant on markets of many products, affecting spot prices.

- NG - European prices of natural gas, from April 2015 Netherlands Title Transfer Facility (TTF), and in the years 2011-April 2015 average import border price and a spot price component, data of the World Bank. In the paper, natural gas prices were selected instead of oil prices, as oil had practically no significance in Poland with regard to electricity production. Although the significance of gas is not so considerable as coal, but it is slowly increasing.

Figure 1: Prices of hard coal ($/t) and natural gas ($/mmbtu)

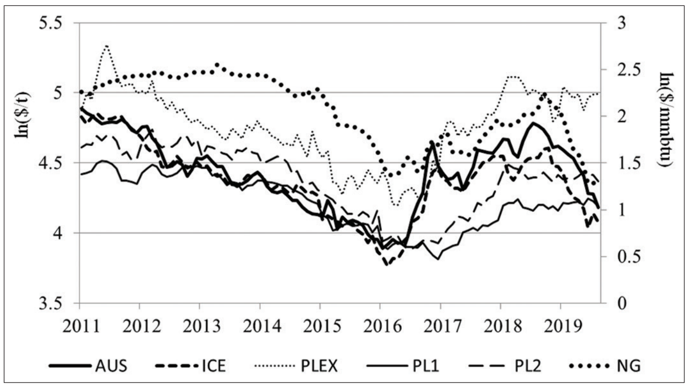

Table 1: Multiple breakpoint tests for coal prices (Bai-Perron test, max 3 breaks)

Prices	Break dates
AUS	2012M05, 2014M08, 2016M10
ICE	2012M04, 2015M01, 2016M10
PLEX	2012M10, 2015M01, 2017M02
PLI	2013M06, 2015M01, 2017M11
PLII	2014M09, 2016M01, 2017M02
NG	2015 M04, 2017M11

Table 2: Coal and natural gas prices - unit root with break tests

Prices	I~0[1]		I~1[1]	
	intercept	intercept and trend	intercept	intercept and trend
AUS	−1,8691	0,3710	−8,7843[d]	−9,1646[d]
ICE	−2,8363[a]	−1,2120	−9,9638[d]	−10,9050[d]
PLEX	−2,3924	−2,6884	−12,4754[d]	−12,4764[d]
PLI	−2,4235	−2,1397	−8,8240[d]	−8,8829[d]
PLII	−2,4311	−2,0853	−10,4457[d]	−10,5579[d]
NG	−2,3129	−2,2317	−8,9694[d]	−8,9654[d]

[1] – significant at: [a] - 0.1, [b] - 0.05, [c] – 0.025, [d] – 0.01

Data covered the period of January 2011-August 2019. Data concerning prices on the Polish market (PLI and PLII), available since 2011, constituted the time limitation.

4. RESULTS

Energy product markets are described with a high short- and long-term variability of prices. In the studied period, no extreme price changes occurred, but they were significant, regardless (Figure 1). In the years 2011-2016, prices were in a strong downward trend. In the years 2016-2018, prices went up twice. The presented data indicated that the AUS and ICE coal prices were similar throughout the analysed period, while prices on the Polish market showed significant differences in prices on the international market through the majority of the studied period. Export prices of the Polish coal were much higher than the AUS and ICE prices, while prices on the domestic market were usually similar or lower. Differences between prices on the Polish and international market increased after 2016.

Table 1 presents break dates for particular prices. Due to a relatively short period of analyses, the number of breaks was limited to three. The obtained results confirm a significant long-term compliance of changes in coal prices on the international market. Break dates for the AUS and ICE prices were similar. Slightly larger differences concerned export prices of the Polish coal. However, the largest differences were stated for the Polish coal prices on the domestic market. Break dates for prices on the Polish market, in particular PLII prices, were delayed by many months towards export prices and prices on the international market. That indicates the occurrence of an inertial price mechanism on the domestic market, which may be caused by long-term contracts, but also by non-competitive market structures. In the case of natural gas prices, only two breaks were discovered, while their dates were significantly delayed towards break dates for coal prices on the international market.

While characterising the studied prices, the unit root test was conducted at the subsequent stage. As all variables were described with the occurrence of breaks, the ADF test with breaks was applied. The obtained results indicate that at the level of significance coming to 0.05, all variables were non-stationary, while the first differences in variables were stationary. Therefore, the results enable to use ARDL models in the price correlation analysis (Table 2).

The second stage was constituted by testing relationships between coal prices and oil prices. In 2016, the coal output in China had

Table 3: Coal and natural gas prices - bounds tests and ARDL long run form

Prices	F-bounds test				Long run: level equation
	Value	Signific. (%)	I(0)	I(1)	
PLEX	3,7539	10	4,04	4,70	n.s.
PLI	0,6192	10	3,02	3,51	n.s.
PLII	0,6834	10	3,02	3,51	n.s.
ICE	10,1480	1	6,10	6,73	ICE=0,0945 NG–0,0100 Trend+EC
AUS	7,1618	1	6,10	6,73	AUS=0,0791 NG–0,0051 Trend+EC

significantly decreased, thus affecting higher coal prices on the international market, which might disturb the coal and gas price correlations. Therefore, while developing the ARDL models, there was considered the potential occurrence of changes in price linkages, which might be described by the trend and dummy variable. Those modifications were relevant only for the ICE and AUS prices. For the AUS prices, 0 was adopted for January 2011-July 2016 and 1 for subsequent months, while for the ICE prices 0 was adopted for January 2011-June 2016. In models describing coal prices in Poland, no significant impact of the trend and dummy variable was declared.

All models were characterised with no autocorrelations, which created the basis for an analysis of cointegration. According to the methodical comments, those analyses were conducted based on the model 2. The bounds test results indicated significant differences between coal prices in Poland and prices on the international market (Table 3). Prices of the Polish coal did not show any long-term linkages with prices of natural gas and no long-run level equations were presented for them. Cointegrating relationships were discovered between coal prices on the international market and prices of natural gas. Long run level equations indicate that in the long term coal prices were falling against gas prices (negative coefficients for the trend). According to the adopted methodology, the analysis of short-term linkages (model 3) was conducted only for prices showing long-term relationships. The results presented in Table 4 indicated that approx. 40% of short-term variability of AUS and ICE coal prices was explained. According to the theoretical assumptions, coefficients for delayed variables EC were negative. However, taking into account the fact that monthly data were applied in the analyses, the value of coefficients indicated a moderate rate of return to equilibrium between coal prices and gas prices on the international market.

To sum up this part of the analysis, it might be stated that coal prices in Poland were not integrated with gas prices on the European market. Such a connection was demonstrated by the ICE and AUS coal prices, although it was not very strong. Different outcomes might result from the structural conditions of the energy market in Poland. Coal is the most important for the electricity production, while the natural gas share is insignificant. The natural gas share is larger in the heat production, but this production is local and there is no domestic heat market. As a consequence, coal and natural gas do not constitute substitutes on the energy market in Poland.

The obtained results do not have to mean the separation of the Polish coal market from the international market, unless its prices are linkaged with coal prices on the international market. In the case of coal prices on particular markets, arbitration should directly lead to the connection between them. Therefore, while accomplishing the paper objectives, relationships between coal prices on the Polish market and ICE and Australian coal prices were analysed. The results presented in Table 5 indicate that prices of the Polish coal and the ICE prices demonstrated the long-term equilibrium relationships with the Australian coal prices. Long-term relationships were significant for PLI prices at the level of

Table 4: Coal prices and natural gas prices – unconditional ECM models

ICE		AUS	
Variable	Coeff.[1]	Variable	Coeff.[1]
C	0.7008[d]	C	0,6733[d]
dICE-1	−0,1990[b]	dAUS-1	0,1663[a]
dNG	0,2875[d]	cNG	0,3257[d]
dNG-1	0,2367[d]	dNG-1	−0,0580
Dummy	0,1048[d]	dNG-2	0,1148
EC-1	−0,1585[d]	dNG-3	−0,0963
		dNG-4	0,1869[b]
		dNG-5	0,2295[b]
		Dummy	0,0708[d]
		EC-1	−0,1549[d]
Adj. R^2	0,40	Adj. R^2	0,38

[1] – significant at: [a] - 0.1, [b] - 0.05, [c] – 0.025, [d] – 0.01

Table 5: Polish and ICE coal prices - ARDL long run form and bounds tests

Prices	F-bounds test				Long run level equation
	Value	Signific. (%)	I(0)	I(1)	
PLEX	8,8977	1	4,94	5,58	PLEX=1,0163 AUS+0,2513+EC
PLI	4,3904	5	3,62	4,16	PLI=0,8967 AUS+0,2402+EC
PLII	5,0275	2,5	4,18	4,79	PLII=1,1637 AUS–0,8020+EC
ICE	7,6704	1	6,10	6,73	ICE=0,8077 AUS–0,0021 Trend+EC

Table 6: Polish and ICE coal prices - unconditional ECM models

PLEX		PLI		PLII		ICE	
Variable	Coeff.[1]	Variable	Coeff.[1]	Variable	Coeff.[1]	Variable	Coeff.[1]
dAUS	−0,0288	dAUS	−0,0322	dAUS	0,1937[a]	C	0,2708[d]
dAUS-1	−0,1357			dAUS-1	−0,1443[a]	dICE-1	−0,0919
dAUS-2	−0,3329[c]					dICE-2	0,0736
						dICE-3	0,1208
						dICE-4	0,3100[d]
						dAUS	0,3667[d]
EC-1	−0,3509[d]	EC-1	−0,0556[d]	EC-1	−0,0691[d]	EC-1	−0,3032[d]
Adj. R^2	0,2079	Adj. R^2	0,1068	Adj. R^2	0,1712	Adj. R^2	0,4893

[1]significant at: [a] - 0.1, [b] - 0.05, [c] – 0.025, [d] – 0.01

0.05 and 0.025 for PLII prices, while for PLEX and ICE prices they were significant at the level of 0.01. Coefficients for the long run level equation indicate that in the long term changes in prices on the Polish and Australian market were close to equivalent. In a model for ICE prices, responses were slightly weaker, while there was declared the trend of their decrease towards the Australian coal prices.

As in all analysed models the long-term relationships between coal prices and Australian coal prices were declared, an analysis of short-term linkages was conducted. Table 6 presents the results for unconditional ECM models. They indicate a diverse power of integration of particular markets. Diverse results were obtained for the coefficients of determination and for EC-1 coefficients. Presented models explained the short-term variability of coal prices on the domestic market in Poland only to a relatively small extent. For PLI prices, the adjusted R^2 came only to 10.7%, while for PLII - 17.1%. For prices of coal export from Poland, the obtained coefficient was only slightly larger. In the case of ICE coal prices, the adjusted R^2 was much larger and explained almost a half of short-term variability of the exogenous variable. In turn, coefficients for EC-1 indicate that export prices of Polish coal and ICE prices had the highest rate of achieving the long-term balance after exogenous price shock. The rate of those adjustments was also higher than in the case of previously stated adjustments between coal and gas prices. Price adjustments on the domestic coal market were much slower. That confirmed its weaker integration with the international market.

5. CONCLUSION

While interpreting the results obtained in the paper, their local and global aspect may be highlighted. The conclusions depend on the fact of whether they concern price behaviour at the level of domestic or international market. Specificity of domestic energy markets may result in their relatively weak integration with the international market. Due to coal prevalence in the electricity production, coal and natural gas do not constitute substitutes on the Polish market. Also non-competitive structures on the energy market in Poland may weaken the linkages between domestic and international prices. The analysis results confirmed that assumption.

Coal prices on the Polish market were not cointegrated with natural gas prices and they were relatively poorly integrated with coal prices on the international market. Coal prices exported from Poland and international prices were connected more strongly. The strongest relationships were stated, though, between coal and gas prices on the international market. At that level, coal prices behaved in a manner characteristic to the global market. Therefore, the obtained results indicate a clear hierarchy of markets. Prices on domestic markets, giving the example of the Polish market in the paper, may be significantly separated from prices on the international market, while prices on the international market are described with strong integration.

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