

Practical Application of Selected Panel Data Techniques in Analyzing Sales Capabilities of Coal Assortments



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Abstract

The article presents an analysis of the possibilities of selling hard coal in reference to environmental regulations of the European Union. Analysis of this sale made it possible to develop a theoretical model for forecasting demand on the domestic market. Proper forecast of demand allows for flexible and dynamic adjustment of the level of production or inventory to changes taking place on the market. It also enables the adjustment of the assortment manufactured to the requirements and expectations of the recipients, which in turn translates into increased sales, the release of financial resources, a reduction of the company's operating costs, an increase in the financial liquidity of the mines

Keywords: Sales of hard coal; Mathematical modelling; Environmental directives of the European Union

JEL Code: O14; C4; Q5

Introduction

The structure of the Polish energy mix is largely determined by mineral resources in our possession. Hard and brown coals are basic sources of primary energy in Poland due to rich deposits of

these raw materials. However, the energy mix structure in Poland is undergoing a change which relates to a decrease in the fossil fuels share in the energy mix in accordance with the environmental requirements of the European Union.

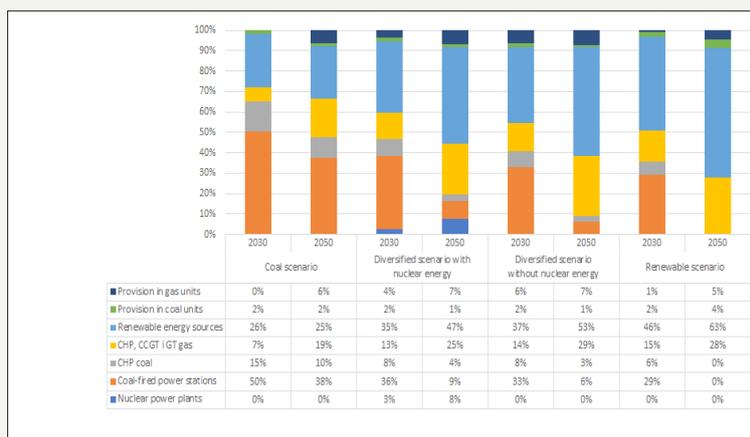


Figure 1: Scenarios of the energy mix in Poland.

The Ministry of Energy has among its studies the energy mix structure until 2050, shown in Figure 1. Four scenarios of the energy sector development have been taken into account. The first, coal scenario, assumes that energy production is based on coal with the 26% share of the renewables; the second scenario, the

so called diversified one, forecasts building nuclear power plants and the 47% share of the renewables in the mix; the third scenario, diversified one, does not include nuclear energy. It replaces nuclear power with gas and the renewables, which account for a 53% share in the mix. The fourth scenario, a renewable one, assumes

total replacement of coal power plants by gas power plants and renewable sources, which account for a 63% share in the energy mix. More in [1].

The aim of the article is to analyze the directives of the European Union in the field of environmental protection, which contain requirements for reducing the emission intensity of EU countries, including Poland. The article presents mathematical models for warning forecasting in terms of hard coal production in Poland, which is the basic energy resource of the country and requires the implementation of measures improving its quality parameters.

Literature Review - Environmental Directives

The process of energy generation, transport and utilization leads to significant environmental pollution. In the past decade, concern for the environmental pollution has increased considerably. This issue is widely described in the literature [2-6]. An essential element influencing the situation of the Polish coal sector is its regulatory environment. European directives transposed into the domestic legislative system are mainly aimed at decarbonisation actions, which shall result in significant reduction of the role of the qualitatively worst coals in economy. The impact of these regulations on the functioning energy and fuel sectors poses a challenge both for the mining industry as well as energy companies.

In order to provide suitable mechanisms helping to achieve the declared goals of the climate and energy package, a plethora of regulations have been introduced to implement the postulates of the '3x20' package. In particular these are [7-9].

Apart from the legal regulations mentioned above, the energy sector and hard coal position as a fuel for electrical energy production are indirectly influenced by the following regulations [8].

Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe,

A. Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment,

B. Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC with further amendments,

C. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC [10-12]. The significant element resulting from the presented regulations

is a decrease in coal share and an increase in the renewables share in the Polish energy mix. It requires high investments in order to build a new energy system adjusted to the diversified energy sector.

The quality of produced and used coals

The origins of qualified coal fuels go back to the first half of the 1990s [13,14]. Currently, hard coal supply to Polish customers is ensured by both domestic and foreign producers [15]. Coal from imports finds its recipients in a wide group of users: from commercial power industry, to heating plants and a group of individual consumers. The leading supplier of coal is Russia, the Czech Republic and the USA. The parameters of hard coal offered for sale on foreign markets are presented in Table 1.

The Table 1 shows that on the market there are coals with high quality parameters. Ash content in final products in 205 American processing plants is very low and accounts for between 5-15% (it should not exceed 15%). The data quoted above characterize the production of energy coal and its quality giving us a glimpse of the world energy sector. Table 2 below presents average quality parameters of energy coals sold to various national consumers. The parameters refer to the working state.

Table 1: Quality parameters of coal offered for sale by ten major world exporters according to coal week International.

Country	Calorific Value Qmin-Qmax GJ/Mg	Ash Content Amin-Amax %	Sulphur Content Smin-smax %
Australia	25-27	0.6-0.8	14-14
China	24.2-25	0.8-1.0	8-15
Indonesia	20.9-27	0.1-0.8	01-8
Canada	24.2-29.0	0.5-1.0	0ct-14
Columbia	25.4-27	0.7-0.8	08-9
Russia	25.4-27.2	0.4-1.0	13-16
RSA	24.2-25.8	1.0	16-16
USA	19.7-29	0.4-2.5	5-15

Source: Dubiński [20].

The Table 2 shows that hard coal mines deliver to the market energy coal with crucially diversified quality parameters. It proves considerable production capacity of coal industry, which tries to adapt to high quality demands of the market. Alas, it must be noted that Polish power engineering still burns coal of the worst quality (calorific value, ash content, sulphur content). It is currently a rarity in Europe. Almost the whole production of electrical energy is based on fine coal with a low calorific value of 21,6GJ/Mg. After Poland had joined the European Union, the issue of mechanical processing, which influences the quality of market coal, became a major issue due to effective European coal quality requirements.

Table 2: Quality parameters of coals purchased by various national consumers.

Coal Consumers	Calorific value GJ/Mg	Ash Content %	Sulphur Content %
Power plants	19-23(śr.21.6)	12-30	0.6-1.2
Heat and power plants	20-26	14-15	0.6-0.8
Metallurgy and metal industries	19-25	6-25	0.6-1.2(0.6-0.8)
Chemical industry	17-25	12-28	0.6-1.3
Timber and paper industries	19-26	10-22	0.5-1.0(0.4-0.8)
Textile industry	20-26	8-25	0.5-1.0(0.5-0.8)
Sugar industry	22-29	8-18	0.4-0.9
Mining industries	20-26	11-25	0.6-1.0(0.5-0.7)
Cement industry	min. 22	12-18	0.8-1.0
Lime industry	min. 24	max 12	max 0.8

Source: Dubiński [20].

Methodology and Data

Coal assortments are described by usually present multiple dimensions in terms of calorific value, ash content, sulphur content and the complexity of variables interacting with each other. The aim of the study is to determine the determinants influenced volume sales using panel data techniques. Econometric models estimated based on panel data are usually oriented to cross-section analysis, and their task is to isolate differences between objects that are inseparable from factors specific to individual objects. In econometric models, estimated based on panel data, it is assumed that the evolution of an explanatory variable is influenced by, in addition to explanatory variables, immeasurable, constant over

time and factors specific to a given object, called group effects and or fixed factors specific to a given period factors, called time effects. Inclusion of group and time effects in panel models makes it necessary to use specific estimation methods. The article analyses the impact of environmental protection regulation on the sale of carbon products, to obtain an answer, which quality parameter influences the choice of coal product by the power industry. The analysis of available data shows that sales are gradually decreasing. The decline concerns lower sales to commercial and industrial power plants. There is also a noticeable stable level of sales in commercial and non-commercial heat plants. The data provided by the Industrial Development Agency was used to build the model. Data with individual categories of assortments is shown in Figure 2.

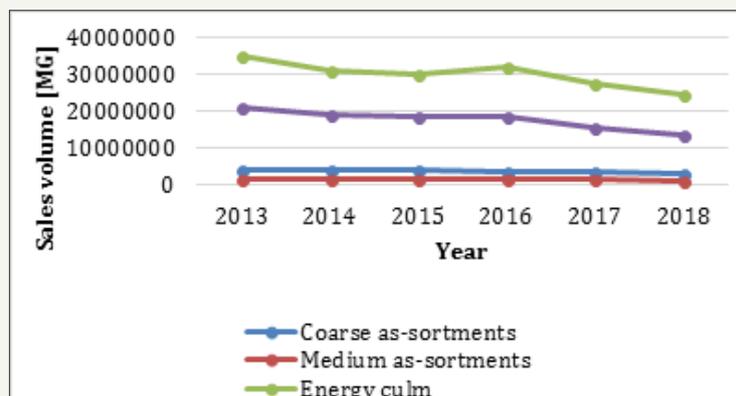


Figure 2: Coal assortments sold to consumers on the domestic market.
Source: individual study.

In principle, it is possible to estimate time series for each case or cross-sectional regressions for each time unit by using the expressions (1) and (2) correspondingly [16].

$$y_{it} = x_{it}\beta + v_{it} \quad (1)$$

$$y_{it} = x_{it}\beta + u_{it} + \varepsilon_{it} \quad (2)$$

where

y_{it} - explained variable,

x_{it} - explanatory variable (vector of variables),

β - vector with the N dimension of the structural parameters of the model

v_{it} - random error,

u_{it} - individual effect,

ε_{it} - pure random error,

Where (1) is a model with fixed effects, while 2 is a model with random effects. The importance of panel models is emphasized by articles [17]. Wide range of panel models for econometric analysis is also presented by other articles [18-21]. They undoubtedly apply in the analysis of economic phenomena [19-21].

Results

Analyzes were carried out on panel data techniques and panel models were constructed with a generalized least squares method, a panel model with fixed effects and a panel model with variable effects. The statistics such as R^2 , standard error of residuals and sum of residual squares, statistics F. were used to verify the models. The sales level was used as the explanatory variable, the explanatory variables were: caloric content, ash content and sulfur content.

Table 3: Fixed effects model.

Coefficients	Estimate	Std.Error	t-Value	p-Value
Const	-1505.09	798.91	-1.884	0.07
LnCalorific value	146.23	77.08	1.898	0.07
Ash content	1.81	1.10	1.655	0.01
Sulphur content	130.20	17.67	7.368	0.00
Multiple R2	0.74			
Adjusted R2	0.70			
F-statistic (3,20)	18.87			0.00
Residual standars error	2.265			

Source: own study

Table 4: Random effects model.

Coefficients	Estimate	Std.Error	t-Value	p-Value
Const	-602.46	995.35	-0.605	0.05
LnCalorific value	64.92	95.51	0.680	0.05
Ash content	0.43	2.16	0.198	0.08
Sulphur content	41.08	33.01	1.245	0.02
Medium as.	7.08	17.39	0.407	0.06
Energy culm	2.05	20.64	0.099	0.01
Energy mixes	-5.35	2.03	-2.647	0.01
Multiple R2	0.87			
Adjusted R2	0.82			
F-statistic (6,17)	18.89			0.00
Residual standars error	1.736			

Source: Own study

Table 5: Random effects model.

Coefficients	Estimate	Std.Error	t-Value	p-Value
Const	-17.30	14.91	-1.160	0.02
Price	17.86	2.42	7.383	0.00
Medium as.	13.70	1.74	7.875	0.00
Energy culm	11.06	2.33	4.755	0.00
Energy mixes	-6.83	0.51	-13.286	0.00
Multiple R2	0.96			
Adjusted R2	0.95			
F-statistic (4,19)	123.6			0.00
Residual standars error	0.875			

Source: own study

Table 3 contains the numbers characterizing the results of panel estimation using the least squares method. It was found that calorificity is the strongest stimulant of the sales volume. Sulfur content is also closely related to the level of sales. Table 4 presents the results of panel data techniques estimates with variable effects. Similarly to the model 1, the factor shaping the sales volume is caloric content and sulfur content. The smallest share has ash content. Pay attention the model fitting by coefficients: multiple R^2 , adjusted R^2 and F statistics. The model also compared products with respect to coarse assortments. You can see that the remaining products are characterized by inferior quality parameters; however, they have a significant impact on the level of sales. It can be concluded that the price is the decisive parameter in choosing products. Therefore, a model with variable effects was also considered including the price. The results are shown in Table 5.

From the developed model the price level is the factor influencing the level of sales. The products purchased by the energy industry are energy culm and energy mixes, and the prices of these products are lower in comparison to coarse and medium assortments. This model has also the very high the model fitting ($R^2=95\%$).

Discussion and Conclusion

Panel data techniques are useful for solving problems related to the search for determinants shaping the sales volume in mining enterprises. The obtained results indicate an advantage of panel models with variable effects over panel models built with estimation using the classic least squares method and panel models with fixed effects. Factors determining the sales volume include: caloric content, sulfur content and price. The increase in the quality of these parameters has a positive effect on the change in the level of sales volume.

The Polish mining industry is characterized by large coal resources and a well-developed, modern and efficient technological infrastructure in the field of coal mining, extraction and enriching. It allows for providing a proper amount and high quality of coal fuel to produce electrical and heat energy. An essential problem connected

with energy processing of coal fuel is meeting increasingly strict ecological requirements for gases emission into the atmosphere.

To ensure this leading position for the next decades it is necessary to intensify re-research on advanced technologies of clean coal and rationalization of its use for the sake of future generations. What is also necessary is a reasonable promotion of good quality coal, which would benefit the whole fuel and energy sector as well as the national economy.

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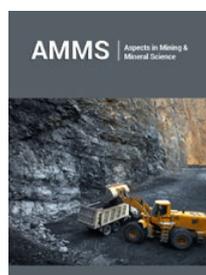
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