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SALES FORECASTING AND COAL MINING PLANNING IN THE CONTEXT OF HARD COAL PRODUCTION STRATEGIES

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Dr Aurelia Rybak
Dr Anna Manowska
Silesian University of Technology, **Poland**

Abstract: Polish energy security is based mainly on a coal. Such dependency will be still maintained for several years. It is therefore necessary to improve the economic situation of polish mining companies. The mining companies in Poland are operating under tremendous uncertainty of turbulent environment. The article presents used by the authors methods to facilitate the creation and selection of optimal production strategy. These are scenario planning, forecasting and linear programming, which allow the simulation of company operations in the future. The authors suggest the most successful and optimal forecasting models for the Polish mining industry, as well as factors affecting the demand for hard coal in Poland. The manuscript presents also possible to apply coal production strategies and the method of evaluation and selection of optimal strategy in the difficult conditions of Polish mining companies environment. This makes it possible to take a decision burdened with minor errors and less risk.

Keywords: energy security**,** strategic planning, production economics, coal production strategies, scenario planning.

1. INTRODUCTION

The desire to survive and grow in a turbulent environment, forces the companies to adapt to the rapidly changing conditions. This is an extremely complex challenge, which may, however, initiate a creative approach to solving strategic problems (Chakravarthy, 1997; Jonek-Kowalska, 2015). To prepare the enterprise for the development of events in the unclear future with a necessary advance we should know in what direction may follow the trend's course of key environmental factors, affecting the coal company. A scenario planning, forming usually several alternative versions of a future enterprise environment, allow to enhance the level of strategic decisions. The energy industry and heating operate in Poland on the basis of hard coal and lignite (domestic resources of these raw materials). That's why the insurance of the mining industry survival in Poland is strategically important (Mohr and Evans, 2009; Sierpińska-Sawicz and Bąk, 2016, Bluszcz, 2016). The scenarios make it possible to expand horizons, make clear unrecognised and unnoticed possibilities, but also risks. They reveal the potential threats and problems encountered by company in the future. Therefore, it becomes necessary to identify solutions that will allow the company to minimize weaknesses or eliminate them. With this in mind, it must be chosen optimal coal mining strategy for specific environment conditions (O'Neill, 1986). The company should take into account several possible scenarios, analyse them in terms of selected factors and choose the optimal option (Hejden, 2000; Chaharsooghi et al., 2015; Rybak, 2011).

2. METHODOLOGY OF RESEACH

Creation of a coal mining production strategy should include:

- obtaining information about the methods and techniques used to achieve increased production efficiency - in our case forecasting, linear programming;

- establishing the conditions for business entities, enabling the elimination of losses;
- sales and production forecasting, taking into account environmental factors affecting them;
- creating the coal company environment scenarios;
- testing a chosen strategy in the light of each scenario;
- choosing the optimal strategy in terms of selected factors.

Forecasting provides important information for planning future processes, especially in the field of applied strategies. It can give an answer to the question:

- will the continuation of existing policies bring the expected benefits?
- whether and where to make the changes in planned strategies?

Essential elements shaping the demand for hard coal are:

- economic growth and associated therewith development of manufacturing, especially the production of electricity, heat, steel;
- the effectiveness of new techniques and technologies introduced to reduce the production energy intensity;
- advances in the heating industry technology;
- the share of natural gas and fuel oil in covering the needs of industry, processing and municipal sector;
- preferences of individual customers in the selection of fuel;
- competitiveness of coal substitutes.

The internal factors affecting the domestic coal market are:

- coal demand, coal prices;
- level of production capacities and their use in the mining industry;
- the quality of coal;
- production costs, which included the cost of mining and coal beneficiation;
- the cost of transporting coal from the mine to the recipient;
- climatic conditions.

These factors should be considered during the determination of sales, and coal mining volumes forecast.

Created time series models include such components as linear function, the first cyclical component, the second cyclical component, random component (Farnum and Stanton, 1989; Diettman, 2008).

The forecasts were made by the authors in the following perspective:

- Short-term and medium-term forecasting is particularly useful in the field of excavation face recovery, the intensity of exploitation, renovations and for human resources management, e.g. holiday planning, training, delegation.
- Phenomena projected in the horizon of several years are useful for managers, in particular, to determine the future of the company.

Based on the obtained by the author's analysis results, we can conclude that for annual increments forecasting can be used the sigmoidal curve, resembling the letter S. It is highly suitable to describe the dependence of mining and sale of the hard coal (Fig. 2) (Przybyła and Rybak, 2007):

$$f_i(x) = \frac{(a_{s1} - a_{s2})}{1 + e^{\frac{(x_i - x_0)}{dx}}} + a_{s2} \tag{1}$$

where:

a_{s1} – Initial $f_i(x)$ value;

a_{s2} – final $f_i(x)$ value;

x_0 – center, half way between two limiting values a_{s1} and a_{s2};

x_i – years;

d_x – width;

1,2,...,n.

Comparing theoretical and empirical data in subsequent years it was noticed that their average deviation is only approx. 3%. This allows to use the curve to forecasting production sales volumes in the coming years with the high accuracy. We can anticipate the further decline of production, but compared to previous years it is more stable and mild (Fig.1.).

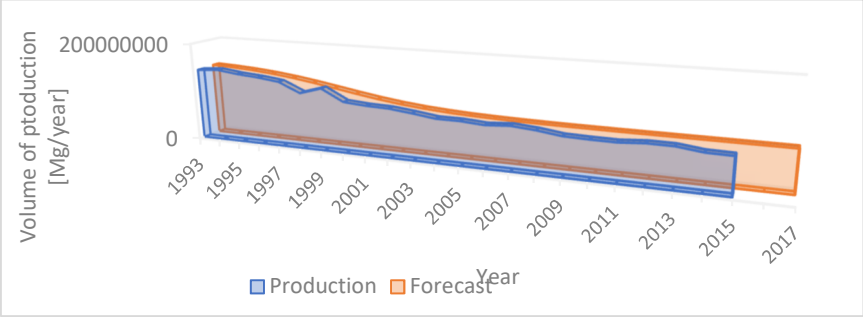

Fig. 1. The volume of hard coal production in years 1993-2017

The authors use most successfully harmonic analysis, exponential smoothing, ARIMA and SARIMA models in the case of semi-annual and monthly forecasts. The final choice is made on the basis of ex-post and ex-ante error analysis of each created model. For further analysis, is assumed always the model burdened with the smallest error (Table 1). Harmonic analysis model is defined by a general formula (Cieślak, 2001):

$$y_t = \alpha_0 + \sum_{i=1}^{\frac{n}{2}} \left[\alpha_i \sin\left(\frac{2\pi}{n} it\right) + \beta_i \cos\left(\frac{2\pi}{n}\right) it \right] \tag{2}$$

where:

y_t – variable empirical values;
$\alpha_0, \alpha_i, \beta_i$ – model parameters;
i – harmonics number;
t – the number of y_t in time series.

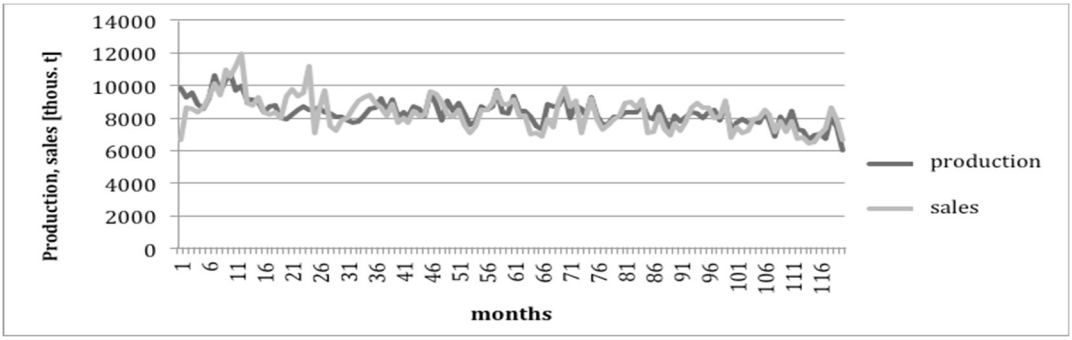

Fig. 2. Forecast of production and sales of hard coal - harmonic analysis

Table 1
Mining and coal sales ex-post errors

Error	Mining			Sales		
	Harmonic analysis	Winters model 0,1 0,1 0,1	ARIMA (2,1,0)	Harmonic analysis	Winters model 0,4 0,1 0,1	ARIMA (0,1,2)
V_{RMSE}	1.18%	0.03%	0.9%	0.005%	0.015%	1.7%
MAPE	2.22%	4,49%	5.84%	2.72%	7.03%	9.09%
RASE	0.00005%	0.00146%	0.00302%	0.0001%	0.0076%	0.01780%

In the Table 1 are presented ex post errors for each of the considered methods: the mean absolute percentage error (MAPE), root average squared error (RASE) and relative root-mean square error (V_{RMSE}).Obtained forecasts will enable scenario planning, which is necessary in determining the strategy of the company functioning in a turbulent environment, in terms of seasonality of supply and demand for hard coal. In order to investigate the relevance of selected components of mining company macro environment and identify those of them that have a decisive influence on its functioning, we conducted an anonymous survey of experts. The scenarios also included forecasts of the analyzed environmental factors. To build the forecasts, we used sigmoidal, linear, logistics, exponential, exponential Holt, Winters, ARIMA, SARIMA, harmonic analysis models. Construction of the company's strategy has been carried out in the following stages:

- environment analysis of hard coal companies;
- the creation of scenarios;
- testing of each strategy in the environment of each scenario;
- selecting the optimal strategy for each scenario.

Created forecasts and environment scenarios allow the verification of proposed strategies. This facilitates the selection of an appropriate, optimal strategy, which will allow the company to survive and develop. The level of demand for hard coal varies throughout the year in each quarter, because coal mining in Poland is subject to very strong impact of seasonality, which is a threat for the mining industry (Rybak and Rybak, 2016). The authors confirmed that by using seasonal decomposition of the production and sale time series (Census I and Census II method) (Grudkowska and Nehrebecka, 2009).

In order to eliminate or mitigate the negative impact of seasonality the following strategies can be used:

- the production adjusted to seasonal fluctuations;
- the elimination of seasonal demand changes by mining stabilization;
- the production of goods characterized by other peaks of sale;
- the introduction of hard coal to markets characterized by a lack of seasonality or complementary seasonality;
- the mining stabilization and use of "seasonal pressure " by raising the level of production during periods of increased coal demand.

Forecasts allow to create an emergent strategy. They enable to predict the necessary mining volume in a given year. Monthly forecasts determine the specification of annual plans, creation of tactical and operational plans. So far, we analyzed and characterized two strategies for coal production - flexible and stable strategy. It was specified, to what extent and scope, they affect production results. Finally, has been proposed two completely different coal mining strategies, what was the result of years of analysis, observation, and the information obtained during the survey of experts.

Flexible strategy

This strategy eliminates the costs of opportunities, reduce costs related to employee advantages and administrative costs. The strategy is carried out in accordance with the principle of Just In Time (Fig. 3). It involves adjustment of capacity (C) to the seasonal demand (D) as closely as possible. In periods of high demand, the production capacity (P) can be increased through technical means or employees acquired through outsourcing (Anwar et al., 2013; Freytag et al., 2012).

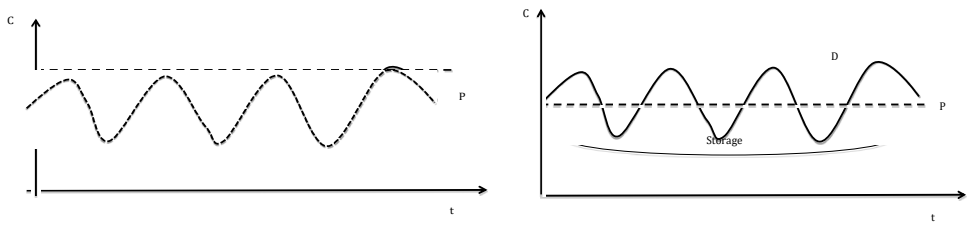

Fig. 3. The strategy of flexible (a) and stable coal mining (b)

The strategy of stable coal mining

Its basic principle is to determine the coal mining at a constant level unchanged throughout the year (Fig. 3). This level is consistent with the requirements of coal consumers, the break-even point, but it does not respond to changes in demand. This type of condition can be achieved in many ways, for example:

- the elimination of storage costs by creating an earlier demand for the coal by securitization, commission sale, etc.;
- the cost of carbon storage shall be incurred by the producer of hard coal.
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3. RESULTS AND DISCUSSION

We conducted a simulation, which allowed us to check the impact of proposed strategies on selected factors like, for instance: mining unit cost, sales value, employee turnover and the level of employment. The simulation was carried out for both strategies, mainly by changing the size of employment.

The desired level of hard coal mining in stable strategy was determined by Riemann integral. The level of employment was adjusted to the monthly level of production by means of linear programming. Optimization involved the adaptation of the employment level to the forecasted coal mining and total costs desired level. The analysis also allowed the optimization of the total cost components primarily the costs of electric power, materials, employment, depreciation. Considering the fact that the wage costs account for about 39% of total production costs we achieved a significant reduction in coal production unit cost. The most important results of simulations for each strategy are presented in Table 2.

Table 2
Results of simulations

Factor	Flexible strategy	*Stable coal mining strategy*
The mining unit cost	2% decrease	3% decrease
The sales value	unchanged	9% increase
The employee turnover	67%	8% decrease
The level of employment	10% decrease	8% decrease

The strategy of stable coal mining enables the company:

- The reduction of fixed costs by eliminating capacity excess and over-staffing.
- Reduction of the unit production cost by means of economies of scale.
- Production stabilization which was the consequence of unit production cost constant level.
- Increase of labor productivity by the complete usage of possessed production capacity during the whole year.
- The increase in sales value (commission sale, securitization, discount).

Flexible mining strategy:

- Is mainly achieved through more flexible employment.
- Is characterized by the lowest fixed cost. Such a situation causes the fact that the production level is adapted completely to the demand. In this way enterprise can reduce the level of employment and technical support by leasing and outsourcing.
- Eliminates any stocks.

Selection of the optimal hard coal production strategy

In order to choose the most appropriate strategy for each of the scenarios, authors use the taxonomic method. Each strategy was evaluated by a synthetic measure. The procedure was conducted in the following steps:

- the determination of criteria for the strategy evaluation by conducting a survey of experts;
- the result's analysis and determination of ranks for each criterion;
- the determination of diagnostic variable's nature (stimulants, destimulants, nominants);
- the standardization of diagnostic variables;
- the determination of a benchmark;
- the determination of the distance of each object from the benchmark;
- the designation of a synthetic evaluation measure.

In the comparison, we used the following groups of measures:

- economic (including the cost of production, storage and operating income);
- socio-ecological (including the liquidity of employment, job security);
- customer satisfaction (e.g. the continuity of supply and quality of service).

The analyses provide the necessary information enabling to take the best possible decision. They enable a choice, not based only on feelings and subjective judgement of the situation. As a result, the decisions can be taken in favourable conditions, sufficiently in advance and with a lower risk of failure. The final choice shall be obliged to make a decision-maker, directly in the coal company, referring the current market situation to the diagrams contained in scenarios and strategies.

4. CONCLUSIONS

Enterprises of the twenty-first century usually operate in far unstable environment, called the era of turbulence. The main reason of such instability is the globalisation, the global economic crisis, the fluctuations of exchange rates, raw materials and fuel prices. The most important in such difficult conditions is a rapid response to changes in the appropriate time. It is extremely significant in the case of Polish hard coal mines. Coal is the main source of electricity, which is a prerequisite for economic and civilizational development of the Polish population. The company can use appropriate strategies to transform changes into a success, if it manages to react ahead of the competition. Such a changes are also a daily routine for Polish coal companies. Decades ago, the uncertainty of environment was limited in 4 point scale to grade 1, 2. Currently, we are increasingly dealing with the 3 and 4 degree of uncertainty. The business management methods used, until now, in Polish mining industry are no longer sufficient. Company should look for new solutions enabling the efficient and effective response. Authors for such a method consider scenario planning, which is an excellent tool for planning under environment uncertainty. To create scenarios we use forecasts of varying scope and planning horizon: annual, half-yearly, quarterly, monthly, with a very wide range of applications from organization of individual departments current activities, to planning of the company's future. Scenarios and forecasts, in turn, allow and facilitate the selection of the optimal at a given moment strategy.

Properly chosen strategy will give among others the opportunity to:

- first of all, to survive on the market and ensure the energy security;
- achieve success and operating profit;
- the economies of scale;

- winning the competitive struggle;
- eliminate all kinds of waste in the form of storage costs, employment and opportunity cost;
- optimal use of machinery and equipment and labour cost;
- elimination of unused production capacity;
- adjustment to the demand for hard coal;
- lack of need for additional financial resources.

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