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Forecasting-Scenario-Heuristic method proposal for assessment of feasibility of steel production scenarios in Poland – Managerial implications for production engineering

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ABSTRACT

The goal of presented research is to assess the feasibility of environmental scenarios for the Polish metallurgical sector until year 2020. The study employed: (I) Quantitative elaboration of steel production volume forecasts for Poland until year 2020; (II) Qualitative evaluation of factors influencing production processes in the environment of metallurgical companies; (III) Analytic Hierarchy Process for assessment of probability of occurrence of particular environmental scenarios for Polish steel industry: (i) optimistic (steel production volume exceeding the projected average of 8.895 mln tons); (ii) pessimistic (steel production volume lower than the projected average of 8.895 mln tons); (iii) base (steel production volume conform to the projected average of 8.895 mln tons, with a possible 10% deviation). The relevance of decision-making criteria has been assessed by scientists and practitioners with specialization in metallurgy. In result the most probable scenario has been chosen. Practical outcome are managerial conclusions from the perspective of production engineering. Main research limitations originate from the territorial limitation to Poland. Further research should be led in the metallurgical sectors of other European and emerging economies.

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1. Introduction

Past two decades in the steel industry have been dominated by restructuring that aimed at the increase of innovativeness, quality and customer orientation. Durlik [1] (p. 15) observes that the time of product shortages in European and global economy has irrevocably elapsed. Enterprises have been forced to shrink their production, which is especially visible in traditional branches of industry (i.e. mining, metallurgy). In the steel market, despite a general growth of global production volume, alarming changes can be observed. One of them is a growing inflow of cheaper steel from emerging economies into developed countries, despite deficient use of production capacities of their ironworks.

Accordingly to the World Steel Association's analyses, global steel production varied from 1.348 bn tons in 2007 until 1.669 bn tons in 2014. In 2017 it has reached 1.691 bn tons of crude steel, which means 5.3% production growth in relation to 2016. Same numbers for Europe equal 313.2 mln tons in 2017, which counts for 3.8% growth from 2016 steel production levels. In European Union Member States the 4.1% yearly growth accounted for 168.7 mln tons produced in 2017, after 210.6 mln tons in 2007 and 162 mln tons in 2016 [2] (steel production volumes in 2017 were estimated on basis of preliminary data). In Poland steel production volume varied from 8.3 mln tons in 2005 to 10.333 mln tons in year 2017 (14.8% growth from 2016) with use of less than 70% of production capacity [3].

Martyniak [4] observes that trend analysis should not aim only at trends exposure, but at explaining their background and manage the effects of their inevitability. Following this approach, the first part of our research focused at identification of reasons of mentioned changes on the steel market. The resulting conclusions have been compared with forecasts of steel production volume in Poland for the forthcoming years, which allowed us to elaborate environmental scenarios for the Polish metallurgical sector. The goal of presented research is to assess the feasibility of particular scenarios of steel production volume in Poland until year 2020.

2. Material and methods

The complex scope of the research task required us to employ a three-stage segmental methodology: (i) forecasts; (ii) scenarios; (iii) expert evaluations. Quantitative econometric and qualitative managerial decision-making methods have been combined. Such a joint methodological approach allowed us to assess both measurable production processes (steel production volumes) and immeasurable environmental factors. For this purpose an original Forecast-Scenario-Heuristic (FSH) method has been elaborated and complemented by an Analytic Hierarchy Process (AHP) decision-making model. It resulted in a precise forecast of steel production volumes, obtained by incorporating into the analysis non-linear saccadic environmental changes, which cannot be foreseen because of their immeasurable character.

Table 1 – Steel production volumes in Polish metallurgical sector in years 2000–2017 (mln tons).

Y.	2000	2001	2002	2003	2004	2005	2006	2007	2008
Pr.	10.5	8.81	8.37	9.11	10.58	8.34	9.99	10.63	9.73
Y.	2009	2010	2011	2012	2013	2014	2015	2016	2017
Pr.	7.13	7.99	8.78	8.35	7.95	8.56	9.2	8.999	10.3

3. Steel production forecasts – FSH stage 1

Forecasting knowledge is an integral part of the managerial process. It lowers the uncertainty and raises the accuracy of managerial decisions, which raises company's efficiency. Pelikán [5] (p. 312) states that the forecasting results shape the inputs for the subsequent planning and decision-making step. Nevertheless, econometric forecasting bears some constraints that lower its accuracy. Pierdzioch and Rülke discuss this issue and conclude by stating that these limitations can be surpassed through forecast differentiation [6] (p. 7). Therefore, to raise the accuracy of presented research, we aimed at assuring forecast differentiation in two ways: (i) by combining different forecasting methods into one FSH method in order to obtain scenarios of steel production volumes in Poland until year 2020; (ii) by providing expert evaluations of feasibility of obtained scenarios via an AHP-based decision-making model – in order to choose the most feasible scenario.

Steel production forecasts until year 2020 have been obtained with use of linear and non-linear econometric forecasting together with adaptive and autoregressive methods – which are frequently used forecasting tools [7] (p. 2). Input data came from empirical steel production volumes in Poland in years 2000–2015 [8] and has been presented in Table 1.

Production forecasts for years 2016–2020 have been obtained basing on data from past periods, from year 2000 to 2015 (Table 1). They have been calculated in 2016, with last available empirical data from 2015. Empirical data from years 2016 and 2017 served for later verification of former forecasts.

Fig. 1 presents trends in Polish steel production – 3-year cycles can be observed, with downturn, growth and peak phases. Data came from statistics published in [8].

Table 2 presents 30 various methods employed for calculation of forecasts of steel production volumes in Polish metallurgical sector for years 2016–2020. ''Forecast for minimal errors'' column shows forecasted values for different smoothing parameters (models 9–26). Optimal values for the respective calculation method are shown in the ''prognostic method/model'' column. Parameter α value has been calculated for both forecast errors via Solver software, academic license, and the lower expired forecast error value has been chosen. The relative forecast error for years 2016 and 2017 – after comparison with the empirical values. Grey background corresponds to forecasts for optimal values of parameters α, β_i, ϕ. Source data, calculation methods and econometric analysis of presented forecasts have been discussed in [9–11].