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THE BEST-CASE SCENARIO FOR WORLD STEEL PRODUCTION ON THE BASED OF FORECAST OF QUANTITY OF WORLD STEEL PRODUCTION

SCENARIUSZ ROZWOJU SEKTORA STALOWEGO NA ŚWIECIE NA PODSTAWIE PROGNOZY WIELKOŚCI PRODUKCJI STALI

Summary: *the analysis of the prognostic trends of the level of steel production on the basis of statistical data on the quantity of the world steel production in the years 2000 – 2017, was carried out. To determine the forecast for steel production level, different statistical methods were employed. The prognoses for the level of the world steel production were determined up to 2022. The real (historical data) data concerning the quantity of the world steel production in 2018 were compared to the forecast for the level of steel production in 2018, with the establishment of prognostic error (deviation of real data and the prognostic ones). The basic aim of the study was to obtain the answer to the following question: whether we may assume the development of the discussed industry in the future in the light of the determined forecasts of the world steel production level.*

Keywords: *world steel production, forecast for the amount of the steel production*

Streszczenie: *w publikacji dokonano analizy trendów prognostycznych wielkości produkcji stali na podstawie danych statystycznych o wielkości produkcji stali na świecie w latach 2000-2017. Do wyznaczenia prognoz wielkości produkcji stali zastosowano różne metody statystyczne. Prognozy wielkości produkcji stali na świecie wyznaczono do 2022 roku. Dane rzeczywiste (historyczne) dotyczące wielkości produkcji stali na świecie za 2018 rok porównano z prognozą wielkości produkcji stali w 2018 roku, ustalając błąd prognostyczny (odchylenie wielkości rzeczywistych od prognozowanych). Podstawowym celem pracy jest uzyskanie odpowiedzi na pytanie: czy w świetle wyznaczonych prognoz wielkości produkcji stali na świecie można zakładać rozwój przemysłu w przyszłości.*

Słowa kluczowe: *produkcja stali na świecie, prognoza wielkości produkcji stali*

Introduction

Forecasting the size of manufacture of the particular products is a basic component of strategic management. The forecasts for the level of production are implemented by the enterprises, for its internal use, as well as by the market researchers and scientists in relation to the particular industry sectors or national economy. The forecast is a scientifically justified judgement on the state of phenomenon in a defined moment (period), belonging to the past period. The forecast must be a reasonable inferring, leading from premises to conclusions, referring to the future [Cieślak, 1998, p. 91]. In spite of the fact that the forecast is a certain approximation of the size of a defined phenomenon in the future, it is recognized as an effective tool of planning. Each forecast is burdened with the error; however the smaller is the forecast's error, the more accurate the forecast is. Well defined and performed forecast has a key value in business and economy. The managers must possess the capability of forecasting the future situation of the company and consider various options of its development, perceive the possibilities (chances for development) and identify a business risk [O. Penc-Pietrzak, 2010, p. 10-11]. The forecast for the size of production is implemented in relation to different time intervals – for the nearest years to come, for days or even hours. The investment on construction of new technological line in manufacturing enterprise is preceded by the determination of the forecast for the level of production and demand on a given product. The steel industry belongs to the key sector of the economy. Steel is a basic material for production of cars, ships, machines and equipment and material used in construction. The development of the steel industry will require forecasting of the size of steel production level for the years to come in order to establish the strategic trends of changes via the adjustment of production size to the possibilities of the particular producers. In the present work, the forecasts for the size of steel production for the nearest years were developed, using the forecasting methods for time series, based on the data concerning the world steel production reports of World Steel Association]. Vector of historical data, i.e. size of the world steel production in the years 2000 – 2017 (steel production in million tonnes – Mt), has become the basis for establishing the forecast trends of the world production level until 2022 (trends of the size of the world steel production were established based upon the historical data).

The methodology of the studies

The prognostic methodology is a sequential process which runs according to a certain general scheme of the research (scientific) procedure. P. Dittmann [2003] in his book "Forecasting in enterprise" presents the prognostic study according to 8 stages: Stage 1 - definition of prognostic task, Stage 2 – determination of prognostic premises, Stage 3 – collection, statistical treatment and analysis of prognostic data, Stage 4 – Choice of the

Tab.1. Methodology for forecasting the size of the world steel production

No.	Stage	Methodological scope	Methodological details
1	Prognostic task	Forecasting the size of the world steel production until 2022 on the basis of the level of steel production (in million tonnes – Mt) in 2000 – 2017	• Prognostic variable size of the steel production (in total) for a given year (million tonnes, Mt) • Time period of historical data: world steel production in 2000-2017
2	Historical data	Collection of data necessary for construction of the forecast	• Source of information: reports Steel statistical yearbook, published by WorldSteel Association
3	Analysis of historical data	Analysis of the trend of the level of the world steel production in 2000 – 2017	• Establishment of the reasons for seasonal/situational variations in the level of world steel production in the adopted time period
4	Choice of the forecast method	Models of time series	• Technique of exponential smoothing of time series
5	Construction of the forecast	Determination of the forecast according to the scheme of the chosen forecasting method	• Comparison of the accuracy of the obtained forecasts
6	Evaluation of the acceptability of the forecast	Optimization of the forecasts	• Rejection of the inaccurate data
7	Analysis of the forecast	Analysis of the trend of the forecast for the size of the world steel production	• Establishment of the trend of changes in the size of the world steel production until 2022
8	Evaluation of the accuracy of the forecast	Valuation of the accuracy of the forecast using the ex post errors(equations 1-3)	• Comparison of the real data i.e. the size of steel production in a given year and the forecast for the size of steel production

Source: own development based on the methodology of forecasting (Dittmann, 2003)

forecast method, Stage 5 – construction of forecast, Stage 6 – evaluation of the acceptability of the forecast, Stage 7 – application of the forecast, stage 8 – evaluation of the accuracy of the forecast, using ex post errors. The mentioned above stages were implemented during the prognostic task entitled 'Forecast of the world steel production level until 2022'. The forecast was performed on the grounds of historical data for the period of 2000 – 2017. The methodological details have been shown in tab.1.

Equations for calculation of the forecast error:

$$RMSE^* = \sqrt{\frac{1}{n-m}\sum_{t=m+1}^{n}\left(y_t - y_t^*\right)^2} \quad (1)$$

$$\Psi = \frac{1}{n-m}\sum_{t=m+1}^{n}\frac{|y_t - y_t^*|}{y_t} \quad (2)$$

For world steel production in 2018 which was equal to 1.788.002 Mt, additionally, the forecast error was calculated according to the formula:

$$\Psi_t = \frac{y_t - y_t^*}{y_t} * 100 \quad (3)$$

Where:

yt – value of time series (value of variable forecast for a moment of t period),

yt* – value of expired forecast (ex post),

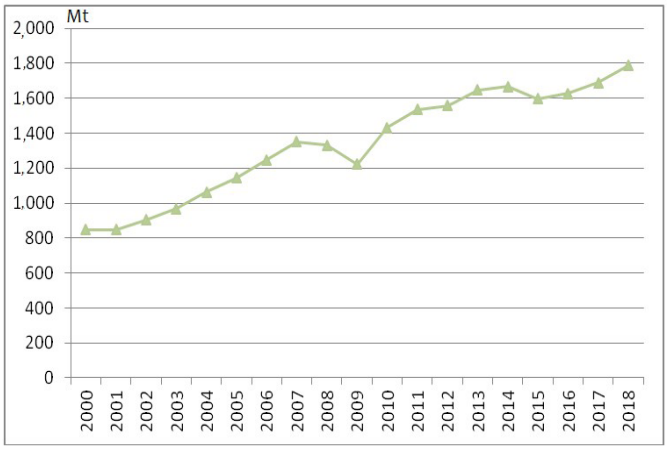
n – number of elements of time series (length of time series),

m – number of initial periods or moments of time t, for which the expired forecast was not implemented, or the mentioned forecast is the effect of start-up mechanism.

In his book" Forecasting: principles and practice", R. Hyndman pointed to the necessity of "constant care of models", therefore, he verifies periodically the earlier obtained models which were published [e.g. Gajdzik, 2018 – Monograph; Gajdzik, Gawlik, Skoczypiec, 2018, p. 1651 – 1660; Gajdzik, MAPE 2018; Gajdzik, Metal 2018, Gajdzik, 2017, p. 279 – 282]. Reliability of the forecast of the size of steel production is better in longer time horizon if the process of forecasting is continued.

It is worthy to pay also attention to a high quality of the data, used in determination of the forecast for the size of the world steel production. When creating the forecast, the current data on the level of steel production, being published by WorldSteel Association were employed [https://www.worldsteel.org].

Fig. 1. Steel production in the world in 2000-2018



Source: WorldSteel Association

Tab.2. World steel production in the years 2000 – 2017 (million tonnes – Mt)

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
846.811	849.365	903.020	968.826	1,061.854	1,144.827	1,247.873	1,351.188	1,330,313	1,212.157	1,431.570	1,535.693	1,558.323	1,648.023	1,667.154	1,597.926	1,627.004	1,690.479

Source: WorldSteel Association

Tab.3. The forecast of the size of the world steel production

No.	Model		Total *yt**	Forecast error *ex post*		Additional information about model	Production in 2018 y_{2018}= 1,788.002 [Mt]
			Mt	Ψ	*RMSE*		Ψ_{2018}
1	Single exponential smoothing (Brown's model) for: α opt. for Ψ	2018 2019 2020 2021 2022	1,727.833 1,756.928 1,779.589 1,797.239 1,810.987	0.0498	89.610	Ψ: α=0.7789	-3.365
2	Single exponential smoothing (Brown's model) for: α opt. for RMSE	2018 2019 2020 2021 2022	1,707.836 1,718.729 1,725.565 1,729.855 1,732.547	0.0531	85.354	RMSE: α=0.2716	-4.484
3	Brown's double exponential smoothing (linear), and with α opt. for Ψ	2018 2019 2020 2021 2022	1,706.754 1,732.993 1,759.231 1,785.470 1,811.709	0.0562	87.928	Ψ: α=0.5006	-4.544
4	Brown's double exponential smoothing (linear), and with α opt. for RMSE	2018 2019 2020 2021 2022	1,706.917 1,733.236 1,759.555 1,785.875 1,812.194	0.0564	87.931	RMSE: α=0.4952	-4.535
5	Brown's triple exponential smoothing (quadratic), and with α opt. for Ψ	2018 2019 2020 2021 2022	1,695.716 1,709.094 1,722.472 1,735.850 1,749.229	0.0525	96.930	Ψ: α=0.4436	-5.161
6	Brown's triple exponential smoothing (quadratic), and with α opt. for RMSE	2018 2019 2020 2021 2022	1,706.909 1,720.483 1,734.056 1,747.630 1,761.203	0.0560	93.750	RMSE: α=0.3344	-4.435

Source: Own research

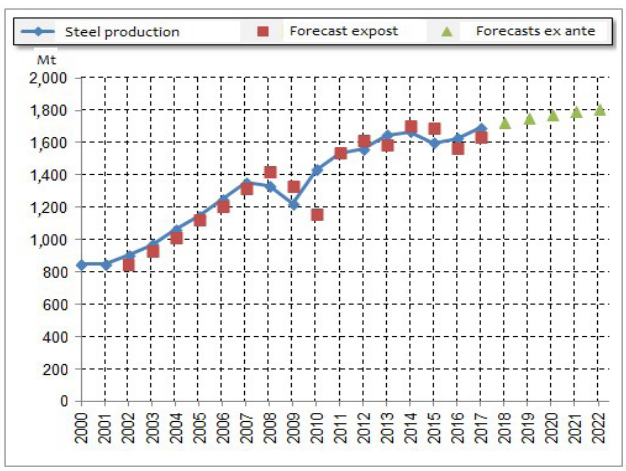
Production of steel in 2018 – the real data – during the construction of the forecast were not published (The report of World Steel Association appeared in the Quarter I of 2019 and the forecast was performed in December 2018).

Analysis of the trend (Fig.1):

- Increasing trend of the size of world steel production;
- Occurrence of economic variations
- Inconsiderable decrease in production in 2015 in relation to the previous year,
- A considerable decline in the level of steel production in 2009 in relation to the previous year as reaction of industry to the world economic crisis.

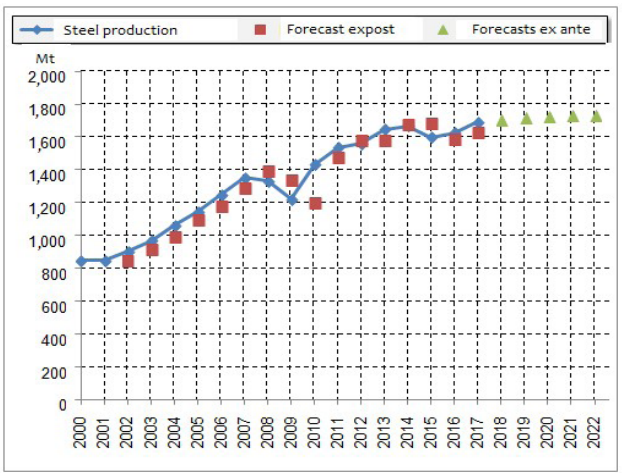
The aim of the forecast in the analyzed time series was to define how the model-constructing observations - the size of the world steel production - would behave in the future. When ignoring the external conditions, the models of time series determine accurately the trends and seasonability of observations. In the methods for analysis of the time series, the attempts were undertaken to capture quite subtle, internal mechanism, causing that the past of the time series affected its future. The forecasts of the size of the world steel production were created with the aim to facilitate undertaking (in advance) appropriate decisions and measures, having a short-term and strategic nature. On the ground of the mentioned activities, it is possible to undertake the corrective measures and optimize the results. The forecasts concerning the level of steel production are aimed at helping the metallurgical enterprises to construct competitive advantage by decrease of the decision risk.

Fig. 2. Single exponential smoothing (Brown's model) – model no. 1



Source: Own research.

Fig. 3. Single exponential smoothing (Brown's model) – model no. 2



Source: Own research.

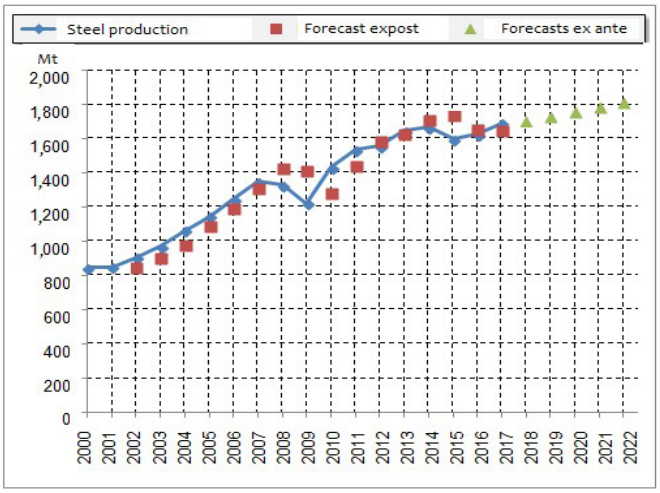
Presentation of the forecast of the world steel production

For construction of the forecast of the world steel production until 2022, the selected models for time series were used. The following models were presented: model of simple exponential smoothing (Brown's model), model of single exponential smoothing (Brown's model) for linear model and model of triple exponential smoothing (Brown's model) for quadratic model. The particular models were obtained for different start-up points and with optimization α due to value of forecast errors: Ψ and RSME* (equations 1-2). The results of the forecasting using the mentioned models were given in Tab. 3. In Tab. 3, the forecast obtained with the application of simple model of exponential smoothing (Brown's model) was not presented due to a low accuracy of forecasts.

The forecast of the size of the world steel production as obtained using the models for time series (Tab. 3) is shown in Fig. 2 – 7.

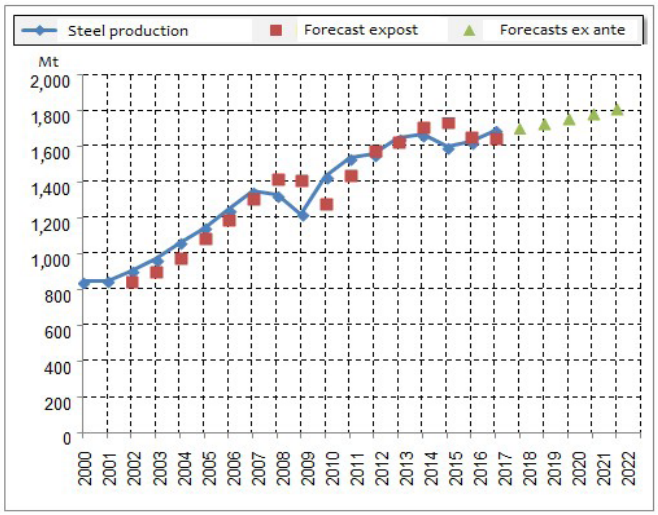
The obtained forecast of the size of the world steel production until 2022 was arranged on the grounds of the forecast trend. In the obtained models, the forecast trend of the level of steel production is growing. The distribution of the forecast points (models 1 – 6) has been given in Fig. 8.

Fig. 4. Brown's double exponential smoothing (linear) – model no. 3



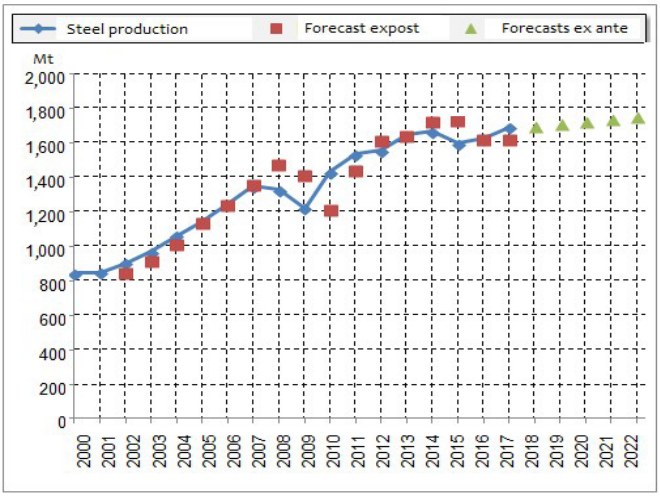
Source: Own research

Fig. 5. Brown's double exponential smoothing (linear) – model no. 4



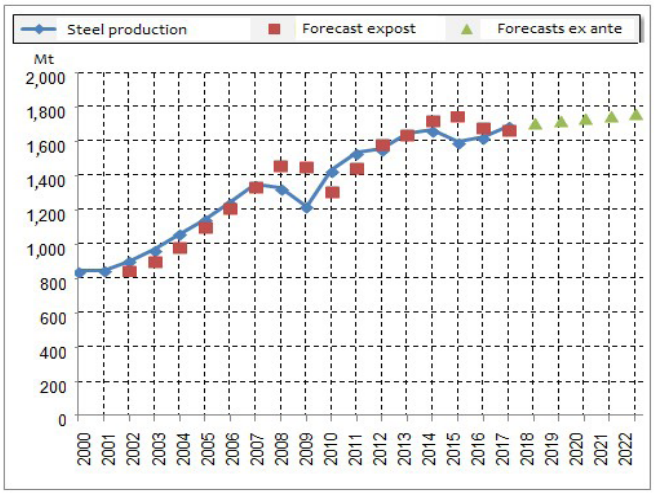
Source: Own research

Fig. 6. Brown's triple exponential smoothing (quadratic) – model no. 5



Source: Own research

Fig. 7. Brown's triple exponential smoothing (quadratic) – model no. 6



Source: Own research

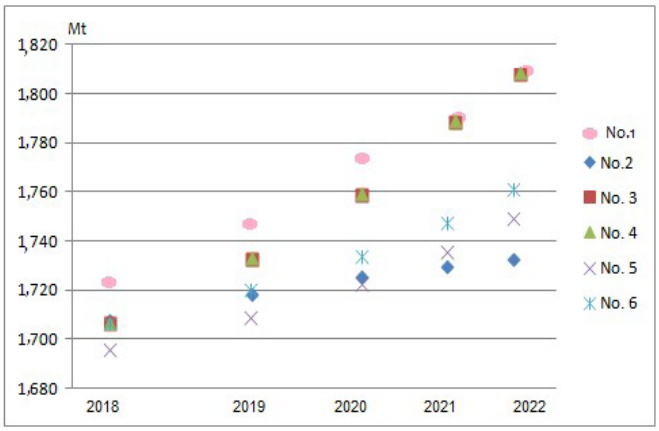
Scenario for the forecast of the world steel production

The scenario for the forecast of the size of steel production is a logic and supposed description of changes in the future. In methodological context, the mentioned scenario is a result of the forecasting methodology and allows passing from quantitative methods (statistical models) to the quality methods (description of the change in the phenomenon in the future). The combination of the forecast and the scenario is the prognostic-scenario analysis, constituting a certain comprehensive hypothetic vision of the future for the examined phenomenon [Rue, Holland, 1986, p. 430 – 432]. We may distinguish the following scenarios for the future [Bensoussan, Fleisher, 2010]:

- Base-case scenario for the most probable situation;
- Worst-case scenario as projections of the worst change of the examined phenomenon;
- Best-case scenario as the best anticipated situation.

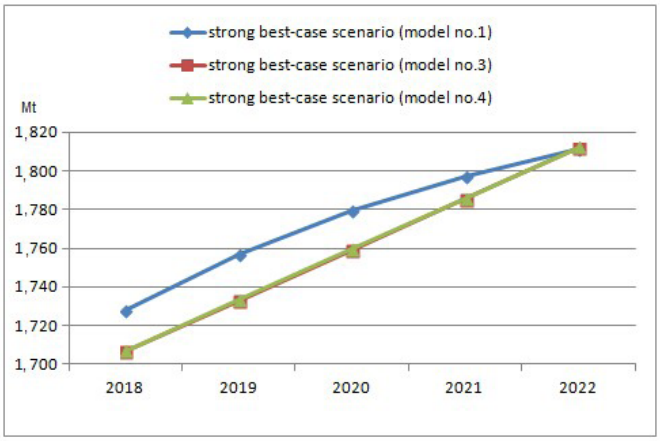
We may also establish average-case scenario, as a medium scenario between the basic and the extreme one: worst-case scenario or best-case scenario. The prognostic-scenario analysis was already the subject of the

Fig.8. World steel production forecast based on models 2-7



Source: Own research

Fig.9. Strong-best scenario for the forecast of the world steel production



Source: Own research

studies of the author but for steel production in Poland [Gajdzik, Nova, 2018]. In the present publication, the scenario of the forecasts for the size of the world steel production has been shown. On the grounds of the distribution of the points of the forecast for the size of the world steel production, there were established three optimistic prognostic scenarios:

Strong best-case scenario for steel production in the world with more than 1 800 million tonnes of steel production in 2022 (models 1, 3, 4),

Average best-case scenario with 1 760 million tonnes of the world steel production in 2022 (Model no. 6),

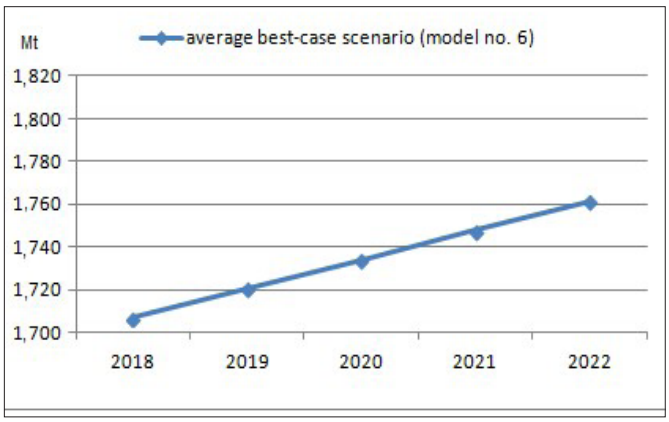
Weak best-case scenario with less than 1 750 million tonnes of the world steel production in 2002 (Models 2 and 5).

Due to the trend of the world steel production (Fig.1) – increasing steel production in the years 2000 – 2017 – the obtained scenarios of the forecast are optimistic (Fig. 9 – 11).

For the particular scenarios (Fig. 9 – 11), the dynamics of the changes in the forecast world steel production in the system: year to year (Tab.4) was calculated.

The dynamics of the changes year to year in strong scenario reaches maximum 1.7%, in the average one – 0.8% and in the weak case - in model 5, the dynamics of the changes in the forecast year to year is equal to 0.8% (oscillating around 0.8% in 2018 – 2022); on the other head, for model 2, it amounts to 0.6% and less (the lower level of dynamics is ca. 0.2%). Due to the dynamics of the changes, model 5 may be classified as a moderate scenario.

Fig.10. Average best-case scenario for the forecast of the world steel production



Source: Own research

The conducted analysis considered also the so-far existing dynamics of the changes in the size of the world steel production (Tab. 5) and the mean real gain was calculated. The mean annual gain in the world steel production was equal to 4.4%.

Tab. 4. Dynamics of the changes (year to year) in forecasts of the world steel production [Mt]

year	Strong best-case scenario						Average best-case scenario		Weak best-case scenario			
	No.1	%	No. 3	%	No. 4	%	No. 6	%	No.2	%	No. 5	%
2018	1,727.833	-	1,706.754	-	1,706.917	-	1,706.909	-	1,707.836	-	1,695.716	-
2019	1,756.928	1.684	1,732.993	1.537	1,733.236	1.542	1,720.483	0.795	1,718.729	0.638	1,709.094	0.789
2020	1,779.589	1.290	1,759.231	1.514	1,759.555	1.519	1,734.056	0.789	1,725.565	0.398	1,722.472	0.783
2021	1,797.239	0.992	1,785.470	1.491	1,785.875	1.496	1,747.630	0.783	1,729.855	0.249	1,735.850	0.777
2022	1,810.987	0.765	1,811.709	1.470	1,812.194	1.474	1,761.203	0.777	1,732.547	0.156	1,749.229	0.771

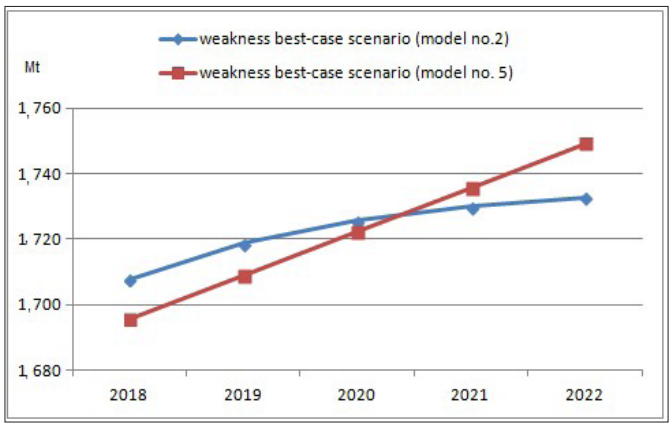
Source: Own research

Tab.5. Dynamics of the changes (year to year) in the world steel production in 2000 – 2018

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	average
%	0.302	6.317	7.287	9.602	7.818	8.993	8.283	-1.545	-8.205	17.231	7.273	1.474	5.756	1.161	-4.152	1.820	3.901	5.769	4.394
decline								-1.545	-8.205						-4.152				-4.634
growth	0.302	6.317	7.287	9.602	7.818	8.993	8.283			17.231	7.273	1.474	5.756			1.820	3.901	5.769	6.199

Source: Own research.

Fig. 11. Weak best-case scenario for forecast of world steel production



Source: Own research

Summing up

Understanding the forecast of the world steel production supports the decision processes of metallurgical enterprises. The managers possess the operational knowledge about the strategy of the company, and the forecast enables the additional verification of the adopted directions of development. Based upon the so-far existing trend of the changes in the world steel production, we may adopt the optimistic scenario of the forecasts. The forecasts, as obtained on the basis of the selected models of time series, supply information about the steel industry.

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