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Research Paper

Prediction of Lead (Pb) and Zinc (Zn) Prices in the Global Market

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Abstract The price of metals is the most important category in the production chain of basic metals, as it defines the business position of the mine. Besides this, the selling price of metals impacts the sustainability of the metal exploitation in general and basic metals as well. The prediction of metal prices at the same time is both science and art through which future economic events are predicted. Since the manager's role is to think attractively for a future period, nowadays he is equipped with more advanced mathematical tools. The mathematical methods that will be used, must be selected carefully for each case because there is no single universal method for all cases. Predictions and their coming through vary, the slighter variations of the reality from predictions may be compensated with capacities, quality, by changing the inventory amount or by changing the orders. However, greater variations may cause great production and business disorders.

Key words: *production, metals, market, cost*

Introduction

Mining companies search for and exploit various metals for the purpose of profiting, this implies that they must find a market for the products they manufacture. On the other hand, the existence of current demand for a given resource directly reflects on the price that in the end is important to all mining companies. Anyway, there is always the risk that we are based on the fact that the price is always driven by the demand, this fact is sometimes a wrong assumption (Rafet., 2012; Rafet et al., 2016). The definition of the price is connected closely with the demand and supply, however, in the end this equation is not the only one to define the price. The price is very much dependent on the local and regional specifics of the places where the lead and zinc (Pb, Zn) and other mineral resources are located.

The general conditions that would reflect in the metal price namely mineral resources would be:

- The political stability of the region namely the location where specific mineral resources are located.
- The economic development of the country and region in general.
- Regional geographic position of the country, transportation connections, harbours and road and railroad infrastructure.
- Geologic and geomorphological conditions of the mineral source location.
- Local and regional economic development level, *etc*.
- Application of innovations in the extraction and metal processing technology.

On the other hand, it is unrealistic to provide any good and sustainable relationship between the metal price and the primary ore production level or the product manufacturing level at higher rates such as high purity metals.

Importance of metal prices and the perspective of ore bodies for exploitation

Seen from the historic aspect, the metal prices have increased gradually over long time periods, whereas in various decades there were visible fluctuations and these fluctuations have a serious impact in the business of mining companies. However, price fluctuations do not have a decisive impact only in the creation of long-term projections of state policies for mineral exploitation namely, metals. Globally, from the moment the price metals have been registered to this day, a permanent trend of their increase is visible.

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The reason for this permanent increase of prices is without a doubt the rapid development of all industrial branches in the middle of last century, the linear depletion of exploitable geological reserves, and a visible increase of mining exploitation intensity, both underground and on the surface, as a result of technological developments, modern machineries, robotics and computer-controlled mining processes (Hughes., 2001; Rafet., *et al*., 2016).

At the same time, while tracking the prices at the London Stock Exchange we pay special attention to the ore production planning, this because we are obliged to study all the mine chambers (rooms) in various levels to prepare them for exploitation (Hoke., 2000; Rafet., 2020). The methods of preparing the ore bodies for exploitation and the assessment of the metal quality is argued in the following figures from the metal source of Trepça Mine in Stantërg (Gundewar., 2014; Rafet *et al*., 2019).

Chamber-119/F has a massive area of 2,856.0 m^2 suitable for exploitation with high production equipment with electro-hydraulic energy. The height of unused ore body is 45 m, the space up to 5 m height must be filled with hydro-filling material of 14,280 m^3 (Izet., *et al*., 2011; Jahir *et al*., 2016). The ore production from one floor reaches 31,701 tons of ore of the following quality Pb-2.2%, Zn-1.8%, Ag-25 gr/t (Figure 1).

Chamber-154 has an area of 1,094 m^2 in which ore is exploited with modern equipment. 12,143 tons of ore can be exploited from one floor, and the ore body has an unused height up to the upper level at 30 m. The empty space with a volume of 5,470 m^3 has to be filled with hydro-filling material. From the preparation objects a 60m filling shaft has to be built. Chamber-154 belongs to the central part of the source with the following metal quality: Pb-2.54%, Zn-1.34% and Ag-100 g/t, (Figure 2).

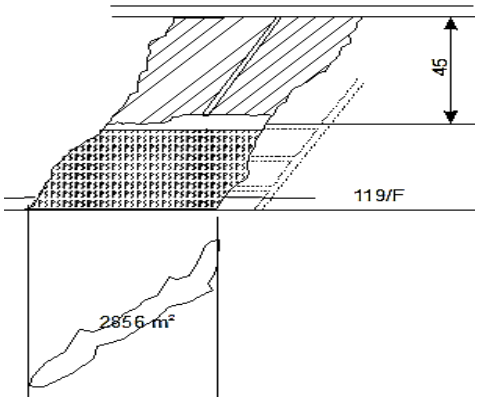

Figure 1. Chamber-119/F

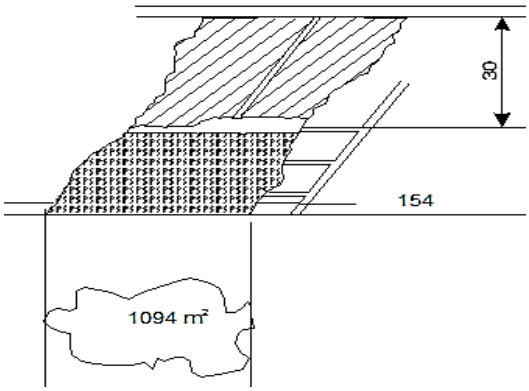

Figure 2. Chamber-154

Chamber-139/C1 has a horizontal area of the ore body of 737 m^2 of high quality and the exploitation is justified with modern production equipment. 13,634 tons ore can be exploited from one floor with the following ore quality: Pb = 3.46%, Zn = 6.1% and Ag = 60 g/t, (Figure 3).

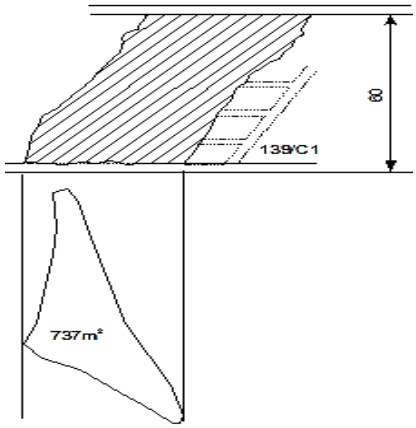

Figure 3. Chamber-139/C1

Weekly and monthly metal prices

Seen from the analytical processing of the fluctuations of prices, in particular lead and zinc we shall include the weekly and monthly fluctuation of prices presented in tables and graphs (Kelmendi. *et al*., 2006; Rafet. *et al*., 2016). So far, two groups of methods have been developed to be used for the prediction needs in business management (Izet. *et al.,* 2013; Jahir. *et al*., 2016).

1. Qualitative prediction methods, which are usually used when we have insufficient notes, or when past notes do not provide sufficient ground to predict the future. In this case, human decision-making ability prepares notes and selects the quality methods to predict future possible events (Shyqri. *et al*., 2012; Rafet., 2020).
2. Quantitative prediction methods that are grounded in past systematic time series or even conditioned predictions. These methods use quantitative models and methods to realize a prediction. A good starting point for all quantitative methods, are past notes and data samples (Rafet., 2020).

In Table 1, we see the tracking of daily prices, in this specific case we have taken February and for each day or week of this month we have tracked prices of lead (Pb) and zinc (Zn) in the London Stock Exchange.

Table 1. Metal prices for the first week of February 2017 according to the London Stock Exchange.

Date	Pb ($/t)	Zn ($/t)
2/2/2017	1180	1172.5
2/3/2017	1152	1145.5
2/4/2017	1145	1123.5
2/5/2017	1135	1121.5
Average	1153	1140.75

Based on Table 1 with the daily metal prices and their graphic presentation in Figure 4 we notice that in the first week of February, metal prices had slight declines.

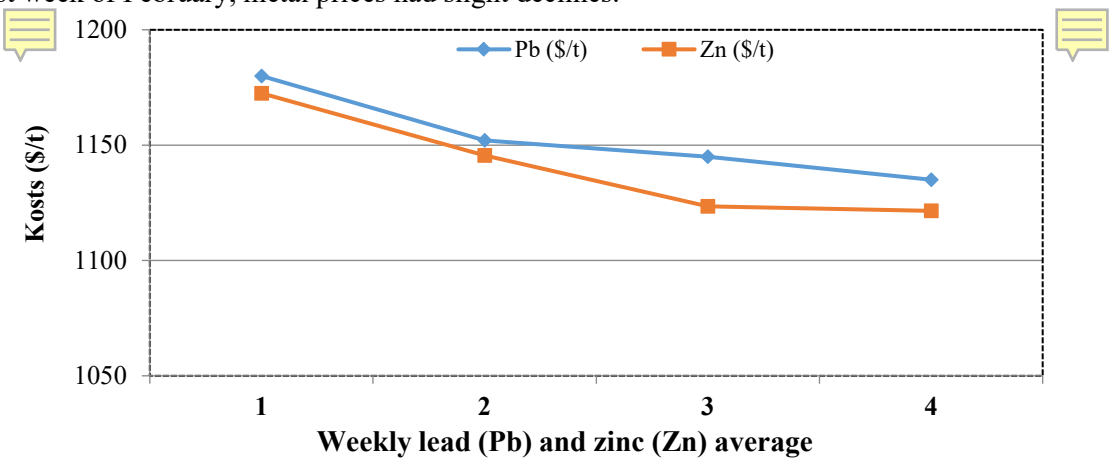

Figure 4. Graphic presentation of daily fluctuations of Pb and Zn prices

Table 2. Metal prices for the second week of February 2017 according to the London Stock Exchange.

Date	Pb ($/t)	Zn ($/t)
2/8/2017	1145	1139.5
2/9/2017	1135.5	1091
2/10/2017	1102.5	1090
2/11/2017	1060	1071
2/12/2017	1085	1112.5
Average	1105.6	1100.8

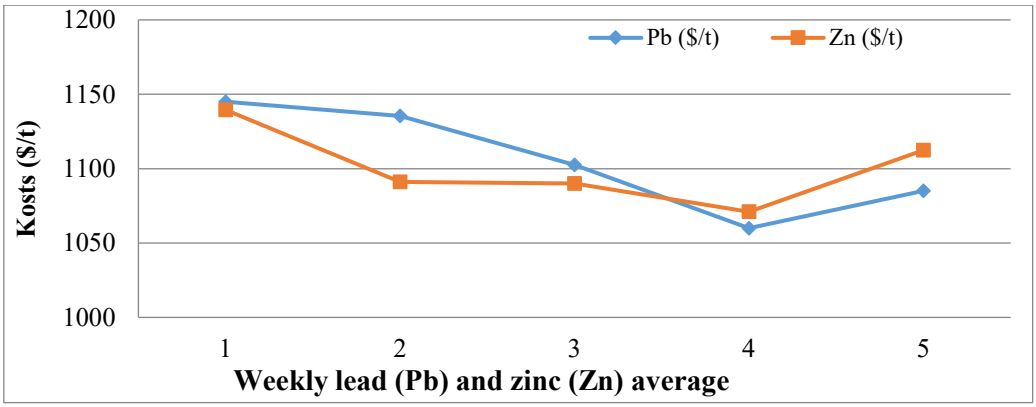

Figure 5. Graphic presentation of daily fluctuations of Pb and Zn prices

Price declines are also noticed at the start of second week, but price increases started on the second day of the second day, and these price changes are presented in Table 2 and Figure 5.

Table 3. Metal prices for the third week of February 2017 according to the London Stock Exchange.

Date	Pb ($/t)	Zn ($/t)
2/15/2017	1015.5	1059.5
2/16/2017	1026	1086
2/17/2017	991.5	1064
2/18/2017	1008	1101
Average	1010.25	1077.63

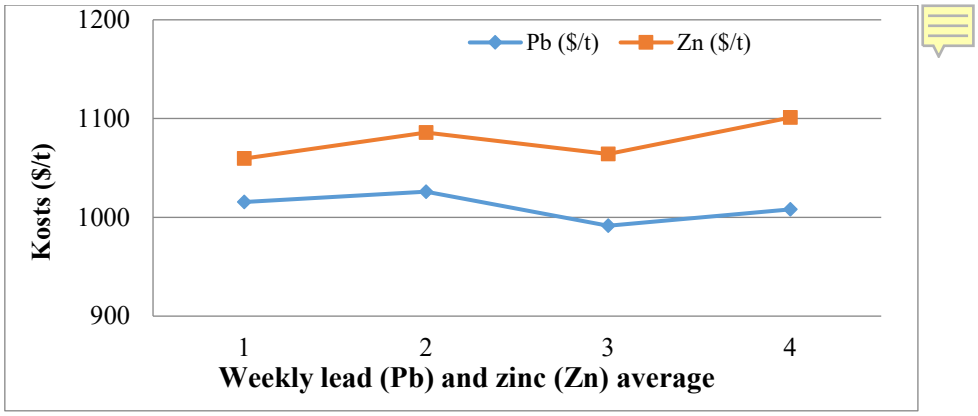

Figure 6. Graphic presentation of daily fluctuations of Pb and Zn prices

Based on Table 3 of daily metal prices and their graphic presentation in (Figure 6), we notice that in third week prices went up and down during the weekdays.

Table 4. Metal prices for the fourth week of February 2017 according to the London Stock Exchange.

Date	Pb ($/t)	Zn ($/t)
2/21/2017	1025	1075.5
2/22/2017	1024	1078.5
2/23/2017	1042	1105
2/24/2017	1104	1146
3/25/20017	1160	1186.5
Average	1071	1118.3

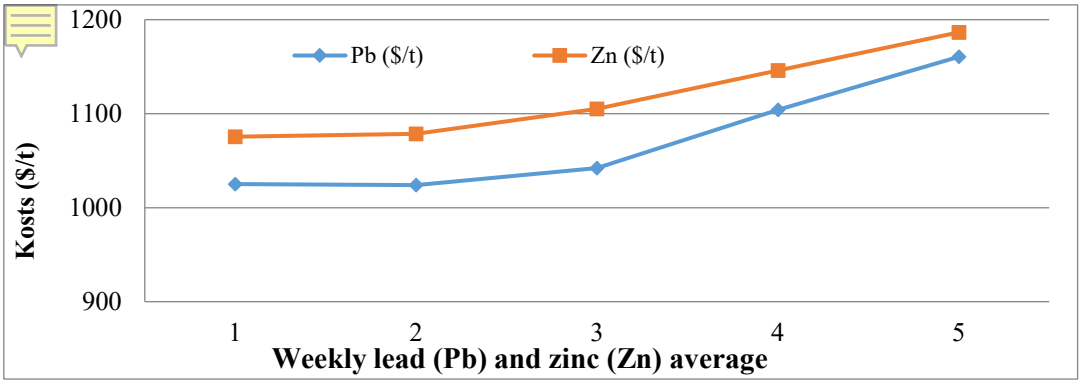

Figure 7. Graphic presentation of daily fluctuations of Pb and Zn prices

In the last week of February 2017, the metal price increase continued gradually, this increase is argued in Table 4 and Figure 7. This way, for a long time period we have tracked daily prices for each week of each month, until the collection of a database with an average price for 16 months including months of 2017 and 2018.

Results and discussion of metal prices predictions

Such a prediction provides high certainty for the future of the mine, namely the engagement of the work force both in the field of research and the performance of preparatory work of ore bodies for exploitation. The prediction of Pb and Zn prices is a key factor in planning the production of the ore, thus the prediction method is continuously described as well. The simplest prediction method is the average displacement method. Let us explain this through the example of the Pb and Zn progress in the stock market. We have the tracked progress of prices for 16 months in a row (basic notes). We calculate the average for the first 3 months. Next, from the first three notes, we remove the first note and we add to the remaining group the fifth note - we calculate the average for this new group.

We go on like this until the end. In the following table are shown three columns: the first column are the monitored months, the second column are basic notes of price progress for each month, in the third column are the calculated values of the displacement average for three-month periods, and column four shows the predicted values. Pursuant to the moving average described above we have analysed the prediction of lead (Pb) prices based on the moving average of the third row and the prices of metals in 2017 and 2018 that includes 16 months, Table 5.

Table 5. Monthly prices and lead (Pb) price prediction table

LME 2017/018	Monthly prices 2017/18	Moving average	2017/18 monthly prices prediction	Assessment error
February 2017	858.17			
March 2017	927.8			
April 2017	1045.58			
May 2017	1078.12	977.42		
June 2017	1258.4	1077.48	977.42	-280.98
July 2017	1252.28	1158.60	1077.48	-174.8
August 2017	1422.89	1252.92	1158.6	-264.29
September 2017	1664.24	1399.45	1252.92	-411.32
October 2017	1701.25	1510.17	1399.45	-301.8
November 2017	1767.89	1639.07	1510.17	-257.72
December 2017	1766.36	1724.94	1639.07	-127.29
January 2018	1835.95	1767.86	1724.94	-111.01
February 2018	1613.0	1745.80	1767.86	154.86
March 2018	1645.99	1715.33	1745.80	99.81
April 2018	1708.15	1700.77	1715.33	7.18
May 2018	1475.72	1610.72	1700.77	225.05

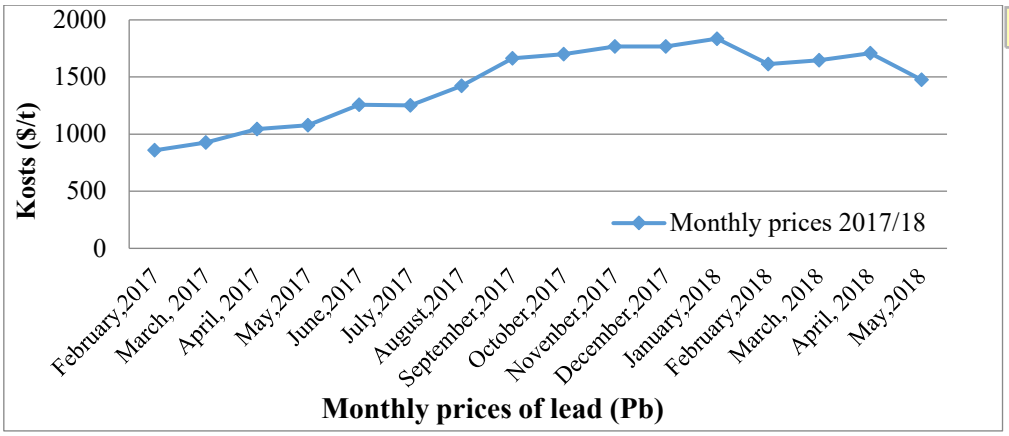

Figure 8. The graphic presentation of lead (Pb) monthly prices during 2017 and 2018

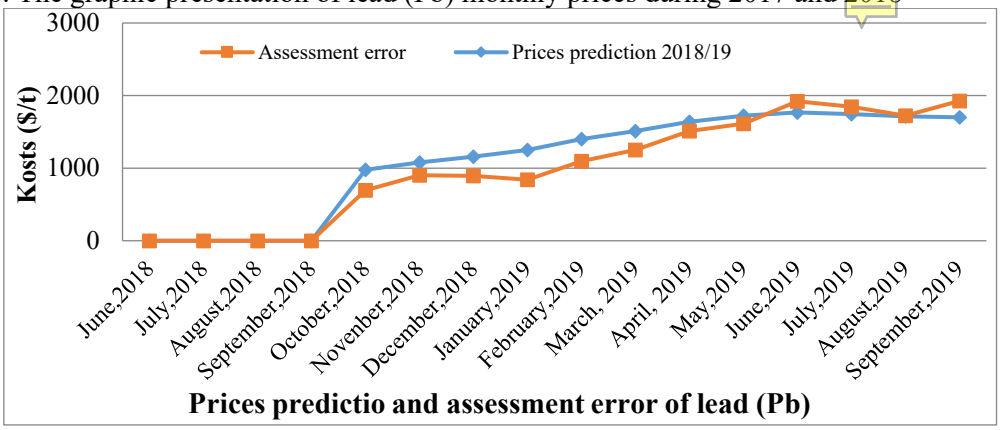

Figure 9. Graphic presentation of lead (Pb) price prediction and the prediction assessment error.

During the prediction of prices, we have assessed the minimum and maximum error of lead (Pb) price prediction, the assessment error varies from 7,18 up to 280,98 $/t, it is noticed that the progress of price predictions and error assessment have reasonable consistency and real expectations of future predicted prices should result with a high predicting accuracy.

We have further analysed the prediction of zinc (Zn) prices based on the moving middle of third row and at the same time metal prices for 2017 and 2018 that includes 16 months, Table 6.

Table 6. Monthly prices and zinc (Zn) price prediction table

LME 2017/018	Monthly prices 2017/018	Moving average	Monthly prediction prices	Assessment error
February 2017	869.71			
March 2017	911.65			
April 2017	1042.68			
May 2017	1114.92	984.74		
June 2017	1176.77	1061.51	984.74	-192.03
July 2017	1168.77	1125.79	1061.51	-107.26
August 2017	1371.74	1208.05	1125.79	-245.95
September 2017	1419.66	1284.24	1208.05	-211.61
October 2017	1546.41	1376.65	1284.24	-262.17
November 2017	1675.96	1503.44	1376.65	-299.31
December 2017	1801.06	1610.77	1503.44	-297.62
January 2018	1884.28	1726.93	1610.77	-273.51
February 2018	1644.1	1751.35	1726.93	82.85
March 2018	1713.88	1760.83	1751.35	37.47
April 2018	1795.59	1759.46	1760.83	-34.76
May 2018	1535.37	1672.23	1759.46	224.09

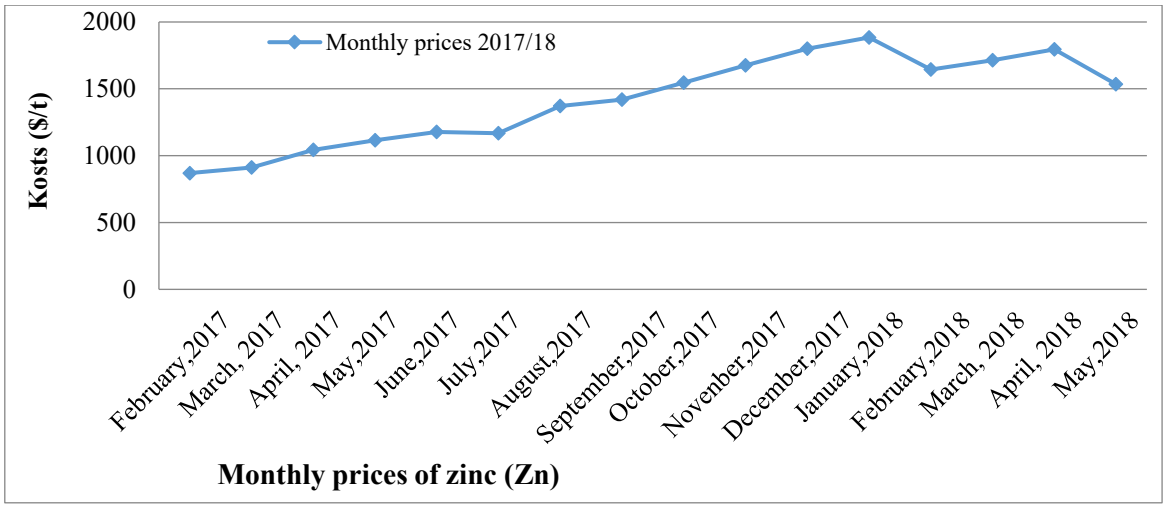

Figure 10. Graphic presentation of zinc (Zn) monthly prices during 2017 and 2018

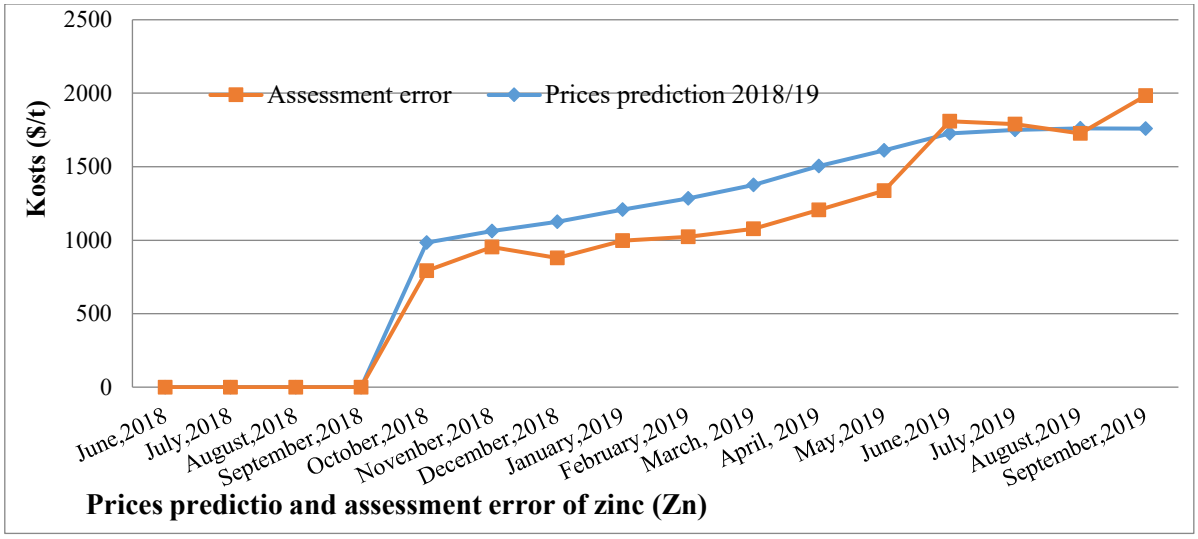

Figure 11. Graphic presentation of Zinc (Zn) price prediction and the prediction assessment error

The minimal and maximal error of zinc (Zn) price prediction varies from 37.47 up to 299.31$/t, we notice that the price prediction progress and assessment error have reasonable compliances and real expectations of future predicted prices should result with a high predicting accuracy.

Conclusions

In the technical aspect the professional mine staff should prepare several ore bodies for exploitation with the aim that price increases in the market and our prediction should be in the function of production cost and increase of income in the mine. Maintaining the economic stability of the mine is based in the prediction assessment of metal prices for future years obliging us to have a reasonable planning after the accurate calculation of daily and monthly production in each chamber, and also the accurate assessment of ore quality in each ore body. In Figure 12 we have presented the organizational chart of ore production planning in several chambers based on time predictions of prices in the stock market.

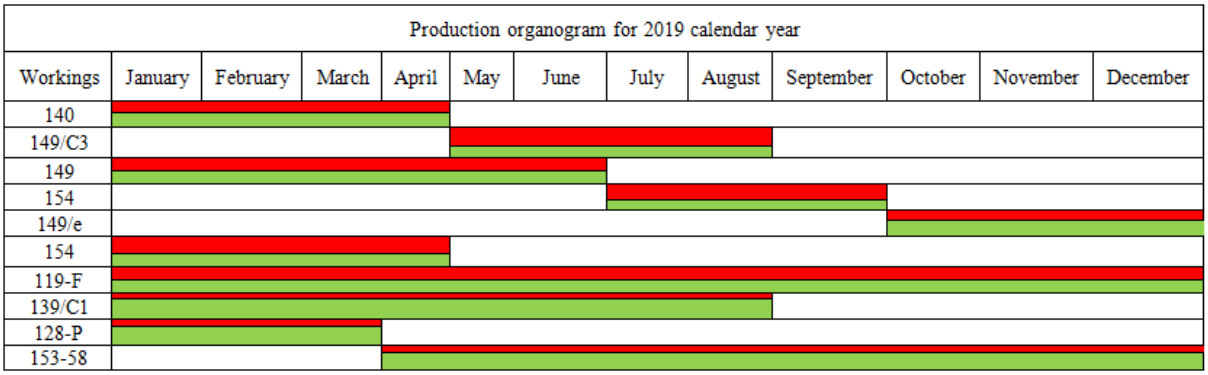

Figure 12. The planned production organizational chart

Based on the size of the ore bodies and the necessary exploitation time pursuant to the organizational chart we have determined the necessary production capacity for the 12 months of 2019, Table 7 and figure 13.

Table 7. Monthly production of metal ore in Trepça mine, Stantërg

Month	Ore production (t)
I	30000
II	40000
III	50000
IV	35000
V	30000
VI	30000
VII	30000
VIII	30000
IX	30000
X	30000
XI	30000
XII	30000

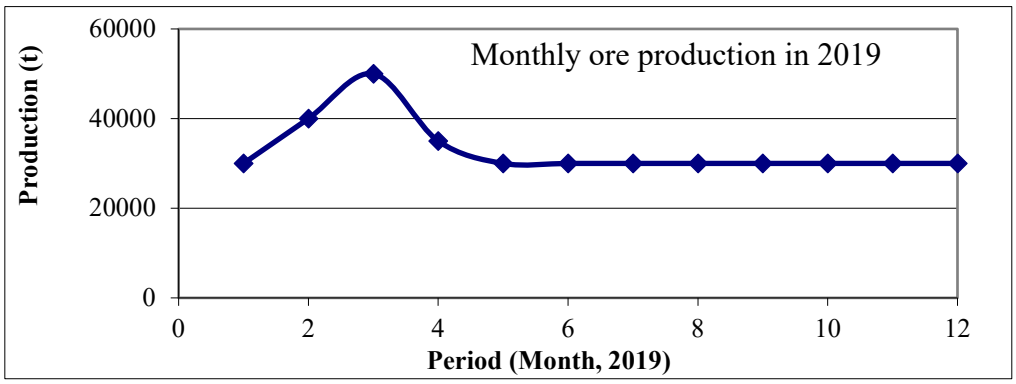

Figure 13. Graphic presentation of metal ore production for 12 months in 2019

During the exploitation and preparation stage of ore bodies for exploitation, it is especially important to track and plan the time interval of each work cycle through the predicted and planned stages. Production planning, with all the appropriate technical details, is performed by the technical sector of the mine, and this paper presents only the most important details that we call future prediction.

The mine capacity is based on all technical-economic indicators of the mine exploitation level with a new methodology that enables the easier determination of the mine optimum capacity while maintaining the optimal production cost.

Such a prediction, not only enables us to predict the prices for a two-year period, but with this method we can also predict for 5-to-15-year time periods, by tracking the LME, *i.e*. Daily, weekly, monthly and annual prices.

With the harmonization of these predictions for Pb, Zn and other minerals such as Ag and Au for long term periods I recommend the following:

- When the market demand for metals decreases and the offer increases, big capacity mines such as Trepça should create reserve Funds to use them.
- When world market price fluctuations fall (as in the case of Corona virus COVID-19), then enterprises should create production stocks as long as the crises lasts and during that time utilize the reserve budget fund of the mine.
- The production trend should always adapt with the world market price fluctuations trends.

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