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Forecasting of Southeast Sulawesi Nickel Ore Production using Arima & Holt-Winter Method

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Abstract:- Nickel is an important metal element in the battery cell components used for electric cars. For the manufacture of batteries, three main raw materials are needed, namely nickel, lithium and cobalt. For nickel, Indonesia controls 30 percent. Compared to some other countries.From the results of experiments conducted by the author, it was found that the most accurate forecasting for nickel ore production data is the ARIMA forecasting method. The results obtained from nickel ore forecasts that there will be a decline after 2020. This is not a good thing for the government's plan to increase electric battery vehicles that use nickel.The decline in nickel production was due to the excavation that was exhausted in 2018 and 2019 resulting in production of 20,219,885/ton & 23,967,427/ton. Therefore, to stabilize nickel ore production, it is necessary to control nickel ore production targets so that production and demand for nickel are not unequal but should be statistically parallel.Forecasting using the ARIMA time series method, getting the error valueMAPE = 3.940710675%, and The Winter's method model with the smallest error percentage value of 15.27%.

Keywords:- *Forecasting, ARIMA, Nickel, HOLT-WINTER, ESDM.*

I. INTRODUCTION

Nickel is a mineral that is highly sought after by investors in the mining sector. The function of the nickel mineral itself is very much, one of which is in the manufacture of stainless steel, it can also be used as a Physics and Chemistry laboratory tool and many more. Nickel is hard but malleable, resists rust, and its mechanical and physical properties persist even when exposed to extreme temperatures. This metal is of high quality because it is useful for coatings and batteries. Nickel also serves to give a brilliant metallic finish such as in faucets and showers in bathrooms. Even in today's time, almost no one can not escape from nickel. This is because this metal is used as one of the main ingredients for making rechargeable lithium batteries in gadgets. Nickel is also very valuable in the future with the rapid trend of electric vehicles in the world.

At present and in the future, the demand for nickel is increasing in addition to other needs whose supply is increasingly limited. This is because Nickel is a mineral that has high economic value. Therefore, the storage area which we usually call the stockyard can greatly determine the amount of nickel that will be produced.

Starting January 1, 2020, the Government officially stopped nickel exports. The decision to ban exports is contained in the Minister of Energy and Mineral Resources Regulation (Permen) Number 11 of 2019 Second Amendment to the Regulation of the Minister of Energy and Mineral Resources Number 25 of 2018 concerning Mineral and Coal Mining Concessions. This policy was born from consideration of the domestic nickel stock which estimates that there are only 700 million tons left. Of the remaining amount, it is predicted that it will run out in 8 years if mining continues.

According to data from the Badan Pusat Statistika(BPS) for 2004-2014, three of the six export destinations for Indonesia's nickel are Switzerland, Greece and Ukraine. These three countries are part of the European Union. The following is data on the number of Indonesian nickel exports to the three countries. In 2004, there were 258,350 tons of nickel exported worth USD 6.92 million. In 2005, there were 582,787 tons of nickel worth USD 21.35 million. In 2006, there were 914,664 tons worth USD 51.45 million. In 2007, there were 983,167 tons of nickel valued at USD 86.82 million. In 2008, there were 1,603,733 tons of nickel worth USD 103.8 million. In 2009, there were 922,170 tons of nickel worth USD 42.30 million. In 2010, there were 921,096.6 tons of nickel valued at USD 67.9 million. In 2011, there were 1,283,671.5 tons of nickel worth USD 85.06 million. In 2012, there were 1,844,640.7 tons of nickel valued at USD 93.17 million. In 2013 there were 1,941,139.7 tons of nickel worth USD 90.93 million. In 2014 there were 38,532.8 tons of nickel valued at USD 1.67 million. This is a new challenge for Indonesia where Indonesia has to process its own nickel ore. The depletion of nickel in nature has forced the government to take steps to downstream and industrialize the raw materials of its natural resources. For this reason, the government has decided to stop the export of nickel ore by 2020.

Southeast Sulawesi Province has unstable nickel ore & nickel ore production in a decade (2003 – 2013). Nickel production is important because of the increasing demand for nickel, expansion is expected to increase capacity so that it can be a reserve if production is interrupted one day, so that delivery can still run with the existing backup. In this thesis, we will look for the most accurate forecasting technique, with stable production without worrying about shortage of reserves. From the description above, it is necessary to conduct research on forecasting to achieve the target and stabilize the production value.

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Tahun	Produksi		Nilai Produksi (Juta Rp)	
	Bijih Nikel (Ton)	Ferro Nikel (Ton Ni)	Bijih Nikel	Ferro Nikel
2001	700.740	9.302	165.051	604.163
2002	969.689	n.a	96.534	n.a
2003	1.702.267	8.279.135	287.280	628.337
2004	1.426.672	7.441.235	n.a	n.a
2005	1.157.657	9.892.440	410.506	925.409
2006	1.486.442	n.a	622.492	n.a
2007	2.499.935	1.712.147	1.204.647	245.511
2008	1.782.356	n.a	303.753	n.a
2009	1.026.975	n.a	140.673	n.a
2010	230.870	3.206	37.241	2.149.516
2011	1.943.383	19.690	213.414	2.571.059
2012	18.778.406	.17.250	5.351.845,72	2.932.500,00
2013	29.431.004	.15.535	8.387.836,14	2.563.275,00
2014	1.387.140	16.851	138.714,00	1.152,61.
2015	n.a	n.a	n.a	n.a
2016	n.a	3.957	744.324,73	1.616.600,59
2017	9.043.233	15.821	4.058.801,55	2.458.839,11
2018	20.220.717	n.a	n.a	n.a
2019	23.967.146	n.a	n.a	n.a

Table 1: Production Nickel Sulawesi Tenggara

Source: Badan Pusat Statistik Sulawesi Tenggara

The data shows an upward trend in the value of nickel production, Indonesia is one of the countries with the highest production in the world, this is one of the reasons the Indonesian government has closed nickel exports. If Indonesia can process nickel ore itself, it will increase the selling value of Indonesian nickel ore. Nickel ore is one of the results of the refining of nickel ore.

II. LITERATURE QUERY

A. Definition of Forecasting

Forecasting is an activity to predict what will happen in the future. Forecasting is necessary because there is a time difference between awareness of the need for a new policy and the time of implementation of the policy. If the time difference is long, then the role of forecasting becomes important and very much needed, especially in determining when an event occurs so that actions can be prepared that need to be taken. [1]

While the forecast is a situation or condition that is expected to occur in the future. The forecast can be based on various methods known as forecasting methods. Forecasting method is a way of predicting quantitatively what will happen in the future, based on relevant data in the past. The forecasting method will assist in conducting an analytical approach to behavior or patterns from past data, so that it can provide a systematic and pragmatic way of thinking, working and solving, as well as providing a greater level of confidence in the accuracy of the predictions made or compiled.

B. Function of Forecasting

There is often a time lag between awareness of an upcoming event or need and the event itself. The existence of this lead time is the main reason for planning and forecasting. In the above situation forecasting is necessary to determine when an event will occur or a need will arise, so that actions can be prepared that need to be taken.

In planning in an agency, be it government or private, forecasting is a very basic requirement. Where good or bad forecasts can affect all parts of the agency, because the grace period for decision making can range from several years. Forecasting is an important tool in effective and efficient planning. The usefulness of a forecast can be seen at the time of decision making. A good decision is a decision that is based on consideration of what will happen when the decision is made. If the decision taken is not appropriate, the decision should not be implemented. Because the problem of decision making is a problem that is always faced, forecasting is also a problem that is always faced because forecasting is related to making a decision.

Whether or not a forecast is prepared, besides being determined by the method used, it is also determined by whether or not the information or data used or the accuracy of the forecast made. As long as the data and information used cannot be used, the forecasting results compiled will also be difficult to believe in their accuracy.

Therefore, the accuracy of the prediction is very important, however it should be realized that a prediction is still a prediction, where there is always an element of error.

So the important thing to note is to minimize the error.

Within the Organization section there are several important roles in forecasting:

- Scheduling of available resources. Efficient use of resources requires scheduling production, transportation, cash, personnel, and so on. Important inputs for such scheduling are forecasts of the level of customer or customer demand, materials, labor, finance or services.
- Provision of additional resources. Lead times for acquiring raw materials, hiring new workers or purchasing machinery and equipment can range from a few days to several years. Forecasting is needed to determine future resource requirements.
- Determination of the desired resource. Every organization must determine the resources it wants to have in the long term. Such decisions depend on market opportunities, environmental factors and internal development of financial, human, product, and technological resources. All of these decisions require good forecasts and managers who can interpret forecasts and make informed decisions.

Although there are many other fields that require forecasting, the three groups above are typical forms of the use of short, medium, and long-term forecasting.

From the description above, it can be said that the forecasting method is very useful, because it will help in conducting an analysis of data from the past. So that the forecasting method will provide a way of thinking, orderly and directed work and systematic planning to provide accurate analysis results.

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C. *Meaning of Time Series*

Periodic data (time series) is data that is compiled based on time sequences or data collected from time to time. The time used can be in the form of weeks, months, years and so on. Time Series is a series of observational data originating from one fixed source and occurring based on a time index t in succession with fixed time intervals. Each observation can be expressed as a random variable Zt with the notation Zt1, Zt2, ...,Ztn

Periodic data or time series is data that is usually used to describe a development or trend of circumstances/events/activities. Usually the distance or interval from time to time is the same.

Examples of periodic data are as follows:
a) the economic growth of a country per year;
b) the amount of oil production per month;
c) stock price index per day.

Time series, periodic data or time series are a series of observations of an event, occurrence, symptom, or variable taken from time to time, carefully recorded in the order in which they occur, and then compiled as statistical data. In general, observations and recordings are carried out within a certain period of time, for example at the end of each year, at the beginning of each year, every ten years, and so on .

Data movement patterns or variable values from time series data can be known. So that time series data can be used as the basis for:

a) current decision making.
b) forecasting the state of trade or the economy in the future.
c) planning activities for the future.

Identify Time Series Models

The formation of the ARIMA model can be seen from the results of the ACF and PACF plots. The ACF and PACF plot patterns in the model formation are as follows.

Proses	ACF	PACF
AR(p)	Menurun secara cepat (dies down)	Cuts off setelah lag ke- p
MA(q)	Cuts off setelah lag ke- p	Menurunsecara cepat (dies down)
ARMA(p,q)	Menurun secara cepat (dies down)	Menurun secara cepat (dies down)

Table 2: Plot ACF and PACF

D. *Autoregressive Integrated Moving Average (ARIMA) Method*

The Autoregressive Integrated Moving Average (ARIMA) model is a model that completely ignores the independent variables in making forecasts. ARIMA uses past and present values of the dependent variable to produce accurate short-term forecasts. ARIMA has very good accuracy for short-term forecasting, while for long-term forecasting the forecasting is not good. Usually it will tend to be flat (flat/constant) for a fairly long period.

The general form of the autoregressive integrated moving average (ARIMA p,d,q) model is:

$$(1-B)(1-\emptyset_1 B)X_t = \mu' + (1-\theta_t B)e_t$$

Keterangan :

$(1-B)$ = Pembedaan Pertama

$(1 - \emptyset_1 B)X_t$ = AR (1)

$\mu' + (1-\theta_t B)e_t$ = MA (1)

Fig. 1: ARIMA Method

The AR, MA, and ARMA models that have been discussed previously use the assumption that the time series data analyzed are stationary. The mean and variance of time series data are constant and the covariance is not affected by time. ARIMA is also known as the Box Jenkins time series method. The ARIMA model consists of three basic steps, namely the identification stage, the assessment and testing stage, and the diagnostic examination stage. Furthermore, the ARIMA model can be used for forecasting if the model obtained is adequate.

E. *Triple Exponential Smoothing (Winters Method)*

This method is used when the data shows seasonal trends and behavior. To deal with seasonality, a third equation parameter has been developed called the Holtn Winters method after the name of the inventor. There are two Holt-Winters models depending on the type of seasonality, namely the Multiplicative seasonal model and the Additive seasonal model. The exponential smoothing method that has been discussed previously can be used for almost any type of stationary or non-stationary data as long as the data does not contain seasonal factors. However, if there is seasonality, this method is used as a way to predict data containing seasonal factors, but this method alone cannot solve the problem well. However, this method can handle seasonal factors directly. The formula used for triple exponential smoothing is:

Trend smoothing:
Bt =g (St – St-1) + (1 - g) bt-1

Seasonal Smoothing:
I = b t X t S + (1-b) t -L +m

Forecasting:
Ft + m = (St + bt m)It – L + m

Where L is the seasonal length (i.e., the number of quarters in a year), b is the trend component, I is the seasonal adjustment factor, and Ft + m is the forecast for m periods ahead can be hypothesized either as a function of time or as a function of the independent variables. , then tested. An important step in choosing the right time series model is to consider the type of data pattern, so that the most appropriate method with that pattern can be tested. Data patterns can be divided into four types of cyclical and trend.

The exponential smoothing method is a procedure that repeats calculations continuously using the latest data based on the average calculation of smoothing past data exponentially. The method proposed by Winter is based on 3 (three) smoothing parameters, namely one for stationary elements, one for trend, and one for seasonality. The advantages of the refining method are that it can provide accuracy in short-term forecasts and adjustments can be made quickly and at low costs. [6]

Ord et al. (1997:1621) stated that the problem that arises in the WES method is that each parameter can have a value between 0 (zero) to 1 (one) so it is necessary to use a random value to fill in the parameter or by doing trial and error, the number of which can be very large. . Makridakis et al. (1991:110) stated that to reduce doubts about the optimal parameter values, a small value was set for each parameter. The parameter values used in this study were 0.1 and 0.2.

III. RESEARCH RESULTS AND ANALYSIS

A. Missing Data Analysis

The Southeast Sulawesi ESDM data for Nickel Ore has some missing data, first it is necessary to calculate the missing data using the Basic Statistics Minitab, the results are as shown below.

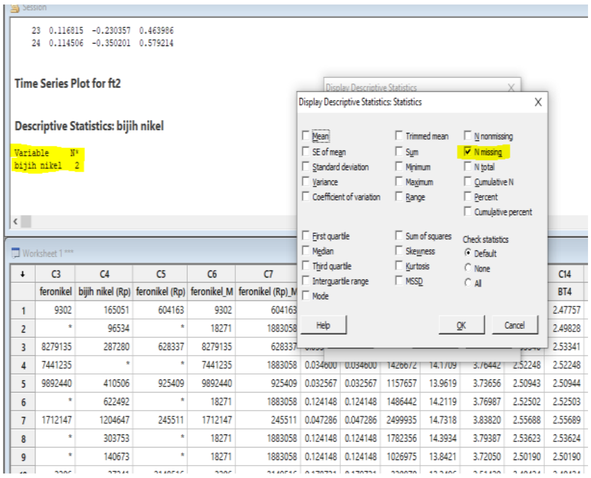

Fig.2: Missing Data N Missing Minitab

In Figure 4.3 it can be seen that N missing = 2, meaning that there are 2 missing values from the Southeast Sulawesi Nickel Ore data.

B. Replacing missing data using Median

To perform more accurate forecasting, it is not possible to delete data for missing data, therefore we will use the median to replace missing data.

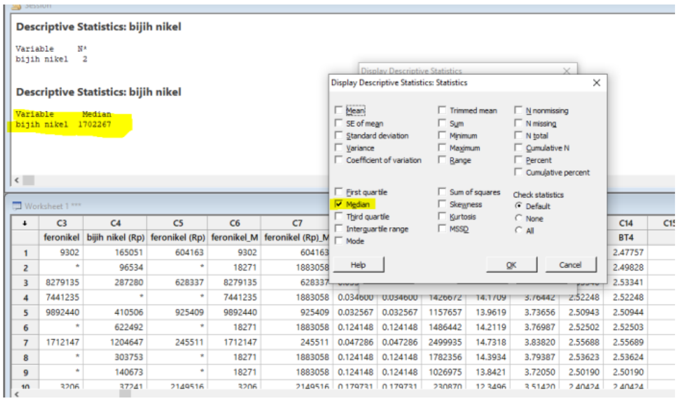

Fig. 3: Median Calculation using Minitab

the median value of Nickel Ore production data (Median = 1702267) is obtained. This value will be used to replace the missing value.

C. Calculation of ARIMA forecasting for Nickel Ore production

Production and production value of Nickel Ore will be calculated using the Minitab program. First, the researcher will use ARIMA forecasting.

Tahun	bijih nikel
2001	700740
2002	969689
2003	1702267
2004	1426672
2005	1157657
2006	1486442
2007	2499935
2008	1782356
2009	1026975
2010	230870
2011	1943383
2012	18778406
2013	29431004
2014	1387140
2015	1702267
2016	1702267
2017	9043233
2018	20220717
2019	23967146

Table 3: Data after analysis missing data

The data is processed from BPS data from Southeast Sulawesi

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D. First Rounded Value Check

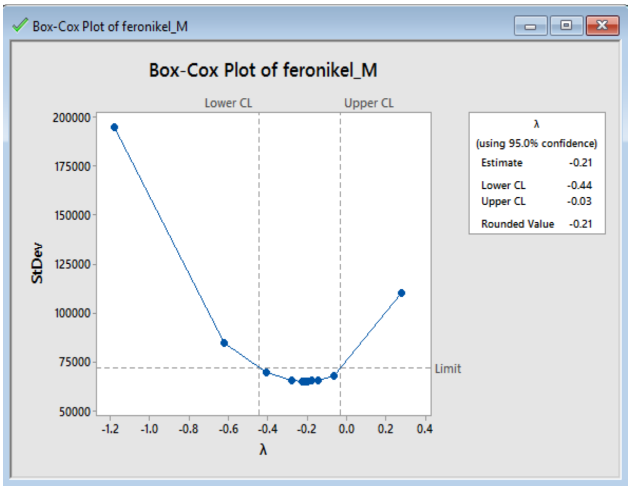

Fig. 4: First Rounded Value Check

Because the Rounded Value is still not at a value of 1, the data is not stationary, it is necessary to do a transformation. This transformation will be used for the ARIMA difference value.

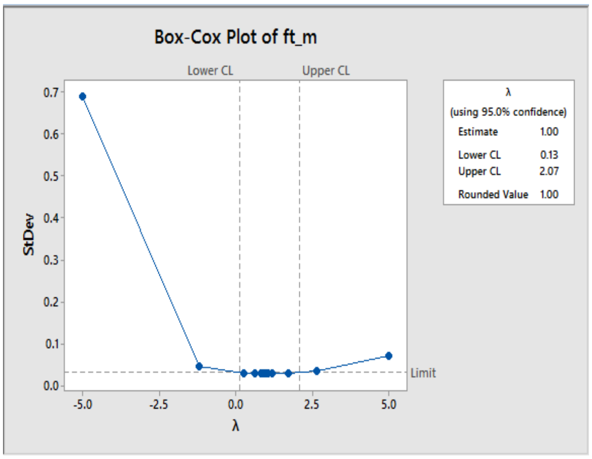

Fig. 5: The result of the 2nd transformation stationary data

After four times the differentiation is obtained rounded value = 1 , then the data can be called stationary. From the number of differentiations, we get i = 4 for the formula/model from ARIMA, the next is an experiment to find the Arima model with the smallest error value. The following is the data from the 4 box-cox transformations.

bijih_M	BT1	BT2	BT3	BT4
700740	13.45989	3.668773	2.477567	2.477571
969689	13.78473	3.712779	2.498273	2.498276
1702267	14.34747	3.787806	2.533403	2.533407
1426672	14.17086	3.76442	2.522476	2.522479
1157657	13.96191	3.736564	2.509433	2.509436
1486442	14.2119	3.769867	2.525023	2.525026
2499935	14.73178	3.838199	2.556882	2.556885
1782356	14.39345	3.79387	2.536233	2.536237
1026975	13.84213	3.720501	2.501898	2.501902
230870	12.34961	3.514201	2.404237	2.40424
1943383	14.47994	3.805252	2.541542	2.541545
18778406	16.74822	4.092459	2.673955	2.673959
29431004	17.19756	4.146994	2.698776	2.69878
1387140	14.14275	3.760685	2.520729	2.520732
1702267	14.34747	3.787806	2.533403	2.533407
1702267	14.34747	3.787806	2.533403	2.533407
9043233	16.01753	4.00219	2.63265	2.632653
20220717	16.82222	4.10149	2.678073	2.678076
23967146	16.99219	4.122159	2.687485	2.687489

Table 4: Nickel Ore Box-Cox Transformation

The data is processed from BPS data from Southeast Sulawesi.

E. ARIMA model experiment

ARIMA model (p,d,q) where p and q are lag levels and d are differencing levels (transformations).

Bijih Nikel tansformasi rounded value = 1	Forecasting ARIMA	Selisih Error	[Selisih Error]	Error^2	%Error	Tahun	bijih nikel
2.477570504						2001	700740
2.49827605						2002	969689
2.533406501						2003	1702267
2.52247918						2004	1426672
2.509435915	2.45805	0.051386	0.051386	0.002640521	2.047711189	2005	1157657
2.525026066	2.43551	0.089512	0.089512	0.008012398	3.544993107	2006	1486442
2.556885059	2.52523	0.031658	0.031658	0.001002229	1.23814717	2007	2499935
2.536236692	2.58673	-0.050489	0.050489	0.002549139	1.990705369	2008	1782356
2.501901502	2.47056	0.031339	0.031339	0.000982133	1.252607266	2009	1026975
2.404239936	2.40662	-0.002384	0.002384	5.68346E-06	0.099158157	2010	230870
2.541545283	2.24301	0.298536	0.298536	0.089123743	11.74623966	2011	1943383
2.673959079	2.75353	-0.079575	0.079575	0.006332181	2.975924375	2012	18778406
2.698780314	2.9216	-0.222822	0.222822	0.049649644	8.256396375	2013	29431004
2.520732134	2.64376	-0.123024	0.123024	0.015134905	4.880486838	2014	1387140
2.533406501	2.15302	0.380388	0.380388	0.144695031	15.01488213	2015	1702267
2.533406501	2.52178	0.011627	0.011627	0.000135187	0.458947271	2016	1702267
2.632653453	2.62536	0.007292	0.007292	5.31733E-05	0.276982904	2017	9043233
2.678076353	2.7681	-0.090021	0.090021	0.00810378	3.361405283	2018	20220717
2.687489182	2.74033	-0.052838	0.052838	0.002791854	1.96607303	2019	23967146
		Jumlah	1.522891	0.331211601	59.11066012		
			0.101526067	0.022080773	3.940710675		
			MAD	MSE	MAPE		

Table 5: Model ARIMA (1,4,0)

The data is processed from BPS data from Southeast Sulawesi

MAD = 0.101526067
MSE = 0.022080773
MAPE = 3.940710675%

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Bijih Nikel tansformasi rounded value = 1	Forecasting ARIMA	Selisih Error	[Selisih Error]	Error^2	%Error	Tahun	bijih nikel
2.477570504						2001	700740
2.49827605						2002	969689
2.533406501						2003	1702267
2.522478918						2004	1426672
2.509435915	2.41881	0.090629	0.090629	0.008213616	3.611528769	2005	1157657
2.525026066	2.45495	0.070072	0.070072	0.004910085	2.775100065	2006	1486442
2.556885059	2.53562	0.021267	0.021267	0.000452285	0.831754244	2007	2499935
2.536236692	2.57311	-0.036873	0.036873	0.001359618	1.453846958	2008	1782356
2.501901502	2.42818	0.073719	0.073719	0.005434491	2.946518875	2009	1026975
2.404239936	2.42497	-0.02073	0.02073	0.000429733	0.862226756	2010	230870
2.541545283	2.21266	0.328887	0.328887	0.108166659	12.94043439	2011	1943383
2.673959079	2.90994	-0.235983	0.235983	0.055687976	8.825228549	2012	18778406
2.698780314	2.77843	-0.079654	0.079654	0.00634476	2.951481438	2013	29431004
2.520732134	2.58649	-0.065759	0.065759	0.004324246	2.608726216	2014	1387140
2.533406501	2.10495	0.428452	0.428452	0.183571116	16.91209049	2015	1702267
2.533406501	2.73675	-0.203344	0.203344	0.041348782	8.026505019	2016	1702267
2.632653453	2.50416	0.128494	0.128494	0.016510708	4.880779118	2017	9043233
2.678076353	2.82501	-0.146938	0.146938	0.021590776	5.486699431	2018	20220717
2.687489182	2.6516	0.035885	0.035885	0.001287733	1.335261189	2019	23967146
		Jumlah	1.966686	0.459632585	76.44818151		
			0.1311124	0.030642172	5.096545434		
			MAD	MSE	MAPE		

Table 6: Model ARIMA (0,4,1)

The data is processed from BPS data from Southeast Sulawesi

With the ARIMA model (0,4,1) by using the minitab the researcher gets the Error value:

MAD = 0.1311124
MSE = 0.030642172
MAPE = 5.096545434 %

From these results, this model cannot be used because the MAPE exceeds 5%

Bijih Nikel tansformasi rounded value = 1	Forecasting ARIMA	Selisih Error	[Selisih Error]	Error^2	%Error	Tahun	bijih nikel
2.477570504						2001	700740
2.49827605						2002	969689
2.533406501						2003	1702267
2.522478918						2004	1426672
2.509435915	2.458049626	0.051386289	0.051386289	0.002640551	2.047722711	2005	1157657
2.525026066	2.435514243	0.089511823	0.089511823	0.008012367	3.544986115	2006	1486442
2.556885059	2.52522689	0.031658169	0.031658169	0.00100224	1.238153765	2007	2499935
2.536236692	2.586725322	-0.05048863	0.05048863	0.002549102	1.990690788	2008	1782356
2.501901502	2.47056206	0.031339442	0.031339442	0.000982161	1.252624943	2009	1026975
2.404239936	2.406624261	-0.002384326	0.002384326	5.68501E-06	0.0991717	2010	230870
2.541545283	2.243008784	0.298536499	0.298536499	0.089124041	11.7462593	2011	1943383
2.673959079	2.753534094	-0.079575016	0.079575016	0.006332183	2.975924967	2012	18778406
2.698780314	2.921601882	-0.222821568	0.222821568	0.049649451	8.256380385	2013	29431004
2.520732134	2.643756256	-0.123024123	0.123024123	0.015134935	4.880491715	2014	1387140
2.533406501	2.15301868	0.380387822	0.380387822	0.144694895	15.0148751	2015	1702267
2.533406501	2.521779749	0.011626753	0.011626753	0.000135181	0.458937505	2016	1702267
2.632653453	2.625361353	0.007292101	0.007292101	5.31747E-05	0.276986733	2017	9043233
2.678076353	2.768097247	-0.090020894	0.090020894	0.008103761	3.361401339	2018	20220717
2.687489182	2.74032724	-0.052838058	0.052838058	0.00279186	1.966075185	2019	23967146
		Jumlah	1.522891513	0.331211588	59.11068225		
			0.101526101	0.022080773	3.94071215		
			MAD	MSE	MAPE		

Table 7: Model ARIMA (1,4,1)

The data is processed from BPS data from Southeast Sulawesi

With the ARIMA model (1,4,1) using the minitab the researcher gets the Error value:

MSE = 0.022080773
MAD = 0.101526101
MAPE = 3.94071215%

From the three ARIMA model tests, it can be concluded that adding the MA(q) value causes the MAPE value to increase. Subsequent experiments did not use MA(q).

Bijih Nikel tansformasi rounded value = 1	Forecasting	Selisih Error	[Selisih Error]	Error^2	%Error	Tahun	bijih nikel
2.47757	*	*	*	*	*	2001	700740
2.49828	*	*	*	*	*	2002	969689
2.53341	*	*	*	*	*	2003	1702267
2.52248	*	*	*	*	*	2004	1426672
2.50944	2.47144	0.038000	0.038	0.001444	1.514282071	2005	1157657
2.52303	2.46266	0.062367	0.062367	0.003889643	2.469950852	2006	1486442
2.55689	2.59387	-0.036983	0.036983	0.001367742	1.446405594	2007	2499935
2.53624	2.63218	-0.095942	0.095942	0.009204867	3.782843895	2008	1782356
2.5019	2.45037	0.051529	0.051529	0.002655238	2.059594708	2009	1026975
2.40424	2.40906	-0.004819	0.004819	2.32228E 05	0.20043756	2010	230870
2.54155	2.25209	0.289455	0.289455	0.083784197	11.38891621	2011	1943383
2.67396	2.92585	-0.251894	0.251894	0.063450587	9.420260587	2012	18778406
2.69878	2.9689	-0.270124	0.270124	0.072966975	10.00911523	2013	29431004
2.52073	2.48504	0.035694	0.035694	0.001274062	1.416018376	2014	1387140
2.53341	2.01506	0.518343	0.518343	0.268679466	20.4602887	2015	1702267
2.53341	2.70605	-0.172643	0.172643	0.029805605	6.81464903	2016	1702267
2.63265	2.75185	-0.119201	0.119201	0.014208878	4.527795187	2017	9043233
2.67808	2.77049	-0.092418	0.092418	0.008541087	3.450905126	2018	20220717
2.68749	2.69296	-0.005468	0.005468	2.9899E 05	0.203461222	2019	23967146
		Jumlah	2.04488	0.561325469	79.16492435		
			0.136325333	0.037421698	5.277661624		
			MAD	MSE	MAPE		

Table 8: Model ARIMA (2,4,0)

The data is processed from BPS data from Southeast Sulawesi

With the ARIMA model (2,4,0) by using the minitab the researcher gets the Error value:

MSE = 0.136325333
MAD = 0.037421698
MAPE = 5.277661624%

It can be found that increasing the value of autocorrelation (AR = p) more than 1 increases the value of the percentage error. So from this experiment, it can be found that the ARIMA(p,d,q) model with the smallest error percentage is ARIMA (1,4,0).

F. Winters Method

In the winter's method the researcher gets the smallest error value as follows:

Forecasting	Selisih Error	[Selisih Error]	Error^2	%Error	Tahun	bijih nikel
-267216	967956	967956	936938817936	138	2001	700740
2444113	-1474424	1474424	2173926131776	152	2002	969689
1702267	0	0	0	0	2003	1702267
1426672	0	0	0	0	2004	1426672
1157657	0	0	0	0	2005	1157657
1486442	0	0	0	0	2006	1486442
2499935	0	0	0	0	2007	2499935
1782356	0	0	0	0	2008	1782356
1026975	0	0	0	0	2009	1026975
230870	0	0	0	0	2010	230870
1943383	0	0	0	0	2011	1943383
18778406	0	0	0	0	2012	18778406
29431004	0	0	0	0	2013	29431004
1387140	0	0	0	0	2014	1387140
1702267	0	0	0	0	2015	1702267
1702267	0	0	0	0	2016	1702267
9043233	0	0	0	0	2017	9043233
20220717	0	0	0	0	2018	20220717
23967146	0	0	0	0	2019	23967146
	Jumlah	2442380	3110864949712	290		
		128546.3158	1.6373E+11	15.27287508		
		MAD	MSE	MAPE		

Table 9: Model Winter's Method (1,1,1)

The data is processed from BPS data from Southeast Sulawesi

From these experiments to determine the model (α, β, γ). The researcher found that changing the value of on the minitab did not affect the error percentage. However, in this model the smallest MAPE obtained is 15.27%.

G. Discussion & Suggestions on the results of ESDM data research

From the results of experiments conducted by the author, it was found that the most accurate forecasting for nickel ore production data is the ARIMA forecasting method. The results obtained from nickel ore forecasts that there will be a decline after 2020. This is not a good thing for the government's plan to increase electric battery vehicles that use nickel.

Nickel is an important metal element in the battery cell components used for electric cars. For the manufacture of batteries, three main raw materials are needed, namely nickel, lithium and cobalt. For nickel, Indonesia controls 30 percent. Compared to some other countries. The decline in nickel production was due to the excavation that was exhausted in 2018 and 2019 resulting in production of 20,219,885/ton & 23,967,427/ton. Therefore, to stabilize nickel ore production, it is necessary to control nickel ore production targets so that production and demand for nickel are not unequal but should be statistically parallel.

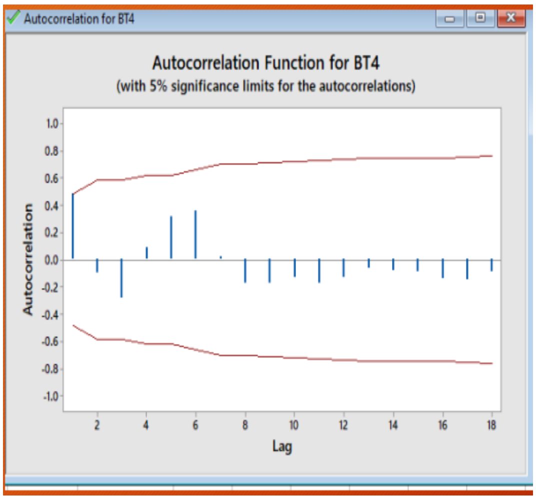

Fig. 6: Autocorrelation of Nickel Ore Production Data

The ARIMA model used is ARIMA p = 1, d = 4 and q = 0, in Figure 3.5 this is in accordance with the autocorrelation which gets 1 lag touching the significant limit line. This proves the value of P = 1, and d = 4 of the number of transformations from the nickel ore production data.

IV. SUGGESTIONS AND CONCLUSIONS

A. Conclusions

In this last chapter, the researcher presents the conclusions from the research findings.

1. Forecasting using the ARIMA time series method, get the error values (MAPE, MSE, MAD) as follows
MAD = 0.101526067
MSE = 0.022080773
MAPE = 3.940710675%

2. The Winter's method model with the smallest error percentage is α = 1, β = 1, γ = 1. With an error percentage value of 15.27%. Here are MAD, MSE and MAPE
MAD = 128546.3
MSE = 1.64E+11
MAPE = 15.27288

3. Analysis of Missing data for nickel ore production in 2015 and 2016 was 1,702,267/ton, representing the median result of nickel production data from 2001 to 2019.

B. Suggestions

The author's suggestion is to make observations on other variables that affect the rise and fall of nickel ore production.

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