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Indonesia's Export-Import Prediction: A Hybrid Moving Average Approach

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Abstract: Indonesia as one of the largest countries in Asia Pacific region plays a crucial role in international trading. Since both the import and export performance have become key variables in economic growth of a nation, the urgent to have a proper prediction and analysis of those variables has become a major issue. In this study, we try to address the issue by using a relatively new hybrid moving average approach, i.e. the WEMA (Weighted Exponential Moving Average) method. Using different parameters, it has been shown that WEMA approach could predict Indonesia's export-import future values. Based on MAPE (Mean Absolute Percentage Error) and MASE (Mean Absolute Scaled Error) values as forecast error measurement criteria, WEMA gives the best performance in predicting Indonesia's export weight in kg unit.

Key words: *economic growth, hybrid moving average, international trades, Indonesia's export-import, prediction*

INTRODUCTION

In this 'global' era, international trading between nations has become one of key economic variables. Therefore, forecasts of exports and imports of major trading countries and regional blocks become a central feature of providers in economic forecasts [1]. The International Monetary Fund (IMF) and Organisation for Economic Co-operation and Development (OECD) as two leading providers of macroeconomics and forecasts at international level also included the import and export performance as a key factor.

Indonesia as one of the largest countries in Asia Pacific region also plays an important role in international trades. It has many potential and eminent products that become export commodities. Ten eminent export commodities of Indonesia are Textile and its products, Electronics, Rubber and its products, Palm oil, Forest products, Footwear, Automotive, Shrimp, Cocoa, and Coffee [2]. The export value of Indonesia's commodities also has a rising trend. Based on January to October 2017 report, Indonesia's export value to seven main destination countries, i.e. Japan, South Korea, Taiwan, China, Singapore, USA, and Germany, has increased 17.62% than the same period of last year [3].

Although exports' impact on economic development is more than imports since it is more related to domestic activities [4], the urgent to have a proper prediction and analysis of both export and import has become a major issue. It can be clearly seen through the vast amount of research papers that mainly questioned the relationship between export, import, and economic growth of a nation. Darman, for example, has studied and analyzed the international trade relations in export and import of goods between Indonesia and USA [5]. Ustriaji [6] also conducted a research to investigate the growth, contribution, and competitiveness of excellent commodity exports from Indonesia to the international world. Cetintas and Barisik [7] have analyzed the relationships between export, import, and economic growth for the 13 transition economies. Moreover, Dasgupta [8] and Velnampy and Achchuthan [9] have conducted and answered the same research question related to specific countries, i.e. India and Sri Lanka.

In this study, we further developed the same question related to the export and import performance of a nation, especially Republic of Indonesia, using a relatively new hybrid moving average approach. The hybrid moving

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average method which is taken into consideration is the Weighted Exponential Moving Average (WEMA) method that had been introduced in 2013. Since its first appearance, WEMA has been widely used in time series analysis and forecasting as an alternative method, as we can see from the works of Chen et al. [10] and Hansun et al. [11-13].

Furthermore, the organization of this paper can be explained as follows. In the next section, WEMA as a time series approach and hybrid moving average method will be explained briefly. Its building block methods, i.e. Weighted Moving Average (WMA) and Exponential Moving Average (EMA), will be discussed after that. Following the methods explanation, Mean Absolute Percentage Error (MAPE) and Mean Absolute Scaled Error (MASE) as two unit-free forecast error measurement tools will be presented. The export and import prediction results then will be depicted and analyzed in the Results and Discussion section. Some concluding remarks and future suggestions will end the paper's presentation.

WEMA AS A TIME SERIES APPROACH

WEMA Method

WEMA is a relatively new hybrid forecasting method in Moving Average (MA) family that combines the weighting factors calculation in WMA with EMA procedures [14]. It has been proven to be a better forecasting technique than its building block methods which will be described later. Figure 1 shows a diagram of WEMA method to be implemented in this study.

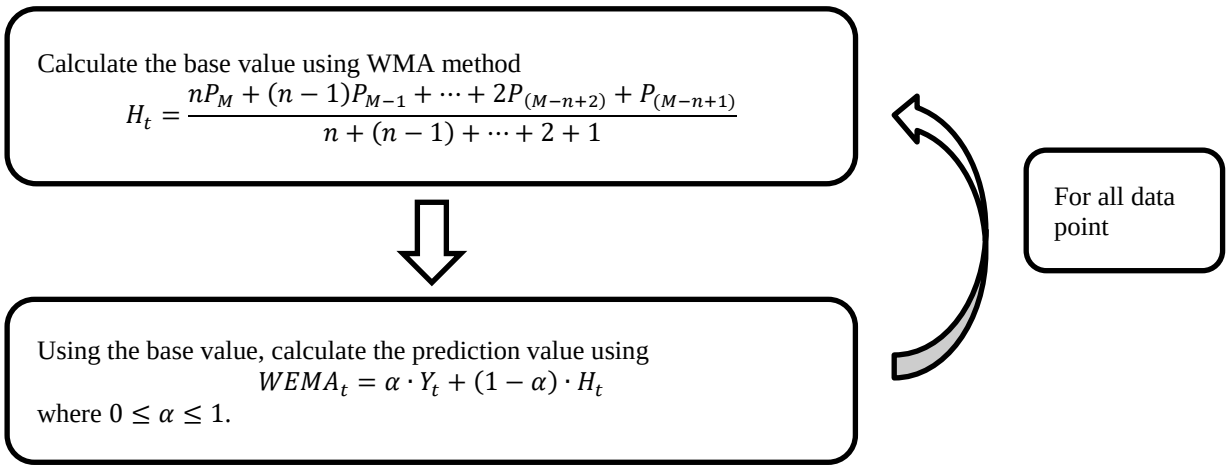

Fig 1 WEMA's procedures

WMA and EMA as Building Block Methods

WMA is a Simple Moving Average (SMA) with a constant weight decrement from the newest datum to the older one. Using our own notation from Zakamulin [15], WMA formulation can be written as

$$WMA_n = \frac{\sum_{t=k-n+1}^{k} w_t A_t}{\sum_{t=k-n+1}^{k} w_t} \quad (1)$$

where n is the span data, k is the relative position of the period currently being considered within the total number of periods, A_t is the actual value at time t, and w_t is the weight of data A_t.

EMA is a better and improved version of WMA, which is originated from Brown's work, who was assigned to develop a tracking model for fire-control information on the location of US Navy submarines [16]. EMA also puts a greater weight to more recent data, but in exponentially manner. As described in [17], EMA for time series Y can be calculated recursively using

$$S_1 = Y_1, \quad (2)$$

$$for\ t > 1, S_t = \alpha \cdot Y_t + (1-\alpha) \cdot S_{t-1} \quad (3)$$

where Y_t is the value at time period t, S_t is EMA value at time t, and α represents the constant smoothing factor from 0 and 1.

MAPE AND MASE

MAPE is the average of absolute error sum between the predicted and actual data divided by the actual data, and can be formulated as [18]

$$MAPE = \left(\frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|\right) \cdot 100\% \quad (4)$$

where n refers to the total number of data, A_t is the actual data, and F_t is the forecasted data. In MAPE, the accuracy is expressed in percentage.

MASE is another unit-free forecast error method that was first introduced by Hyndman and Koehler [19]. It scales error based on the in-sample Mean Absolute Error (MAE) from naïve forecasting method that can be expressed as [20]

$$MASE = mean\left(\left|\frac{A_t - F_t}{Q}\right|\right) \quad (5)$$

where A_t is the actual data, F_t is the forecasted data, and Q is a stable measure of the scale of the time series calculated on the training dataset, which can be found using [21]

$$Q = \frac{1}{n-1}\sum_{i=2}^{n}|A_i - A_{i-1}| \quad (6)$$

for non-seasonal time series data, and

$$Q = \frac{1}{n-m}\sum_{i=\mathrm{m}+1}^{n}|A_i - A_{i-\mathrm{m}}| \quad (7)$$

for seasonal time series data. Symbol $\boldsymbol{m}$ denotes the season length.

INDONESIA'S EXPORT-IMPORT DATA

To predict Indonesia's export and import performance, we take its export and import data from Badan Pusat Statistik (BPS) Indonesia [22]. BPS gives data in two different scales, i.e. the value in US $ and the weight in kg. Table 1 shows Indonesia's export-import data recorded from January 2015 to March 2018. These data will be used to predict future export-import value and weight using hybrid moving average approach.

TABLE I. INDONESIA'S EXPORT-IMPORT DATA GROUPED BY MONTH

Month	Export		Import	
	Value (US $)	Weight (KG)	Value (US $)	Weight (KG)
January 2015	13.244.876.797,53	43.443.195.035,04	12.612.648.838,00	11.995.411.291,00
February 2015	12.172.802.862,67	39.768.342.676,62	11.510.111.399,00	12.134.877.571,00
March 2015	13.634.041.965,14	48.209.231.343,05	12.608.691.718,00	12.815.242.585,00
April 2015	13.104.596.804,38	44.113.167.148,17	12.626.278.785,00	13.205.353.501,00
May 2015	12.754.659.043,69	41.543.644.059,26	11.613.585.485,00	11.452.923.855,00
June 2015	13.514.101.879,06	40.886.554.950,92	12.978.091.752,00	12.789.548.820,00
July 2015	11.465.779.764,41	40.908.711.754,63	10.081.863.504,00	9.777.959.395,00
August 2015	12.726.037.506,73	41.703.962.147,89	12.399.248.090,00	12.392.071.524,00
September 2015	12.588.359.370,70	41.130.727.933,85	11.558.601.330,00	12.517.106.390,00
October 2015	12.121.740.572,30	43.492.324.675,64	11.108.916.259,00	11.725.231.343,00
November 2015	11.122.182.554,29	41.572.222.679,35	11.519.468.515,00	12.396.999.154,00
December 2015	11.917.112.381,67	42.889.680.221,37	12.077.298.548,00	13.890.623.811,00
January 2016	10.581.883.837,98	39.593.480.160,23	10.466.995.371,00	11.170.356.250,00
February 2016	11.316.734.188,51	38.699.176.125,86	10.175.631.438,00	12.777.162.927,00
March 2016	11.812.127.477,93	43.029.049.633,14	11.301.709.941,00	14.280.888.506,00
April 2016	11.689.745.851,03	39.558.381.868,75	10.813.624.836,00	12.028.222.569,00
May 2016	11.517.409.125,88	40.622.406.240,97	11.140.679.613,00	13.132.879.687,00
June 2016	13.206.122.765,22	44.766.894.584,67	12.095.220.496,00	13.501.715.838,00
July 2016	9.649.503.975,97	39.032.046.988,71	9.017.159.102,00	10.138.881.648,00
August 2016	12.753.921.321,13	45.800.576.791,74	12.385.153.588,00	14.001.735.399,00
September 2016	12.579.750.249,95	44.146.271.670,66	11.297.511.237,00	12.809.168.012,00
October 2016	12.743.736.883,72	47.378.384.671,57	11.507.180.543,00	12.391.159.183,00
November 2016	13.502.920.382,69	46.606.206.087,96	12.669.434.720,00	12.804.703.935,00
December 2016	13.832.355.186,41	45.551.700.747,95	12.782.515.616,00	12.988.497.126,00
January 2017	13.397.676.587,81	43.565.989.974,33	11.973.765.825,00	11.677.887.405,00
February 2017	12.615.825.080,54	37.467.776.841,18	11.359.410.570,00	12.640.301.805,00
March 2017	14.718.477.686,89	47.776.913.741,86	13.283.186.576,00	13.474.016.869,00
April 2017	13.269.689.617,58	44.248.565.280,56	11.950.612.898,00	12.432.054.822,00
May 2017	14.333.859.523,55	44.049.700.226,86	13.772.553.263,00	14.996.662.995,00
June 2017	11.661.376.380,86	39.899.123.547,30	9.991.567.566,00	11.067.266.662,00
July 2017	13.611.062.499,27	45.104.086.462,25	13.889.809.439,00	13.474.009.387,00
August 2017	15.187.990.996,89	47.603.859.326,86	13.509.196.595,00	14.290.326.822,00
September 2017	14.580.216.111,80	48.289.451.395,64	12.788.291.967,00	13.017.265.351,00
October 2017	15.252.563.526,06	50.820.828.191,65	14.249.179.382,00	14.703.970.178,00
November 2017	15.334.735.600,61	47.905.955.325,27	15.113.523.078,00	14.557.794.980,00
December 2017	14.864.547.089,61	49.114.346.862,32	15.104.466.563,00	14.417.729.365,00
January 2018	14.553.404.792,01	48.201.600.004,83	15.309.429.258,00	13.227.092.240,00
February 2018	14.132.633.647,88	46.062.236.353,82	14.185.493.772,00	13.779.364.997,00
March 2018	15.586.866.516,52	52.335.443.378,38	14.463.601.047,00	12.979.524.178,00

RESULTS AND DISCUSSION

In this study, we tried to predict Indonesia's export and import performance by using historical data as shown in Table 1. To predict the future values, we used WEMA method as a hybrid moving average approach in time series forecasting. Different parameter values, especially for the span number, will be taken into consideration. Two forecast error measurement tools being used are MAPE and MASE criteria.

Moreover, in the earlier study [23], we have developed a web-based forecasting tool known as Phatsa. It stands for PHP Application for Time Series Analysis, and can be accessed freely on http://phatsa.com. Phatsa has accommodated three different conventional moving average techniques, i.e. Simple Moving Average (SMA), Weighted Moving Average (WMA), and Exponential Moving Average (EMA). During this study, we also implemented and integrated Weighted Exponential Moving Average (WEMA) as a hybrid moving average method in Phatsa. Then, it will be used as a forecasting tool in predicting Indonesia's export-import data.

The prediction results of Indonesia's export-import data will be divided into several parts as can be seen in following figures. Figure 2 depicts the forecasting results of Indonesia's export value in US $, while Figure 3 shows the forecasting results of Indonesia's export in weight unit. Figure 4 shows the forecasting results of Indonesia's import value in US $, and Figure 5 depicts the forecasting results of Indonesia's import in weight unit. All the results shown here are the scenario results for parameters where span number is 3, start index is 3, and prediction period is 1.

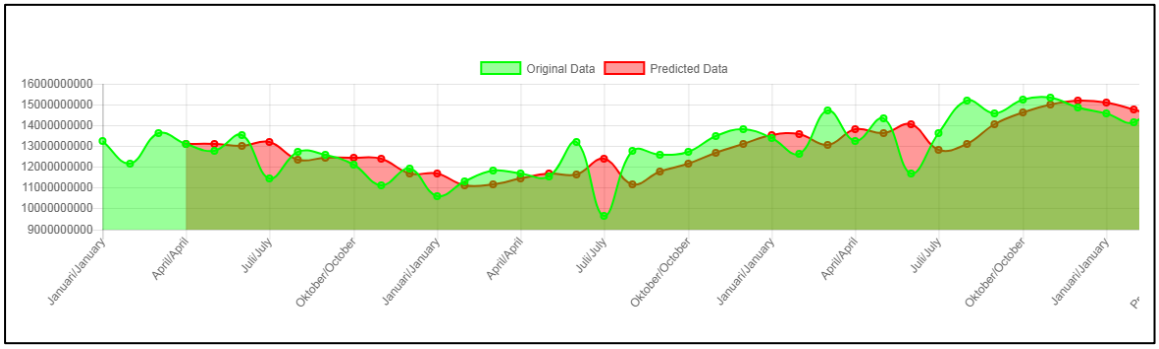

Fig 2 Indonesia's export in US $

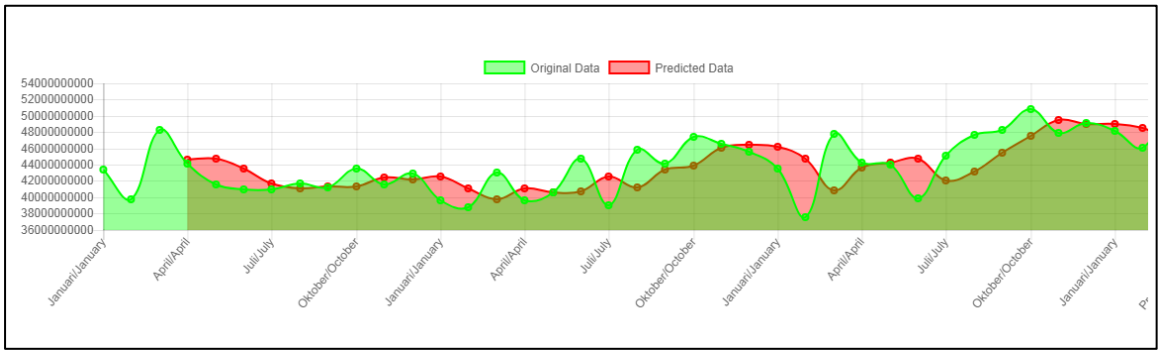

Fig 3 Indonesia's export in weight unit

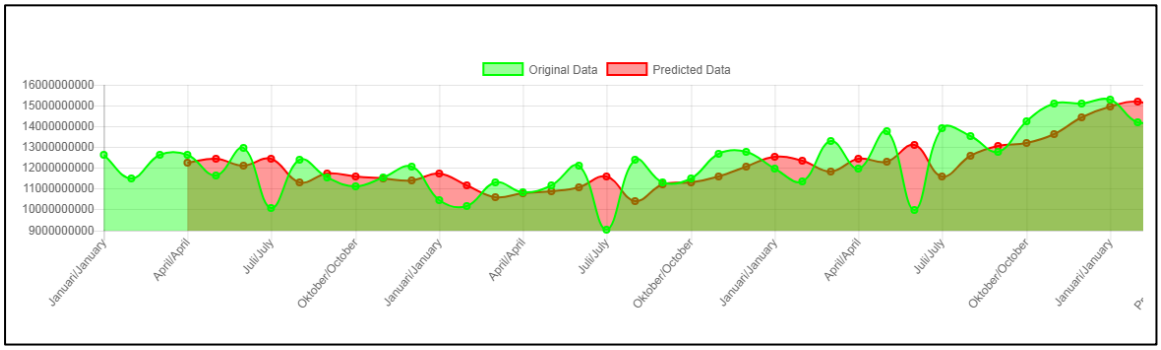

Fig 4 Indonesia's import in US $

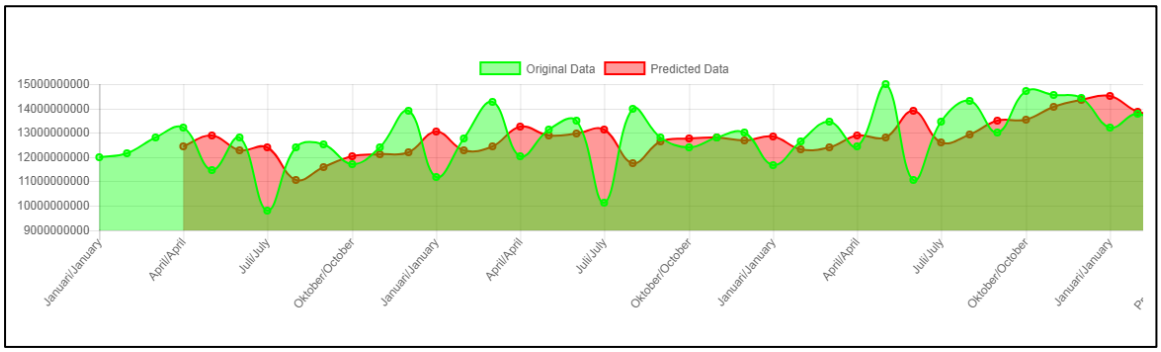

Fig 5 Indonesia's import in weight unit

The graphs have depicted the prediction results for Indonesia's export and import values in US $ and weight units, and give us an initial understanding of the prediction performance. Furthermore, we used MAPE and MASE criteria to get the forecast error measurement for all the scenarios taken. We used different values for forecasting parameters, i.e. the span number and the start index, started from 2 to 12. The prediction period will be set to 1, which means that we will just forecast one step ahead.

Table 2 shows the MAPE and MASE values for Indonesia's export data prediction using WEMA approach, while the prediction error values for Indonesia's import data is shown in Table 3.

TABLE II. INDONESIA'S EXPORT ERROR RESULTS

WEMA parameters	**Export Value (US $)**		**Export Weight (kg)**	
	MAPE	**MASE**	**MAPE**	**MASE**
span=2, start=2	6.86461	0.806631	5.819393	0.699131
span=3, start=3	**6.507963**	**0.64705**	5.444389	**0.39375**
span=4, start=4	6.520325	0.807983	5.551444	0.450357
span=5, start=5	6.628838	0.985657	5.405014	0.505355
span=6, start=6	6.773995	1.028225	**5.401015**	0.611888
span=7, start=7	6.54835	0.80517	5.497724	0.748341
span=8, start=8	6.746013	0.802394	5.719806	0.873319
span=9, start=9	6.959836	0.928563	5.885778	0.999385
span=10, start=10	7.09549	1.004462	5.982194	1.027208
span=11, start=11	6.987512	0.984608	6.117694	1.079457
span=12, start=12	7.245884	1.032555	6.25473	1.154421
Average	6.807165	0.893936	**5.734471**	**0.776601**

TABLE III. INDONESIA'S IMPORT ERROR RESULTS

WEMA parameters	**Import Value (US $)**		**Import Weight (kg)**	
	MAPE	**MASE**	**MAPE**	**MASE**
span=2, start=2	8.610572	0.920877	9.534107	8.456282
span=3, start=3	8.065388	0.865397	8.286319	2.493844
span=4, start=4	8.102861	1.299089	8.177443	2.502791

span=5, start=5	8.055452	1.188011	7.962693	1.334172
span=6, start=6	8.018358	1.040657	7.841472	1.134464
span=7, start=7	**7.540785**	0.73304	7.14548	0.749398
span=8, start=8	7.713197	**0.666705**	7.161624	**0.647076**
span=9, start=9	7.883142	0.717899	7.120864	0.727803
span=10, start=10	8.011406	0.790728	7.258064	0.775697
span=11, start=11	8.320209	0.882032	7.359684	0.824803
span=12, start=12	8.547888	0.952831	**7.096757**	0.771792
Average	8.079023	0.914297	7.722228	1.856193

From Table 2, we could infer that the best scenario to predict Indonesia's export future values is by using span number and start index equals to 3 since it gave the smallest MAPE and MASE forecast error values among other scenarios. However, for Indonesia's import values, it seems that there is no preference scenario since the smallest MAPE and MASE values are scattered in different parameter values.

Among all the dataset studied in this research, i.e. the export value in US $, export weight in kg, import value in US $, and import weight in kg, it's found that WEMA approach could best predict the export weight in kg, since it gave the smallest MAPE average value at 5.734471% and smallest MASE average value at 0.776601.

CONCLUSION

The main focus of this study is to predict Indonesia's export-import data using hybrid moving average approach, in this case, the WEMA method. As has been shown, we have successfully predicted the export and import data using WEMA method which was integrated into Phatsa framework. Using different WEMA parameter values, it has been shown that WEMA could give forecasting results with different forecasting error values. Based on the MAPE and MASE criteria, prediction on Indonesia's export weight in kg unit using WEMA approach gives the best result. Moreover, the preference parameters for export data prediction are known to be 3 for the span number and start index, while for import data prediction there is no preference at all.

In the future study, other variants of WEMA method, such as B-WEMA (Brown's Weighted Exponential Moving Average) and H-WEMA (Holt's Weighted Exponential Moving Average) could be integrated into Phatsa framework and be used to forecast Indonesia's export-import data as a comparison with this study. Another study to combine different zero-lag moving average approach (for example Hull Moving Average) can also be taken to develop a new hybrid variant of moving average methods.

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