

# Analysis Of Nonlinear Models For The Acceleration Of Increasing HDI In Asia

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**Abstract:** Exponential is a non-linear function. We do numerical calculations to find exponential non-linear functions in the acceleration of increasing HDI data in Asia. We have used HDI data from 2005-2017 from 30 countries which are divided into three categories namely developed countries, developing countries and underdeveloped countries. From these data we determine the average of each category then forecast for the next period using the double exponential type Holt method. Based on the simulation results using the GUI of MATLAB, we get information is obtained that HDI developed countries have an average of 0.86257 with a mathematical model  $y = 0.8027e^{0.0052x}$ ; developing countries have an average of 0.71588 with a mathematical model  $y = 0.6505e^{0.0069x}$ ; and underdeveloped countries an average of 0.60344 with a mathematical model  $y = 0.4986e^{0.0137x}$ . So, the highest increase is in the underdeveloped category, which is 3,020. On the other hand, the GUI of MATLAB provides simulation techniques and a fairly accurate numerical solution.

**Index Terms:** Numerical Solution, HDI, Holt Method, Forecasting.

## 1 INTRODUCTION

The numerical method is one approach that is done if analytically does not produce a good solution. Numerical methods are generally used in complex and non-linear cases. Where the roots of an equation or evaluation of functions at a certain point cannot be done manually or substitution. So an approach method is needed by considering a relatively small error rate. One of the numerical functions is exponential. The exponential function is widely used as an illustration of a fact in the field that describes the relative increase or decrease in data and no extreme points that are too striking are found. Therefore, exponential methods are widely used in time series data forecasting processes, such as population growth, poverty, the human development index (HDI), and various other fields. Forecasting is an activity carried out to estimate data or events in the future by looking at existing data patterns. The more data involved or used to build a mathematical model, the better the model will be produced with a high degree of accuracy. The purpose of forecasting is to determine the policies that must be taken after seeing the results of the predictions. In the past few years, the exponential method has been able to represent a mathematical model of many cases whose data characteristics are relatively constantly increasing. One of the most frequently used exponential methods is the Holt method. This method is a second level method of the exponential method, so it is often referred to as double exponential.

This is because the Holt method uses two amplifier parameters to anticipate if there is extreme data in modeling that makes the data abnormal.

## 2 METHODS

This research is development research methods. The results of data analysis using the double exponential type Holt method. The HDI data that we use consists of 11 developed countries, 11 developing countries, and 8 underdeveloped countries. The developed countries consist of Saudi Arabia, Japan, South Korea, Israel, Bahrain, Qatar, China, Hong Kong, Kuwait, Brunei Darussalam and Malaysia. Developing countries consist of the Philippines, Vietnam, Iraq, Indonesia, Lebanon, Thailand, Iran, India, Armenia, Palestine and Kyrgyzstan. While the least developed countries are Afghanistan, Myanmar, Papua New Guinea, Bangladesh, Tajikistan, Laos, Cambodia and Timor Leste. Data for each category is determined by the average HDI, then tabulated in Ms. Excell and then loaded into the GUI for forecasting. The HDI data average for each category is as follows.

**TABLE 1**  
HDI AVERAGE EVERY CATEGORY

Year	Developed	Developing	Underdeveloped
2005	0.80573	0.64991	0.49412
2006	0.81055	0.65809	0.50638
2007	0.81627	0.66536	0.52075
2008	0.82073	0.66982	0.52988
2009	0.82209	0.67527	0.53825
2010	0.82727	0.67909	0.54925
2011	0.83282	0.68464	0.55775
2012	0.83800	0.69064	0.56138
2013	0.84264	0.69355	0.56925
2014	0.84682	0.69718	0.57263
2015	0.85109	0.70127	0.57925
2016	0.77827	0.70518	0.58250
2017	0.85582	0.70836	0.58575

Whereas to determine the accuracy of forecasting, we use the parameters MSE, MAD, and MAPE with X as actual data and Y as predictive data:

a. Mean Square Error (MSE).

$$MSE = \sum_{i=1}^n \frac{(X_i - Y_i)^2}{n} \quad (1)$$

b. Mean Absolute Deviation (MAD)

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$$MAD = \sum_{t=1}^n \left| \frac{(X_t - Y_t)}{n} \right| \tag{2}$$

c. Mean Absolute Percentage Error (MAPE)

$$MAPE = \sum_{t=1}^n \left| \frac{PE}{n} \right|, PE = \frac{X_t - Y_t}{X_t} \times 100 \% \tag{3}$$

So, the steps taken in this research are as follows:

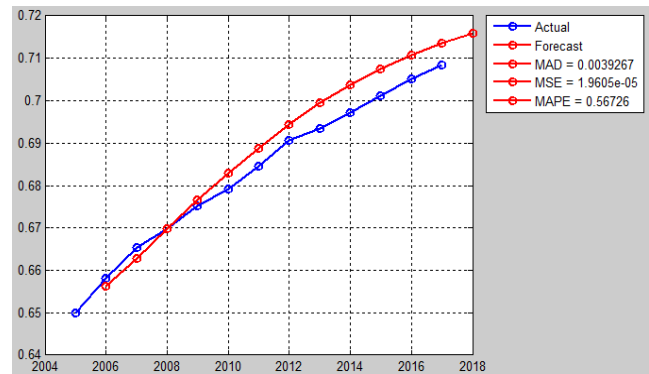
- a. Gathering HDI data of countries in Asia and grouping them into three categories namely developed countries, developing countries, and underdeveloped countries.
- b. Determine the average HDI data for each category.
- c. Build the Holt GUI method.
- d. Simulation HDI data to determine the predicted results in 2018, based on input data from 2005-2017.
- e. Tabulate prediction data consisting of 2018, MAD, MSE, and MAPE prediction data for each category during simulation.
- f. Determine the mathematical model and the size of the HDI increase in each category.
- g. Make interpretations and conclusions.

### 3 RESULT

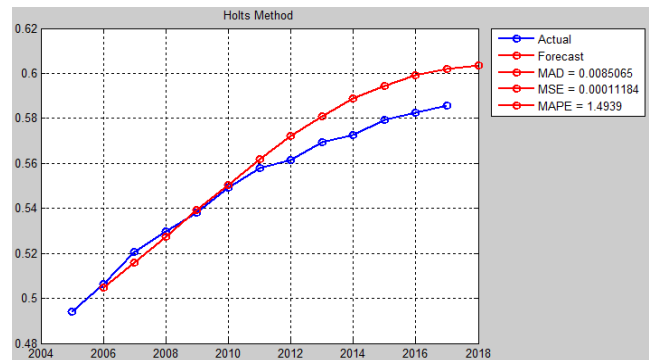
Based on the simulation results of the data using the GUI of MATLAB, accuracy is obtained according to Table 2 and the graph of the actual and predicted data according to Figure 1, Figure 2, and Figure 3 below.

**TABLE 2**  
LEVEL OF ACCURACY

No	Category	Accuracy Parameter		
		MAD	MSE	MAPE
1	Developed countries	0,0019	0,00006	0,2273
2	Developing countries	0,0039	0,00019	0,5672
3	Underdeveloped countries	0,0085	0,0001	1,4939



**Fig. 2** Developing Countries Predictions Chart



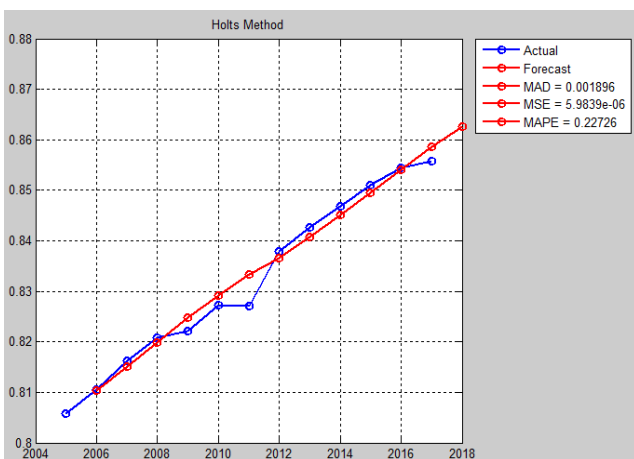
**Fig. 3** Underdeveloped Countries Predictions Chart

Based on the output of tables and graphs from the GUI of MATLAB that have been developed, the prediction results are obtained according to Table 3 below.

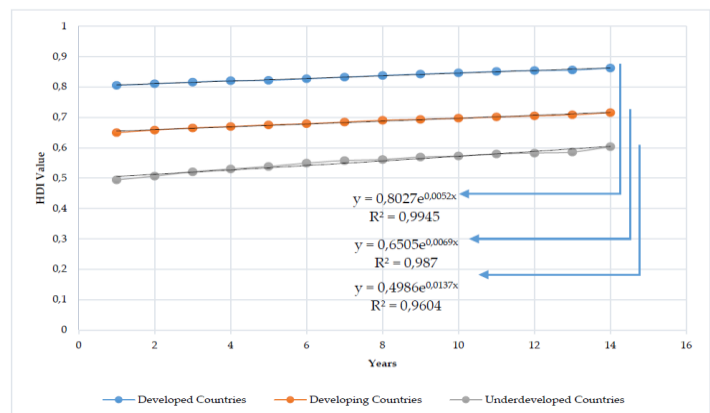
**TABLE 3**  
PREDICTION RESULTS

No	Category	Prediction	Enhancement
1	Developed countries	0,86257	0,789
2	Developing countries	0,71588	1,061
3	Underdeveloped countries	0,60344	3,020

The mathematical models and graphs of prediction results are according to Figure 4 below.



**Fig. 1** Developed Countries Prediction Chart



**Fig. 4** HDI Asia Graphs and Models

Based on Figure 4 above, it can be seen that the mathematical model for developed countries is  $y = 0.8027e^{0.0052x}$  so that for  $x = 14$  (prediction in 2018) we get the HDI value is 0.86257. Then the mathematical model for developing countries is  $y = 0.6505e^{0.0069x}$ , so that for  $x = 14$ , we get the HDI value is 0.71588. Whereas for underdeveloped countries, the mathematical model  $y = 0.4986e^{0.0137x}$ , so that for  $x = 14$ , the HDI value is 0.60344. Based on the results of this prediction, the increase in HDI value from 2017 to 2018 for developed countries are 0.789, for developing countries are 1.061, while for underdeveloped countries are 3,020.

#### 4 CONCLUSION

Based on the results of data analysis, the prediction results for 2018 for developed countries are 0.86257 with an increase of 0.789; for developing countries is 0.71588 with an increase of 1.061; and for underdeveloped countries is 0.60344 with an increase of 3.020. So, from the three prediction results, it can be seen that a very high increase is seen in the human development index of underdeveloped countries.

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