

# Predicting the Future Minimum Wage in Indonesia Using Historical Data and Purchase Power Parity Equivalency <sup>1</sup>

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## ABSTRACT

This study focuses on predicting the future of Indonesia's minimum wage using two different types of methods. The first type of approach uses past values over a certain period, and the second uses the equivalency with the price of certain goods' historical data. This analysis's feasible methods are MS Excel's "Best Fit" regression analysis curve, Monte Carlo simulation using MS Excel, and the use of other good's price as an equivalency index (Gold and Burger Big Mac). The MS Excel "Best Fit Regression" shows the best performance due to 5.32 IDR Million/Month in 2022. Base on this study, three significant factors support this MS Excel "Best Fit Regression" as the best prediction method: The method using the past data itself, no analogies data or borrowing other item data, the similarity of the characteristic data between the projection item and baseline data, and various alternatives according to trend line solution.

**Keywords:** Indonesia Minimum Wage, Labor, Monte Carlo, Big Mac, Gold, MS Excel

## INTRODUCTION

### 1. 1. The Indonesia Minimum Wage

"The regulation of minimum wage in Indonesia was set in the Regulation of the Minister of Manpower No. 15/2018 on Minimum Wage"<sup>2</sup>. The minimum wage shall be the lowest wage consisting of the standard salary or the basic salary and the Governors' fixed allowance as a safety net. The minimum wages of each region are issued and updated annually by Governors<sup>3</sup>.

Wages are determined annually through a long process. At first, the Regional Wage Council (DPD) consisted of bureaucrats, academics, laborers, and entrepreneurs. They held a meeting, formed a survey team, and went to the field to determine the price of a number of needs needed

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<sup>2</sup> Menteri Ketenagakerjaan Republik Indonesia. (n.d.). Peraturan Menteri Ketenagakerjaan Republik Indonesia Nomor 15 Tahun 2018. JDIH Kemnaker. [https://jdih.kemnaker.go.id/data\\_puu/Permen\\_15\\_2018.pdf](https://jdih.kemnaker.go.id/data_puu/Permen_15_2018.pdf)

<sup>2</sup> Vivie Kartika Ayu. (n.d.). Proses Perumusan Kebijakan Upah Minimum Kota Semarang. Neliti.

<https://media.neliti.com/media/publications/183009-ID-proses-perumusankebijakan-upah-minimum-k.pdf>

<sup>3</sup> Construction Labor Market Analyzer. (n.d.). CLMA® Project Labor Cost Allocation. Construction Skilled Labor Risk Analytics | CLMA®. <https://myclma.com/wp-content/uploads/2015/02/CLMA-Allocation-of-Project-Cost-2014Oct27.pdf>

by employees laborers<sup>2</sup>. The decent living needs component is used as the basis for determining the minimum wage based on a single (unmarried) worker's living needs.

In Indonesia, the minimum wage is the foundation for the formulation of labor costs. The minimum wage standard will affect the labor cost. According to the Construction Labor Market Analyzer, the percentage of construction labor costs should be 20 to 40% of total cost<sup>3</sup>.

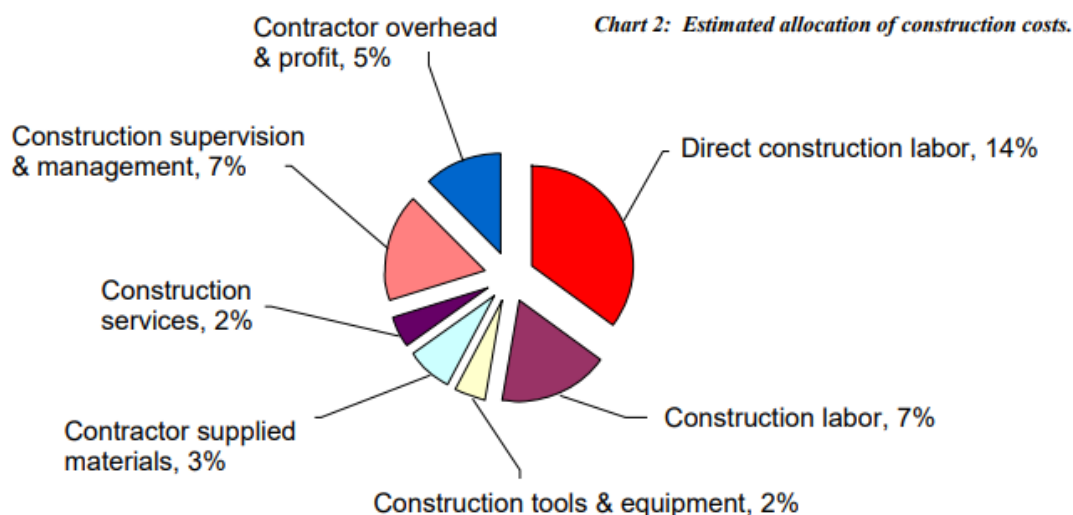


Figure 1. Estimated Allocation of Construction Cost<sup>3</sup>.

This study aimed to predict Indonesia's minimum wage as it is a significant part of Indonesia's labor cost structure for any projects. The ability to indicate one of the substantial components of a project can minimize the possibility of underestimation and overestimation in a project.

## 1. 2. The Clusters of Method for Predicting Indonesia's Minimum Wage

This study focuses on predicting the future minimum wage using two different types of methods. The first type of method utilizes the past values in a certain period to determine the value of a point in the future. According to Stephen J. C. Paterson<sup>4</sup>, there are eight common cost forecasting methods that use past values as the data. Two of the feasible techniques in this study are MS Excel's "Best Fit" regression analysis curve and Monte Carlo simulation using MS Excel. Those two methods are categorized in the first cluster of methods, which projects the value of a variable by employing the past variable's values.

On the other hand, the second category of the method develops prediction using the equivalency with the price of certain goods' historical data. This equivalency makes use of the theory of Purchase Power Parity (PPP). PPP is a principle that states that exchange rates between

<sup>4</sup>Stephen J.C Paterson. (2018, January). A Comparison Between 8 Common Cost Forecasting Methods. PM World Journal. <https://pmworldlibrary.net/wp-content/uploads/2018/01/pmwj66-Jan2018-Paterson-comparison-of-8-common-forecasting-methods-featured-paper.pdf>

currencies are in balance when their buying power is the same in both countries<sup>5</sup>. The focus of PPP is the "law of one price." In the absence of transport and other transaction costs, fair markets would equalize the same product price in two countries where prices are expressed in the same currency<sup>5</sup>.

Based on the study of Hari Kumar Sellappan<sup>6</sup> which explored gold's PPP for future cost estimation and the analysis of The Economist<sup>7</sup> which invented The Big Mac Index, which underlies PPP, in this study, historical data of gold's and Big Mac's price are used as equivalency indexes to forecast Indonesia's minimum wage in the future. The clustering of the prediction methods was mapped in Table 2.

Table 1. The Clustered Prediction Methods of Indonesia's Minimum Wage<sup>8</sup>

Using the Historical Data of Indonesia's Minimum Wage	Using the Historical Data of Basket of Other Goods' Price in Indonesia (PPP)
MS Excel's "Best Fit" Regression Analysis Curve	Gold's Price Equivalency
Monte Carlo Simulation Using MS Excel	Big Mac's Price Equivalency

<sup>5</sup>Purchasing power parity. (n.d.). PACIFIC Exchange Rate Service. <https://fx.sauder.ubc.ca/PPP.html>

<sup>6</sup> Hari Kumar Sellappan. (2012, November). Exploring Gold as Alternative Currency for Future Cost Estimation in Telecommunication Projects. PM World Journal. <https://pmworldlibrary.net/wp-content/uploads/2013/01/PMWJ4-Nov2012-SELLAPPAN-Gold-AlternativeCurrencyForProjectEstimation-Featured-Paper.pdf>

<sup>7</sup>The big Mac index. (2020, July 15). The Economist. <https://www.economist.com/news/2020/07/15/the-big-mac-index>

<sup>8</sup>By Author

### 1. 3. Prediction Using the Historical Data of Indonesia's Minimum Wage

In this cluster of the method, the prediction was developed by gathering Indonesia's minimum wage historical data in the past years, as illustrated in Figure 2, and projecting the future value.

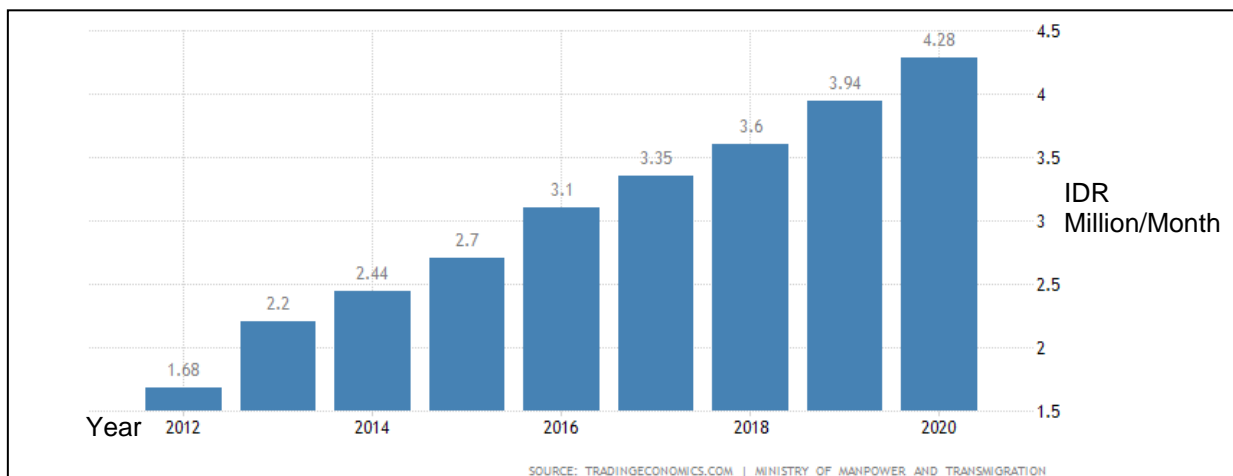


Figure 2. The Data of Indonesia's Minimum Wage<sup>9</sup>.

The projection of the future value by using historical data can be executed by applying several tools. Two tools that will be involved in this study are elaborated as below:

#### a. MS Excel's "Best Fit" Regression Analysis Curve

Regression analysis is a group of statistical techniques used to approximate the relationships between a dependent variable<sup>4</sup> and one or more independent variables<sup>10</sup>. By utilizing Indonesia's minimum wage historical data among the past years, MS Excel is used to establish a trend regression curve as a model to predict the future minimum wage.

#### b. Monte Carlo Simulation Using MS Excel

The Monte Carlo simulation conducts a risk analysis by constructing models of potential outcomes by substituting a set of values—a probability distribution—for any factor with inherent uncertainty<sup>11</sup>. It then measures outcomes repeatedly, each time using a different

<sup>9</sup> Indonesia minimum monthly wages | 2012-2020 data | 2021-2022 forecast | Historical. (n.d.). TRADING ECONOMICS | 20 million INDICATORS FROM 196 COUNTRIES.

<https://tradingeconomics.com/indonesia/minimum-wages>

<sup>4</sup> Stephen J.C Paterson. (2018, January). A Comparison Between 8 Common Cost Forecasting Methods. PM World Journal. <https://pmworldlibrary.net/wp-content/uploads/2018/01/pmwj66-Jan2018-Paterson-comparison-of-8-common-forecasting-methods-featured-paper.pdf>

<sup>10</sup> Corporate Finance Institute. (2020, February 24). Regression analysis - Formulas, explanation, examples and definitions. <https://corporatefinanceinstitute.com/resources/knowledge/finance/regression-analysis/>

<sup>11</sup> Palisade. (n.d.). What is Monte Carlo simulation? Monte Carlo Simulation: What Is It and How Does It Work? - Palisade.

[https://palisade.com/risk/monte\\_carlo\\_simulation.asp](https://palisade.com/risk/monte_carlo_simulation.asp)

set of random values from the probability function. By modeling using the probability function, Monte Carlo will show the amount of future minimum wage and its level of confidence.

As a pure statistic method developed by historical data of the predicted variable, this prediction method is very dependent on the period and the number of data. A more extended period results in more data. More data means better prediction results. Furthermore, any data fluctuation may also affect the outcome.

#### **1. 4. Prediction Using the Historical Data of Basket of Other Goods' Price for Equivalency (PPP)**

While the previous cluster of methods predicts Indonesia's future minimum wage using the predicted variable's historical values, this method uses other good's prices as equivalency index (PPP)<sup>12</sup>.

The equivalency uses a good's price instead of currency, such as the US dollar, which may be widely accepted and utilized yet requires further evaluation to be used as a basis for forecasting cost<sup>13</sup>. According to Trian Hendro Asmoro<sup>14</sup>, using US Dollar in terms of purchasing power is not applicable in the last decade as price instability and quantitative decisions of central governments have contributed to significant swings in the US dollar value.

In this method, there are two alternatives to good's price, which were measured for Purchasing Power Parity (PPP) as explained below:

##### **a. Gold's Price**

Gold has traditionally been one asset that people go to for safety<sup>15</sup>. It is considered a safe haven because it has served as a store of value, retaining its buying power for thousands of years. The reality is that the value of gold remains constant over the long term, while the values of most other things depreciate. This study will establish the gold price model as the equivalency of predicting the future minimum wage.

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<sup>12</sup> Purchasing power parity. (n.d.). PACIFIC Exchange Rate Service.  
[https://fx.sauder.ubc.ca/PPP.html#:~:text=Purchasing%20power%20parity%20\(PPP\)%20is,each%20of%20the%20t wo%20countries](https://fx.sauder.ubc.ca/PPP.html#:~:text=Purchasing%20power%20parity%20(PPP)%20is,each%20of%20the%20t wo%20countries)

<sup>13</sup> Carbaugh, R. & Hendrick, D. (2009). Will the Dollar be Dethroned as the Main Reserve Currency?. Global Economy Journal. Vol 9, Issue 3, Article 1. The Berkeley Electronic Press

<sup>14</sup> Trian Hendro Asmoro. (2013, March). Exploring Gold Equivalency for Forecasting Steel Prices on Pipeline Projects. PM World Journal. <https://pmworldlibrary.net/wp-content/uploads/2013/05/pmworldjournal-may2013-asmoro-gold-equivalency-for-forecasting-steel-prices-FeaturedPaper.pdf>

<sup>15</sup> (n.d.). Fox Business | Business News & Stock Quotes - Saving & Investing. <https://www.foxbusiness.com/markets/why-is-gold-a-safe-haven>

## b. Big Mac's Price

"Sold in 120 countries around the world, the Big Mac is a generic package of products" <sup>16</sup>. "The Big Mac Index was introduced in The Economist in September 1986 by Pam Woodall as a semi-humorous example of PPP and has been published annually" <sup>17</sup>. This study will build the model of Big Mac's price in Indonesia as the second equivalency of predicting future minimum wage

## 1. 5. Problem Statement

In this paper, the author demonstrates the evaluation of Indonesia's minimum wage prediction methods, which are clustered into two main approaches, both in the process and the result. This study should find the answers to the questions below:

- Prediction of Indonesia's minimum wages in the future using its historical data
- Prediction of Indonesia's minimum wages using other goods' prices as equivalency index (PPP)

Comparison between two alternative clusters of Indonesia's minimum wages prediction method

## METHODOLOGY-

### 2.1 Method by Historical Data of Indonesia's Minimum Wage

Historical Data of Indonesia's Minimum Wage is gathered from the year 2012 to the year 2020. The characteristic of the data for each year is a single value, and it means the Indonesia Minimum Wage that Year applies for the whole day of the year<sup>9</sup>. Based on the above, we get 8 data each for eight years of data each year. In general, there are no fluctuations or changes in Indonesia's Minimum Wage in the current year or during periods under one year.

The Minimum Wage in Indonesia is published by each local government, which applies to a certain area<sup>18</sup>. The author uses Indonesia's Minimum Wage data from the Jakarta area to represent the overall Indonesia Minimum Wage.

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<sup>16</sup> Michael R. Pakko, & Patricia S. Pollard. (2003, November). Burgernomics: A Big Mac™ Guide to Purchasing Power Parity. FEDERAL RESERVE BANK OF ST. LOUIS.  
<https://files.stlouisfed.org/files/htdocs/publications/review/03/11/pakko.pdf>

<sup>17</sup> Big Mac index. (n.d.). Tree of Knowledge Wiki. Retrieved November 20, 2020, from  
[https://tok.fandom.com/wiki/Big\\_Mac\\_Index](https://tok.fandom.com/wiki/Big_Mac_Index)

<sup>9</sup>Indonesia minimum monthly wages | 2012-2020 data | 2021-2022 forecast | Historical. (n.d.). TRADING ECONOMICS | 20 million INDICATORS FROM 196 COUNTRIES.  
<https://tradingeconomics.com/indonesia/minimum-wages>

<sup>18</sup>Indonesia Investments. (2018, 17). What are Indonesia's minimum wages by province in 2019? Investing in Indonesia | Indonesia Investments. <https://www.indonesia-investments.com/id/news/todays-headlines/what-are-indonesia-s-minimum-wages-by-province-in-2019/item9012>



### 2.1.1 Microsoft Excel "Best Fit" Regression Curve

Using past data from Indonesia's minimum wage for the past eight years<sup>9</sup>, each year's data is entered on a graph in Microsoft Excel. The x-axis is the time (year), and the y-axis is Indonesia's Minimum Wage value for that year.

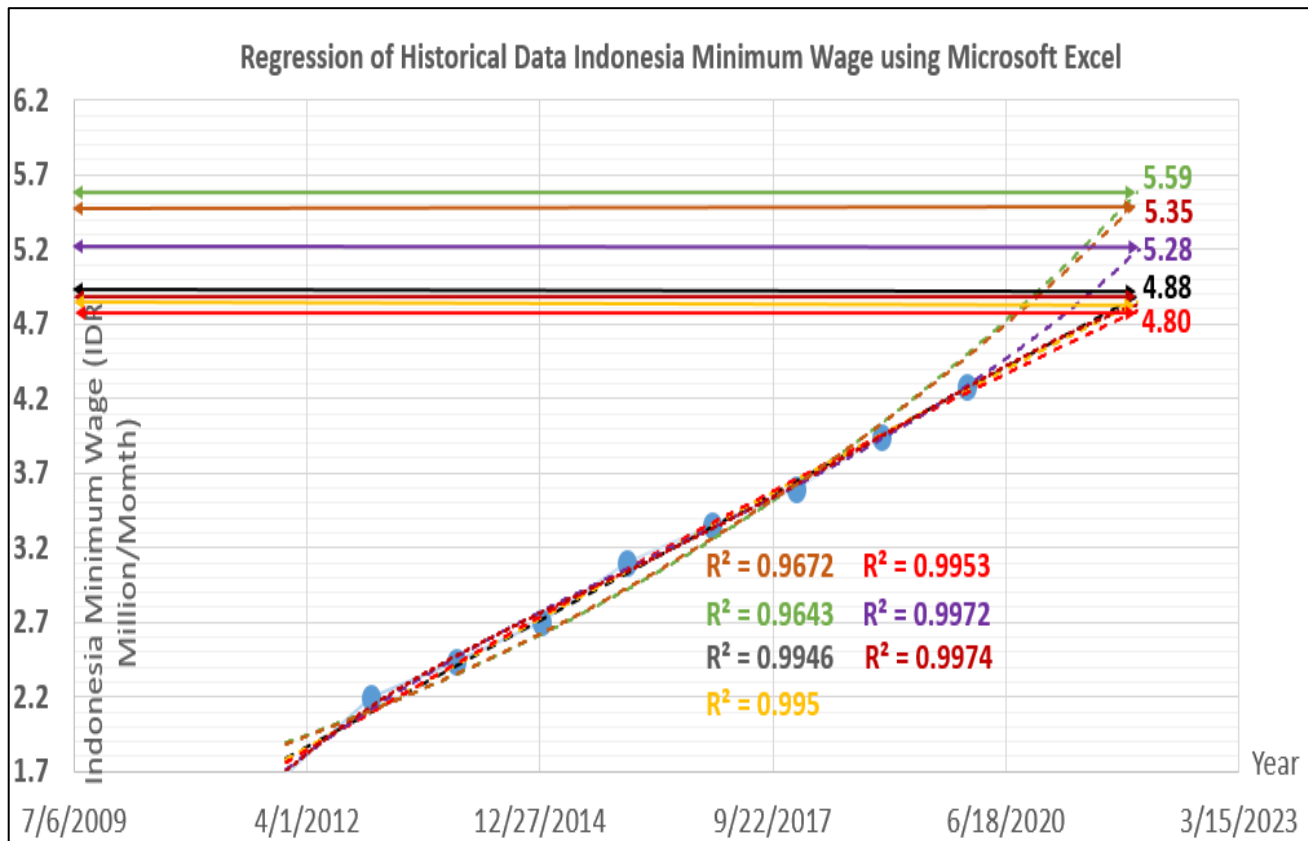


Figure 4. Regression Result of Historical Data by Using Microsoft Excel<sup>19</sup>

Based on Figure 4, the blue dotted is the value of the Indonesia Minimum Wage at that year. Using the data, we develop the trend line and line equation utilizing Microsoft Excel Software. The Trendline is shown by a dashed line that lengthens or projected (forward) up to 740 points (equal with 740 days) toward the target of prediction in 2022. The color of the line equation and R squared, shown in figure 4, corresponds with the same color trendline.

To develop multiple options solutions and minimize the process of eliminating solutions too early, we use all feature trend lines created by Microsoft Excel. There are several types of line equation generated by the software:

<sup>9</sup>Indonesia minimum monthly wages | 2012-2020 data | 2021-2022 forecast | Historical. (n.d.). TRADING ECONOMICS | 20 million INDICATORS FROM 196 COUNTRIES.  
<https://tradingeconomics.com/indonesia/minimum-wages>

<sup>19</sup>By Author



Table 2. Type of Trend Line regression, Line Equation, and R Squared Value<sup>20</sup>

No	Type of Trendline	Line Equation	R squared value
1	Linear	$y = 0.0008x - 32.912$	$R^2 = 0.9946$
2	Polynomial Orde 2	$y = -3E-08x^2 + 0.0031x - 80.954$	$R^2 = 0.9953$
3	Polynomial Orde 3	$y = 6E-11x^3 - 7E-06x^2 + 0.3092x - 4401.9$	$R^2 = 0.9972$
4	Polynomial Orde 4	$y = -3E-14x^4 + 5E-09x^3 - 0.0003x^2 + 8.6193x - 92373$	$R^2 = 0.9974$
5	Exponential	$y = 1E-05e^{0.0003x}$	$R^2 = 0.9643$
6	Power	$y = 3E-58x^{12.549}$	$R^2 = 0.9672$
7	Logarithmic	$y = 35.939\ln(x) - 379.86$	$R^2 = 0.995$

There are seven Trendlines generated by Microsoft Excel, which can be projected for prediction of Indonesia's Minimum Wage at the year 2022. To get the "best fit" trendline, we use PERT analysis to get the P90 value estimation<sup>21</sup>.

Table 3. Value at the Year 2022 Using Projected Trend line and Rank for PERT Exercise<sup>22</sup>

Value at Year 2022 (Projected) - IDR Million	Rank	for PERT Exercise
4.80	Low	4.80
4.82	Most Likely	5.02
4.85		
4.88		
5.21		
5.35	High	5.59
5.59		

Base on the result of the projected value at the year 2022 by each Trendline, we get the result for Low = 4.8 IDR Million/Month, Most Likely = 4.92 IDR Million/Month (Average of the value except for the highest value and lowest value) and High = 5.59 IDR Million/Month. Therefore, the calculation of the result based on PERT formulas are:

- Mean =  $(4.80 + (4 \times 5.02) + 5.59) / 6 = 5.07$
- Standard Deviation  $(5.59 - 4.80) / 6 = 0.13$

<sup>20</sup>By Author

<sup>21</sup>Use PERT technique for more accurate estimates. (2007, June 25). TechRepublic.

<https://www.techrepublic.com/blog/it-consultant/use-pert-technique-for-more-accurate-estimates/>

<sup>22</sup>By Author

- Variance = 0.01

In correspondence with the PERT formula, using a normal distribution curve to determine P50, P75, P85, and P90 for evaluation, the estimate aligns with risk and contingency.

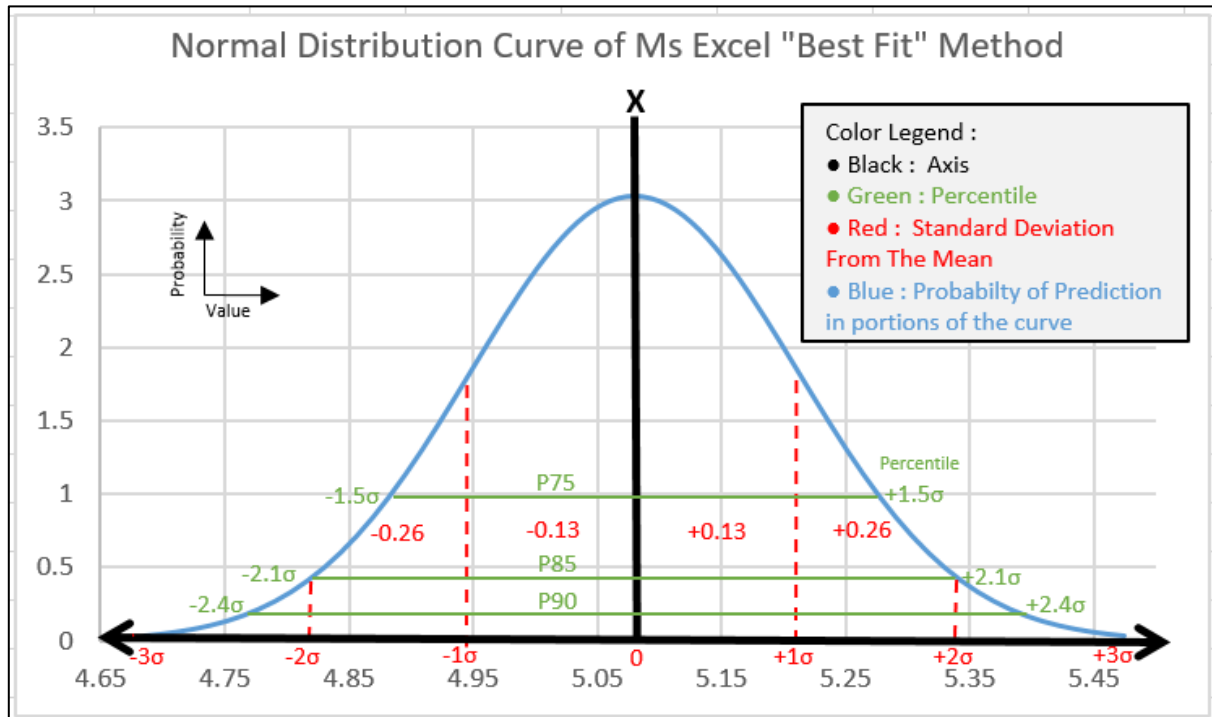


Figure 5. Normal Distribution Curve of MS Excel "Best Fit" Method<sup>23</sup>

From Figure 5 above, we get the estimation of the Indonesia Minimum Monthly Wages at the year 2022 are:

P50 = 5.01 IDR Million/Month

P75 = 5.20 IDR Million/Month

P85 = 5.28 IDR Million/Month

P90 = 5.32 IDR Million/Month

### 2.1.2 Monte Carlo Simulation Using Microsoft Excel

To evaluate the output of Indonesia's Minimum Wage by these simulation models, we will develop the value in the year 2022 with a percentage of the growth rate each year during the year 2020 to 2021 and the year 2021 to 2022. Using the same historical data of Indonesia's Minimum Wage as models 2.1.1 above, we obtain a percentage of the past growth rate through the difference between the values of two consecutive years and the older years' values.

<sup>23</sup>By Author

Table 4. The Growth Rate of Indonesia's Minimum Wage<sup>24</sup>

Iteration 10.000	
No.	Output Value
1	12.17%
2	12.73%
3	11.76%
9997	5.80%
9998	13.90%
9999	16.99%
10000	11.65%
<b>Min</b>	<b>-1.18%</b>
<b>Max</b>	<b>29.18%</b>
<b>Average</b>	<b>13.36%</b>
<b>Std Dev.</b>	<b>3.95%</b>
<b>N</b>	<b>10000</b>

From the figure, to get the primary data for the Monte Carlo simulation, we rank the data of The Growth Rate of Indonesia's Minimum Wage by using low, most likely, and high category as a shown table,

Table 5. The Growth Rate of Indonesia's Minimum Wage Rank<sup>25</sup>

The Growth Rate of The Indonesia's Minimum Wage	Rank	for PERT Exercise
7.46%	Low	7.46%
8.06%	Most Likely	10.42%
8.63%		
9.44%		
10.66%		
10.91%	High	30.95%
14.81%		
30.95%		

Based on the table above, we determine the value for mean, standard deviation, and variance with the formula:

- Mean =  $(7.46\% + (4 \times 10.42\%) + 30.95\%) / 6 = 13.35\%$
- Standard Deviation  $(30.95\% - 7.46\%) / 6 = 3.91\%$
- Variance = 0.15%

<sup>24</sup>By Author

<sup>25</sup>By Author

### Monte Carlo 1: The Growth Rate of The Indonesia Minimum Wage Year 2021 - 2020

Based on the Monte Carlo simulation generated by Microsoft Excel, we have shown the results below for 10.000 iterations for two consecutive years, 2021 - 2020<sup>26</sup>.

Table 6. Iteration Result and Summary Using Microsoft Excel<sup>27</sup>

Iteration 10.000	
No.	Output Value
1	21.86%
2	13.43%
3	10.72%
9997	5.96%
9998	13.55%
9999	9.93%
10000	6.07%
<b>Min</b>	<b>-3.99%</b>
<b>Max</b>	<b>28.63%</b>
<b>Average</b>	<b>14.07%</b>
<b>Std Dev.</b>	<b>3.93%</b>
<b>N</b>	<b>10000</b>

From the table above, we generated Monte Carlo Recommended Chart using Microsoft Excel, which curves with the x-axis is a result range (difference from the maximum and minimum value generated by Monte Carlo simulation and divided into fifteen groups range)<sup>28</sup>.

<sup>26</sup>Introduction to Monte Carlo simulation in Excel. (n.d.). Microsoft Support. <https://support.microsoft.com/en-us/office/introduction-to-monte-carlo-simulation-in-excel-64c0ba99-752a-4fa8-bbd3-4450d8db16f1>

<sup>27</sup>By Author

<sup>28</sup>Create a chart with recommended charts. (n.d.). Microsoft Support. <https://support.microsoft.com/en-us/office/create-a-chart-with-recommended-charts-cd131b77-79c7-4537-a438-8db20cea84c0>

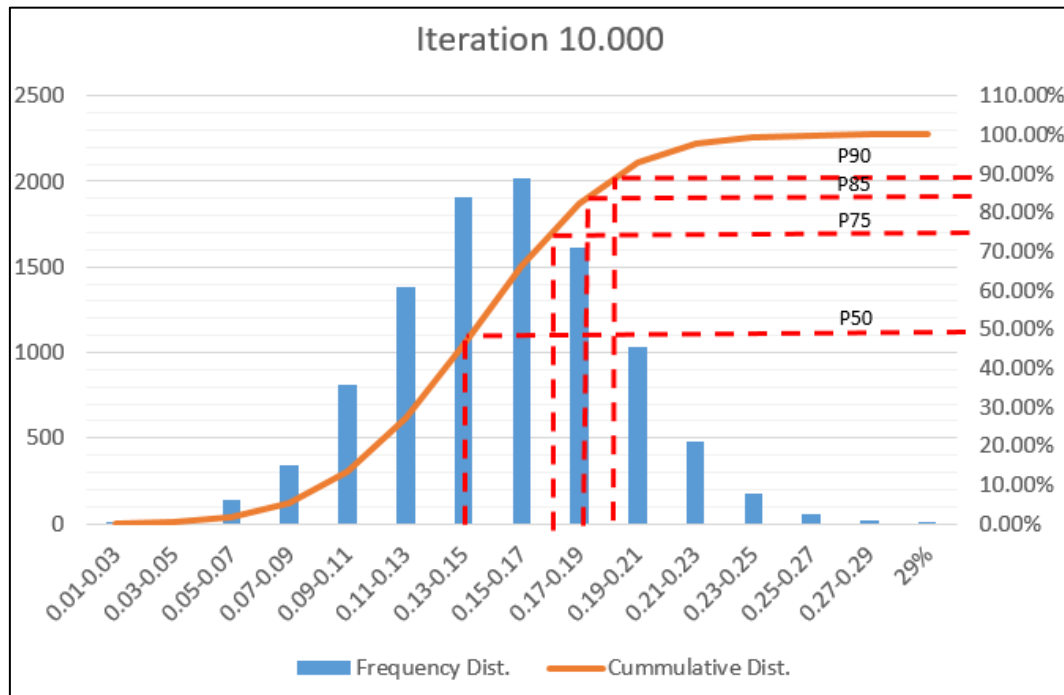


Figure 6. Iteration N=10.000<sup>29</sup>

Based on the curve above, we get the P90 number for each iteration, as shown below:

Table 7. P90 value based on Iteration<sup>30</sup>

Iteration	P90 Value (IDR Million/Month)
10000	18.39%

### Monte Carlo 2: The Growth Rate of The Indonesia Minimum Wage Year 2022 - 2021

From the table above, we get the P90 value for The Percentage of the growth rate of Indonesia's Minimum Wage at the year 2021 – 2020 is 18.39%. Using this number of the percentage in this period, we continue to generate The Percentage of the growth rate of Indonesia's Minimum Wage for the year 2022 – 2021.

<sup>29</sup>By Author  
<sup>30</sup> By Author

Table 8. The Growth Rate of Indonesia's Minimum Wage Which Filled by Monte Carlo Simulation 1<sup>31</sup>

Two Consecutive Years	The Growth Rate of The Indonesia's Minimum Wage
2013 - 2012	30.95%
2014 - 2013	10.91%
2015 - 2014	10.66%
2016 - 2015	14.81%
2017 - 2016	8.06%
2018 - 2017	7.46%
2019 - 2018	9.44%
2020 - 2019	8.63%
2021 - 2020	Monte Carlo Simulation 1 = 18.39%
2022 - 2021	Monte Carlo Simulation 2 =

We get additional data from the figure, two consecutive years, 2022 – 2021, for the Monte Carlo simulation. Then we rank the data of The Growth Rate of Indonesia's Minimum Wage by using low, most likely, and high category as a shown table,

Table 9. The Growth Rate of Indonesia's Minimum Wage Rank for Monte Carlo 2<sup>32</sup>

The Growth Rate of The Indonesia's Minimum Wage	Rank	for PERT Exercise
7.46%	Low	7.46%
8.06%	Most Likely	11.56%
8.63%		
9.44%		
10.66%		
10.91%		
14.81%	High	30.95%
18.39%		
30.95%		

The same as the Monte Carlo simulation one generated by Microsoft Excel showed the results below for 10.000 iterations for two consecutive years 2022 - 2021.

<sup>31</sup>By Author

<sup>32</sup>By Author

Table 10. Iteration Result and Summary Using Microsoft Excel<sup>33</sup>

Iteration 10.000	
No.	Output Value
1	21.86%
2	13.43%
3	10.72%
9997	5.96%
9998	13.55%
9999	9.93%
10000	6.07%
<b>Min</b>	<b>-3.99%</b>
<b>Max</b>	<b>28.63%</b>
<b>Average</b>	<b>14.07%</b>
<b>Std Dev.</b>	<b>3.93%</b>
<b>N</b>	<b>10000</b>

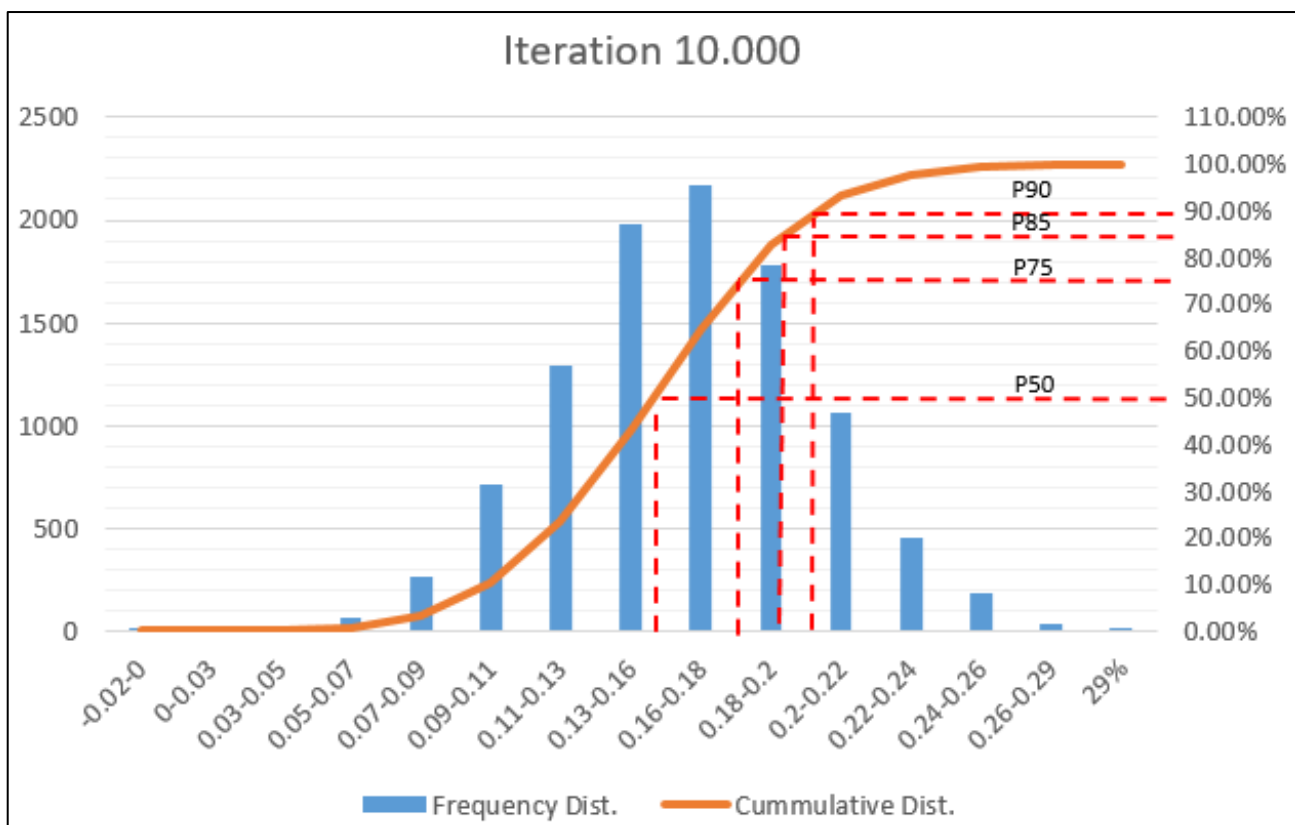


Figure 7. Iteration N=10.000<sup>34</sup>

Based on the curve above, we get the P90 number for each iteration, as shown below:

<sup>33</sup>By Author

<sup>34</sup>By Author

Table 11. P90 value based on Iteration<sup>35</sup>

Iteration	P90 Value (IDR Million/Month)
10000	19.11%

From the table above, we get the P90 value for The Percentage of the growth rate of Indonesia's Minimum Wage at the year 2021 – 2020, around 19.11% (average). Using the result from the P90 value of the Monte Carlo Simulation 1 and Monte Carlo Simulation 2, the growth of the Indonesia Minimum Wage for the year 2021 and year 2022 follow the formula below

Prediction of the Indonesia Minimum Wage at the Year 2022 =

Indonesia Minimum Wage at the Year 2020 x (100%+Monte Carlo Simulation1) x (100%+Monte Carlo Simulation2)

Prediction of the Indonesia Minimum Wage at the Year 2022

= 4.28 IDR Million x (100% + 18.39%) x (100%+19.11%) = 4.28 x 118.39% x 119.11% = 6.03 IDR Million / Month

## 2.2 Method by Historical Data of Basket of Other Goods' Price for Equivalency (PPP)

### 2.2.1 Gold Price Equivalency Index

To develop a model, we gather information about Indonesia's Minimum Monthly wage in the year 2020 is 4.28 IDR Million/Month. The data model is created by gold price per ounce in USD from the year 2010 up to the year 2020.



Figure 8. Gold Price (per OZ) Trend in USD<sup>36</sup>

<sup>35</sup>By Author

<sup>36</sup>XE: XAU / USD currency chart. Gold ounce to US dollar rates. (n.d.). XE – The World's Trusted Currency Authority: Money Transfers & Free Exchange Rate Tools.  
<https://www.xe.com/currencycharts/?from=XAU&to=USD&view=5Y>



The gold price reflects the purchasing power parity, which is proved within all the world. From the data above, we plot the regression using linear, 2nd, 3rd, and 4th polynomial

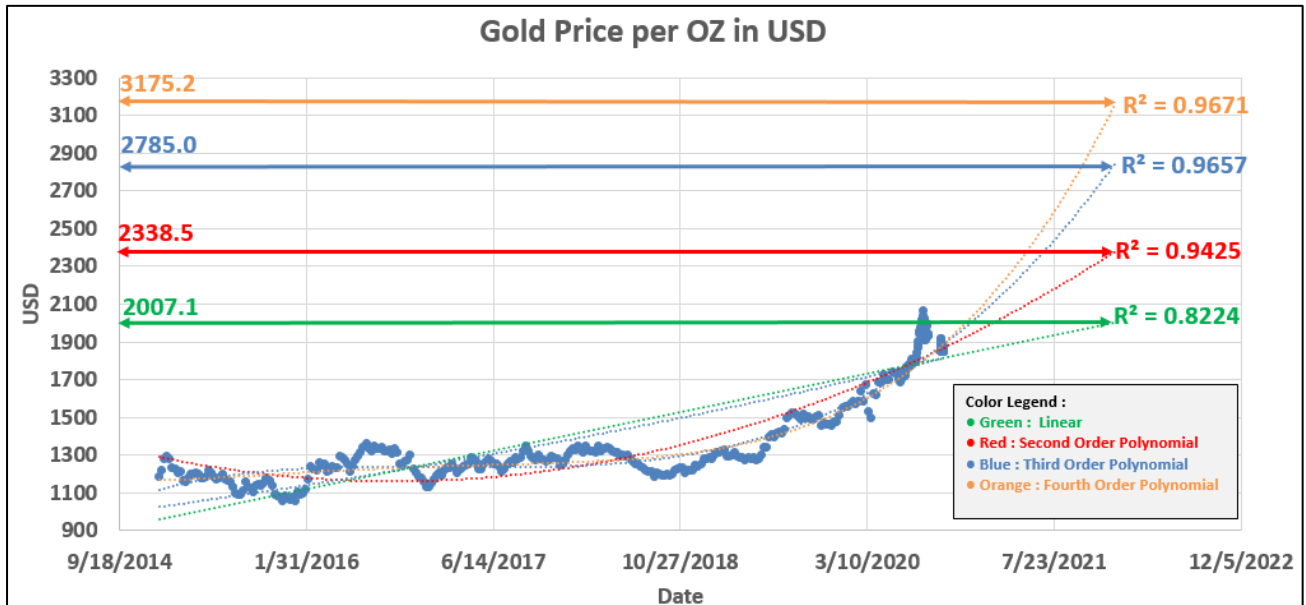


Figure 9. Regression Result using Microsoft Excel of Gold Price<sup>37</sup>

From the regression shown in Figure 9, we get the data

Table 12. R Squared Value of The Regression Result<sup>38</sup>

Regression	R <sup>2</sup>	Gold Price
Linear	0.8224	\$2007.1
2 <sup>nd</sup> order Polynomial	0.9425	\$2338.5
3 <sup>rd</sup> order Polynomial	0.9657	\$2785.0
4 <sup>th</sup> order Polynomial	0.9671	\$3175.2

The best-fit graph will be used for better accuracy of price forecasting. And based on the result, three regression models (2nd order polynomial, 3rd order polynomial, and 4th order polynomial) match the criteria with an R2 value minimum of 0.9<sup>39</sup>. From each equation of the regression model, we get the gold price per OZ for date 1, January 2022: 2nd Order Polynomial = 2338.5, 3rd order polynomial = 2785.0, and 4th order polynomial = 3175.2. Then we can classify each output with labels low, Medium, and high. From the graphic, we get data that the average gold price in 2020 is US\$ 1712 / Oz

Base on the Indonesia Minimum Monthly Wages in the year 2020 is 4.28 IDR Million/Month, and the Gold Equivalency Indices, the project cost in 2022 are the low = 5.84 IDR Million/Month; the

<sup>37</sup>By Author

<sup>38</sup>By Author

<sup>39</sup>R-squared. (n.d.). Investopedia. <https://www.investopedia.com/terms/r/r-squared.asp>

Medium = 6.96 IDR Million/Month; and the high= 7.93 IDR Million/Month. Therefore, the calculation of the result based on PERT formulas are<sup>40</sup>:

- Mean=  $(5.84 + (4 \times 6.96) + 7.93) / 6 = 6.935$
- Standard Deviation  $(7.93-5.84) / 6 = 0.348$
- Variance =  $0.348 \times 0.348 = 0.1211$

Correspondence with PERT formula, also using normal distribution value to determine P50, P70, P80 for evaluation the estimate align with risk and contingency

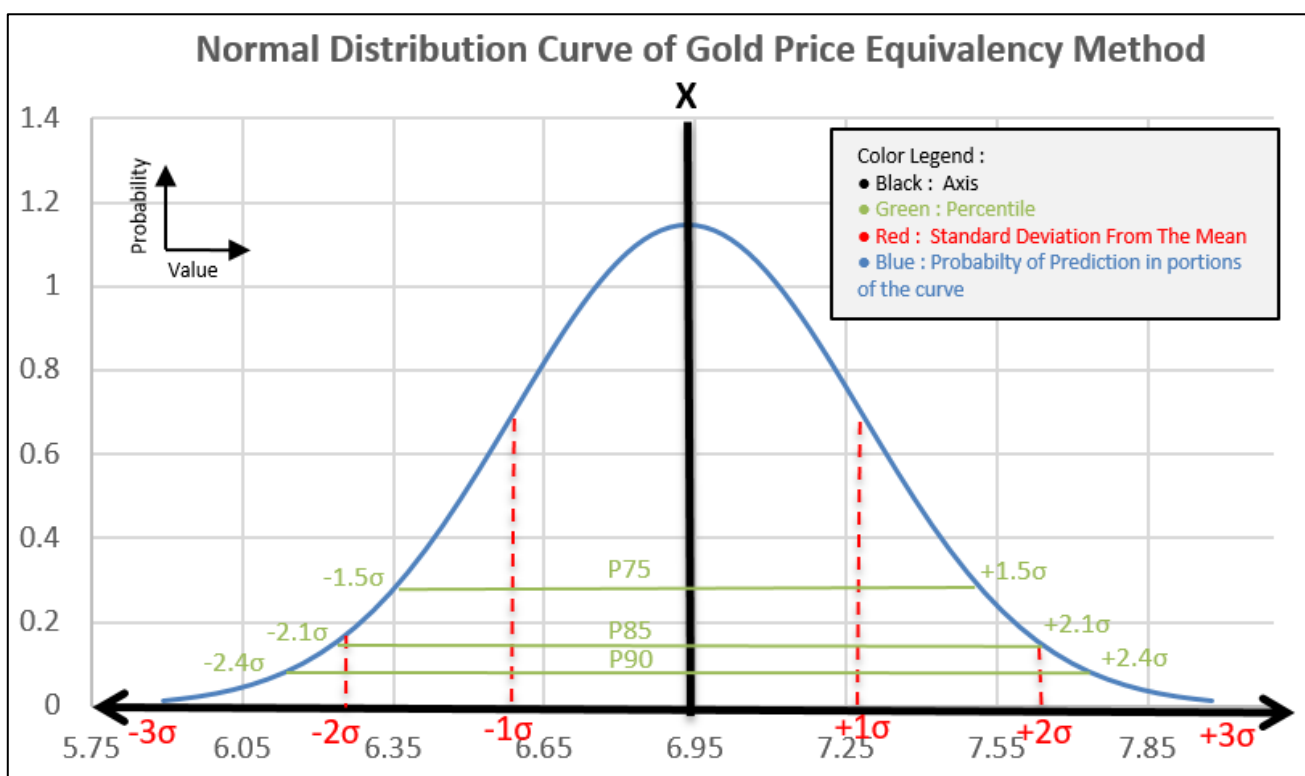


Figure 10. Normal Distribution Curve of Gold Price Equivalency Method<sup>41</sup>

From the graphic above, we estimate the Indonesia Minimum Monthly Wages in the year 2022 is P90 = 7.770 IDR Million/Month.

<sup>40</sup> Use PERT technique for more accurate estimates. (2007, June 25). TechRepublic. <https://www.techrepublic.com/blog/it-consultant/use-pert-technique-for-more-accurate-estimates/>

<sup>41</sup>By Author

### 2.2.2 Big Mac Price Equivalency Index

To develop a model, the amount of Indonesia's Minimum Monthly Wages in 2020, which was 4.28 million IDR per month, is used as the baseline of estimation<sup>9</sup>. The data model of equivalency is developed using Indonesian Big Mac's price in the local currency of 2014-2020.

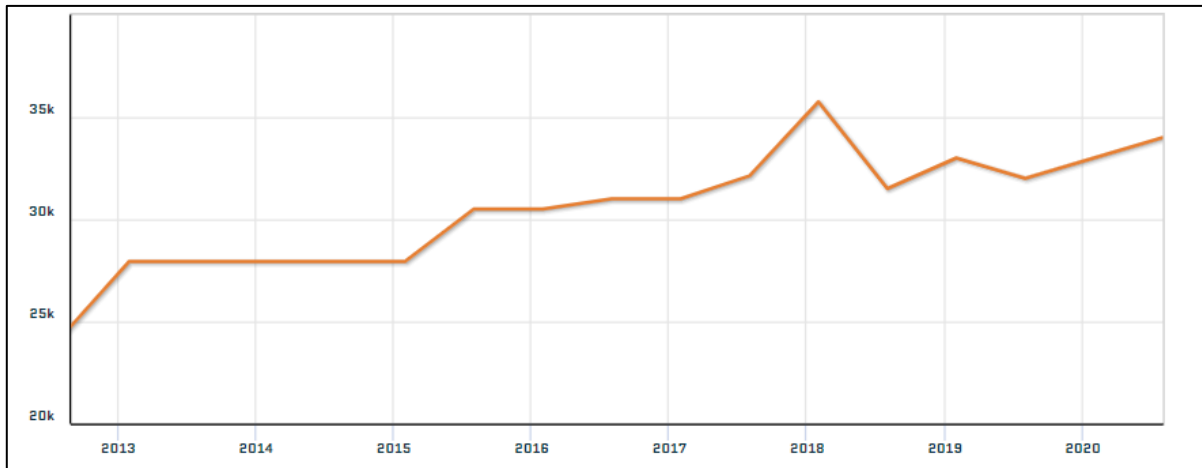


Figure 11. Big Mac's Burger price of 2014 – 2020 (local currency)<sup>42</sup>

From the data of Figure 1, the regressions using linear, 2nd order polynomial, 3rd order polynomial, and 4th order polynomial trends are plotted in Figure 13.

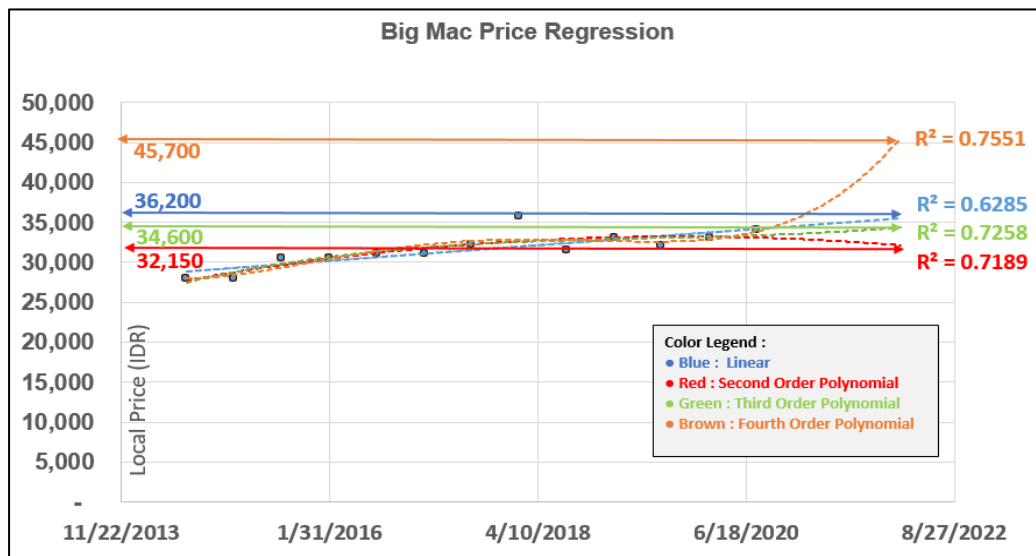


Figure 12. Regression Result using Microsoft Excel of Big Mac Price<sup>43</sup>

<sup>9</sup> Indonesia minimum monthly wages | 2012-2020 data | 2021-2022 forecast | Historical. (n.d.). TRADING ECONOMICS | 20 million INDICATORS FROM 196 COUNTRIES. <https://tradingeconomics.com/indonesia/minimum-wages>

<sup>42</sup> Quandl. (n.d.). [https://www.quandl.com/data/ECONOMIST/BIGMAC\\_IDN-Big-Mac-Index-Indonesia](https://www.quandl.com/data/ECONOMIST/BIGMAC_IDN-Big-Mac-Index-Indonesia)  
[https://www.quandl.com/data/ECONOMIST/BIGMAC\\_IDN-Big-Mac-Index-Indonesia](https://www.quandl.com/data/ECONOMIST/BIGMAC_IDN-Big-Mac-Index-Indonesia)

<sup>43</sup> By Author

The R-squared values of the regressions are shown in Table 13, along with the price of a Big Mac Burger.

Table 13. R Squared Value of The Regression<sup>44</sup>

Regression	R <sup>2</sup>	Big Mac Price (IDR)
Linear	0.6285	36200
2 <sup>nd</sup> order Polynomial	0.7189	32150
3 <sup>rd</sup> order Polynomial	0.7258	34600
4 <sup>th</sup> order Polynomial	0.7551	45700

To get the most accurate forecast, we choose the best-fit regression graph that is supposed to be selected. However, based on the result in Table 13, no graph represents a satisfying R-squared value. Therefore, analysis using four non-compensatory models are applied to find out the best fit graph<sup>45</sup>.

### Dominance

Table 14. Dominance result.<sup>46</sup>

Attributes	Linear vs 2nd Order Polynomial	Linear vs 3rd Order Polynomial	Linear vs 4th Order Polynomial	2nd order Polynomial vs 3rd order Polynomial	2nd order Polynomial vs 4th order Polynomial	4th order Polynomial vs 3rd order Polynomial
Graph Trend	Better	Equal	Equal	Worse	Worse	Equal
R Squared	Worse	Worse	Worse	Worse	Worse	Better
Polynomial Order	Better	Better	Better	Better	Better	Worse
Dominance ?	Yes	Maybe	Maybe	No	No	Maybe

Based on Table 14, linear regression dominates the 2nd polynomial order one. Hence, linear regression is selected in the dominance model.

### Satisficing

Table 15. Satisficing result.<sup>47</sup>

Attributes	Minimum Acceptable Value	Maximum Acceptable Value	Unacceptable Alternative
Graph Trend	Positive		2nd order Polynomial
R Squared	0.7	1	Linear
Polynomial Order	Linear	4th	None

<sup>44</sup>By Author

<sup>45</sup>W5.0\_MA Predicting Indonesia minimum monthly wages using big Mac™ price equivalency index. (2020, October 2). Vaccine Team 2020. [https://2020vaccineace.wordpress.com/2020/10/02/w5-0\\_ma\\_predicting-indonesia-minimum-monthly-wages-using-big-mac-price-equivalency-index/](https://2020vaccineace.wordpress.com/2020/10/02/w5-0_ma_predicting-indonesia-minimum-monthly-wages-using-big-mac-price-equivalency-index/)

<sup>46</sup>By Author

<sup>47</sup>By Author

In the satisficing model, each attribute's value of an alternative must fall in the acceptable range so that the choice can be considered the feasible one. Based on Table 4, two options do not meet the criteria. They are the 2nd order polynomial regression and linear regression in graph trend and R-squared, respectively. In the satisficing model, those two alternatives do not fulfill the best alternative's requirement.

### Disjunctive Resolution

The pairwise comparison of the attributes is tabulated in Table 5. The winner is scored by 1, while the one that loses gets a score of 0.

Table 16. Disjunctive resolution result.<sup>49</sup>

Attributes	Graph Trend	R Squared	Polynomial Order	Ordinal Rank
Graph Trend		1	1	2
R Squared	0		1	1
Polynomial Order	0	0		0

### Lexicography

Table 17. Lexicography result.<sup>50</sup>

Attributes	Graph Trend	R Squared	Polynomial Order	Ordinal Rank
Graph Trend		1	1	2
R Squared	0		1	1
Polynomial Order	0	0		0

The chosen alternative is the one that has the highest score in the essential attribute. Based on the ordinal ranking developed from disjunctive resolution, the 4th order polynomial regression is on the top of the rank, while the linear has the lowest score.

From the analysis above, the 4th order polynomial regression is selected because it is superior in one of the four non-compensatory models and fulfills the requirement in the satisficing model. , the price of the Big Mac™ is predicted to be 45.700 IDR in 2022, using the 4th order polynomial graph. Based on the calculation using Indonesia's Minimum Monthly Wages data in 2020 (4.28 million IDR per month) and 4th order polynomial regression of Big Mac's price, the Indonesia Minimum Monthly Wages in 2022 is predicted to be 5.75 million IDR per month.

### Step 3- DEVELOPMENT OF OUTCOMES

As mentioned in step 2 before, four models of prediction of the Indonesia Minimum Wage in the year 2020 are being used to get the best or better accuracy. This paper will compare all of the

<sup>49</sup>By Author

<sup>50</sup>By Author

results of the four-model prediction and choose the best option, whereas this paper will review the metrics from each alternative:

Table 18. The Comparison and Result of Prediction of Indonesia's Minimum Wage by each Alternatives<sup>51</sup>

	Microsoft Excel "Best Fit" Regression	Monte Carlo using Microsoft Excel	Gold Price Equivalency Index	Big Mac Price Equivalency Index
Baseline Data	Past data of the Indonesia Minimum Wage		Past Data of Basket of Other Goods' Price for Equivalency (PPP)	
PPP item			Gold	Big Mac Burger
Unit	IDR (local currency)	Percentage / Ratio	USD in Oz	IDR (local currency)
Quantity of the past data	9 value (9 year)	8 value (9 year)	1262 value (9 year)	13 value (9 year)
How to use past data	Value every year	Ratio of between two consecutive year	Value every year	Value every year
How to generate prediction	Projected to the destination time	Multiply by ratio (growth rate)	Projected and Equivalent to the destination time	Projected and Equivalent to the destination time
Possible alternative outcome during simulation	seven equation line (polynomial, linear, logarithmic, power)	three iteration (N=10000, 5000, 1000)	four equation line (polynomial, linear)	four equation line (polynomial, linear)
Using Trendline equation	Yes	No, Random Data	Yes	Yes
P90 Result of the Indonesia Minimum Wage at year 2022	5.32 IDR Million/Month	6.03 IDR Million/Month	7.77 IDR Million/Month	5.75 IDR Million/Month

#### Step 4 - SELECTION OF THE CRITERIA

In this section, we choose the most favorable decision for the simulation of Indonesia's Minimum Wage in the year 2022. Evaluation is based on the scoring attributes of alternatives standard<sup>52</sup>. The highest score of alternatives will lead to the selection of the best standard for developing prediction. The criterion should serve to prepare accurate and credible, which equals or exceeds the standard requirements. The choice of feasible alternatives shall be made according to the scores obtained. The acceptance criteria for the options are 50%<sup>53</sup>.

According to the scores obtained, the Microsoft Excel "Best Fit" simulation, Monte Carlo Simulation, Gold Price Equivalency, and Big Mac Burger equivalency will be further analyzed.

#### FINDINGS

##### Step 5-ANALYSIS AND COMPARISON OF ALTERNATIVES

According to the result of each proposed models prediction of the Indonesia Minimum Wage in the year 2022, In this study classifies the four aspects based on the level of priority as a scoring parameter:

<sup>51</sup>By Author

<sup>52</sup>Sullivan, G. W., Wicks, M. E., & Koelling, C. P. (2012). Engineering economy 16th Edition. Chapter 14 Decision Making Considering Multiattributes, pp.599

<sup>53</sup>Wisnugroho. (2020, February). Indonesia Oil & Gas Cost Estimating vs International "Best-Tested and Proven" Practices – A Benchmarking Study. PM World Library | A Global Resource for Continuous Learning in PPM. <https://pworldlibrary.net/wp-content/uploads/2020/02/pmwj90-Feb2020-Wisnugroho-benchmarking-indonesia-og-cost-estimating-vs-international3.pdf>

### **P90 Result of The Indonesia Minimum Wage at the Year 2022 vs. Prediction of Trading Economics at the Year 2022**

As the main priority in conducting a comparative analysis of prediction models, in this section, The author compares the results of predictions to one of the published prediction results, namely economic trading<sup>54</sup>. Economics Trading released prediction results for the Indonesia Minimum Wage in 2011 and 2022 using the econometric model method.

In that publication, it is reported that in 2022 the value of Indonesia's Minimum Wage will reach 4.60 IDR Million / Month. Based on this primary value, the error quantification of each of the prediction results of the four models above is carried out

Table 19. Comparing between The Result of each Model of Prediction versus Trading Economics Prediction<sup>55</sup>

<b>Parameter / Baseline</b>	<b>Models of Prediction</b>			
Trading Economics Prediction	Ms. Excel "Best Fit Regression"	Monte Carlo using Ms. Excel	Gold Price Equivalency Index	Big Mac Burger Price Equivalency Index
4.60 IDR Million	5.32 IDR Million	6.03 IDR Million	7.77 IDR Million	5.75 IDR Million
% Deviation (Models/Trading Economics)	15.65%	31.08%	68.91%	25.00%

### **Correlation Primary Data of Prediction to the Indonesia Minimum Wage**

Using this parameter, we evaluate the correlation between Indonesia's Minimum Wage with The primary data used as models of prediction. The availability data in Indonesia are the main aspects to be reviewed in this study.

Table 20. Characteristic Baseline Data of each model of Prediction<sup>56</sup>

<b>Parameter / Baseline</b>	<b>Models of Prediction</b>			
Real Data of Indonesia Minimum Wage	Ms. Excel "Best Fit Regression"	Monte Carlo using Ms. Excel	Gold Price Equivalency Index	Big Mac Burger Price Equivalency Index
Single Data During a Year	Single Data During a Year	Single Data During a Year	365 Data During a year	Two data During a year

<sup>54</sup>Indonesia minimum monthly wages | 2012-2020 data | 2021-2022 forecast | Historical. (n.d.). TRADING ECONOMICS | 20 million INDICATORS FROM 196 COUNTRIES.  
<https://tradingeconomics.com/indonesia/minimum-wages#:~:text=Minimum%20Wages%20in%20Indonesia%20is%20expected%20to%20reach,Million%2FMonth%20in%202022%2C%20according%20to%20our%20econometric%20models>

<sup>55</sup>By Author

<sup>56</sup>By Author

### Compatibility of Characteristic Data of Prediction Models

In this section, a comparison of the data's characteristics is carried out where the Indonesian minimum wage data changes every year and only has one value for one year. Furthermore, the data from the four prediction models will match the characteristics of the Indonesia Minimum Wage.

Data on the model prediction with single data will have a better match than data that fluctuates each year.

Table 21. Availability Data for Baseline Prediction or Estimate<sup>57</sup>

Parameter / Baseline	Models of Prediction			
Real Data of Indonesia Minimum Wage	Ms. Excel "Best Fit Regression"	Monte Carlo using Ms. Excel	Gold Price Equivalency Index	Big Mac Burger Price Equivalency Index
Available within All region of Indonesia	Available within All area of Indonesia <sup>58</sup>	Available within All area of Indonesia	Available within All region of Indonesia <sup>59</sup>	45 Cities in Indonesia <sup>60</sup>

### Ease of Use of Forecast Method

As the last factor in the analysis considerations, this section compares the convenience of each prediction method. The simpler the application of the prediction model, the better the score

Table 22. Ease of Use of Forecast Method<sup>61</sup>

Parameter / Baseline	Models of Prediction			
Real Data of Indonesia Minimum Wage	Ms. Excel "Best Fit Regression"	Monte Carlo using Ms. Excel	Gold Price Equivalency Index	Big Mac Burger Price Equivalency Index
	Trend line Equation Feature of Microsoft Excel	Monte Carlo Feature of Microsoft Excel	Trend line Equation Feature of Microsoft Excel	Trend line Equation Feature of Microsoft Excel

From all the four aspects based on the level of priority as the scoring parameter, the author uses Multi Attributes Decision Making, as shown in the table below:

<sup>57</sup>By Author

<sup>58</sup>Badan Pusat Statistik. (n.d.). Badan Pusat Statistik. <https://www.bps.go.id/linkTableDinamis/view/id/917>

<sup>59</sup>Harga emas Indonesia. (n.d.). Gold Price. <https://goldprice.org/id/gold-price-indonesia.html>

<sup>60</sup>Indonesia, M. (n.d.). Location. McDonald's Indonesia. <https://mcdonalds.co.id/location>

<sup>61</sup>By Author



Table 23. Multi-Attributes Dimensionless Calculation<sup>62</sup>

Attributes	Value	Rating Procedure	Dimensionless Value
Accuration of The Prediction towards to Trading Economics Prediction	15.65%	$(68.91\% - \% \text{ Deviation})$ 53.26%	1
	31.08%		0.710289148
	68.91%		0
	25.00%		0.824446113
Correlation Data of The Prediction	1.00	$(365 - \text{Quantity the Data During a year})$ 364	1
	1.00		1
	365.00		0
	2.00		0.997252747
Characteristic Data of Prediction	All Region	Available Data Completed in All Region = 1 Available in Not all Region = 0	1
	All Region		1
	All Region		1
	45 Cities		0
Ease of Use of Forecast Method	Trend line	Trendline = 1 Monte Carlo = 0	1
	Monte Carlo		0
	Trend line		1
	Trend line		1

This study uses additive weighting techniques to determine the best Method of Model Prediction<sup>63</sup>. The calculation result is shown in the table below.

Table 24. Additive Weighting Technique<sup>64</sup>

Attributes	Relative Rank	Normalized Weight (A)	Ms Excel "Best Fit Regression"		Monte Carlo using Ms. Excel		Gold Price Equivalency Index		Big Mac Price Equivalency Index	
		$\frac{\text{Relative Rank}}{\text{Total Rank}}$	(B)	(A) x (B)	(B)	(A) x (B)	(B)	(A) x (B)	(B)	(A) x (B)
Accuration of The Prediction towards to Trading Economics Prediction	4	0.4	1	0.4	0.7103	0.284116	0	0	0.8244	0.3297784
Correlation of The Quantity Data of The Prediction towards to Indonesia Minimum Wage	3	0.3	1	0.3	1	0.3	0	0	0.9973	0.2991758
Characteristic Data of Prediction	2	0.2	1	0.2	1	0.2	1	0.2	0	0
Ease of Use of Forecast Method	1	0.1	1	0.1	0	0	1	0.1	1	0.1
Total	10	1	Total	1	Total	0.784116	Total	0.3	Total	0.7289543

The highest point calculated with multi-attribute analysis is obtained by Microsoft Excel "Best Fit Regression" curve from the table above.

### Step 6 - SELECTION OF PREFERRED ALTERNATIVES

According to the table and criteria of the selection in Step 4, three models of the Prediction Method comply with a minimum score of 0.5. The Microsoft Excel "Best Fit Regression" shows the best performance towards all alternatives. The Gold Price Equivalency index method does

<sup>62</sup>By Author

<sup>63</sup>Afshari, Mojahed, & Yusuff. (2010, December 5). Simple Additive Weighting approach to Personnel Selection problem. IJIMT. <https://www.ijimt.org/papers/89-M474.pdf>

<sup>64</sup>By Author

not comply with the evaluation criteria through multi attributes decision making (MADM)<sup>65</sup>, under 0.5. There are several factors why the prediction method of the Microsoft Excel "Best Fit Regression give the best results

The First Factor supporting the prediction by using Microsoft Excel "Best Fit" is because the method uses the past data itself<sup>66</sup>. There are no analogies data or borrowing other item data to develop this prediction<sup>67</sup>. Unlike the other two Equivalency Index, which uses other items PPP (Gold and Burger Big Mac) as primary data, Microsoft Best Fit only uses real Indonesia, Minimum Wage, from 2012 until 2020 as a baseline prediction. Using other data is to make a bias prediction in this simulation. Another Model of Prediction using the same data is the Microsoft Excel Best Fit Regression is the Monte Carlo Simulation Method. The Monte Carlo Simulation Prediction result is higher than Microsoft Excel Best Fit. Although the same data drive the Monte Carlo and Microsoft Excel Best Fit, there is a significant difference. Monte Carlo is generated by the growth of the Data in consecutive years. The data used by Monte Carlo is generated by derivative from the primary data, not directly used. The Monte Carlo is also developed by a random formula based on mean and standard deviation. It is different from Microsoft Excel Best fit, which using a projected trendline base on timeline<sup>68</sup>.

The Second Factor why Microsoft Excel Best Fit is superior to other methods is the data's characteristics. The object studies in this paper are The Indonesia Minimum Wage. The Indonesia Minimum wage is published once a year by the Ministry of Manpower and Transmigration, forming annual data. In other words, only single data Indonesia Minimum Wage during a year. Except for the Monte Carlo simulation, the other method uses more than one data (single) during a year as a prediction baseline. Using itself information, which is single data from the past, establish the Microsoft Excel Best Fit Regression superior in this factor. Unlike other methods that show by hundred data during a year (Gold) and Twice data during a year (big mac burger). This produces an estimation with more fluctuation and does not match the prediction object's original data.

The Third Factor, which supports the performance of the Microsoft Excel Best Fit Regression, is the option during the simulation. Using the trend line feature of the Microsoft excel give more

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<sup>65</sup>Sullivan, G. W., Wicks, M. E., & Koelling, C. P. (2012). Engineering economy 16th Edition. Chapter 14 Decision Making Considering Multiattributes, pp.599

<sup>66</sup>Technologies, B. (2019, August 22). How enterprises are using predictive analytics to transform historical data into future insights. Medium. <https://medium.com/@BangBitTech/how-enterprises-are-using-predictive-analytics-to-transform-historical-data-into-future-insights-73d8ee8dec0f>

<sup>67</sup>Estimation techniques - Analogous. (n.d.). RxJS, ggplot2, Python Data Persistence, Caffe2, PyBrain, Python Data Access, H2O, Colab, Theano, Flutter, KNime, Mean.js, Weka, Solidity. [https://www.tutorialspoint.com/estimation\\_techniques/estimation\\_techniques\\_analogous.htm](https://www.tutorialspoint.com/estimation_techniques/estimation_techniques_analogous.htm)

<sup>68</sup>Scratchapixel. (2015, April 18). Monte Carlo methods in practice (Generating random numbers). <https://www.scratchapixel.com/lessons/mathematics-physics-for-computer-graphics/monte-carlo-methods-in-practice/generating-random-numbers>

variety of solution. More than seven alternatives equations are generated by Microsoft Excel Trendline features (Linear, Polynomial, Power, Logarithmic)<sup>69</sup>.

## CONCLUSIONS

From the study above, several factors are supporting to produce accurate predictions. Choosing the most appropriate prediction method is the first factor. For example, the study above, which uses gold price and burger price to predict the Indonesia Minimum Wage, is enormously a significant bias. The correlation between gold to the Indonesia Minimum Wage does not apply well. There is no real Labor cost or wage in producing gold or determining the price of gold<sup>70</sup>. In otherwise, using burger Big Mac price as a prediction baseline is better than gold. In the Producing burger big mac, they have more real labor costs or component<sup>71</sup>. Also, using the wrong method of prediction will give a bias prediction. Using Monte Carlo, a generated random data formula for the time-based estimation also provides a significant error than the projected estimate like the trendline method<sup>72</sup>.

The Next Step to support accurate prediction is choosing the model of the primary data characteristic. Using the same or nearly the same data characteristic between the prediction and simulation model object is essential.

From this study, the author concludes that before we start the prediction or estimation for the future, there is some consideration:

1. Choosing The Most Relevant Prediction Method towards to The Object of Prediction
2. Match between Characteristic of the Baseline Data towards The Object of Prediction
3. How many alternatives can be generated by the method?
4. Easy of use of the Prediction Method?

## FOLLOW ON RESEARCH

Further research should be done on other Purchasing Power Parity (PPP) items and various Monte Carlo simulation parameters.

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<sup>69</sup>Choosing the best trendline for your data. (n.d.). Microsoft Support. <https://support.microsoft.com/en-us/office/choosing-the-best-trendline-for-your-data-1bb3c9e7-0280-45b5-9ab0-d0c93161daa8>

<sup>70</sup> Gold price: Factors that affect gold price. (2018, June 25). The Economic Times. <https://economictimes.indiatimes.com/wealth/invest/factors-that-affect-gold-price/articleshow/64464960.cms?from=mdr>

<sup>71</sup> Landry. (2008, September). The Big Mac: A Global-to-Local Look at Pricing. Federal Reserve Bank of Dallas - Dallasfed.org. <https://www.dallasfed.org/-/media/documents/research/eclett/2008/e10809.pdf>

<sup>72</sup> Atanassov, & Dimov. (2007, July 3). What Monte Carlo models can do and cannot do efficiently? <https://reader.elsevier.com/reader/sd/pii/S0307904X07001564?token=2F8F884B7289F0500739E7A4CECEED0FC6982FA67926ED3067AD2D92977D53E6BA4A5D5C72990394E40795F4E0840595>

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