Forecasting Gross Domestic Product with Logistic Growth Model

Rahela Abdul Rahim*[1], Mohd. Alif Zikry[2], Noraziah Man[3], and Fatinah Zainon[4]
[1,2,3,4]*School of Quantitative Sciences (SQS), Universiti Utara Malaysia, Kedah, Malaysia*
[1]*rahela@uum.edu.my*
[3]*noraziah@uum.edu.my*
[4]*fatinah@uum.edu.my*

***Abstract*: Gross Domestic Product (GDP) is the sum of income for all goods and services acquired in a given time period. This study develops a model of GDP data for the state of Johor between 2005-2016 using the Logistic Growth model. Long-term GDP equilibrium values are predicted using non-linear equations and tested with different parameters. Forecasts of GDP in the near future are also presented using the appropriate parameters.**

Keywords: *Equilibrium value, Forecasting, Gross Domestic Product, Logistic Growth model.*

1. Introduction

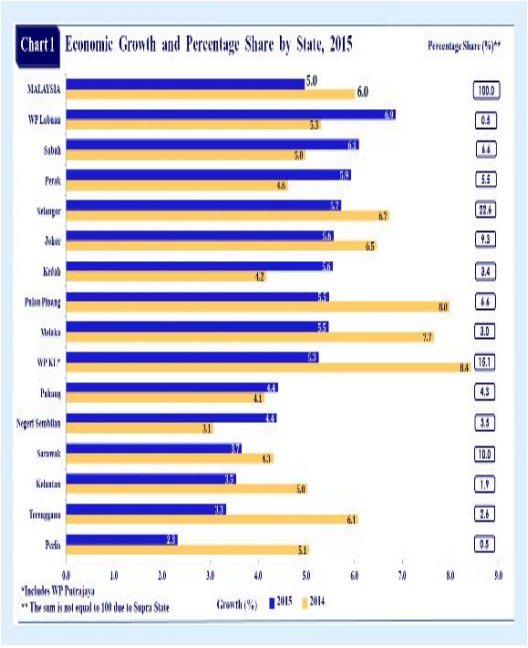

Figure 1. Malaysia States GDP Data in 2010 - 2015

Gross Domestic Product (GDP) is one of the best ways to measures the economy's output or production with the specific period whether in monthly, quarterly or annually. It known as broadest quantitative measure of a nation total economic for all countries. The economic will be affected with the delay by monetory policies decisions so its authorities must be looking forward to forecast future. The graph in Fig. 1 shows the Gross Domestic Product (GDP) of States in Malaysia from year 2005 until 2015. The long-term economic growth will be affected if the data were not monitored or analyzed in an efficient way. In investing sentiment, every changed in GDP give an impact even it was slightly increase or decrease as GDP act as measuring tool for the economy's health. It is clear that economic activity and growth will be affected if data is not examined and analyzed. Therefore, to overcome this situation, mathematical models will be used in order to keep the data on track and analyzed in analytical and logical

2. Literature Review

GDP are one of the important things to see whether the country is in healthy economic growth [1]. Leisure preference, non-marketed activities, underground economy [2] environmental quality and resource depletion, quality of life and poverty and economic inequality are the factor that can affect the GDP [3]. This can show the performance of GDP in a country from year to year. The formula to calculate the GDP had been produced by Simon Kuznets where it had been used over the year [4].

It is accurate and can show the country economic growth. Most of the researchers and statisticians use the formula in their studies. There are a few sectors that include to interpret GDP graph. First is household where it is under the consumption to see if they can be the best sector that can increase or decrease the purchasing power of the country. Second is the business. It is vital to segregate the products created for present consumption versus the products that may aid in maximizing production within the forthcoming years. Third is the government sector where it defines the expenditure of government to the country. Lastly is the net export. The last component is to segregate foreign trade from domestic markets [5].

3. Methodology

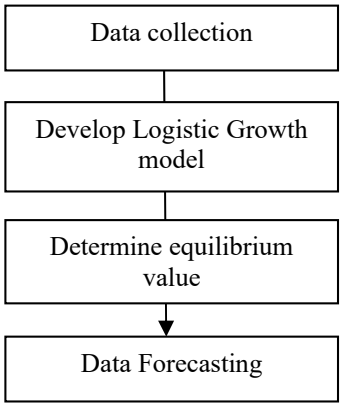

Figure 2. Modeling Methodology

Figure 2 shows the modeling methodology used in this study. There are four phases involved; data collection, model development, determining equilibrium and finally data forecasting.

4. Logistic Growth Model and Results

This study has used Logistic Growth model to calculate the predicted GDP for the state of Johor. The model equations are shown as follows:

n = Number of data

p_n= Gross Domestic Product

$\Delta p_n = p_{n+1} - p_n$

$$\bar{X} = \frac{\sum \frac{\Delta p_n}{(104\,500 - p_n)p_n}}{n-1} = \frac{0.0000261003}{7-1} = 0.00000435005$$

The limiting value of gross domestic product was set at RM 104 500 million and is substituted into the formula as shown below:

$p_{n+1} = p_n + 0.00000435005\,(104\,500 - p_n)p_n$, with $p_0 = 74102$

The equation is transformed into the following nonlinear equation purposely to obtain the equilibrium value.

$a_{n+1} = 1.45458\,(1 - a_n)\,a_n$ where

$a_n = 0.000003\,p_n$ and $r = 1.45458$

Using Microsoft Excel, the value a_n until $n = 2035$ can be calculated. Substituting $p_n = \frac{a_n}{0.000003}$, the predicted value for each value of *n* can be found. Then, the long=term equilibrium value can be determined. The normalized value, a_n and the predicted value, p_n for each *n* is shown in Table I.

Table 1. Predictive GDP of Johor

n	a_n	p_n
2010	0.22231	74102
2011	0.25148	83825
2012	0.27380	91268
2013	0.28922	96407
2014	0.29902	99674
2015	0.30489	101630
2016	0.30827	102757
2017	0.31018	103391
2018	0.31123	103743
2019	0.31181	103937
2020	0.31213	104044
2021	0.31231	104102
2022	0.31240	104133

n	a_n	p_n
2023	0.31245	104151
2024	0.31248	104160
2025	0.31250	104165
2026	0.31251	104168
2027	0.31251	104170
2028	0.31251	104171
2029	0.31251	104171
2030	0.31252	104171
2031	0.31252	104171
2032	0.31252	104172
2033	0.31252	104172
2034	0.31252	104172
2035	0.31252	104172

Using the model to estimate the long-term equilibrium value for the data which represents the limiting bound for Johor's GDP if the current GDP continues its pattern, is expected at RM 104 172 million. However, in order to test the fitness of the model, the comparative error is computed as follows: -

Year, n	Actual Value, p_{actual}	Predicted Value, $p_{predicted}$	Error, $\varepsilon = \frac{p_{actual} - p_{predicted}}{p_{actual}}$
2010	74102	74102	0
2011	78946	83825	0.06181
2012	84050	91268	0.08588
2013	87974	96407	0.09586
2014	93654	99674	0.06428
2015	98889	101630	0.02772
2016	104480	102757	0.016485

Since the Mean Absolute Deviation (MAD), which is 0.04558, is still considered as low, therefore we can say this model fit the GDP data for Johor.

Table 2. GDP of Johor from 2010-2016

YEAR/n	p_n	Δp_n	$(104\,500 - p_n)$	$(104\,500 - p_n)p_n$	$\frac{\Delta p_n}{(104\,500 - p_n)p_n}$
2010	74102	4844	30398	2252552596	2.15045E-06
2011	78946	5104	25554	2017386084	2.53001E-06
2012	84050	3924	20450	1718822500	2.28296E-06
2013	87974	5680	16526	1453858324	3.90685E-06
2014	93654	5235	10846	1015771284	5.15372E-06
2015	98889	5591	5611	554866179	1.00763E-05
2016	104480		20	2252552596	0

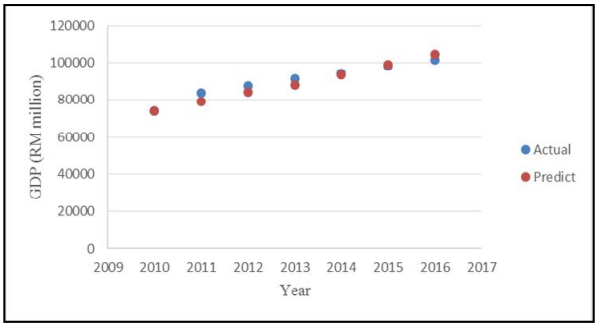

Figure. 3. Graph of Actual data versus Predicted data

Table 3. Actual GDP and Predicted Johor GDP for year 2010-2016

Year	Actual Data	Predicted Data
2010	74102	74102
2011	78946	83900.71
2012	84050	87721.73
2013	87974	91526.96
2014	93654	94298.35
2015	98889	98072.65
2016	104480	101302.69

The scroll bar is developed to analyse the constant r appears in the equation. This constant value can be used to estimate the long-term GDP for the state of Johor. It is expected that Johor GDP reach RM 103 391 million starting year 2035. It is an optimal constant for Johor GDP to reach its equilibrium value for data taken between year 2010 – 2016. It can be shown that different range of r will change the long-term data pattern and may not reach equilibrium in the long term.

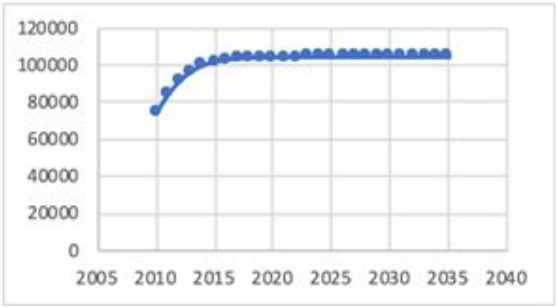

Figure. 4. Logistic Growth Model of Johor GDP for year 2010-2016 when r = 1.45458

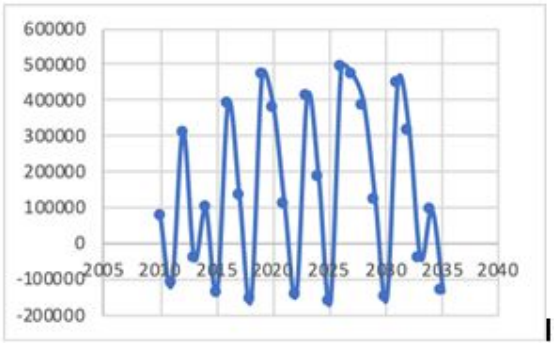

Figure. 5. $r < -1$: The curve is oscillating and diverging. For example: $r = -2$

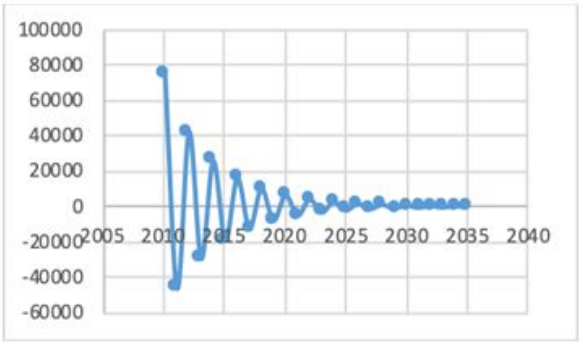

Figure. 6. $-1 \leq r < 0$: The curve is oscillating and converging to 0. For example: $r = -0.8$

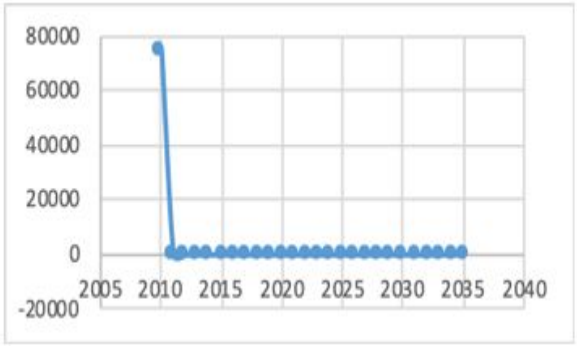

Figure. 7. $r = 0$: The curve is constant at 0.

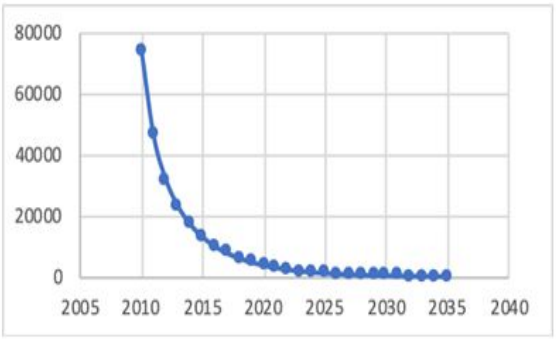

Figure. 8. $0 < r \leq 1$: The curve converges to 0. For example: $r = 0.8$

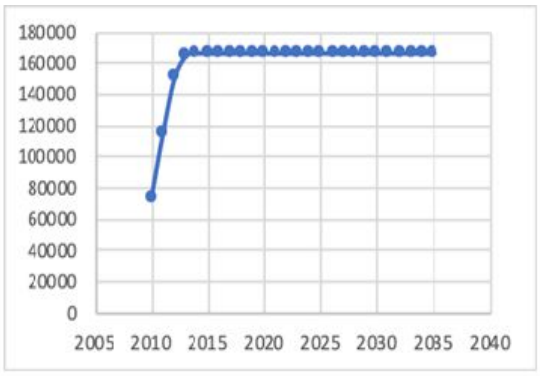

Figure. 9. $1 < r < 3$: The curve is converging to a particular point. For example: $r = 2$

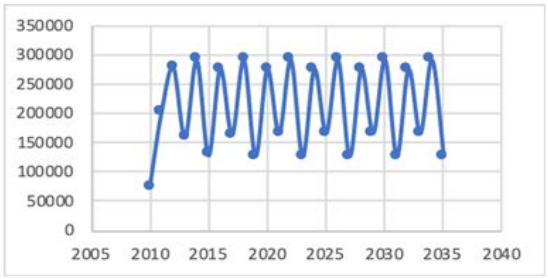

Figure. 10. $r \geq 3$: The curve is oscillating and diverging. For example: $r = 3.5$

Therefore, from the graph, we can say that only in this case:-

1. $0 < r \leq 1$
2. $1 < r < 3$

The curve is converging to a particular point, and it is only meaningful to have r value in the range of $\{r: 0 < r < 3\}$.

5. Conclusion

This study showed an alternative way to model Gross Domestic Products. The model was based on Logistic Growth model. The scroll bar was developed in Microsoft Excel to analyse the constant r that was required in GDP forecasting. This constant value was used to estimate the long-term GDP for the state of Johor. It was expected that Johor GDP reach RM 103 391 million starting year 2035. Finally, the model was flexible as it had the ability to tune its parameter to estimate the GDP long term equilibrium and its stability. The estimated GDP offered a mean for forecasting the trend of selected data and if the value meet the state target, the r value can be used to forecast the future GDP so that the target GDP can be achieved.

ACKNOWLEDGMENT

This research is funded by Universiti Utara Malaysia under the university grant with S/O Code 13876.

REFERENCES

[1] I. H. Azer, Mohamad, H. C., Abdullah, S. A. (2016, January). *Reseach Gate.* Retrieved from https://www.researchgate.net/publication/305726929_Contribution_of_Economic_Sectors_to_Malaysian_GDP/download

[2] N.A.R.A, Raja, A. Azmi A (2017). Factor Affecting Gross Domestic Product (GDP) Growth In Malaysia. *International Journal of Real Estate Studies*, 61-67.

[3] M. Kanodia (2015). Retrieved from Economics Discussion: http://www.economicsdiscussion.net/gdp/6-main-factors-affecting-gdp/15344

[4] A. Tziamalis (2018). Retrieved from Sheffield Hallam University: https://www.shu.ac.uk/

[5] P. Juneja (2015). Retrieved from Management Study Guide: https://www.managementstudyguide.com/components-of-gdp.htm