

The Crude Oil Price Power on Malaysia GDP: Relationship Analysis employing Numerical Method with Optimisation Approach

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Abstract

The natural means that come in the form of crude oil is the global economy's signature ingredient, and its price fluctuations carry pertinent impressions on numerous aspects. These include well-being, advancement and financial thriving globally. In an attempt to examine the interaction between the gross domestic product (GDP) and crude oil prices (COP) in Malaysia of 2009 until 2018, the LotkaVolterra model is employed. The optimisation algorithm is administered to foretell Malaysia's GDP and COP, respectively. The outcome establishes that there is a prey-predator relationship between Malaysia's GDP and the COP. It points out that the numerical method with fminoptimiser algorithm can be adopted to gain optimised parameter of the LotkaVolterra model by applying data of Malaysian GDP and crude oil price.

Keywords: crude oil prices, gross domestic product, predator-prey model, Lotka-Volterra model, optimization.

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1. INTRODUCTION

Throughout the world's economy and course, petroleum works as an indispensable good. Hence, the connection between crude oil and macroeconomics is mainly analyzed over crude oil prices. Since crude oil is input constituent and is vital source earnings for multiple nations for those who import and export it, it becomes an imperative commodity. The price undulation intrigues these correlated markets as it moves numerous macroeconomic components [1]. Even though the contemporary crude oil price has become severe, in actuality, it has been profoundly volatile by the end of World War II. It renders impressions on the economies of oil-exporting nations, particularly Malaysia.

The loop price volatilities hold repercussions on a country's economic atmosphere. The present volatile compartment and oil price fall will unfavorably influence a nation's competitiveness and its exchange valuation [2]. Accordingly, the connection between the price of crude oil and economic advancement has to be examined. Based on the fundamentals that oil and gas are non-renewable and limited, there is a pressure to appreciate the relevance it carries on Malaysian economics.

Regardless of the circumstances of rising or declining in the price of oil, Malaysia's gross domestic product (GDP) per capita is perceived to be more robust and regularly evolving. Besides, from 1960 until 2018, Malaysia's GDP per

capita in averaged at 5267.68 USD. Also, in 2018 it ended at 12109.50 USD. Malaysia's GDP per capita is comparable to 96 per cent of the globe's standard [3]. It implies that the weight of crude oil value to economic development is tricky to foretell. Nevertheless, this inclination works as an initial foresight. Currently, the link between the price of crude oil and GDP is still being reviewed [4-7]. However, the association still in the states of being ambiguous and vague.

Based on the works of literature, the conclusions on the crude oil price impression on Malaysia's GDP are comparatively disordered. The positive relationship between crude oil price and GDP, which considers Malaysia as an oil-exporting nation; suggests that crude oil prices rise implies an increment in the oil resources and pay of the land [4-6].

Howbeit, there is a well-defined negative connection between GDP growth and crude oil prices as being cited by [7]. The consequence of the rise in oil prices jeopardizes the entire marketplace since the oil represents an integral part of producing Malaysian revenue. It is possible when the exchange rate was high, and the input of production rises. Therefore, the product becomes expensive, and people's buying power drops. It then moves the total market's conduct.

These verdicts demonstrate that a consensus of crude oil price power and its forces towards the economy is still missing. The nonexistence of an explicit statement on ways in which energy shock influences the market motion leads to the matter as a loose end and is subjected to advance investigation. Ergo, this paper attempts to investigate the synergy of Malaysia's GDP and crude oil prices.

In order to demonstrate the two competing species' dynamics, the predator-prey models were efficiently employed. Both function as prey and predator. The LotkaVolterra and Rosenzweig-MacArthur models are the

most commonly predator-prey models. The multiple approaches have been employed to solve the predator-prey interplay. Among the methods are Variational Iteration method [8], Homotopy analysis method [9], Adams-Moulton and Fourth-Order Runge-Kutta Methods [10], non-standard weighted average approach [11] and non-standard Trimean approach [12-13].

By employing the LotkaVolterra model, this research aspires to examine the relationship between Malaysia's GDP and crude oil price by executing the numerical approach. This paper discusses methodology and method utilized in Section 2, discloses the empirical result in Section 3, and offers the conclusion in Section 4.

2. METHODOLOGY

2.1. The LotkaVolterraModel

The LotkaVolterra model or known as predator-prey model manifested the competing associations between the two species. It is a system of differential equations. Next, it was introduced into economics to analyze the competition or joint marketing. The following mechanism [14] demonstrates the Lotka-Volterra model of two species, X and Y .

$$\begin{cases} \frac{dX}{dt} = aX - bX^2 - cXY \\ \frac{dY}{dt} = pY - qY^2 - rYX \end{cases} \quad (1)$$

The expressions X^2 and Y^2 disclose intercommunications within species, XY and YX exhibit intercommunion of distinct species. a and p parameters symbolize the ability of growing for X and Y 's population respectively. Besides, b and q parameters are the limiting parameter of decrease in size of populations, while c and r parameters signify the competition rate between the two species. The parameters c and r

signs render the type of relationship between species as disclosed in Table 1, being proposed by [15].

Table 1. Type of interaction between species according to the sign of parameters c and r

Sign of c	Sign of r	Type of Interaction	Explanation
+	+	Pure competition	When both species hurt from each other's presence, it materializes.
+	-	Predator-prey	When one of them works as an immediate food source to the other, it takes place.
-	-	Mutualism	In the atmosphere of a win-win circumstance or symbiosis, it comes to pass.

2.2. Dataset

Both data was sourced from World Databank from 2009 to 2018 and measured in fixed 2010 US dollar prices. The yearly data of GDP per capita growth was obtained from World Development Indicators. While, the annual data of crude oil (Brent) price as a benchmark oil price was obtained from World Bank Commodity Price Data. This research used panel data of Malaysia, which covers ten years after the 2007-2008 Global Financial Crisis.

2.3. Fitting Lotka-VolterraModel to Data of GDP of Malaysia and Crude Oil Price Using Python

Typically, data scientists employ Python as one of the most common

programming languages [16]. Scipy is a Python library that comprises diverse capacities for scientific computing and data analysis [17]. The function *ode.int* represents a conventional ODE integrator for numerically solving system of coupled ordinary differential equations (ODEs). It finds the solution by using *lsoda* from the FORTRAN library odepack as granted by scipy.

The *fminoptimiser* was imported from scipy to determine the optimum parameter that improves the LotkaVolterra model appropriateness to GDP data of Malaysia and crude oil price. The *fminoptimiser* practices the downhill simplex algorithm to obtain the minimum of the objective function beginning from a guessing point.

The algorithm for the methods to utilise the LotkaVolterra model to simulate the interaction of GDP and crude oil price using scipy is shown in Algorithm 1.

Algorithm 1

Set the model equation
Set the ODE integrator

Generating the data to fit the system of ODEs

$X = \text{GDP per capita (constant 2010 US\$)}$
 $Y = \text{crude (Brent) oil price (constant 2010 US\$)}$

Set up info for the system of ODEs
define the model initial parameter a, b, c, p, q, r ,
define the model initial conditions of X and Y
define the model steps start time and end time

Set score fit the system of ODEs
define the solution to the system
define the pick of model points to compare
define the score difference between model and data point

Find the best fit of parameter of the system of ODEs

define the optimization function

Generate solution to system
define the new model parameter

Output
Display the new model parameter
Display the predicted value of X and Y

3. RESULTS AND DISCUSSION

We applied the model (1) to the dataset of GDP in Malaysia and crude oil price using optimisation function from scipy Python. The GDP per capita (US\$) is designated as X, and that the crude (Brent) oil price (US\$/barrel) as Y. By adopting the optimisation method, we employ data from 2009 to 2018 to set up the model system:

$$\begin{cases} \frac{dX}{dt} = 108.5947X + 0.0006X^2 + 165 \\ \frac{dY}{dt} = -19.2231Y - 17.8718Y^2 - 0. \end{cases} \quad (2)$$

From our simulation result, $c = -165.8933$ and $r = 0.0019$ for the GDP and crude oil price, respectively. The value of parameter $c < 0, r > 0$, it follows that the GDP in Malaysia and crude oil price are in prey-predator relationship according to Table 1. We conclude that crude oil price as the role of predator inhibited the GDP in Malaysia as the role of prey in economic growth.

The crude oil price rise is anticipated to push the universal price standard, and unfavorably move the economy. It is plausible as a predator-prey correlation exists between crude oil price and GDP. Also, crude oil contributes a vital energy resource to Malaysia's industries. The economic growth of Malaysia is hence dependent on an uninterrupted supply of energy and any shock to energy supply will hurt economic growth as Malaysia is the second-largest oil producer in Southeast Asia [18].

It is, in fact, possible that crude oil energy prices are endogenous, concerning the macroeconomic condition of Malaysia. The increased energy prices will produce macroeconomic externalities due to consumers and firms altering their expenditures on durable and non-durable goods and decreasing their consumption of energy, bringing down overall consumption and negatively impacting the GDP.

Oil price hikes caused ten of the latest slumps. It is possible due to inflation levels and lay-off [19]. Public's various feedbacks, uniquely business members and families, were the consequences of the increment in oil price in the local industry. Working as a prevalent energy resource to Malaysia's enterprises, the oil prices boost is anticipated to affect the price level, and stir the marketplace unfavorably. It applies, particularly to homes. Costlier oil prices immediately propose exercising a higher per cent of their wages designated for gasoline costs. Moreover, monetary sense experiences decrease and negatively disturbs their expenses and need for services and goods due to the inflation that emerges from more expensive oil prices.

From Figure 1, it is evident that the price of crude oil has somewhat evolved. Starting from year 2018 until year 2019, there was a visible fluctuation. It progresses and sinks. From the perspective of economy, economic data from Malaysia decreased market understandings of the slowdown in economic motion. The real gross domestic product (GDP) had been released by The Department of Statistics Malaysia (DOSM) as shown in Figure 2. Malaysia's economy grew 3.6 per cent in the fourth quarter of 2019. From both figures (Figure 1 and Figure 2), it shows that when crude oil price as the role of predator increase, then the performance of Malaysia economy as the role of prey were decline.



Figure 1. Brent crude oil price for twoyears' period
(<https://www.macrotrends.net/2480/brent-crude-oil-prices-10-year-daily-chart>)

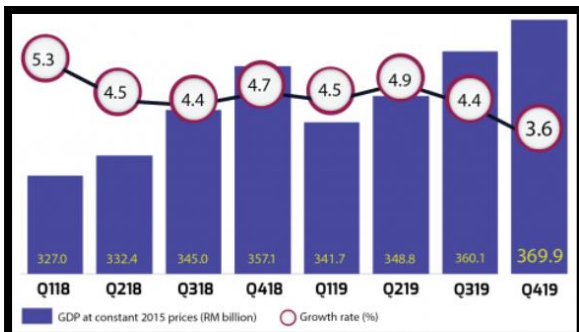


Figure 2. Malaysia Economic Performance from first quarter of 2018 to fourth quarter of 2019 (real GDP) (Department of Statistics Malaysia)

For the GDP per capita every year, the actual values and the predicted values of the optimisation method are presented in Table 2. The MAPE of optimization method is 0.00009% which means that optimisation method from scipy Python provides very high accuracy prediction performance. The MAPE value for the predicted GDP in 2018 is 0% which mean the prediction capability is very high accuracy by using optimised numerical method.

For the crude oil price, the actual values and the predicting values of the optimisation method are presented in Table 3. The MAPE of optimisation method is 2.68294% which indicates that the optimisation method renders compelling accuracy prediction performance. The MAPE value for the

predicted crude oil price in 2018 is 0.71654% which express the prediction capability at a very high accuracy level by using optimised numerical method.

Table 2. Predicting values of GDP per capita and MAPE

Year	Actual Value GDP (USD)	Predicting Value GDP (USD)
2009	8559.23	8559.23
2010	9040.57	9040.57
2011	9372.01	9372.03
2012	9743.10	9743.10
2013	10 061.72	10 061.72
2014	10 524.07	10 524.10
2015	10 912.15	10 912.16
2016	11 219.63	11 219.64
2017	11 720.74	11 720.74
MAPE		0.00009%
2018	12 109.49	12 109.49
MAPE		0%

Table 3. Predicting values of crude oil price (COP) and MAPE

Year	Actual Value COP (\$/bbl)	Predicting Value COP (\$/bbl)
2009	64.13	64.13
2010	79.64	84.79
2011	99.91	94.16
2012	101.58	100.41
2013	99.19	102.63
2014	91.4	90.57
2015	53.51	54.43
2016	46.84	45.55
2017	55.91	56.98
MAPE		2.68294%
2018	69.78	69.28
MAPE		0.71654%

This optimisation method also employed by [20] to examine the relationship between GDP and Malaysia's foreign direct investment (FDI). Both results of MAPE of optimisation method

point very high accuracy prediction performance and outstanding prediction accuracy performance for GDP and FDI, respectively. It reveals that the optimiser *fmin* search algorithm in Python can be used in order to determine the parameter of the LotkaVolterra model.

4. CONCLUSION

In this article, we were examining Malaysia's gross domestic product (GDP) and Brent crude oil price as a paramount criterion for global oil acquisition. The optimum value of parameters a, b, c, p, q and r were obtained by applying the concept of optimisation *fmin* search algorithm in Python. The sign of the estimated parameters of c and r recognized the type of relationship according to Table 1. From our simulation result, $c = -165.8933$ and $r = 0.0019$ for the GDP and crude oil price, respectively. Ergo, the GDP and the crude oil price manifested the prey-predator relationship. The negative c and positive r proved that the world crude oil price influenced Malaysia's GDP, and both of them competed for economic growth in Malaysia.

MAPE value of Malaysia GDP and crude oil price designate compelling foresight performance which is 0.00009% and 2.68294% respectively. Besides, both the accuracy value of the foretold value of Malaysia GDP and crude oil price for 2018 too present very high prediction performance which is 0% and 0.71654% respectively. It points out that the numerical approach with *fmin* optimiser algorithm can be adopted to gain optimised parameter of the LotkaVolterra model by applying data of Malaysian GDP and crude oil price.

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