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PERFORMANCE EVALUATION OF FOOD AND BEVERAGES INDUSTRY IN MALAYSIA USING GRA MODELS

FACTORS AFFECTING THE DIAGNOSIS OF ISCHEMIC HEART DISEASE

OPTIMAL VITAMINS INTAKE TO MAINTAIN A HEALTHY DIET USING WEIGHTED GOAL PROGRAMMING

SELECTION OF INSTITUTE FOR PUBLIC HIGHER EDUCATION (IPTA) AMONG FIRST-YEAR STUDENTS USING FUZZY AHP

IMPLEMENTATION OF NEWTON DIVIDED DIFFERENCE INTERPOLATION METHOD ON THE EFFECTS OF INFLATION RATE ON THE UNEMPLOYMENT RATE IN POLAND

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1. Introduction

Poland's economy has done very well over the past 20 years, despite the fact that the country has no natural resources, a low debt leverage, and a slow growth rate compared to other European countries (Piatkowski, 2018). These changes that happen in the process of economic development in Poland contribute to wide representation, especially for Central and Eastern European economies (Hunter and Ryan, 2005). Inflation is a steady rise in prices that can affect a country's economic growth, employment, investment, wealth distribution, social and political situations, and even its social and political climate (Mohseni and Jouzaryan, 2016). A person who is willing to work but is unable to obtain employment is considered to be unemployed (Garrido and Toharia, 2004). Numerous academics have discussed how important it is to control inflation and unemployment for the economic development of various societies (Mohseni and Jouzaryan, 2016). When there is financial stress due to inflation, unemployment rates increase, which means the inflation needs to be controlled from getting higher to lower rates (Singh, 2018). Most people think that when inflation is high and out of the blue, it hurts businesses and consumers and causes people to lose their jobs (Barro, 2013). Singh (2018) examines how inflation is causing issues by increasing the price level and decreasing the purchasing power of money. Besides, inflation also leads to financial problems that affect many people.

This study aims to estimate the best equation that fits the available data set to define the relationship between inflation rate and the unemployment rate. To find an approximation function, the interpolation method which is the process of finding the values of y for any intermediate value of x between a and $a+nh$ can be applied (Dass, 2008). Without making certain assumptions about the characteristics of a function, it is impossible to interpolate a generic function. It is expected that it is regular in the interpolation interval and that a function may be used to estimate it over the specified interval (Datta, 2003). The process of solving the interpolation problem is generally categorised into two smaller problems; (1) to find an interpolation function $p(x)$ (the computation of $f(x)$ is replaced by that of $p(x)$) and (2) to evaluate the interpolation error (when $f(x)$ is replaced by $p(x)$, the interpolation error is introduced) (Radi and El Hami, 2018). The interpolation methods include the Newton Divided Difference Interpolation Method, Lagrange Interpolating Method and Neville's Method. In this study, however, the Newton Divided Difference Interpolation Method is used because it is easy to go from a polynomial of order $n-1$ to a polynomial of order n, which is a higher order. Hence, the Newton Divided Difference Interpolation Method is applied to approximate a polynomial function given its value at a finite set of points.

2. Methodology

In this section, the implementation of Newton Divided Difference Interpolation Method to approximate the polynomial equation will be discussed (Chapra, 2011). The ($n-1$)th-order polynomial is defined by:

$$f_{n-1}(x) = b_1 + b_2(x - x_1) + ... + b_n(x - x_1)(x - x_2)...(x - x_{n-1}) \tag{1}$$

n data points such as $[x_1, f(x_1)], [x_2, f(x_2)], ..., [x_n, f(x_n)]$ are required to construct the (*n-1*)th-order polynomial equation. These data points and the following equations are used to evaluate the coefficients $b_1, b_2, ..., b_n$:

$$b_1 = f(x_1) \tag{2}$$

$$b_2 = f[x_2, x_1] \tag{3}$$

$$b_3 = f[x_3, x_2, x_1] \tag{4}$$

$$\vdots$$

$$b_n = f[x_n, x_{n-1}, ..., x_2, x_1] \tag{5}$$

where the bracketed function evaluations are finite divided differences. For example, the first finite divided difference and the second finite divided difference, which represents the difference of two first divided differences are defined generally as follows respectively:

$$f[x_i, x_j] = \frac{f(x_i) - f(x_j)}{x_i - x_j} \tag{6}$$

$$f[x_i, x_j, x_k] = \frac{f[x_i, x_j] - f[x_j, x_k]}{x_i - x_k} \tag{7}$$

Similarly, the *n*th finite divided difference is defined as:

$$f[x_n, x_{n-1}, ..., x_2, x_1] = \frac{f[x_n, x_{n-1}, ..., x_2] - f[x_{n-1}, x_{n-2}, ..., x_1]}{x_n - x_1} \tag{8}$$

These differences can be used to evaluate the coefficients in Eqs. (2) to (5). The coefficients are then substituted into Eq. (1) to construct the general form of Newton Divided Difference Interpolating polynomial:

$$f_{n-1}(x) = f(x_1) + (x - x_1) f[x_2, x_1] + ... + (x - x_1)(x - x_2)...(x - x_{n-1}) f[x_n, x_{n-1}, ..., x_2, x_1] \tag{9}$$

So, once the polynomial function is obtained, the absolute error, *E*=|True value-Approximated value| is computed to measure how far off a measurement is from the actual value.

The data about the inflation rate (x) and unemployment rate (y) in Poland is shown in Table 1. The Newton Divided Difference Method is applied to approximate the polynomial equation for the given data set. To implement the Newton Divided Difference Interpolation Method, the points should be ordered so that they are centered around and as close as possible to the unknown data (Chapra, 2011). The mathematical analysis is then performed using Maple software version 2022.

Table 1: Inflation Rate against the Unemployment Rate in Poland

Inflation rate (x)	Unemployment rate (y)
2.9	3.2
3.0	3.5
3.1	3.3
3.2	3.4
3.3	3.4
3.4	3.1

3. Result and Discussion

Table 2 shows the finite divided differences (DD) table of the x and y values. By using the Newton Divided Difference Interpolation Method, the approximation polynomial function of degree 5, $P_5(x) = -379241.4001 + 597457.4669x - 376139.1668x^2 + 118291.6667x^3 - 18583.33334x^4 + 1166.666667x^5$ is obtained. The unique 5th-order polynomial equation fits the given 6 data points.

Table 2: Finite Divided Differences

x	y	First DD	Second DD	Third DD	Fourth DD	Fifth DD
2.9	3.2					
		3				
3.0	3.5		-25			
		-2		133.3333		
3.1	3.3		15		-500	
		1		-66.6667		1166.6667
3.2	3.4		-5		83.3333	
		0		-33.3333		
3.3	3.4		-15			
		-3				
3.4	3.1					

The results in Table 3 shows that the Newton Divided Difference Interpolation Method is able to find the approximated polynomial function. Also, Microsoft Excel 2019 is used to figure out the accuracy of the equation by calculating the absolute error. The largest absolute error is found to be equal to 0.0003, which is close to zero and can be thought of as a small error. So, the equation fits the data sets because the absolute error for each data point is small and near zero.

Table 3: Approximation Value of Unemployment Rate and Its Absolute Error

Inflation rate (x)	Unemployment rate (y)	$\hat{y}$	E
2.9	3.2	3.1999	0.0001
3.0	3.5	3.4998	0.0002
3.1	3.3	3.2998	0.0002
3.2	3.4	3.3998	0.0002
3.3	3.4	3.3998	0.0002
3.4	3.1	3.0997	0.0003

4. Conclusion

The Newton Divided Difference Interpolation Method is successfully applied to approximate the polynomial function in analysing the effects of inflation on the unemployment rate in Poland. The function can be used to estimate the values of the unemployment rate corresponding to a given inflation rate on the basis of the range of a discrete set of known data points. Since the smaller absolute error is achieved, the polynomial function of degree 5 fits the given data set. It can be concluded that the polynomial function suits the values of the finite set points. Hence, the objective of the study is achieved. Another interpolation method, namely the Lagrange Interpolation Method, can also be applied to approximate the polynomial function of the same degree. The Lagrange Interpolation Method is a reformulation of the Newton polynomial by avoiding the computation of divided difference (Chapra and Canale, 2006). Another advantage

of the Lagrange formula is that it is independent of the order in which the points are arranged (Berrut and Trefethen, 2004).

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