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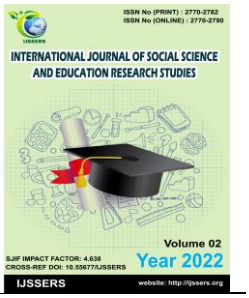

Mathematical Modelling of the Number of Philippines Population

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ABSTRACT

The population of the Philippines keep increasing and many other aspects that affects from the growth of the population. This study focused on what best fits models being used to predict the main variable which the population in specific year. The researcher uses different statistical tool that is available in Microsoft Excel Data Analysis ToolPack to create a model. From that result, the researcher easily chooses where the best fit model is and predicts the main variable. Also, the researcher uses simple linear regression and multiple linear regressions to determine if the main variable has statistically significant relationship to the other variable. Based on the results, the best fit models are the polynomial which is sextic. As a result, the research found out that every year the population increase inconsistently.

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Keywords:
Mathematical Modeling, Best Fit Model, Population, Regression

1. INTRODUCTION

The elements that affect population structure and growth are crucial to sustainable development. Numerous nations have previously voiced their worries about rapid population expansion and begun drafting reproductive health legislation (UNFPA, 2012). Bremmer et al (2010) stressed that unbalanced population expansion puts strain on the environment, human well-being, and global warming. However, the decreased population growth rates are causing worry in industrialized nations and several middle-income economies. Due to this scenario, the number of people in working age has decreased, the population is aging quickly, and there are issues with the labor force's ability to be renewed and the viability of the social security and healthcare systems (UN DESA, 2011). It is important to note that the wavering official stance on the importance of reducing fertility rates continues to this day.

The Philippines had the 12th-highest population in the world in 2011. (CIA, 2013). The Philippines' population growth rate is higher than that of the 11 most populous nations, with the exception of Nigeria (UN DESA, 2012). The Philippines' slowing population growth rate is still greater than the 1.19 percent global average (UN DESA, 2012; POPCOM, 2013).

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Jones (2013) stated that even India and China will have slower population growth than the Philippines. The Philippines will see Southeast Asia's largest relative population growth during the following 20 years, nonetheless. The Philippines' gradual fall in population growth and persistently high total fertility rate can be attributed to this (Pastrana and Harris, 2011; NSO, 2012a). High fertility is caused by unwelcome pregnancy and a desire for a larger family beyond two kids (Bongaarts and Bruce, 1998).

The 1987 Philippine Constitution, which expressly guarantees "the right of couples to form their family and freely choose the number of their children based on their religious beliefs and the demands of responsible parenthood," continues to be the basis for population policies and programs in the Philippines (Osias et al., 2010). According to an assessment by the Philippines Institute of Development Studies, the Philippine government's population policies, which target fertility and population increase, did not remain consistent under several administrations (Herrin, 2002).

The RH Bill ensures that all people have access to reproductive health services and products, such as contraception, family planning, health and sexuality education, prenatal care, and maternal care (Senate, 2009). The RH Bill has effects on population growth and fertility even if its primary goal is to address whole family health. The original RH Bill (Section 20) states that while encouraging families to have two children and the State shall promote in achieving the desired size of families. However, having more

than two children is not punishable and this is neither necessary nor compulsory (Congress, 2013). In general, Virola and Martinez (2007) emphasized that having two children is ideal for eventually taking care of your aging parents. Researchers think that there is a correlation between poverty and household size for the majority of cases in the Philippines. Hence, this study focusses on the best fit model to predict the population in the Philippines on certain year.

II. STAEMENT OF THE PROBLEM

This study aimed to determine the best fit model to predict the main variable. Specifically, this aimed to:

1. Determine the trend of the number of population from the government expenditures to employment rate.
2. Find if the number of population has significant linear relationship with following variables;
   a. Government Expenditures
   b. Inflation Rate
   c. Employment Rate
3. Construct time series model of the main variable using the following models to predict the percentage for 2020.
   a. Linear
   b. Quadratic
   c. Exponential
   d. Polynomial (cubic, quartic, quantic, sextic)
   e. Power
   f. Moving Average
   g. Exponential Smoothing
   h. Auto regression
4. Determine the best fits models and predict the main variable for 2020.

III. RESULTS

SECTION 1: TREND OF THE NUMBER OF POPULATION FROM THE GOVERNMENT EXPENDITURES TO EMPLOYMENT RATE.

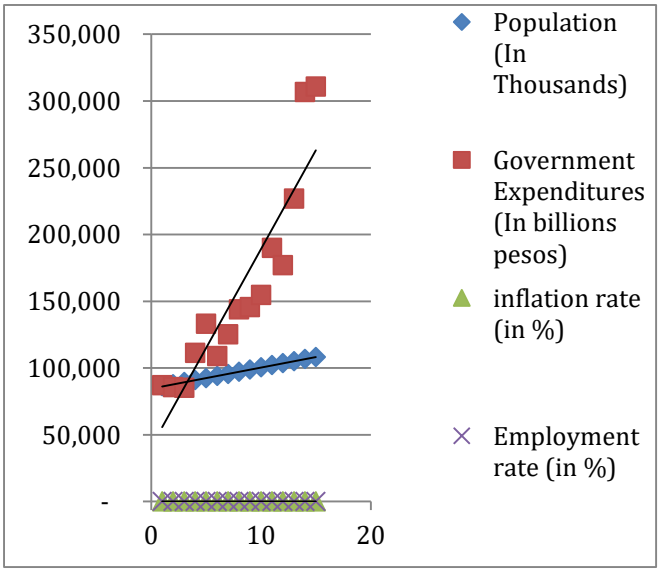


Figure 1. The Trend of the Population from Government Expenditures To Employment Rate.

SECTION 2: SIGNIFICANT LINEAR RELATIONSHIP

2.1 Government Expenditures

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.910218004
R Square	0.828496814
Adjusted R Square	0.815304262
Standard Error	31193.5311
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	61107016853	6.11E+10	62.80034	2.47984E-06
Residual	13	12649472974	9.73E+08		
Total	14	73756489827			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-753706.3621	115513.2433	-6.52485	1.93E-05	-1003257.552	-504155.172	-1003257.552	-504155.1718
Population (In Thousar	9.389740957	1.1848752	7.924667	2.48E-06	6.829973714	11.9495082	6.829973714	11.9495082

Figure 2. Simple Linear Regression of Population to the Government Expenditures

The summary results stated that there is statistically significant relationship between the Philippines population and Government Expenditures, wherein the Significance F value which is 0. 00000247 is less than at alpha of 0.05.

2.2 Inflation Rate

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.594685084
R Square	0.35365035
Adjusted R Square	0.303931146
Standard Error	1.584411895
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	17.85607964	17.85608	7.112953	0.019374232
Residual	13	32.6346937	2.510361		
Total	14	50.49077333			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	19.46863601	5.867259983	3.318182	0.00555	6.793191439	32.1440806	6.793191439	32.14408057
Population (In Thousa	-0.00016051	6.01833E-05	-2.66701	0.019374	-0.000290528	-3.0491E-05	-0.000290528	-3.04915E-05

Figure 3. Simple Linear Regression of Population to the Inflation Rate

The summary results stated that there is statistically significant relationship between the Philippines population and Inflation Rate, wherein the Significance F value which is 0. 01937 is less than at alpha of 0.05.

2.3 Employment Rate

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.929792464
R Square	0.864514026
Adjusted R Square	0.854092028
Standard Error	0.417905366
Observations	15

ANOVA

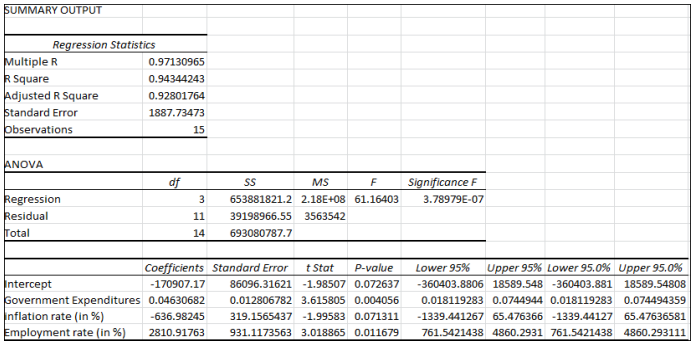
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	14.4869497	14.48695	82.95089	5.26153E-07
Residual	13	2.27038363	0.174645		
Total	14	16.75733333			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	79.58627336	1.547551767	51.42721	2.08E-16	76.24299103	82.9295557	76.24299103	82.9295557
Population (In Thousa	0.000144576	1.5874E-05	9.107738	5.26E-07	0.000110282	0.00017887	0.000110282	0.00017887

Figure 4. Simple Linear Regression of Population to the Employment Rate

The summary results stated that there is statistically significant relationship between the Philippines population and Employment Rate, wherein the Significance F value which is 0. 000000526 is less than at alpha of 0.05.

2.4. Philippines population, Government Expenditures, Inflation rate, and Employment Rate



SUMMARY OUTPUT

Regression Statistics

Multiple R	0.97130965
R Square	0.94344243
Adjusted R Square	0.92801764
Standard Error	1887.73473
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	653881821.2	2.18E+08	61.16403	3.78979E-07
Residual	11	39198966.55	3563542		
Total	14	693080787.7			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-170907.17	86096.31621	-1.98507	0.072637	-360403.8806	18589.548	-360403.881	18589.54808
Government Expenditures	0.04630682	0.012806782	3.615805	0.004056	0.018119283	0.0744944	0.018119283	0.074494359
Inflation rate (in %)	-636.98245	319.1565437	-1.99583	0.071311	-1339.441267	65.476366	-1339.44127	65.47636581
Employment rate (in %)	2810.91763	931.1173563	3.018865	0.011679	761.5421438	4860.2931	761.5421438	4860.293111

Figure 5. Multiple Linear Regression of Philippines population, Government Expenditures, Inflation rate, and Employment Rate

The summary results stated that there is significant multiple linear relationship or models among the Philippines population, Government Expenditures, Inflation rate, and Employment Rate, wherein the Significance F value which is 0. 0000003789 is less than at alpha of 0.05.

SECTION 3: TIME SERIES MODEL

The following are the data collected from the PSA and NSO annual report.

Table 1. Data from PSA and NSO from 2005 - 2019

Year (2005 - 2019)	Population (In Thousands)	Government Expenditures (In billions pesos)	inflation rate (in %)	Employment rate (in %)
1	86,326	86998	7.1	92.3
2	87,889	85698	7.6	92.7
3	89,405	85177	6.2	92.2
4	90,902	111265	2.8	93.2
5	92,414	133028	2.8	92.4
6	93,967	109017	3.0	93.1
7	95,570	125196	4.7	93.6
8	97,213	143994	2.8	93.0
9	98,872	145546	3.0	93.5
10	100,513	154793	4.1	94.0
11	102,113	190037	1.4	94.3
12	103,664	176987	1.8	95.3
13	105,173	226868	2.9	95.0
14	106,651	306627	5.2	94.6
15	108,116	310815	2.5	95.5

Based on figure 1 and section 2 analysis, below are the results of the equation of each model.

Table 2. Model Equation

Model	Equation
Linear	$y = 1573.1x + 84667$
Exponential	$y = 85207e^{0.0162x}$
Logarithmic	$y = 8439\ln(x) + 81556$
Quadratic	$y = 0.2423x^2 + 1569.3x + 84678$
Cubic	$y = -1.3999x^3 + 33.841x^2 + 1347.2x + 85021$
Quartic	$y = -0.1196x^4 + 2.4278x^3 - 6.4358x^2 + 1501.7x + 84862$
Quantic	$y = 0.0405x^5 - 1.7409x^4 + 25.914x^3 - 155.05x^2 + 1889x + 84563$
Sextic	$y = 0.0009x^6 - 0.0046x^5 - 0.9069x^4 + 18.486x^3 - 122.48x^2 + 1825.5x + 84603$
Power	$y = 82381x^{0.0879}$
Moving Average	$y = 1581.1x + 83025$
Exponential Smoothing	$y = 1499.8x + 82385$
Autoregression	$y=1686.3044+0.9987y_{n-1}$

SECTION 4: BEST FIT MODEL PREDICTION

The following summary table are the models of the main variable with R^2 and Standard Error.

Table 3. Model Equation, R^2, and Standard Error

Model	Equation	R^2	SE
Linear	y = 1573.1x + 84667	0.9998	104711.0931
Exponential	y = 85207e$^{0.0162x}$	0.9989	1.972002302
Logarithmic	y = 8439ln(x) + 81556	0.8797	87596.60375
Quadratic	y = 0.2423x^2 + 1569.3x + 84678	0.9998	104711.7932
Cubic	y = -1.3999x^3 + 33.841x^2 + 1347.2x + 85021	1	104711.589
Quartic	y = -0.1196x^4 + 2.4278x^3 - 6.4358x^2 + 1501.7x + 84862	1	104711.938
Quantic	y = 0.0405x^5 - 1.7409x^4 + 25.914x^3 - 155.05x^2 + 1889x + 84563	1	104706.5744
Sextic	y = 0.0009x^6 - 0.0046x^5 - 0.9069x^4 + 18.486x^3 - 122.48x^2 + 1825.5x + 84603	1	104617.6651
Power	y = 82381x$^{0.0879}$	0.8969	104639.6025
Moving Average (3)	y = 1581.1x + 83025	0.9998	1493.721
Exponential Smoothing	y = 1499.8x + 82385	0.9966	3095.615
Autoregression	y=1686.3044+0.9987y_{n-1}	0.9999	65.9498

Based on the result of Table 3, the best fit model is the Polynomial model which is Sextic to predict the Philippines population because of the R^2=1. In determining the best fit model, the researcher is looking for the value of R^2 and if the value is closest to and 1 is the highest and lowest standard error, that model is the best fit to predict the main variable.

IV. DISCUSSION

The importance of why we need to predict the main variable is for the other researcher and government agency that use to make some alternative support to some social issues involving the continuation increase of the population. By the predicted number of populations, government can maximize and implement some programs and to look the probable solution of having the social issues like the inflation rate and the unemployment rate.

The best fit model is the sextic function wherein, it is the only model has the highest R2, although quartic and quantic are also having the highest R2 but only sextic has lowest Standard of error compare to quartic and quantic.

Using the model which is the Sextic, we have the equation y = 0.0009x6 - 0.0046x5 - 0.9069x4 + 18.486x3 - 122.48x2 + 1825.5x + 84603. If we let x=16 (by year 2020) , the projected Philippines population is equals to 109, 016 (in thousands).

The trend of the Philippines population from government expenditures to employment rate is increasing (see figure 1.1)

There is a significant linear relationship between the main variable and the government expenditures. However, when the variables were combined together, there is linear relationship among them.

The time series models using 2005 – 2019 are y = 1573.1x + 84667 for linear, y = 85207e0.0162x for exponential, y = 8439ln(x) + 81556 for logarithmic, y = 0.2423x2 + 1569.3x + 84678 for quadratic, y = -1.3999x3 + 33.841x2 + 1347.2x + 85021 for cubic, y = -0.1196x4 + 2.4278x3 - 6.4358x2 + 1501.7x + 84862 for quartic, y = 0.0405x5 - 1.7409x4 + 25.914x3 - 155.05x2 + 1889x + 84563 for quantic, y = 0.0009x6 - 0.0046x5 - 0.9069x4 + 18.486x3 - 122.48x2 + 1825.5x + 84603 for sextic, y = 82381x0.0879 for power, y = 1581.1x + 83025 for moving average (3), y = 1499.8x + 82385 for exponential smoothing, and y=1686.3044+0.9987y_(n-1) for autoregression.

The best fit models is Sextic under polynomial. Using thus model the main variable will increase to 109, 016 (in thousands).

V. CONCLUSION

It implies that the increase of population, the other variables like the government expenditures, inflation rate and the employment rate also affected. Based on the results, there is significant multiple linear relationship among the variables, It means that when the population increases, the other variables also affected it may decreases or increases in some manners regardless of the outside unexpected factors can also affects to the other variables.

VI. ACKNOWLEDGMENTS

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VII. DISCLOSURE

There is no conflict of interest in the present study. Rest assured that the privacy of the participants would be respected, and all the data collected treated with outmost confidentiality. Further, the data provided would be transferred to excel in analyzing the data to a specific statistical tool.

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