Estimation of Departmental Students' Intake for Capacity Building and Manpower Planning

Ezeanyim O. C.[1], Okpala C. C.[2], Ezeliora, D. C.[3], Aguh P. S.[4]
[1,2,3,4]*Department of Industrial/Production Engineering, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria*

Abstract: - **In an effort to determine the students intake and the need for adequate infrastructure, space allocation, personnel, as well as accruing revenue planning, a forecast of three academic sessions of 2019, 2020 and 2021, was made for a department within a university. The daunting challenge posed by this lack of information to the various heads of departments could lead to unplanned expenditure and policy summersault. The admission list of students for the Industrial/Production Engineering Department, Faculty of Engineering, Nnamdi Azikiwe University Awka admission unit for eleven consecutive years, was used as a test case for the analysis. The ordinary least square approach was used to determine the expected number of students' intake for the succeeding years under review. The result of time series decomposition analysis showed that approximately 45, 39, and 43 students should be admitted fir 2018/2019, 2019/2020, and 2020/2021 academic sessions respectively. The Mean Absolute Deviation (MAD) and the Mean Absolute Percentage Error (MAPE) of 7.942 and 16.318 respectively were also obtained as forecast performance accuracy measures to validate the results. The adoption of the research findings by the relevant authorities in the university will lead to mot just proper manpower planning, but also efficient capacity building.**

Keywords: forecast, time series, estimation, accuracy measures, mean absolute deviation, mean absolute percentage error

I. INTRODUCTION

The ever increasing quest for education has given rise to the large number of prospecting students seeking admission into various institutions of higher learning in variegated university's departments and programs. According to the Joint Admission and Matriculation Board (JAMB), over one million students applied to about 137 universities and 1347 available courses, in the undergraduate scheme.in 2017, 2018 and 2019 alone, the board recorded over three million applications from students seeking admission into the tertiary institutions within Nigeria.

These huge applications have created numerous challenges for the universities and its departments, despite the quota allotted to it by the Nigerian Universities Commission (NUC). In an attempt to mitigate these challenges, a departmental students' intake estimate was made using previous admission list for a department, using the Ordinary Least Square (OLS) approach, the results established a relationship between the inherent variables. This approach is aimed at improving the capacity planning, infrastructure development, space allocation, personnel financing and other aspects of departmental function and growth.

Arising from this, futuristic planning option, various disruptions and congestions previously experienced with new students will be effectively managed. Such information, when spread across other departments will also aid the university in the improvement of its ranking based on infrastructural adequacy and student-staff ratio for improved academic learning.

II. LITERATURE REVIEW

Pavelescu (2004), highlighted the features of the Ordinary Least Square method in his review and agreed that it is frequently used for parameter estimation of different functional relationships. He equally determined size estimation parameters, coefficients of determination, Fisher and student test for assessment of each estimated parameter. Several scholars have utilized the Ordinary Least Square method or linear regression, in diverse ways to establish a relationship between two variables and in the process, make forecast for succeeding years based on available data [3].

Abazid and Alkoud (2019), deployed the ordinary least square method in determining the corresponding future pharmaceutical sales for three consecutive years using the best fit from available sale data [1]. They concluded that Least Square Method are generally used in data fitting and that the best fit minimizes the residual squared sum [1]. Taylor et al (2015), determined the prices of land for agricultural purposes using data from Kansas City [5]. The result showed price fluctuations across the months of the years under review. A study of fire outbreaks and quantified monetary value of losses was carried out by Sulaimon (2015), using Simple weighted least square regression [4]. The data were analyzed using the SPSS software which showed a very strong relationship between the number of fire outbreaks and the property losses [4].Ezeliora et al (2014), expressed the application of forecasting methods using double exponential smoothing and winters method to estimate the more appropriate production demand in the case they studied [2].

III. RESEARCH METHOD

The research method adopted is the application of time series forecasting methods to estimate the more appropriate method or techniques that will promote the number of students' intake in Industrial/Production Department, Faculty of Engineering, Nnamdi Azikiwe University, Awka, Anambra State.

The number of students admitted for the period of eleven years in the Industrial/Production Engineeringis given in table 1.

Table 1: Departmental Students' Intake for 2008 – 2018

Year	No of Students (y)
2007/08	56
2008/09	42
2009/10	44
2010/11	64
2011/12	44
2012/13	43
2013/14	40
2014/15	36
2015/16	41
2016/17	69
2017/18	34

According to Telsang (2003), where the time series consists of odd number of years, the middle value of the time series is chosen as the origin for $\Sigma_x = 0$ and table 2 depicts this order [6].

Table 2: Secondary data for students' intake for a department for 2008 - 2018

Year	No of Students (y)	Deviation(x)	x^2	xy
1	56	-5	25	-280
2	42	-4	16	-168
3	44	-3	9	-132
4	64	-2	4	-128
5	44	-1	1	-44
6	43	0	0	0
7	40	1	1	40
8	36	2	4	72
9	41	3	9	123
10	69	4	16	276
11	34	5	25	170
	$\sum y = 513$	$\sum x = 0$	$\sum x^2 = 110$	$\sum xy = -71$

+Given that $\Sigma y = Na$ and $\Sigma xy = b\Sigma x^2$

Therefore,

$$a = \frac{\Sigma y}{N} \text{ and } b = \frac{\Sigma xy}{\Sigma x^2} \quad (1)$$

Substituting, we have that;

$$a = \frac{513}{11} = 46.64 \text{ and } b = \frac{-71}{110} = -0.65$$

The straight line equation that best fits is

$$y = 46.64 - 0.65x \quad (2)$$

IV. ANALYSIS AND RESULTS

Arising from the above straight line equation obtained, the number of students in the succeeding years is as shown in table 3.

Table 3: Student data obtained from straight line equation

Year	No of Students (y)
1	56
2	42
3	44
4	64
5	44
6	43
7	40
8	36
9	41
10	69
11	34
12	43
13	42
14	41

Table 4: Descriptive Statistics

	N	Minimum	Maximum	Sum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
No of Students	11	34.00	69.00	513.00	46.6364	3.41992	11.34260	128.655
Valid N (listwise)	11							

Table 4 shows the statistical description of the data. It reveals the minimum, maximum, sum, mean, standard deviation, standard error and variance in the historic data.

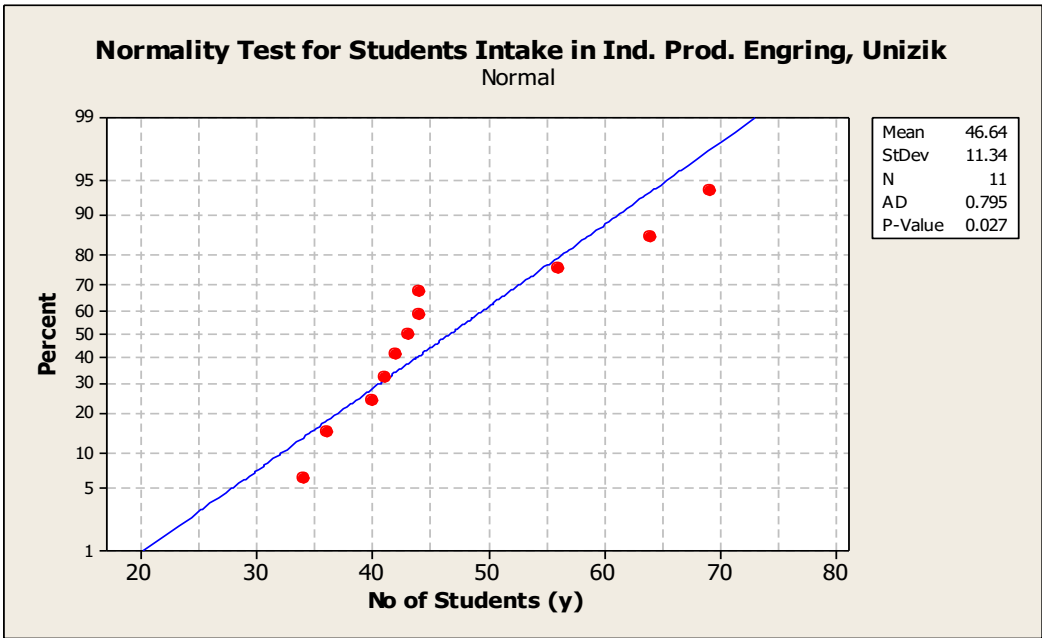

Fig 1: Normality Test for Students Intake in Ind. Prod. Engring, Unizik

The normality plot shows the test of normal fitness of the data. It reveals that the historic data is significance with significance value of 0.027. The value shows that the data is good and fit to model the system.

Table 5: In-sample forecast and associated errors

No of students	forecast	error	/error/	PƐt	‘Ɇ^2	α	α^2
56	49.89	6.11	6.11	12.25%	37.3321	9.36	87.61
42	49.24	-7.24	7.24	14.70%	52.4176	-4.64	21.53
44	48.59	-4.59	4.59	9.45%	21.0681	-2.64	6.97
64	47.94	16.06	16.06	33.50%	257.9236	17.36	301.37
44	47.29	-3.29	3.29	6.96%	10.8241	-2.64	6.97
43	46.64	-3.64	3.64	7.80%	13.2496	-3.64	13.25
40	45.99	-5.99	5.99	13.02%	35.8801	-6.64	44.09
36	45.34	-9.34	9.34	20.60%	87.2356	-10.64	113.21
41	44.69	-3.69	3.69	8.26%	13.6161	-5.64	31.81
69	44.04	24.96	24.96	56.68%	623.0016	22.36	499.97
34	43.39	-9.39	9.39	21.64%	88.1721	-12.64	159.77
					SUMMARY		
						MAE	8.57
						MAPE	18.62
						RMSE	10.62

In-sample forecast performance analysis carried out based on the obtained straight line equation is depicted in Table 5.

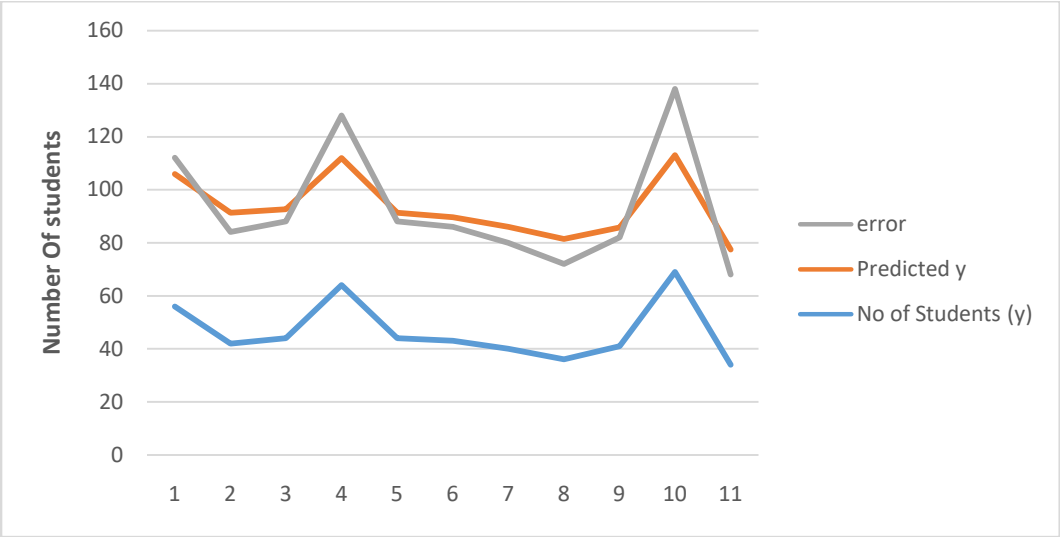

Figure 2: Graph of Actual Number of Students, Forecast and the Associated Error

On a closer look at the forecast results against the actual as well as the residuals, it will be seen that there is a wide margin between actual and forecast as shown in figure 2.

Winters' Method for Number of Students

Winters' method is a time series method of forecast, used to estimate the forecast of the more appropriate number of students necessary to be admitted in Industrial/Production Department. In winters' method, it has two major types of winters' method, namely: additive and multiplicative methods. In this research, multiplicative method is used because; it has more preferred accurate measure and fewer errors in its system when compared with additive method.

Table 6: Time Series Analysis and Forecasting Results

Time	No of Students(y)	Smooth	Predict	Error
2007	56	41.2984	43.6846	12.3154
2008	42	54.4201	57.8148	-15.8148
2009	44	48.3231	50.7654	-6.7654
2010	64	53.2964	55.6388	8.3612
2011	44	51.9704	54.3978	-10.3978
2012	43	59.0414	61.3114	-18.3114
2013	40	49.4601	50.7792	-10.7792
2014	36	53.7936	54.7760	-18.7760
2015	41	44.4813	44.6830	-3.6830
2016	69	47.4392	47.4979	21.5021
2017	34	47.3411	48.1809	-14.1809
Forecasts				
Period	**Forecast**	**Lower**	**Upper**	
2018	53.2271	21.8482	84.6060	
2019	43.5934	11.7230	75.4639	
2020	53.8630	21.4443	86.2816	

Accuracy Measures	
MAPE	28.660
MAD	12.808
MSD	191.510

Table 6 presents time series analysis and its forecasting results for a period of extra three (3) years using winters' forecasting method. The forecasting results showed that in 2018/2019, 2019/2020, and 2020/2021 academic sessions, that the approximate number of students that are to be admitted are 53, 44, and 54 respectively. Furthermore, the forecasts also revealed the lower and upper boundary limits of the forecasts which have ninety five (95) confidence intervals that the forecasting system must be within the specified limits.Finally, it expressed the accuracy measures in students' historic data.

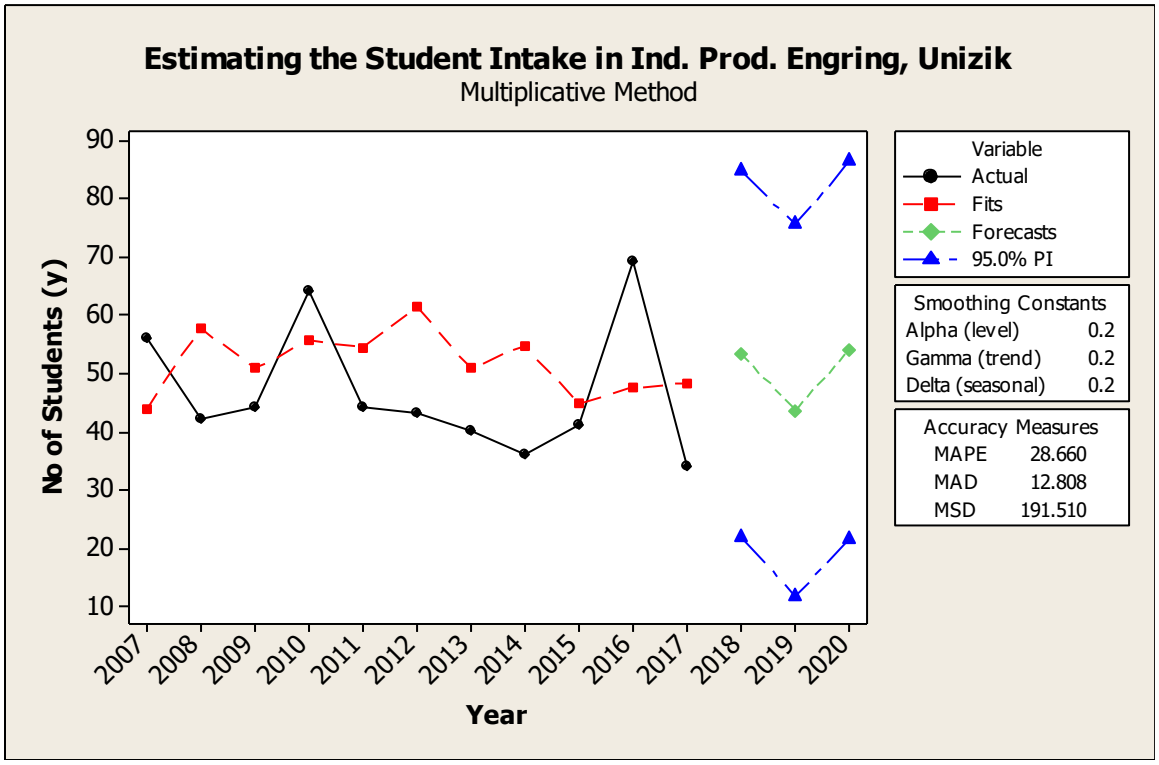

Fig 3: Winters' Method Plot for No of Students

Figure 3 shows the actual data, it's predicted of fits, the forecast of extra three (3) years, the upper and lower probability levels in the forecasting results.

Time Series Decomposition for Number of Students

Time series decomposition method is a time series method of forecast, used to estimate the forecast for more appropriate number of students necessary to be admitted in Industrial/Production Engineering Department. In this research, multiplicative method is used because it has more preferred accurate measure and fewer errors in its system when compared with the additive method.

The Fitted Trend Equation developed and used for the forecast is Yt = 51.23 - 0.736455*t

Table 7: Time Series Decomposition Analysis and Forecasting Results

Time	No of Students(y)	Trend	Seasonal	Detrend	Deseason	Predict	Error
2007	56	50.4895	0.94424	1.10914	59.3070	47.6742	8.3258
2008	42	49.7531	1.05576	0.84417	39.7817	52.5273	-10.5273
2009	44	49.0166	0.94424	0.89765	46.5984	46.2834	-2.2834
2010	64	48.2802	1.05576	1.32560	60.6198	50.9723	13.0277
2011	44	47.5437	0.94424	0.92546	46.5984	44.8926	-0.8926
2012	43	46.8072	1.05576	0.91866	40.7289	49.4173	-6.4173
2013	40	46.0708	0.94424	0.86823	42.3622	43.5018	-3.5018
2014	36	45.3343	1.05576	0.79410	34.0986	47.8622	-11.8622

2015	41	44.5979	0.94424	0.91933	43.4212	42.1111	-1.1111
2016	69	43.8614	1.05576	1.57314	65.3557	46.3072	22.6928
2017	34	43.1250	0.94424	0.78841	36.0078	40.7203	-6.7203

Period	**Forecasts**
2018	44.7521
2019	39.3295
2020	43.1971
Accuracy Measures	
MAPE	16.318
MAD	7.942
MSD	101.036

Table 7 presents time series decomposition analysis and its forecasting results for a period of extra three (3) years using decomposition forecasting method. The forecasting results showed that in 2018/2019, 2019/2020, and 2020/2021 academic sessions, the approximate number of students that are to be admitted are45, 39, and 43 respectively. However, it also expressed the accuracy measures in number of students' historic data.

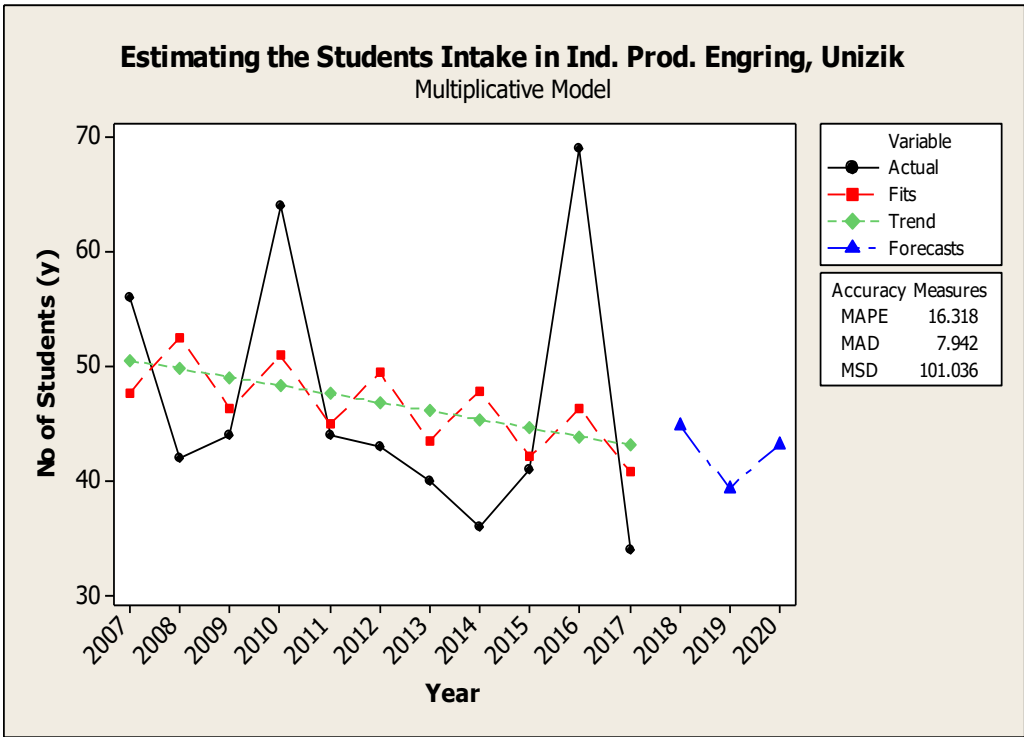

Fig 4: Time Series Decomposition Plot for No of Students

Figure 4 showed the historic data, the forecasts, the data trend and the data fit in the system. It also reveals the accuracy measure in the system. However, the time series decomposition system has the lowest reduced errors in the forecasts

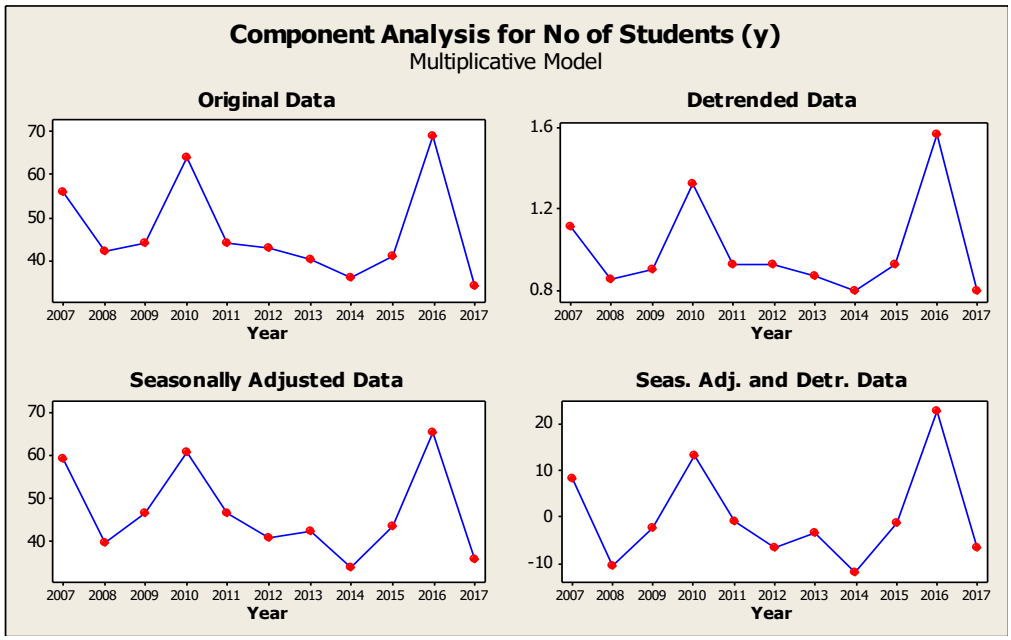

Fig 5: Decomposition - Component Analysis for No of Students

Figure 5 showed the actual data collected, the results of detrend data for number of students. It also expressed the seasonal influence in the data.

Trend Analysis for Number of Students

Time series Trend method is a technique for forecast, used to estimate the forecast for more appropriate number of students necessary to be admitted in the Department. Multiplicative method is used because it has more preferred accurate measure and fewer errors in its system, when compared with the additive method in this forecasting technique.

The Fitted Trend Equation developed and used for the forecasts is Yt = 50.668 * (0.9823**t)

Table 8: Trend Analysis and its Forecasting Results

Time	No of Students	Trend	Detrend
2007	56	49.7697	6.2303
2008	42	48.8876	-6.8876
2009	44	48.0211	-4.0211
2010	64	47.1700	16.8300
2011	44	46.3340	-2.3340
2012	43	45.5128	-2.5128
2013	40	44.7061	-4.7061
2014	36	43.9137	-7.9137
2015	41	43.1354	-2.1354
2016	69	42.3709	26.6291
2017	34	41.6199	-7.6199
Forecasts			
Period	Forecast		
2018	40.8823		
2019	40.1577		
2020	39.4459		
Accuracy Measures			
MAPE	15.824		
MAD	7.984		
MSD	113.995		

Table 8 presents trend analysis, accuracy measures and its forecasting results for a period of extra three (3) years using trend forecasting method. The forecasting results showed that in 2018/2019, 2019/2020, and 2020/2021 academic sessions, the approximate number of students that are to be admitted are 41, 40, and 39 respectively. However, it also expressed the accuracy measures in number of students' historic data.

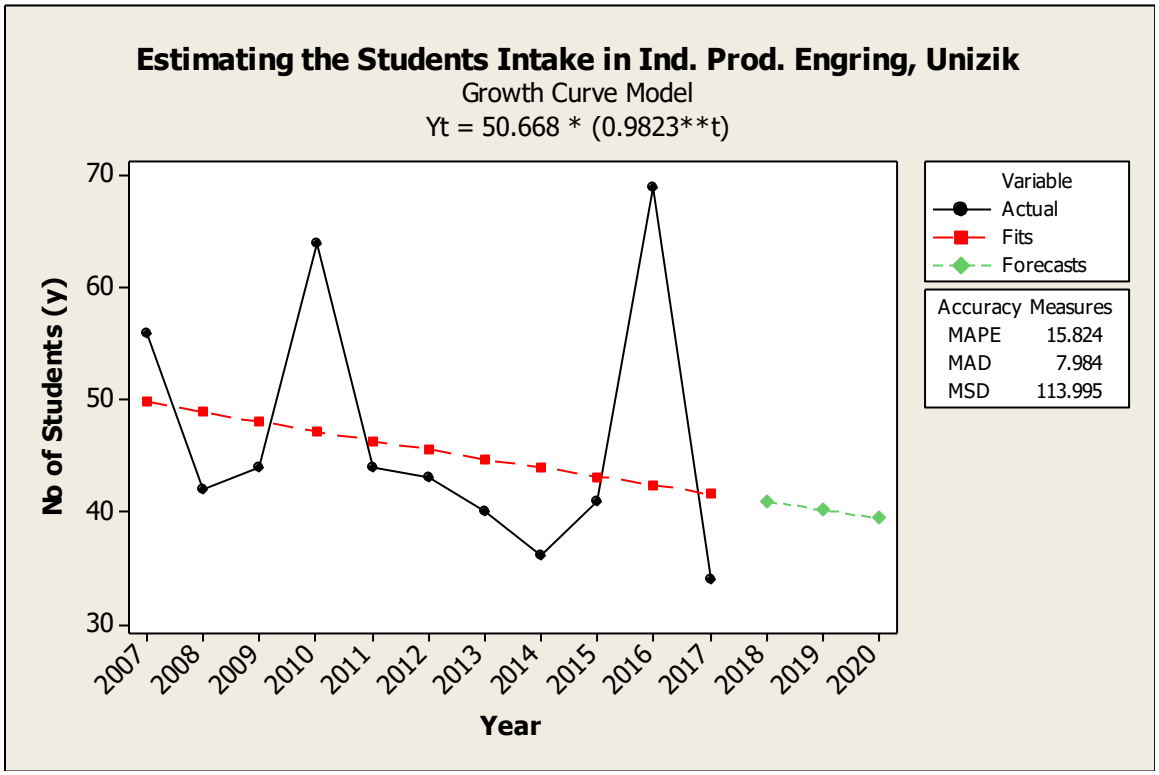

Fig 7: Trend Analysis Plot for No of Students

Figure 7 presents the historic data, the forecasts, the data trend and the data fit in the system. It also reveals the accuracy measure in the system. However, the time series decomposition system has the lowest reduced errors in the forecasts

V. CONCLUSION

This research focused on the estimation of the more appropriate solution to the number of student intake in Industrial/Production Engineering, Faculty of Engineering, Nnamdi Azikiwe University, Awka, Anamnbra State, Nigeria. The application of Least Square methods, Trend Analysis, Decomposition analysis and winters' method showed the more appropriate forecasting results to be adopted. The most probable forecasting results to be adopted is based on the forecasting techniques with the least accuracy measures influence.

The Ordinary Least Square method has been effectively deployed in developing a model which predicted students' admission intake for a department within a university using past students records. The trend analysis, decomposition analysis and Winters' method have been effectively deployed in developing models which predicts students' admission intake for the same case study using past records of students. The more appropriate result is that of decomposition analysis which expressed 45, 39, and 43 approximately as the number of students expected for admission in the 2019, 2020 and 2021 sessions respectively.

The Mean Absolute Deviation (MAD) and the Mean Absolute Percentage Error (MAPE) of 7.942 and 16.318 respectively were also obtained as forecast performance accuracy measures to validate the results. The research will serve as a guide in admission unit for the studied department.

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