Regression Analysis Based Effective Manpower Planning Methodology: A Case Study

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Authors' contributions

This work was carried out in collaboration between both authors. Author BOA designed the study and wrote the protocol. Author RKA managed the analyses of the study and wrote the first draft of the manuscript. Both authors managed the literature searches, developed the model, designed the software and wrote the final manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Adequate staff-students ratio (SSR) is one of the important National Universities Commission (NUC) prescribed criteria to be implemented in manpower planning by Universities in Nigeria. Forecasting manpower requirement has been used for economic planners and even the academic sector. In other to avoid imbalance, the manpower requirement is very vital in determining the desired output in a system. This study is aimed at predicting the adequate manpower required in a unit of an academic institution. Manpower related data of the Mechanical Engineering Department, Federal University of Technology, Akure Nigeria were collected. The data collected includes manpower capacity and students population over a period of thirteen consecutive years. The regression analysis based model was formulated and applied to analyze the collected data. Based on the analyzed data, trends of $y_s = 170.31 + 30.96x_s$, $Y = 7.70 + 0.04X$, and $Y = 8.59 + 0.02X$ are obtained respectively for the student's population size, lecturers and technical staff requirements, where x_s and X are economic indicators. The obtained trends equations were then subsequently applied to compute SSRs and recommendations were made. The developed model was implemented in a computer software, using the Visual Basic programming language, in order to

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facilitate its solution procedure. The outcome of this study will aid the management of the institution in effective manpower determination and students number projection in future years. This will also assist the institution to plan for effective SSR based on the recommendation of NUC.

1. INTRODUCTION

Manpower planning is an important factor that determines the level at which production facilities are being utilized to achieve the desired objectives of an organization. Manpower requirement of any organization has to be planned for, just as we budget for the amount of money to be spent [1,2]. It is important to note that an organization would suffer a huge setback if the manpower structure is not properly settled. The rate at which the production facilities are being transformed into goods and services depends greatly on the manpower structure. In this sense, low-performance manpower operates at low productivity rate as a result of some factors likeability, age, capacity, health status etc., while high-performance manpower can operate at a high productivity rate.

Moreover, it is expected that a high performing worker should be more efficient than a low performing one, in terms of transforming resources into goods and/or services [3]. But, this will be done at a higher cost as well. It is also worthy to note that, not all duties require highly skilled workers. Some duties can be done effectively by low performing staff, especially when they are subjected to proper training and re-training. Hence, to minimize cost, appropriate manpower should be employed based on the available production capacity, time and skill of operation required.

Many quantitative techniques have been applied to determine effective size of manpower to be engaged at a particular time. The most common among them include the Workload method [4-8], Maintenance times analysis [9], Dynamic programming [10], Multiple Activities Process Chart [11], Queuing System [12-14]. Moreover, different models have been developed and applied in this line of study. Among them are descriptive-predictive model [15], normative model [16,17] and lognormal model [18]. Optimisation approach was applied for optimal staffing, based on forecast demand, in [19] and to increase organisation's competitiveness through effective manpower planning in [20]. A conceptual approach to explore the significance of manpower planning has also been carried out in some studies. In [21], the impact of effective manpower planning was conducted on personnel service performance and on the academic standard in [22].

In an academic institution, where there are various duties requiring different skills, such as research, teaching, administrative and technical duties, it is imperative to schedule personnel to duties based on skill and requirement. Also, there is a prescribed criterion regarding staff-students ratio (SSR) which must be implemented by institutions. This ratio, according to the National Universities Commission (NUC), ensures adequate teaching and learning in academic institutions [22]. However, in developing nations like Nigeria, the manpower structure is in a way such that personnel are either over-worked or under-worked. Hence, SSR mostly falls short of the recommended level in various institutions. This problem can be solved by proper manpower requirement determination.

This study aims at establishing models to determine the number of students and respective level of manpower requirements in a technical department of an institution in Nigeria. This will aid the institution to plan for effective SSR based on the recommendation of NUC. Solution procedure of the developed models is implemented in a computer software using Visual Basic programming language. The paper is organised as follows: Methodology used is presented in Section 2. Section 3 presents results and discussion of findings. Finally, conclusions on the presented work are given in Section 4.

2. METHODOLOGY

In achieving the objective of this study, data were collected, classified, analyzed and a regression model was formulated based on the data analyzed. The academic unit whose data was studied is the Mechanical Engineering Department of the Federal University of Technology, Akure, Nigeria. The data were

collected through the use of a questionnaire and oral interviews. The data that were collected include the numbers of students, lecturers and technical staff in the department for a period of thirteen (2005/2006 to 2017/2018) consecutive academic years.

The regression method of least squares was applied in estimating the trend from the collected data. The trend for the number of manpower required (lecturers and technical staff) depends on the number of students which serves as the economic indicator.

The data of thirteen years of the students' population was used to determine the projected number of students for the next seven years. The projected trend of the number of students was then determined as in Equation (1), in which the economic indicator is the serial number of each year

$$y_s = a + bx_s \qquad (1)$$

y_s is projected trend of the number of students, x_s is economic indicator being used for the prediction and a, b are parameters of the regression equation.

The economic indicator used in Equation (1) is the serial number of each year in order. To determine the values of constants a and b, Equations (2) and (3) were solved simultaneously.

$$\sum y_s = na + b \sum x_s \qquad (2)$$

$$\sum x_s y_s = a \sum x_s + b \sum x_s^2 \qquad (3)$$

Similarly, the data of thirteen years of the number of different classes of manpower, which include academic and technical staff, were used to determine the respective numbers of academic and technical staff required for the next seven years. The projected trend of each of these classes of manpower can be determined using Equation (4). The trend equation, in each case, is a measure of the staff-students equation/relationship, in which the economic indicator is the number of students (independent variable).

$$Y = A + BX \qquad (4)$$

Y is number of manpower, X is an economic indicator (number of students) and A, B are parameters of the regression equation.

The regression parameters can be determined by solving Equations (5) and (6) simultaneously.

$$\sum Y = NA + B \sum X \qquad (5)$$

$$\sum XY = A \sum X + B \sum X^2 \qquad (6)$$

N is the number of observed data.

The degree of agreement of the formula with real data was determined by the coefficient of correlation r which is given as in Equation (7)

$$r = \sqrt{1 - \frac{\sum(Y_a - Y_c)^2}{\sum(Y_a - \bar{Y})^2}} \qquad (7)$$

Y_a is actual value of the dependent variables (i.e. manpower), Y_c is calculated value found from the trend line and $\bar{Y}$ is average of the actual values of the dependent variables. The rule of thumb for interpreting the coefficient of correlation r is as given in Table 1.

Table 1. Interpretation of correlation coefficient r

Value of r	Interpretation
$0.90 - 1.00$	Very high correlation
$0.70 - 0.90$	High correlation
$0.40 - 0.70$	Moderate correlation
$0.20 - 0.40$	Low correlation
$0.00 - 0.20$	Slight correlation

Source: [9]

2.1 Data Collection

As this study involves academic staff manpower determination in a department of an institution, data relating to lecturers and technical staff were collected. These entail personnel involved in academic activities, such as teaching, research and lab work in the department under study. The data were extracted from the institution's admin units with the aid of interviews, questionnaires and surveys. Data collected span 2005/2006 to 2017/2018 academic session. Data relating to students population over the stated period of years were also obtained. These served as an economic indicator in the analysis of manpower determination.

Obtained raw data of students' population and academic staff (lecturers and technical staff) are presented in Tables 2, 3 and 4 respectively.

2.2 Data Analysis

The trend equations of the number of students and manpower requirements were determined by analysing the data collected on the students and staff population over the thirteen years under review. These were done respectively as in

Tables 5, 7 and 9. The trend equation in each case was then used to determine the projected number of students respectively, and staff requirements in the next seven years, as presented in Tables 6, 8 and 10. The trend equations developed (mathematical models) was implemented in computer software developed using Visual Basic programming language.

Table 2. Collected data for students population at various levels (academic year)

Session	100 level	200 level	300 level	400 level	500 level
2005/2006	46	61	40	56	19
2006/2007	41	68	59	30	22
2007/2008	52	59	60	57	43
2008/2009	74	59	54	64	40
2009/2010	80	68	55	54	50
2010/2011	79	77	68	55	63
2011/2012	70	58	70	59	49
2012/2013	105	100	95	90	90
2013/2014	105	108	102	92	88
2014/2015	108	110	105	100	90
2015/2016	110	110	101	94	90
2016/2017	115	115	106	97	91
2017/2018	120	117	112	105	101

Table 3. Collected data for lecturers in various ranks

Session	P	R	SL	LI	LII	AL	GA
2005/2006	2	-	1	4	2	4	3
2006/2007	2	-	1	4	2	4	3
2007/2008	2	-	1	4	2	4	3
2008/2009	2	1	2	3	6	6	-
2009/2010	2	1	2	3	6	6	-
2010/2011	2	2	3	2	5	6	1
2011/2012	2	2	3	2	5	6	1
2012/2013	2	2	3	2	5	6	1
2013/2014	2	1	3	7	5	5	2
2014/2015	2	1	3	8	5	5	3
2015/2016	2	1	3	10	6	4	2
2016/2017	2	1	3	13	4	4	2
2017/2018	2	1	4	11	4	4	5

Key: P- Professor, R- Reader, SL- Senior Lecturer, L1- Lecturer I, LII- Lecturer II, AL- Assistant Lecturer, RA- Research Assistant

Table 4. Collected data for technical staff in various ranks

Session	CT	ACT	ST	TI	TII	SS	HC	SLA
2005/2006	1	1	1	1	2	2	3	2
2006/2007	1	1	1	1	2	2	2	2
2007/2008	1	1	1	2	2	2	2	2
2008/2009	1	1	1	2	2	2	3	2
2009/2010	1	1	1	2	2	2	4	3
2010/2011	1	1	1	1	2	2	4	3
2011/2012	1	1	1	1	2	2	4	3
2012/2013	1	1	3	2	2	2	4	3
2013/2014	1	1	3	3	2	2	3	3
2014/2015	1	1	3	3	2	2	3	3
2015/2016	1	1	3	3	2	2	3	3
2016/2017	1	1	4	3	2	2	3	3
2017/2018	1	1	4	3	2	2	3	3

Key: CT- Chief Technologist, ACT- Assistant Chief Technologist, ST- Senior Technologist, TI- Technologist I, TII- Technologist II, SS- Senior W/S Supervisor, HC- Head Craftman, SLA- Senior Lab Assistant

Table 5. Analysis of data of students' population

Year	No of students (y_s)	x_s	x_s^2	$x_s y_s$
2005/2006	222	1	1	222
2006/2007	220	2	4	440
2007/2008	271	3	9	813
2008/2009	291	4	16	1164
2009/2010	307	5	25	1535
2010/2011	342	6	36	2052
2011/2012	306	7	49	2142
2012/2013	480	8	64	3840
2013/2014	495	9	81	4455
2014/2015	513	10	100	5130
2015/2016	505	11	121	5555
2016/2017	524	12	144	6288
2017/2018	555	13	169	7215
$n = 13$	$\sum y_s = 5031$	$\sum x_s = 91$	$\sum x_s^2 = 819$	$\sum x_s y_s = 40851$

Substituting these values in Equations (5) and (6) gives

$$5031 = 13a + 91b$$

$$40851 = 91a + 819b$$

By solving the above equations simultaneously, the regression parameters were obtained as

$$a = 170.31, b = 30.96$$

Therefore the trend equation for the student population was determined by substituting the values of a and b in Equation (4). That is,

$$y_s = 170.31 + 30.96x_s$$

Hence, the trend values for the thirteen years and the projected trend values for the students' population in the next seven years are presented in Table 6.

Table 6. Students' population trend values for the thirteen years and projected values for the next seven years

Year	Students population $y_s = 170.31 + 30.96x_s$	y_s
2005/2006	$= 170.31 + 30.96(1)$	201.27
2006/2007	$= 170.31 + 30.96(2)$	232.23
2007/2008	$= 170.31 + 30.96(3)$	263.19
2008/2009	$= 170.31 + 30.96(4)$	294.15
2009/2010	$= 170.31 + 30.96(5)$	325.11
2010/2011	$= 170.31 + 30.96(6)$	356.07
2011/2012	$= 170.31 + 30.96(7)$	387.03
2012/2013	$= 170.31 + 30.96(8)$	417.99
2013/2014	$= 170.31 + 30.96(9)$	448.95
2014/2015	$= 170.31 + 30.96(10)$	479.91
2015/2016	$= 170.31 + 30.96(11)$	510.87
2016/2017	$= 170.31 + 30.96(12)$	541.83
2017/2018	$= 170.31 + 30.96(13)$	572.79
The projected trend values of students' population for the next seven years:		
2018/2019	$= 170.31 + 30.96(14)$	603.75
2019/2020	$= 170.31 + 30.96(15)$	634.71
2020/2021	$= 170.31 + 30.96(16)$	665.67
2021/2022	$= 170.31 + 30.96(17)$	696.63
2022/2023	$= 170.31 + 30.96(18)$	727.59
2023/2024	$= 170.31 + 30.96(19)$	758.55
2024/2025	$= 170.31 + 30.96(20)$	789.51

The degree of agreement of the calculated data, using the trend equation, with the real data is determined by the coefficient of correlation r which is given in Equation (7). The correlation analysis parameters are determined and presented as thus

$$\sum (y_a - y_c)^2 = 15471.66$$

$$\sum (y_a - \bar{y})^2 = 189878$$

$$r = \sqrt{1 - \frac{15471.66}{189878}}$$

$$= 0.958$$

Table 7. Analysis of data of lecturers' population

Year	No of students (X)	No of lecturers (Y)	X^2	XY
2005/2006	222	16	49284	3552
2006/2007	220	16	48400	3520
2007/2008	271	16	73441	4336
2008/2009	291	20	84681	5820
2009/2010	307	20	94249	6140
2010/2011	342	21	116964	7182
2011/2012	306	21	93636	6426
2012/2013	480	21	230400	10080
2013/2014	495	25	245025	12375
2014/2015	513	27	263169	13851
2015/2016	505	28	255025	14140
2016/2017	524	29	274576	15196
2017/2018	555	31	308025	17205
$N = 13$	$\sum X = 5031$	$\sum Y = 291$	$\sum X^2 = 2136875$	$\sum XY = 119823$

Table 8. Lecturers' population trend values for the thirteen years and projected values for the next seven years

Year	Lecturers population $Y = 7.70 + 0.04X$	Y
2005/2006	$= 7.70 + 0.04(222)$	16.58
2006/2007	$= 7.70 + 0.04(220)$	16.50
2007/2008	$= 7.70 + 0.04(271)$	18.54
2008/2009	$= 7.70 + 0.04(291)$	19.34
2009/2010	$= 7.70 + 0.04(307)$	19.98
2010/2011	$= 7.70 + 0.04(342)$	21.38
2011/2012	$= 7.70 + 0.04(306)$	19.94
2012/2013	$= 7.70 + 0.04(480)$	26.90
2013/2014	$= 7.70 + 0.04(495)$	27.50
2014/2015	$= 7.70 + 0.04(513)$	28.22
2015/2016	$= 7.70 + 0.04(505)$	27.90
2016/2017	$= 7.70 + 0.04(524)$	28.66
2017/2018	$= 7.70 + 0.04(555)$	29.90
The projected trend values of lecturers' population for the next seven years:		
2018/2019	$= 7.70 + 0.04(603.75)$	31.85
2019/2020	$= 7.70 + 0.04(634.71)$	33.09
2020/2021	$= 7.70 + 0.04(665.67)$	34.33
2021/2022	$= 7.70 + 0.04(696.63)$	35.57
2022/2023	$= 7.70 + 0.04(727.59)$	36.80
2023/2024	$= 7.70 + 0.04(758.55)$	38.04
2024/2025	$= 7.70 + 0.04(789.51)$	39.28

Substituting these values in Equations (5) and (6) gives

$291 = 13a + 5031b$

$119823 = 5031a + 2136875b$

Solving the resulting expressions simultaneously gives

$a = 7.70, b = 0.04$

Therefore, the trend equation for the lecturers' population was determined by substituting the values of a and b in Equation (4). That is

$Y = 7.70 + 0.04X$

Hence, the trend values for the thirteen years and the projected trend values for the lecturers' population in the next seven years are presented in Table 8.

The degree of agreement of the calculated data, using the trend equation, with the real data is determined by the coefficient of correlation r which is given in Equation (7). The correlation analysis parameters are determined and presented as thus

$$\sum (Y_a - Y_c)^2 = 52.63$$

$$\sum (Y_a - \bar{Y})^2 = 317.08$$

$$r = \sqrt{1 - \frac{52.63}{317.08}}$$
$$= 0.913$$

Substituting these values into equations (5) and (7) gives

$208 = 13a + 5031b$

$84130 = 5031a + 2136875b$

By solving the above equations simultaneously gives

$a = 8.59, b = 0.02$

Therefore the trend equation for the technicians' population is determined by substituting the values of a and b in Equation (4). That is,

$Y = 8.59 + 0.02X$

Hence, the trend values for the thirteen years and the projected trend values for the technicians' population in the next seven years are presented in Table 10.

The degree of agreement of the calculated data, using the trend equation, with the real data is determined by the coefficient of correlation r which is given in Equation (7). The correlation analysis parameters are determined and presented as thus

$$\sum (Y_a - Y_c)^2 = 6.007$$

$$\sum (Y_a - \bar{Y})^2 = 74$$

$$r = \sqrt{1 - \frac{6.007}{74}}$$
$$= 0.959$$

Table 9. Analysis of data of technicians' population

Year	No of students (X)	No of technicians (Y)	X^2	XY
2005/2006	222	13	49284	2886
2006/2007	220	12	48400	2640
2007/2008	271	13	73441	3523
2008/2009	291	14	84681	4074
2009/2010	307	16	94249	4912
2010/2011	342	15	116964	5130
2011/2012	306	15	93636	4590
2012/2013	480	18	230400	8640
2013/2014	495	18	245025	8910
2014/2015	513	18	263169	9234
2015/2016	505	18	255025	9090
2016/2017	524	19	274576	9956
2017/2018	555	19	308025	10545
N = 13	$\sum X = 5031$	$\sum Y = 208$	$\sum X^2 = 2136875$	$\sum XY = 84130$

Table 10. Technicians' population trend values for the thirteen years and projected values for the next seven years

Year	Technicians population $Y = 8.59 + 0.02X$	Y
2005/2006	$= 8.59 + 0.02(222)$	13.03
2006/2007	$= 8.59 + 0.02(220)$	12.99
2007/2008	$= 8.59 + 0.02(271)$	14.01
2008/2009	$= 8.59 + 0.02(291)$	14.41
2009/2010	$= 8.59 + 0.02(307)$	14.73
2010/2011	$= 8.59 + 0.02(342)$	15.43
2011/2012	$= 8.59 + 0.02(306)$	14.71
2012/2013	$= 8.59 + 0.02(480)$	18.19
2013/2014	$= 8.59 + 0.02(495)$	18.49
2014/2015	$= 8.59 + 0.02(513)$	18.85
2015/2016	$= 8.59 + 0.02(505)$	18.69
2016/2017	$= 8.59 + 0.02(524)$	19.07
2017/2018	$= 8.59 + 0.02(555)$	19.69
The projected trend values of technicians' population for the next seven years:		
2018/2019	$= 8.59 + 0.02(603.75)$	20.67
2019/2020	$= 8.59 + 0.02(634.71)$	21.28
2020/2021	$= 8.59 + 0.02(665.67)$	21.90
2021/2022	$= 8.59 + 0.02(696.63)$	22.52
2022/2023	$= 8.59 + 0.02(727.59)$	23.14
2023/2024	$= 8.59 + 0.02(758.55)$	23.76
2024/2025	$= 8.59 + 0.02(789.51)$	24.38

3. RESULTS AND DISCUSSION

The analyses of data obtained on the students and staff numbers for a period of thirteen years yield the trend equations of $y_s = 170.31 + 30.96x_s$, $Y = 7.70 + 0.04X$, and $Y = 8.59 + 0.02X$ respectively for the students' population size, lecturers and technical staff requirements. As presented in Tables 6, 8 and 10, the trend equations were used to determine the respective trend values for the thirteen years under study. The correlation coefficient analyses also yield correlation coefficients r of 0.958, 0.913 and 0.959 respectively for the relationship between the actual values and calculated trend values (using the trend equation). This indicates a very high correlation between actual data and calculated trend value in the cases of students and staff (manpower) data. Consequently, the trend equations are used to determine the projected number of students as well as the number of manpower required in the next seven years.

Fig. 1 presents the trend of students' population in the thirteen years under review and the projected number of student in the next seven years as determined using the trend equation. Fig. 2 presents the graphical representation of the number of manpower trends over the thirteen years and the next seven years. It was observed that students' population size increases almost linearly with the year. Level of manpower determined over this period also follows a similar trend.

To evaluate the compliance of obtained SSR against the recommendation of NUC (as presented in Table 11), SSRs of the department, for the years under review, are plotted against the NUC's recommended SSR. This is presented in Fig. 3. It was observed that SSR of the department conforms to NUC recommendation in the first seven years (2005/2006 to 2011/2012) under review. It, however, falls short of the recommended value over the next six years (2012/2013 to 2017/2018) and it was projected that this trend will continue in the next seven years (2018/2019 to 2024/2025) under projection. In fact, based on calculated trends for the students' population size and manpower requirement, this trend tends to continue unless adequate manpower is added to break even.

Having successfully demonstrated the application of the developed model, it was then implemented in a computer software using Visual Basic programming language. The data input

and results interfaces of the computer software developed for the established mathematical models are presented in Figs. 3 and 4 respectively. This software was validated by comparing its results with the manually calculated result and both give similar results.
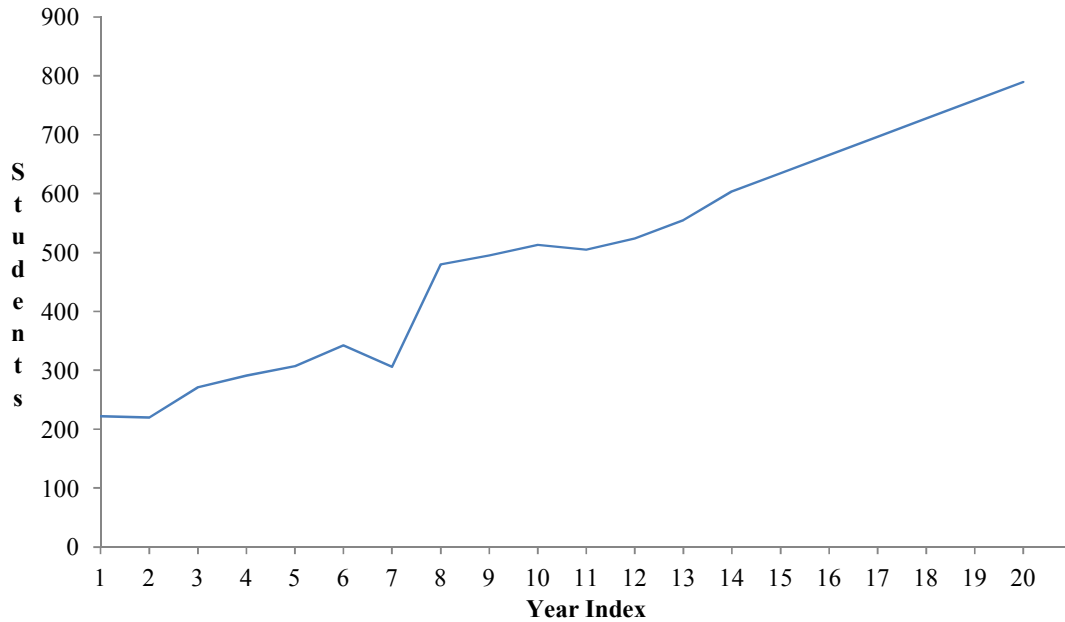

Fig. 1. Students' population in the thirteen years and next seven years

Table 11. Calculated staff-students ratio (SSR) in comparison against NUC recommendation [22]

| Year	No of students	No of academic staff	SSR (Calculated)	SSR (NUC recommendation)
2005/2006	222	29	0.13	0.11
2006/2007	220	28	0.13	0.11
2007/2008	271	29	0.11	0.11
2008/2009	291	34	0.12	0.11
2009/2010	307	36	0.12	0.11
2010/2011	342	36	0.11	0.11
2011/2012	306	36	0.12	0.11
2012/2013	480	39	0.08	0.11
2013/2014	495	43	0.09	0.11
2014/2015	513	45	0.09	0.11
2015/2016	505	46	0.09	0.11
2016/2017	524	48	0.09	0.11
2017/2018	555	50	0.09	0.11
Projected trend values				
2018/2019	603	52	0.09	0.11
2019/2020	634	54	0.09	0.11
2020/2021	665	56	0.08	0.11
2021/2022	696	58	0.08	0.11
2022/2023	727	60	0.08	0.11
2023/2024	758	62	0.08	0.11
2024/2025	789	64	0.08	0.11
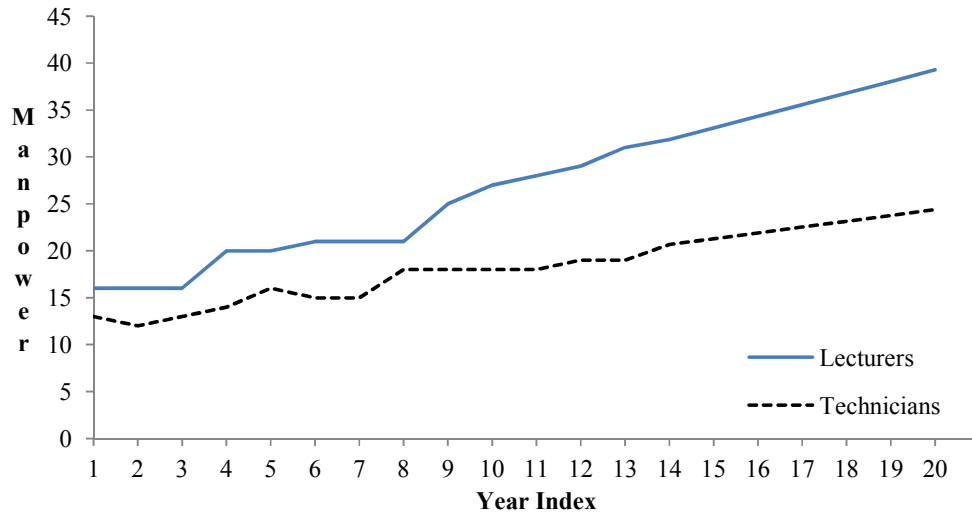
Fig. 2. Manpower requirements for the thirteen years and next seven years
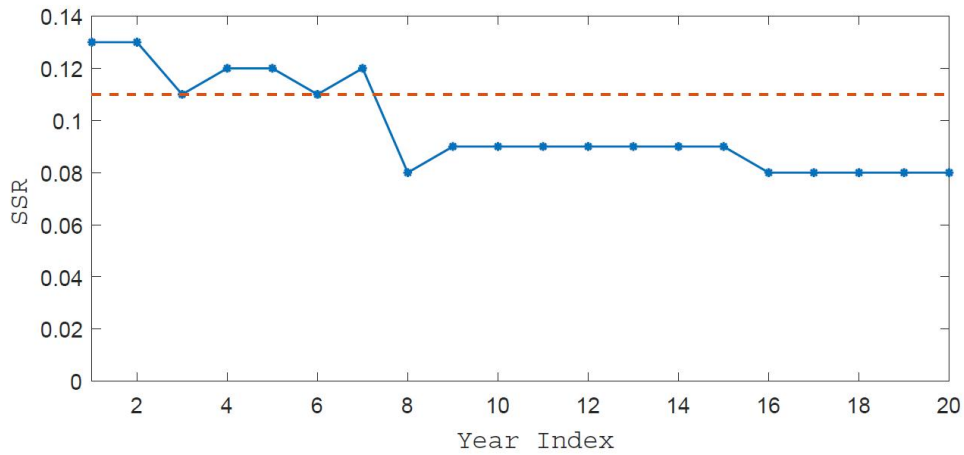
Fig. 3. Comparison of the calculated Staff-Student ratio (-*) against NUC recommendation (- -)

(a)

10

(b)

Fig. 4. Data input interface of the computer software: (a) Lecturers, (b) Technical staff

Fig. 5. Results Interface for the required manpower

4. CONCLUSION

Data on the students' population and academic staff were collected from the Mechanical Engineering Department, Federal University of Technology, Akure, Nigeria. These were analyzed and mathematical models established, using the regression-based method. This led to the determination of the trend values of students' population and manpower requirement over the period of years in view and to forecast the level of manpower required in any future year. The projected number of students and the respective level of manpower requirement determined through the established models will have high accuracy because it was also established that the mathematical models have a very high correlation with the actual data. These were then applied to calculate SSRs and compared against NUC recommendation. This

was done for the years under review and for the projected future years.

It was observed that the department's SSRs have fallen short of NUC recommended value for a period of six consecutive years, and based on projected calculations, it was also observed that this trend will continue over the coming years. Based on these observations, it is recommended that more academic staff are needed in the department in order to meet NUC set criteria on SSR.

The developed mathematical models were also implemented in a computer software using the Visual Basic programming language to facilitate its solution procedure. The study has given insight into how best manpower can be effectively planned in a technical department of an institution. The study is versatile and can be

adapted to all departments in the institution and the entire institution as a whole.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Gray H. Manpower planning and management, operations research. Emerald Group, New York. 1975;21(6)220-255.
2. Wajiga H, Ndaghu JT. Significance of manpower planning for effective utilisation of human resources in an organisation: A conceptual approach. International Journal of Business and Management Invention. 2017;6(8):16-22.
3. Apalowo RK, Ogedengbe TI. A model for optimum scheduling of non-resumable jobs on parallel production machines with multiple availability constraints. Journal of Mechanical and Civil Engineering (IOSR-JMCE). 2015;12(1)37-46.
4. Omolayole MO. Effective human resource management: Pivot to real national development. Institute of Personnel Management Annual Public Lecture, Victoria Island, Lagos; 1996.
5. Banjoko SA. Human resource management: An expository approach, Saban Publishers, Lagos; 1996.
6. Folayan O. Personnel management: Theories and issues. Panaf Publishing, Lagos; 1998.
7. Fajana S. Human resource management: Labofin and Company Publisher, Lagos Island, Nigeria; 2002.
8. Fapetu OP, Kareem B. An effective manpower planning approach for maintenance department. Global Journal of Pure Applied Science. 2003;2(2).
9. Sodiku JI. Planning for scheduled maintenance work in Nigerian industries. Nig. J. Eng. Management. 2001;2:20-24.
10. Aderoba AA. Manpower planning for new jobshops. Nigeria Journal of Engineering Management. 2000;1:24-34.
11. Lindley RH. Maintenance engineering handbook. McGraw-Hill Inc., USA; 1988.
12. Aderoba AA, Kareem B. Development of commercial industrial maintenance centres in Nigeria. Proceeding of the 1997 International Engineering Conference, Nigeria; 1997.
13. Rao PS, Rao VSP. Personnel and human resources management: Text, cases and garnes. Kanast Publishers Ltd. 1993;220.
14. Kareern B, Aderoba AA. Local content development in the Nigerian economy. Proceeding of the National Engineering Conference and Annual General Meeting, Warri; 2004.
15. Howard JW. Production and operations management. Allyn and Bacon Inc. Massachusetts. 1989;332.
16. Lee HT, Kao C. Demand for industrial management manpower in Taiwan. International Journal of Manpower. 1998;19(8):592-602.
17. Lee SM, Park SH, Yoon SN, Yeon SJ. A dynamic manpower forecasting model for the information security industry. Industrial Management and Data Systems. 2008;108(3):368-384.
18. Lane K, Andrew G. Management total quality in global environment. UK Basil Blackwell Publishers Limited, Oxford; 1955.
19. Sing CP, Love PE, Tam CM. Multiplier model for forecasting manpower demand. Journal of Construction Engineering and Management. 2012;138(10):1161-1168.
20. Noel T, Charles F, Devanna M. Human resources management. McGraw Hill Publishers, New York; 2004.
21. Igbokwe-Ibeto CJ, Osadeke KO, Anazodo RO. The effect of manpower planning and development in Lagos State (Nigeria) Civil Service Performance. Africa's Public Service Delivery and Performance Review. 2015;3(4):76-116.
22. Oribabor OA. Impact of national universities commission accreditation exercise on university administrative structure. African Research Review. 2008;2(3):222-234.

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