UNIVERSITY OF PORT HARCOURT

STATISTICS HAS IT THAT…

An Inaugural Lecture

BY

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Acknowledgements

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- The Academic Officer and Personnel Officer (Academic) for providing relevant data on the list of Inaugural Lecturers and their promotion dates respectively.

- To the Vice-Chancellor; for giving me the opportunity to deliver this lecture barely two years of attaining the rank of professor. I consider myself lucky to have a waiting time of two years.
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Finally, I am without words to thank my wife, Flo for all she is to me.

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Vice-Chancellor,
Deputy Vice-Chancellors
Members of Governing Council
Principal Officers
Provost, College of Health Sciences
Dean, School of Graduate Studies
Deans of Faculties
Professors, Directors and Heads of Departments
Distinguished Colleagues
Our Unique Students
Distinguished Audience
Ladies and Gentlemen.

Preamble

I welcome you all to the 57th inaugural lecture of our Unique University, the 12th in the Faculty of Science and of course the maiden entry by the Department of Mathematics and Statistics into the roll call of inaugural lecturers. It is really an honour, a privilege and a challenge for a Professor to be accorded the opportunity to stand before you to face "this public hearing conducted on a Professor" otherwise called inaugural lecture.

It is however, a greater challenge and problem for a Professor in the Mathematical Sciences to address this heterogeneous audience without luring them to sleep with much of mathematical expressions. I will therefore try as much as possible to make this presentation less mathematical, while at the same time urging you to up your residual appreciation of at least mathematical symbols and the impressions they convey. Indeed, in all the inaugural lectures I have come across in the mathematical sciences, none is found wanting in mathematical expressions; I am as such following a tradition.

Introduction

Diagrammatic presentation of inaugural lectures in our University.

Inaugural lectures have to do with the professors, hence it becomes imperative to present some facts about the Professors vis-à-vis inaugural lectures.

Table 1: Number of Professors by Faculty

	Faculty						
Session	**Educa -tion**	**Enginee-ring**	**Health Science**	**Humaniti es**	**Mgt. Sci.**	**Sci-ence**	**Soc. Sci**
1996/97	8	2	7	14	1	11	8
1997/98	7	3	6	14	1	12	7
1998/99 & 1999/00	9	5	8	12	2	13	6
2000/01	11	7	8	12	3	16	9
2001/02	11	4	11	13	3	18	10
2002/03	13	5	10	10	3	19	10
2003/04	Not applicable						
2004/05	Not available						
2005/06	17	8	21	21	3	25	12
2006/07	Not available						

Source: University Brochures: June 1998-March, 2007.

Table 2: Professors and Inaugural Lectures.

Faculty	No. of Professors	No. of Inaugural lectures (%)	Avg. waiting time before inaugural lectures (in yrs)*
Education	17	9(53%)	8
Engineering	8	4(50%)	4
Health Sciences	21	12(57%)	3
Humanities	21	11(52%)	5
Mgt. Sciences	3	1(33%)	Not Applicable
Sciences	25	11(44%)	6
Soc. Sciences	12	8(67%)	6
Total	107	56 (52%)	-

* The time interval between becoming a professor and giving inaugural lecture is the waiting time.

Mr. Vice Chancellor, Sir, based on the above tables, a statistician may be interested in a whole range of issues, questions, answers, solutions, expectations and decisions. e.g comparison between or amongst faculties, years, individual versus average performance of these factors. How many inaugural lectures are we expecting from each faculty (indeed the University) in the year 2008? What is the expected number of persons to become Professors in the year 2008 and even beyond?. Is the number growing as the years go by and at what rate? This will obviously guide the university administration, to think of budgeting for their salaries, cost of hosting their inaugural lectures and other sundry issues about them.

Mr. Vice-Chancellor, Sir, distinguished audience you will appreciate that for instance there may be a difference between the expected number of Professors and the actual number of Professors come 2008. The difference between this expected number and the actual number is the margin of error in our estimation. It is this error that the statistician is expected to minimize in order to arrive at optimal decisions.

Rationale For Title

Very often, we hear or read the statements: statistics has it that… or according to statistics, some events were observed to happen. These statements are made when we want to assert our positions with "facts and figures". For instance, it is said that Nigeria is the most populous black nation in the world. This is driven home with the assertion that statistics has it or according to statistics, one out of every four black Africans is a Nigerian. It gives you a clearer picture and quantifies how populous Nigeria is among the comity of black nations. However, we need to appreciate that in an attempt to present "facts and figures" a third component falsehood or error creeps in. It is this falsehood or error (which may be unintentional) that the statistician is expected to minimize.

Concept of Statistics

To the layman statistics connotes the collection, tabulation and presentation of information in numerical form-figures.

However, beyond this classical concept of statistics being the collection, collation, and presentation of data, it is put succinctly as the science of decision making in the face of uncertainty. Therefore, statisticians reason and take decisions in the realm of uncertainty Oyejola (2006). It is this uncertainty (error) which occurs in every day human activity, physical experiments, businesses, politics etc which is to be minimized. The smaller your error the better your decisions. Minimal errors imply improved efficiency and cost reduction in any system. These are the hallmarks of statistical activities. Statistics is therefore the science (pure and applied) of creating, developing and applying techniques such that uncertainty of inductive inferences may be evaluated, Torrie (1998). It is the whole enterprise of use and development of theory and methods applied in design, analysis and interpretation of information, Bamiduro (2005).

A proper design, analysis and interpretation of data lead to better decision making (policy making and implementation), hence, none of these should be missing in the link; because in any experiment

Wrong Design + Right Analysis ⇔ Biased Results

Right Design + Wrong Analysis ⇔ Biased Result

Right Design + Right Analysis ⇔ Unbiased Results

Nduka (1997)

Some Statistical Distributions

Certain experiments are associated with certain distributions.

(i) If an experiment consists of two possible outcomes say success or failure (like in exams), fertile or infertile (human or animal reproduction), yes or no (opinion polls), etc, independent and identical trials of such an experiment is described by the binomial distribution P(x = k] = $\binom{n}{k}p^k q^{n-k}$, k = 0, 1, … n.

(ii) If in successive trials, the first probability of success after several failures (like students trials in an examination before success), it is described by the geometric distribution P(x = k) = $q^{k-1}p$, k=0,1, …

(iii) Very many distributions abound describing events e.g. Poisson, Exponential (arrival and departure at airports within time interval, queuing models like modeling traffic flows), etc.

However, the most popular and plausible of all distributions is the normal or Gaussian distribution after its founder Gaussian (1777-1855). This bell shaped distribution is associated with many activities in life. This distribution is characterized by two parameters – the mean and variance.

Above all, every other distribution tends to the normal distribution as the number of sample observations becomes large (as large as 30). In other words, regardless of the nature of your experiment if the number of independent trials is at least thirty, it can conveniently be described by the normal distribution. This position has been proved by the Central Limit Theorem, Srinivasan and Mehata (1981).

The figure (1), below represents the shape of the normal distribution.

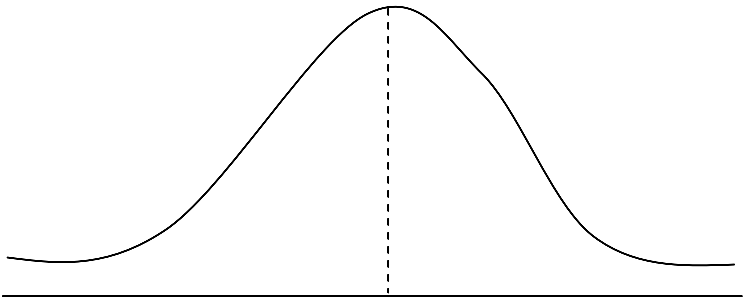

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Figure 1: Normal Curve

Table 3: Degree Results by Faculty

Class of Degree. (%).

Faculty	Pass	3^{rd}	2^2	2^1	1^{st}	Total
Education	-	74(26.3)	183(65.1)	24(8.6)	-	281
Engineering	11(3.2)	83(24.1)	183(53.2)	66(19.2)	1(0.3)	344
* Health Sciences	3(1.1)	59(22.4)	151(57.2)	51(19.3)	-	264
Humanities	2(1.2)	28(16.7)	79(47.0)	54(32.1)	5(3.0)	168
Management Sci.	6(3.0)	96(48.0)	87(43.5)	10(5.0)	1(0.5)	200
Science	12(3.5)	111(32.3)	174(50.6)	46(13.4)	1(0.3)	344
Social Sci.	7(4.3)	62(38.0)	79(48.5)	15(9.2)	-	163
Total	41(2.3)	513(29.1)	936(53.1)	266(15.1)	8(0.4)	1764

* Excluding Medicine.

Source: 23rd Convocation Brochure: University of Port Harcourt, March 2007, pp123-125.

All activities in nature follow the normal distribution as the sample sizes become large.

e.g examination scores (results) tend to follow the normal distribution in a normal population (Hogg and Craig 1978). In this case, it can be used to assess the level of difficulty or easiness of an examination (if not normal it may be skewed to the left indicating “tough exam” or to the right (easy examination) e.g. below is a plot of degree results of University of Port Harcourt (Brochure, 2007).

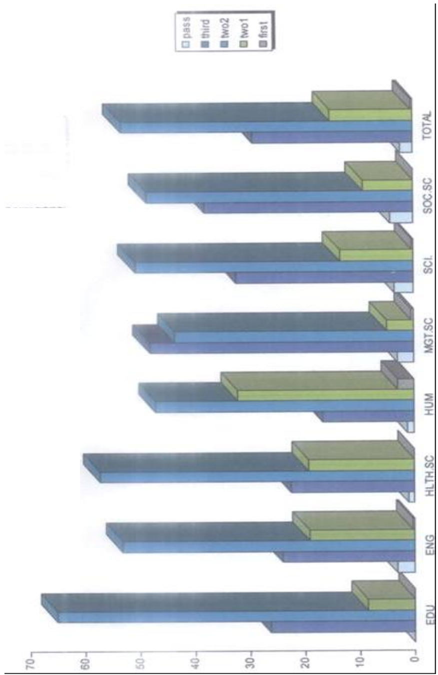


Figure 2: Class of Degrees by Faculty 2007

It has to be stated that in a normally distributed scores, it is peaked at 2nd class lower division; the difference between the number of 2nd upper and 3rd class should not be significantly different, the difference in the number of 1st class and pass degrees should also not be significantly different.

Again, in a large class, for a standard exam, the scores peak at C with the difference between the number with maximum score (A) and minimum score (F) not being significant.

Ladder of Activity in Life

The normal curve can be used to demonstrate man's activity in his ladder of life.

Table 4: Activity ladder

Age Group (years)	**Activity**
0-9	Entry: (infant, nursery / primary)
10-19	Secondary school (learning trade, or skill)
20-29	Tertiary (graduation: trade, skill etc)
30-39	Career prospects (working, marriage, etc)
40-49	Career peak
50-59	Accumulation of career knowledge (slowing down in activity)
60-69	Exiting career (Retiring)
70^+	Exiting (in departure lounge)

Note: We have an error margin of ± 3 in each upper limit.

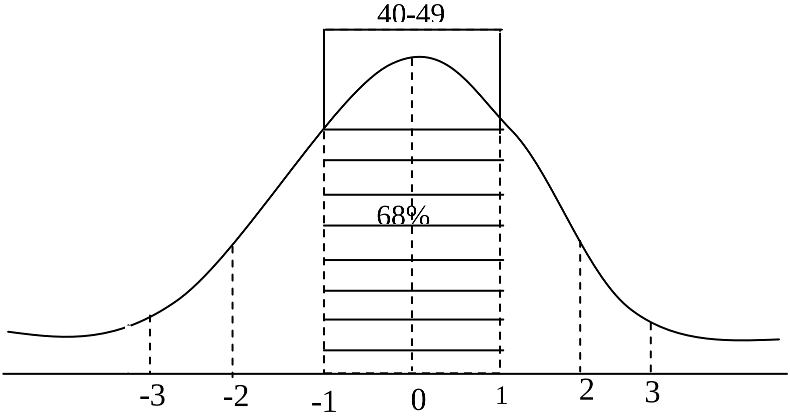


Fig. 3: Normal Distribution Curve.

An artist's impression, Ubeku (2000) of the activity ladder can be appreciated as shown in figure 4 below.

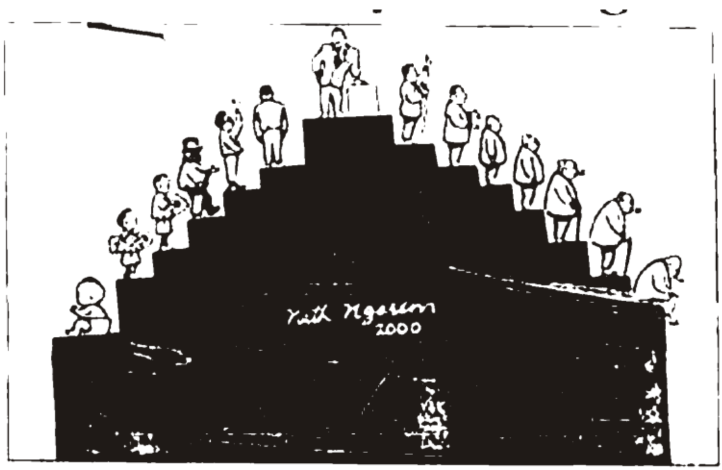


Fig 4: Activity curve

Mr. Vice-Chancellor sir, we can now appreciate in the lighter mood, the maxim that a fool at forty is a fool forever. However, from the statistician's point of view, this statement is not absolute, rather it is probabilistic, and this probability is 0.68. In other words, that a fool, has 32% chance of pulling himself / herself out of foolery.

The above table can therefore be condensed into three, say

0-29 (learning process)

30-59 (working process)

60 and above (retiring process)

What Has Three Got to do with this?

Permit me sir, to demonstrate the usefulness of the number three in the affairs of statistics and man in general.

1. The statistician divides the study of data into three parts:
   - collecting data
   - processing data
   - drawing inference from data
2. We notice that the statistical tables of standard normal distribution is tabulated for values between -3 and 3 (i.e ± 3) Kanji (1993), Meyer (1977), Nwobi and Nduka (2003).

3. If we exclude the children and adolescents, life's major activities are concentrated in three age groups; namely

   20-39 (Youth).

   40-59 (Adulthood)

   60 and above (Old Age).

These age groups have some interesting features:
Knowing scientists. (Vollmann, 1985, Fischof 2007, Vasey 2007) have identified the different temperaments and blood radiations. For the youth, it is melancholic (i.e dreaming and longing for the ideal), for adulthood it is choleric (urging to action), and for the old age it is phlegmatic (quiet reflection). Again some knowing ones and philosophers, Malchow (2007) associated the quest for knowledge in these groups. Youth as the whence in life (i.e where do I come from?).

Adulthood as the why in life (i.e what is the purpose of life and existence?).

Old age as the whiter in life (i.e where do I go to from here? Life beyond the earthly existence).

There is therefore an urge in man to know who he is and his purpose in creation. This is because, man is not just the physical body we see. It is the body and his inner core (the spirit) that make the man. (Genesis 2:7, James 2:26). And the Lord God formed man out of the dust of the ground and breathed into his nostrils the breath of life and man became a living soul. Just as we care for the body we should equally care for the spirit, hence the need for him to discover or indeed re-discover himself. We recognize the concept of Trinity (God the father, the Son and Holy Spirit), body, soul, spirit, triangle, etc.

4. There is also the role of three in holding the balance of governance (the executive, judiciary and

legislature) and social stratification (upper class, middle class and lower class).

5. The computer has three main devices input, processing unit and output.
6. Let me personally say that our country enjoyed healthier economy and politics under the three regional structure than what we have today; in terms of GDP, per capita income and quality of leadership.
7. Above all, three basic natural laws regulate the activities of man in creation (Vollmann, 1985, Huemar 2006, 2007).

i) The law of sowing and reaping or reciprocal action or karma or cause and effect etc. (Galatians 6:7). Be not deceived, God is not mocked; for whatsoever a man soweth, that shall he reap. Again, three basic ways of sowing; through our three abilities; thinking (thoughts), talking (words) and action (deeds).

ii) The law of Attraction of Homogenous species or birds of the same feather flock together, like father like son, tell me your friend, and I will tell you who you are, etc.

iii) The law of gravity (density) made popular by physicists; that light objects float, while heavy objects sink e.g cork immersed in water floats, while stone sinks. If we do something right and noble we feel light, if otherwise we feel heavy and dense.

An understanding and conscious living of these laws, will make us appreciate the import of the admonitions by our

Lord Jesus Christ that we should lay our treasures in heaven and that what does it profit a man if he gains the whole world at the expense of his soul.

The import of this is that even if one is not a fool at forty (indeed has reached his peak there) it is a waste if he has not led a spiritual life (i.e not worshiped God in truth and spirit).

In this wise, I associate myself to some extent the call by Okoh (2005) enjoining man in the Delphic maxim to "know himself" because we are plagued by the problem of "mis-education" caused by the absence of a philosophical base.

Indeed Keller (1880-1968) put it more succinctly "the best educated human being is one who understands most about life he is placed in".

Outliers

Whatever deviates from that which is normal (i.e expected) be it in conduct (behavior), business, measurements etc, we commonly say it is abnormal or unexpected. In statistics, such observation(s) that fall(s) outside the pattern exhibited by the rest of the data set is called an outlier or wild shot (Barnett and Levis (1990).

In accordance, with our number three, the simplest method of identifying an outlier is $\bar{x}$ $\pm 3s$ ($\bar{x}$ – sample mean, s- sample standard deviation). In other words, any value that lies outside the above interval is an outlier. Let me illustrate this with these simple scores of two students in a sessional examination.

Student One: A, B, B, C, A, B, B, **F**,
Student Two: D, C, C, E, E, C, D, **A**,
Note that under normal circumstances, student One is not expected to score an **F** just as Two is not expected to score an **A**. So these scores are potential outliers.
The question that naturally arises is:
What do you do with outlying observations? There exists two schools of thought-one remove the observation if confirmed to be an outlier and use the rest for analysis: two do not discard the observation, rather estimate what the true value should have been and then do your analysis.

Statisticians Dilemma Versus Outliers

i) Probability of discarding an observation as an outlier when it is truly not one (called swamping) e.g if truly these were the students' scores, discarding them means favoring the first candidate while placing the second at a disadvantage or when a true outlier is shielded (masking).

ii) Estimating the "true" value seems a lesser evil but with what level of confidence are we estimating".

My Contributions to the Study of Statistics

I wish to highlight my contributions under three basic components:-

- research
- teaching
- consulting

Statistics was a novel subject introduced as a course in class IV in our secondary school. We were about 15 students who sat for it in the WASC exams that year before WAEC scrapped it later. This marked my attachment to the discipline. I did my National Youth Service at the Institute of Agricultural Research – Samaru Zaria as a "Statistical Research Officer" in the Data Processing and Field Experiments Unit in 1980-81.

This marked the beginning of my interest in statistical modeling with bias in Biometrics (application of statistical methods and principles in biological, agricultural, medical and allied disciplines) particularly in the later part of my career.

Research – (1) My first research effort arose from part of my undergraduate project (Nduka, 1991) which was to find out how efficient students' degree project discriminates among students of varying abilities – which is the sole aim of any exam. This is because the degree project has six credit units in almost all the Nigerian Universities and consumes a lot of resources and time.

The difficulty index $\left(\gamma_{diff} = \frac{2(N_T + N_B)}{N}\right)$, $0 \leq \gamma_{diff} < 1$ and the discriminating power $\left(\gamma_{dis} = \frac{N_T}{\text{"}top\text{" } 25\%} - \frac{N_B}{\text{"}bottom\text{"}25\%} - 1 \leq \gamma_{dis} \leq 1\right)$. Results of updated data collected from the University of Nigeria, Nsukka over the period 1985-1989 are shown below. I was able to prove the theorem that If $\gamma_{diff} \in [0.4, 0.6]$, then $\gamma_{dis} \to 1$.

Table 5: Results of Difficulty Index and Discriminating Power

Faculty		N_T	N_B	γ_{diff}	γ_{dis}
Agriculture	'top' 25% 'bottom' 25%	6 -	- 0	0.04	0.08
Arts	'top' 25% 'bottom' 25%	36 -	- 24	0.28	0.22
Education	'top' 25% 'bottom' 25%	30 -	- 12	0.16	0.14
Engineering	'top' 25% 'bottom' 25%	36 -	- 24	0.24	0.10
Medical Sciences	'top' 25% 'bottom' 25%	30 -	- 24	0.23	0.05
Science	'top' 25% 'bottom' 25%	18 -	- 30	0.25	-0.13
Social Sciences	'top' 25% 'bottom' 25%	18 -	- 6	0.08	0.08
All	'top' 25% 'bottom' 25%	174 -	- 120	0.18	0.07

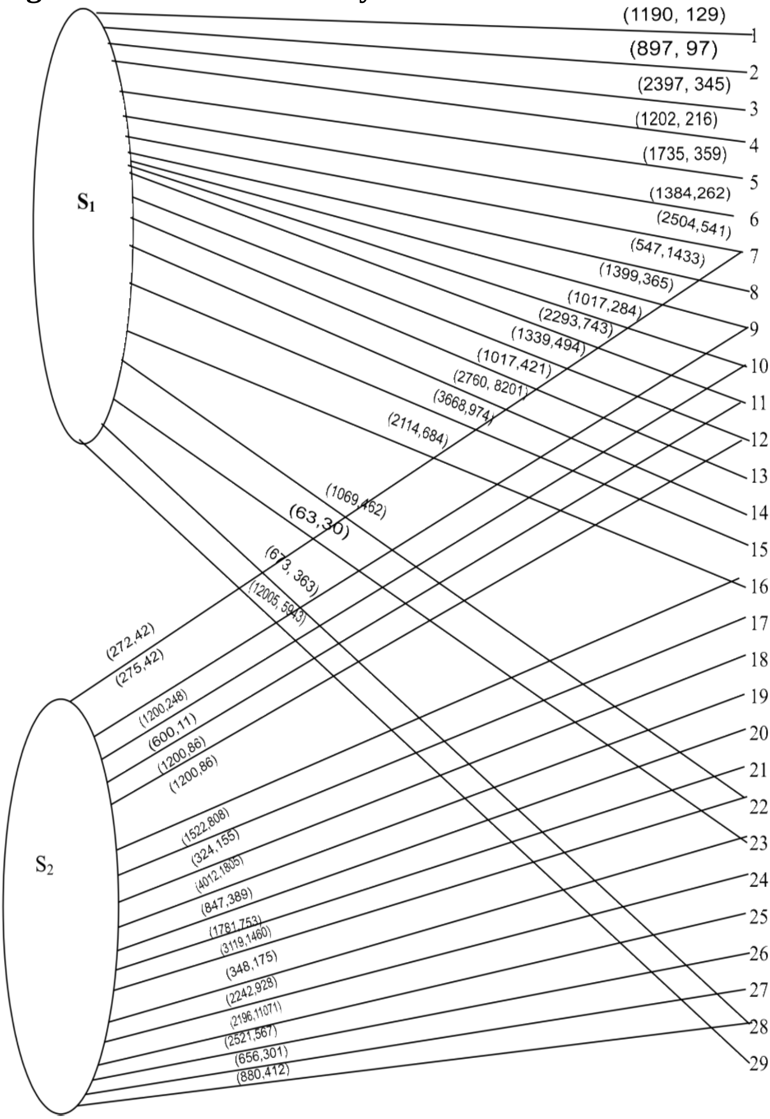
Note: The results suggest that degree project has low difficulty index and discriminating power. The negative discriminating power in sciences tends to indicate that those who perform poorly in degree exams do better in project than brighter students.

Recommendation: This is one exam where no student sampled failed in project examination. There is therefore the need to reduce its credit unit to three.

(2) Another study which formed part of my masters' dissertation arose in an industry that produces detergents at two plants; one at Aba and another at Apapa. They have 29 distribution points (depots) scattered all over the country.

The problem is: how do we optimally allocate these commodities to these depots at a minimal cost?

Fig 5: Current allocation system.



The desire was to construct an optimal network flow $f(n_i, n_j)$ from production points (S_i , i = 1, 2) to the depots such that the total flow cost (transportation).

$\gamma(f) = \sum_i \sum_j \gamma(n_i, n_j) f(n_i, n_j)$ is minimal and the total flow capacity (quantity of goods), $c(f) = \sum_i \sum_j c(n_i, n_j) f(n_i, n_j)$ is maximal.

We proposed an algorithm (Chukwu and Nduka 1993) which iteratively searches the route for the maximal allocation of commodity flows from their restricted or relaxed production points to their corresponding depots at a minimal cost.

The total cost of distributing 66,413 cases of detergents is (in ₦m) N17,701.00). In applying the algorithm to their own distribution schedule the same quantity could be distributed to the various depots at N15,245.00 (13.87% cost reduction) i.e (N2456). Applying the proposed algorithm and suggesting alternative distribution schedule, the same quantity could be distributed at a cost of N14,486.00 (18.16% cost reduction).

The merits: Our algorithm has been proved optimal in solving restricted and relaxed multi-commodity flow problem without intermediate routes; with efficient results.

If distribution cost is equal to zero, the algorithm solves the maximal flow problem of Ford and Fulkerson (1962).

(3) These papers (Erondu & Nduka, 1993[a], 1993[b]) were based on water samples experiment conducted by

Dr. Erondu (Department of Fisheries and Animal Sciences, University of Port Harcourt) at the New Calabar River in 1993. We were to compute the Water Quality Index (WQI) using the Bhargava's (1983) model popularly used in water classification for various beneficial uses. The model is given as

$$= WQI = \pi_{i=1}^{n} f_i (P_i)^{1/n} \; x100; \qquad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_} \quad \text{(I)}$$

Table 6: Observed Experimental Values

Parameter	Dry season (DS) High Tide	Dry Season Low Tide	Wet Season (WS) High Tide	Wet Season Low Tide
Temperature(0^c)	27.5	26.9	27.13	26.6
PH	6.2	5.9	6.01	6.22
DO	5.22	4.85	4.57	4.92
BOD	0.45	2.15	2.28	2.37
NH_4-H	0.22	0.35	0.31	0.40
T – Hardness	27.86	15.00	17.00	14.00
Silica	15.75	19.68	11.46	15.19
Sulphide	0.01	0.003	0.021	0.047

Table 7: Classification, Beneficial and Suitability of Use

Beneficial Use	Limits of WQI	Sensitivity function
(a) Bathing & Swimming	(I) 90% and above (Excellent)	1.0
(b) Public Water Supplies	(II) Between 65% and 89% (Good)	0.8
(c) Fish Culture, Wildlife, Boating & other non-contact recreation.	(III) Between 35% and 64% (Satisfactory)	0.5
(d) Industry	(IV) Between 11% and 34% (Poor)	0.2
	(V) Below 11% (Unacceptable)	0.01

Initially, we obtained results based on the Bhargava's model. These results were criticized by environmental experts, who questioned the realism particularly against the background of environmental degradation in the Niger Delta.

The issues raised necessitated our efforts at proposing a better alternative model – the exponential model (Erondu & Nduka 1993[b]). given as

$$= WQI = \exp - \left[\sum_{i=1}^{n} fi(Pi) \right]^{-1} x \ 100 \ \underline{\hspace{4cm}} \quad \text{(II)}$$

The comparative results can be appreciated below (in %).

Table 8: Comparative WQI Values For Beneficial Use

		(a)		(b)		(c)		(d)	
	Model	D.S	W.S	D.S	W.S	D.S	W.S	D.S	W.S
High Tide	I	98.8	98.4	89.4	63.2	79.6	66.3	43.4	50.0
	II	70.0	62.1	75.7	68.1	79.2	75.7	29.1	40.3
Low Tide	I	68.4	68.4	63.2	63.2	66.3	66.3	43.4	37.2
	II	62.1	62.1	73.9	70.0	77.4	74.6	40.3	40.3

Observation: Bhargava's model classified the use of the water for bathing / swimming and public water supplies at High Tide and Dry Season as excellent, - ours classifies same as good.

Our claim: Results agree with views of environmental experts on level of pollution. It builds more realism to the data.

Benefits: A useful tool for the monitoring, evaluation of the quality of water body, and for the control of water pollution (i.e. abatement programme).

Further modification and applications of the model have also evolved over the years. (Onuoha and Nduka, 2004: 2005).

(4) Mr. Vice Chancellor sir, permit me to discuss briefly my research efforts as a Ph.D candidate. My thesis was in the area of biometrics, specifically response surface methodology using inverse polynomials. Sometimes, the primary aim of an experimenter is to determine the treatment or factor combinations which will give the best response.

The multifactor response is called the response surface; the experiment usually a factorial design used in describing the surface is called the response surface experiment, while the statistical method of exploring this surface to obtain the optimum response (yield) is the response surface methodology (RSM). In other words, if we have the response model

$$Y = f(x, \beta) + e$$

x = vector of design variables

β = vector of parameters

e = experimental random error

$$e \sim IID\ (0, \delta e^2).$$

which is within experimental region of operation or interest, then the surface represented by E(y) = f(x, $\hat{\beta}$) is defined as the response surface. The fundamental issue is at what design points do you explore to obtain the optimum response. This is the concept of RSM.

The fundamental applications of RSM in any experimental design are in approximating the true models (known or unknown), discriminating between (among) models, and the exploration of response surfaces.

Though my study was in the latter, we have traversed the others.

The ordinary polynomials, particularly the second order (quadratic) have been popularly used in exploring response surfaces because of their conceptual and computational simplicity, and easy location of the optimum. However, they exhibit the undesirable problem of unboundedness, symmetry about the optimum, thereby making nonsense of extrapolation if prediction is one of the experimental objectives, Morton (1983), Mead & Pike (1975).

On the other hand, inverse polynomials have the desirable properties of boundedness, asymptotics, distribution free, invariance and speedy convergence.

Awareness in the use of inverse polynomials increased following Nelder's (1966) multi-factor experiment on Bermuda-grass for parameter estimation. This he called generalized inverse polynomial. The major area of application of inverse polynomials has been in agronomy, growth studies in plant yield relationships and inverse linear regression methods of calibration (Zemroch (1986).

However, recent studies show applications in the "other biometrics" chemotherapy, finger-printing and forensic science (Biometric Bulletins 2006).

The major limitations of Nelder's generalized inverse polynomial are:-

(a) it does not establish a common relationship among the various models.

(b) It is not widened in scope by permitting powers of the factorial experiment.

(c) The above observations can be appreciated from his model (Nelder 1966) expressed as

$$\pi_{i-1}^{k} \frac{x_i}{y} = polynomial \;\; in \;\; x_1, x_2, \ldots\ldots\ldots\ldots x_k \quad \ldots(4.1)$$

A new generalized inverse polynomial was justifiably proposed Nduka (1994) which

(a) synthesizes the common relationship among the family of inverse models

(b) has a multi-parametric form that unified the variants of growth models.

The new generalized inverse polynomial (Nduka, 1994) that takes care of inverse polynomial of order p in k-factor experiments is expressed as

$$\underset{i=1}{\overset{k}{\pi}} \frac{x_i}{y} = \underset{i=1}{\overset{k}{\pi}} \left(\beta_{01} + \beta_{1i} x_i + \beta_{2i} x_i{}^2 + \ldots\ldots\ldots \beta_{p-1,\, i} x_i{}^{p-1} \right) \quad \ldots(4.2)$$

Applications

(a) The new generalized inversed polynomial Nduka and Bamiduro (1997) has been applied in response surface design giving a clearer insight to Nelder's (1968), and Meads (1971) yield-density relationship as follows:

(i) In a single factor experiment

where k = 1, p = 1

$y^{-1} = \beta_{11} + \beta_{01}x^{-1}$ …(4.3)

(which is a simple inverse regression model). This (equation 4.3) can be equivalently stated as

$y^{-\theta} = \beta_{11} + \beta_{01}\rho^{-1}$ ...(4.4)

as a general case

y is yield per plant, ρ is number of plants per unit area (plant-density)

ρ_{11}, ρ_{01}, θ, ϕ are parameters such that $\theta/\phi \leq 1$, $\theta > 0$, $\phi = 1$, $0 < \theta \leq 1$. So θ becomes a competitive index. W = ρy (yield per unit area) attains asymptotic maximum at $\rho = \infty$ only for $\theta = 1$ and this is typical of vegetative plant growth (see fig.6.)

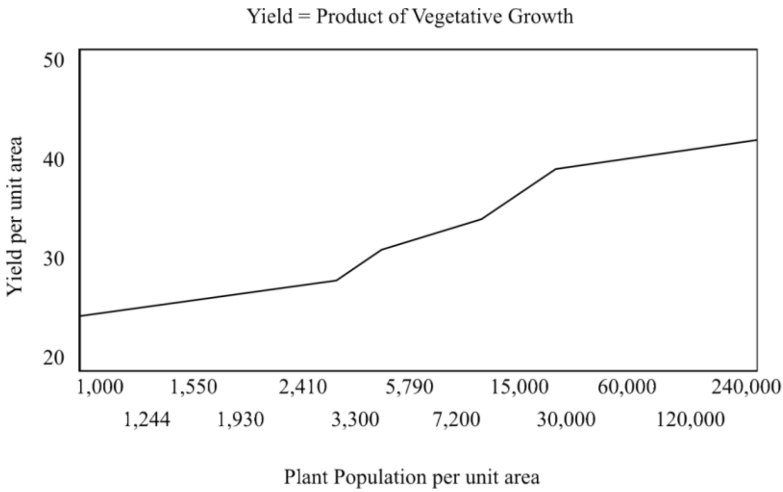


Figure 6: Yield-Density Relationship, θ = 1

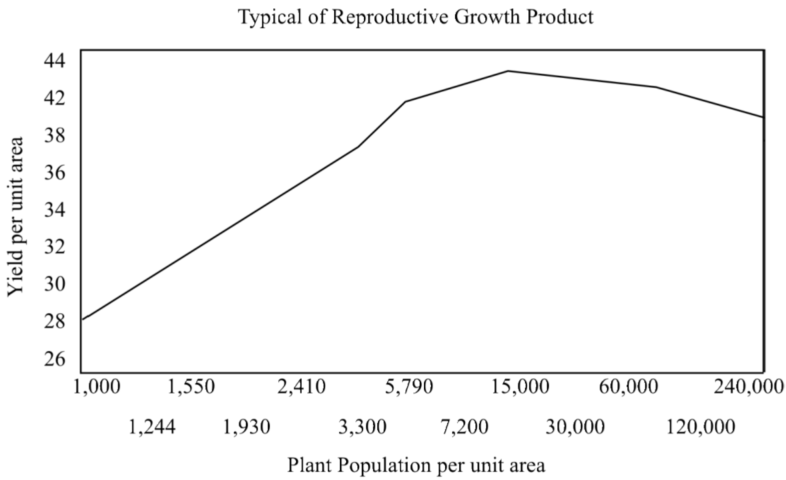


Figure 7: Yield-Density Relationship, θ<1

In attains a definite maximum at $\rho < \infty$ if $\theta < 1$ (which is estimable) and this is typical of reproductive plant growth (see fig5). Taking the exponential of equation (1.0) gives the Gompertz model (Winsor, 1982; Ferrante, et al 2000) used in actuarial studies, while the reciprocal gives the logistic model used in dose-response studies in clinical trials (Sugar, *et al* 2007).

(ii) for a polynomial of order 2, 1-factor experiment gives

$x/y = \beta_0 + \beta_1 x + \beta_1 x^2$ (inverse quadratic model) …(4.5)

(iii) for 2^2 – factorial experiment i.e. 2 factors at 2 levels, this transforms to

$y^{-1} = B_{11} + B_{01}x_1^{-1} + B_{10}x_2^{-1} + B_{00}(x_1x_2)^{-1}$ …(4.6)

This is a variant of Berry's (1968) model if $y = y^{\theta}$; used in crop-yield density involving intra (x_1) and integer (x_2) row spacing and density at $\rho = (x_1\ x_2)^{-1}$.

(b) when the maximum is not attainable, Nduka et al, (1998), contributed expression for the density at which specific proportions of the maximum is obtained.

(c) In (b) above, where it is not feasible to obtain full yield at harvest time because it is unattainable or simply unavoidable; Nduka & Bamiduro (2002) combined methods of calculus of variation and maximum likelihood estimates to obtain *a* proportion of this yield. This was obtained for both known desired and unknown (estimable) proportions of the maximum yield on rectangular and square plot formations. The analytical results (using SAS – Gauss Newton) method of iterative nonlinear least square on soyabean experiment Wiggans,(1984) gives.

$W^{-0.86216} = 0.0164 - 0.00426x_1^{-1} - 0.06832x_2^{-1} + 0.00543(x_1x_2)^{-1}$ …(4.7)

In the circumstance described above where the experimenter may be forced to seek some proportion λ(say), $0 < \lambda < 1$ of this maximum; this can be obtained from the equation

$W'' = \lambda w_{max}$ …(4.8)

Therefore, for known λ

$$W'' = \frac{\lambda\left(1-\widehat{B}_{11}-\widehat{\theta}\right)}{\widehat{B}_{01}\widehat{B}_{10}} \quad \ldots(4.9)$$

For unknown (estimable) λ, we infer that since max(W″) = 1

Then $$\widehat{\lambda} = \frac{\widehat{B}_{01}B_{10}}{\left(1-\widehat{B}_{11}-\theta\right)} \quad \ldots4.10)$$

Therefore, from the above, for known λ, W″ 5.068λ and for λ unknown $\widehat{\lambda} = 0.197$.

This implies that we will obtain a yield growth rate of 5.068 for λ known and 19.7% of optimum yield for λ unknown. The ordinary implication is that premature harvest in this (or similar) experiment will not be profitable or desirable.

Benefits: An experimenter (agriculturist) is now better guided to know what proportion of his full yield is obtainable before full harvest time.

The new generalized inverse polynomial has also been applied as methods for discriminating between models Nduka (1997), for testing the goodness of approximation of model variants Nduka (1995) and model comparisons Nduka (1999).

Teaching

I have been teaching statistics in this University to undergraduate and post graduate students in our department and also as service course to students in biological sciences. The courses include Regression Analysis and Model Building; Design and Analysis of Experiments, Multivariate Analysis, Linear Models, Probability Theory and Statistics for Biological and Agricultural Sciences. I have also supervised and continue to supervise B.Sc projects, M.Sc Theses and Ph.D dissertations. I persuade my graduate students to have their works published in journals and at worst conference proceedings (Nduka and Ijomah 2004, Nduka and Igabari 2006, 2007, Nduka and Consul 2007, John and Nduka 2007).

Consulting

I have been doing some statistical consulting to post graduate students, staff and researchers who apply statistical methods in their studies. My interaction with some colleagues at this level enhanced an appreciation for collaborative studies (Erondu and Nduka, 1993 (a, b), Nduka and Kalu (2001, 2002), Onuoha and Nduka (1994, 2004, 2005), Owate and Nduka (2001), Didia and Nduka (2007). My interaction too has exposed me to some misconceptions or shall I say poor perception of statistics and statisticians. There is little awareness on the need to involve the statistician at all stages of experimentation i.e designing, monitoring (evaluating), data collection, analysis, interpretation and presentation of research results. A good number of researchers come with finished experimental data, demanding analysis that should conform to their expected results, and could express disappointment if otherwise. Some simply want “certified P-value”, while others even come for interpretation of already analysed data (at times wrongly analysed). My personal experience with researchers is that over 70% come with finished experimental data. Little thought is ever given at the experimental stage of a possible analysis sketch that would be suitable to the form of the experimental design, to avoid undue statistical complications during proper analysis. Above all, basic knowledge of statistical principles like randomizations, sampling techniques, questionnaire design and procedures for research experimentations are lacking.

Challenges facing Statistics and Statisticians

Mr. Vice-Chancellor, Sir, statistics is the most widely used, misused and abused of all disciplines, because everybody needs the services of statistics and statisticians. The challenges are (a) use, abuse and misuse (b) poor record keeping (c) dearth of statisticians (among others).

(a) Use, Abuse and Misuse

Statistics is used by all and sundry ranging from the grocery shop owner (who takes stock of daily or weekly sales in order to guide her in the quantity of goods to buy and monitor profit) to large complex organizations (in their policy formulations and planning).

The use can be summarized into

(a) Evaluation of existing conditions
(b) Provision of information for programme formulation and development,
(c) Monitoring of system progress.
(d) Guiding research, decisions making and forecasting.

Today, we talk about biometrics/biostatistics (statistics in biology, agriculture, and medicine), econometrics (statistics in economics), psychometrics (statistics in education and psychology), technometrics (statistics in chemical sciences and engineering), geostatistics (statistics in geosciences) and business statistics, etc.

The basic statistical principles and methodologies in these – metrics are the same. They only differ in applications and details. This implies that no scientific investigation (indeed any investigation in any discipline) is capable of proving anything valid without the aid of statistics. Indeed, it is now a maxim that serious research requires serious statistics – that statistical package goes by the name SYSTAT (2005). No journal worth its name now accepts any publications without statistical input even in the humanities.

Misuse and Abuse

It does seem to me that misuse and abuse of statistics are inseparable. For instance drawing wrong inferences from data constitute misuse and abuse at the same time, hence permit me to treat them as same.

The first thing that strikes me in this is what a foremost professor of statistics, Biyi Afonja (1985) called the fa-fi-fal syndrome (I call it AIDS Version of Statistics). This is the willful and deliberate falsification of facts and figures to gain some advantage. We need not go far to appreciate this. Our electoral system (voter registration and voter turn out) defies all known electoral behaviours and demographic features, our conduct of census and results, results of opinion polls, etc. These falsifications are mostly borne out of selfish desires, to mask what betrays our dishonesty or to protect what is called "sensitive statistics" particularly in government circles. Masking of important information is a bane of our environment right from organizations to individuals. e.g data on age are defective in our system.

Misuse and Abuse of Statistical Methods

I have chosen to discuss the simplest of methods known to every literate person and that is the 'average', called arithmetic mean, also known popularly as the mean. Appreciating the misuse, abuse or even over-use makes it unnecessary to discuss any other statistical methods suffering the same fate (and there are quite a lot). This only shows how serious the problem is.

(i) The most important rule is that only like objects should be included in mean calculations so as to ensure that there is some approximate relationship between the mean and all the individual values.

(ii) When comparing means of separate data sets, users do not often ensure that the sets are themselves comparable before attempting to compare statistics derived from or even do the desirable thing by transforming the data set into terms of common dimension, say the use of percentages often called "percentage persuasion" ,Reichmann(1983).

For instance, when government justifies frequent fuel price increases (hikes) by quoting international prices or prices in developed economies (ignoring the prices in developing countries that belong to OPEC like Nigeria and their wage structures).

(iii) Calculating means from grouped frequency distribution is an approximation which is affected by the class-size.

(See below).

Table 9: Comparative means

	Sturge's Rule		**Terrels Rule**	
Original data	**Class interval**	**Frequency**	**Class interval**	**Frequency**
68, 63, 42, 27, 30, 36 24, 25, 44, 65, 43, 35 28, 25, 45, 12, 57, 51 31, 50, 38, 21, 16, 24 49, 28, 23, 19, 46, 30 28, 32, 49, 27, 22, 23 74, 51, 36, 42, 28, 31 12, 32, 49, 38, 42, 27 79, 47, 23, 22, 43, 27 42, 49, 12	10-19	5	10-23	11
	20-29	8	24-37	21
	30-39	11	38-52	19
	40-49	14	52-65	3
	50-59	4	66-79	3
	60-69	3		
	70-79	2		
Class size	10		14	
Mean 36.53		36.43		36.15
Difference		0.10		0.38

(iv) Other means and their uses exist apart from the arithmetic mean e.g the harmonic mean and the geometric mean.

This is because the arithmetic mean cannot be suitably used for all sets of data. It is not appropriate for use in calculating average rates of speed or sales or growth. If a man cycled to a point 1km away at 2km/hr and returned to the same distance at 6km/hr. You may say he averaged 4km/hr, but this is wrong. It took him 30 minutes to do the first journey and 10mins to return, so he cycled 2kms in 40 minutes, his average speed is therefore 3km/hr

We use harmonic mean to deal with rates which are not dependent upon each other, and the geometric mean rates dependent on each other (e.g population growth over a period of time).

(b) Poor Record Keeping

We as a country and at individual levels have very poor record keeping habits. I may not go far here. How many of us can present our one year pay slip on short notice without searching all the corners of our houses? Even where records are available, most often they are incomplete records.

(c) Dearth of statisticians – the acute shortage of statisticians has made many of us jack of all trades. There are about twenty three professors of statistics in Nigeria, only two are available in the south-south – one at University of Benin and another at the University of Port Harcourt (the two only became professors barely two years ago). Six are retired and three are abroad.

Random Thoughts on national Issues

Mr. Vice-Chancellor, sir, permit my gaze on three issues – population census, minimum wage and academic planning offices.

Population Census

In the words of our foremost professor of statistics Afonja (1985), "to many if not most Nigerians, today, if a Professor of statistics gives an inaugural lecture and does not say anything about census, the professor has not said anything," remember that it was in the course of census exercise that Our Lord Jesus Christ was born (Luke 2:1), also that Moses sent spies to the land of Ca-na-an to count the number of their men, weak or strong, few or many, etc. (Numbers 13:17-20).

This historical perspective also has to do with the genesis of the word **statistics** itself. It was first used to describe data collection by government officials, and these officials involved in collecting and analysing such data were referred to as **statists** (i.e those preoccupied with **facts** of the state (Adegboye, 1997).

Suffice it to say that census is a veritable tool for national planning and development. Sadly, in our country it has been bedeviled with politics. Indeed, Udoidem (2006) captured this sorry state "unfortunately the general understanding of the purpose of census was primitively understood to mean that the more number a region had, the more it would get from the national coffers". Let me amplify this from the use of population as a basis for the following:

(i) revenue allocation
(ii) representation at national assembly
(iii) delineation of electoral constituencies (enumeration areas).
(iv) recruitment into the public service, armed forces, police, etc.
(v) creation of local governments, etc.

For instance, the current statutory allocation is on the following basis:

Population	30%
Equality of states	40%
Land mass and terrain	10%
Internal revenue generation	10%
Education	3%
Health	3%
Water	3%

Because, our national life seems to revolve around population issues, census has become more of a political stratagem than economic barometer. Census exercise is generally decennial (i.e once every ten years) and an intercensal sample surveys (census) in between. It is now becoming a random event in Nigeria, depending on chance or political expediency.

Perhaps the tables below in Nigerian census may throw some light.

Table 10: Population Census in Nigeria

YEAR	POPULATION (IN MILLIONS)	REMARKS
1911	16.05	1st National Census Northern Protectorate 8.12(50.59%) Southern Protectorate 7.93 (49.41%)
1921	18.72	After amalgamation; 1st Truly National Census North 9.73 (52%) Southern 8.99 (48%)
1931	20.56	North 11.44 (55.64%) South 9.12 (44.36%)
1953	30.4	North 16.84 (55.39%) South 13. 56 (44.61%)
1962	45	North 21 (46.67%) South 24 (53.33%) Cancelled
1963	55.67	North 29.81 (53.55%) South 25.86 (46.45%)
1973	79	North 45 (56.96%) South 34 (43.04%) Cancelled
1991	88.5	North 47 (53.11%) South 41.5 (46. 89%)
2006	140	North 75.02 (53.59%) South 64.98 (46.41%)

The breakdown of the 1991 census and 2006 results are as follows:

Table 11: Breakdown of 1991 census and 2006 results

S/no	State	Population		% Increase	% Growth rate	Time (yrs) to double in size
		1991	2006			
1	Abia	1.85	2.83	52.97	2.83	25
2	Adamawa	2.12	3.17	49.53	2.68	26
3	Akwa Ibom	2.36	3.92	66.10	3.38	21
4	Anambara	2.77	4.18	50.90	2.74	25
5	Bauchi	2.76	4.68	69.56	3.52	20
6	Bayelsa	1.11	1.70	53.15	2.84	24
7	Benue	2.78	4.22	51.80	2.78	25
8	Borno	2.60	4.15	59.61	3.12	22
9	Cross River	1.87	2.89	54.54	2.90	24
10	Delta	2.57	4.10	59.53	3.11	22
11	Ebony	1.42	2.17	52.82	2.83	25
12	Edo	2.16	3.22	49.07	2.66	26
13	Ekiti	1.55	2.38	53.55	2.86	24
14	Enugu	2.22	3.26	46.85	2.56	27
15	Gombe	1.53	2.35	53.59	2.86	24
16	Imo	2.48	3.94	58.87	3.09	22
17	Jigawa	2.83	4.35	53.71	2.87	24
18	Kaduna	3.97	6.07	52.90	2.83	25
19	Kano	5.63	9.38	66.61	3.40	20
20	Kastina	3.88	5.79	49.23	2.67	26
21	Kebbi	2.06	3.24	57.28	3.02	23
22	Kogi	2.10	3.28	56.19	2.97	23
23	Kwara	1.57	2.37	50.95	2.74	25
24	Lagos	5.67	9.01	58.35	3.06	23
25	Nasarawa	1.21	1.86	53.72	2.87	24
26	Niger	2.48	3.95	59.27	3.10	22
27	Ogun	2.34	3.73	59.40	3.11	22
28	Ondo	2.33	3.44	47.64	2.60	27
29	Osun	2.20	3.42	55.45	2.94	24
30	Oyo	3.49	5.59	60.17	3.14	22
31	Plateau	2.07	3.18	53.62	2.86	24
32	Rivers	2.87	5.18	80.49	3.94	18
33	Sokoto	2.26	3.70	63.72	3.29	21
34	Taraba	1.48	2.30	55.40	2.94	24
35	Yobe	1.41	2.32	66.54	3.32	21
36	Zamfara	2.13	3.26	53.05	2.84	24
37	FCT	0.38	1.40	268.42	8.69	8
	TOTAL	88.5	140.00	58.19	3.1	22

(After NPC 1992 and 2007)

For instance, the 2006 population census exercise sacrificed two harmless variables (ethnicity and religion) on the altar of politics.

Way Forward

Census is primarily a statistical exercise

Again to amplify: Udoidem (2006) said: "what the nation needs to do is to effect a system shift such that we de-emphasize the distribution of resources and political representation on the basis of census figures, and lay emphasis on resource control and representation by nationalities". I recommend the following:-

(i) every conscious effort should be made to depoliticize census exercise, it is essentially for national planning and not a tool for gaining undue political advantage, Ogum (1986).

(ii) National Population Commission should be an integral of experts in population issues, Nduka (1986, 2006).

(iii) The following revenue allocation criteria should be considered.

1. Derivation should be at least 40%: the principle has the following advantages.

* improves productivity
* promotes healthy competition among states
* each geographical zone is naturally endowed with resources for self sustenance.

* enhances obtaining quality data for better national planning and development
2. Equality of states
3. Population density (not just population)
4 Other factors (e.g. special needs).

The last census exercise, deemphasized ethnicity and religion, we should therefore de-emphasize state of origin and encourage state of residence which is the in thing in any civilized society.

Issues of Minimum Wage

Providing a stable wage structure has remained intractable due mainly to inaccurate data, non-inclusion of certain variables (cross-sectional cost of living) and lack of expertise. It makes more sense to me for wage structure to be a function of where you live and work, and not the tier of government you work for as presently the case. The following (three again) classifications should be put in place in our wage structure.

Group A: Akwa Ibom, Bayelsa, Delta, Kano, Lagos, Rivers, Federal Capital Territory.

Group B: Abia, Anambra, Cross-River, Edo, Enugu, Imo, Kaduna, Kogi, Nasarawa, Niger, Ogun, Ondo, Oyo, Plateau.

Group C: Adamawa, Bauchi, Benue, Borno, Ebonyi, Ekiti, Gombe, Jigawa, Katsina, Kebbi, Kwara, Osun, Sokoto, Taraba, Yobe, Zamfara.

Housing is one of the indicators for measuring the cost of living. This can be used to fix-wages. I have observed that ₦2,000.00 – ₦3,000.00 can pay for the following types of apartment, in these groups, hence the proposed structure.

Table 12: Proposed Wage Structure

Group	**Amount (type of apartment) N2000 – N3000**	**Wage**	
		Lower Limit (LL)	**Upper Limit (UL)**
A	One room	LL_A	UL_A
B	One self contained apartment	LL_B	LL_A
C	One bedroom apartment	LL_C	LL_B

All tiers of government (local, state and federal) can negotiate wages within these bands.

Academic Planning Offices

The academic planning unit of Universities should play the same role as research and development (R & D) does in industries, planning, research and statistics (PRS) does in government ministries and parastatals – some sort of data bank and think – tank. With the exception of few Universities in Nigeria, most are far from these ideals. The general impression is that of National Universities Commission's (NUC) liaison office – pushing data to-and-fro Abuja. There is need to appreciate and strengthen the unit to fulfill its roles.

Concluding Remarks

Mr. Vice-Chancellor sir, in the last few hours of my presentation, I have made efforts to highlight the following:

(a) the distribution of inaugural lectures in our university

(b) the relevance of the number three (3) in statistics and in life.

(c) My modest contributions to statistics in teaching, research, consultancy and training.

(d) Some misuses and abuses which statistics can be subjected to.

(e) The need for a depoliticized census exercise.

(f) Restructured differential minimum wage regime that reflects cost of living in the work place.

Statistics is the power house or the engine room of any establishment in the society. The engine of a car is masked (i.e hidden) by the entire body which is more elegant to behold. The performance and elegance of the car are determined by the engine which is tucked under the bonnet. None of us will like to drive a car that has its engine exposed, but that in reality is the car. So also statisticians are the backbone in any establishment, they are the background people for policy formulation and implementation by the authorities.

Therefore, the right attitude, appreciation and recognition must be accorded the statistician and the data system (all men and materials involved at all stages of experimental design, data collection and analysis) to minimize the ‘fal’ in the ‘fa-fi-fal’ syndrome in the society. This is the only panacea for successes in industrial and government policies and programmes like NEEDS, Vision 2020, UBE, NEPAD, MDG, etc.

It is only in this sense that we can say with high degree of confidence that statistics has it that… according to statistics… and it will be so.

Let me thank you Mr. Vice-Chancellor and distinguished listeners by exhorting in the words of Florence Nightingale (1820-1910) “an administrator would be more successful if he had statistical knowledge” Nay she went further to say “the universe evolved in accordance with God’s plan. But to understand God’s plan you need statistics” (in Nabugoomu, 2005, Encarta Online).

Finally, no work is exhaustive or free from errors, and this is no exception. If any thing displeases, I therefore plead your understanding and forgiveness for such shortcomings are of the head and not of the heart. I willingly accept five percentage error margin; for in the words of Chaucer (1960) “ask any scholar of discerning, he will say the schools are filled with altercations…”.

Thank you.

References

Adegboye, O. O. (1997). The Magicians, the Prophets and the Statisticians. Inaugural Lecture 1997, University of Ilorin.

Afonja, B.(1985). Facts, Figures and Falsehood Syndrome in Society. Inaugural Lecture 1985, University of Ibadan.

Bamiduro, T. A.(2005). Statistics and Search for the Truth: A Biometrician's View. Inaugural Lecture 2005 University of Ibadan.

Barnett, V. and Lewis, T.(1996)3rd Ed. ***Outliers in Statistical Data***. John Wiley New York.

Berry G.(1967). A Mathematical Model Relating Plant Yield with Arrangement for Regularly Spaced Crops. ***Biometrics***, 23, 505-515.

Bhargava, D.C.(1983). Use of a Water Quality Index for River Classification and Zoning of Ganga River. ***Environmental Pollution, Series*** B; 6,51-57.

Biometrics Bulletin of the International Biometric Society, 23,3,2006.

Brochure of 23rd Convocation: University of Port Harcourt, 2007 pp123-125

Chaucer, G.(1960). ***The Canterbury Tales***. Penguin Books Ltd. England, p. 243.

Chukwu, W.I.E. and Nduka, E.C. (1993). Optimal Search Method in Multi-commodity Flow Problem. ***Discovery and Innovation***, Academy of Science, Kenya. 5,3,2

Davies, O.L. and Goldsmith, P.L(1980)Ed. ***Statistical Methods in Research and Production***. Longman Group Ltd. London, 4th Ed.

Didia, B.C. and Nduka. E.C. (2007). Stature Estimation Formulae of Nigerians. ***J. Forensic Science*** (in Press).

Encarta online – 2006 : Florence Nightingale; Keller Helen.

Erondu, E.S. and Nduka, E.C. (1993a). Computation of Water Quality Index (WQI) for Beneficial Uses: Studies on Water Samples From the New Calabar River. ***Nig. J. Biotech***. 11,63-68

Erondu, E.S. and Nduka, E.C.(1993 b). A Model for Determining Water Quality Index for Classification of the New Calabar River at Aluu Port Harcourt Nigeria. ***Int. J. Env. Stud***. 44,131-134.

Ferrante, L. Bompardre, S. Possati, L. and Leone, L.(2000). Parameter Estimation in a Gompertzian Stochastic Model for Tumor Growth, ***Biometrics*** 56, 1076-1081.

Fischof, P. (2007). Greater Self-Awareness Through the Temperaments. *Grail World Magazine* pp. 9-11.

Ford, L.R. and Fulkerson (1962). ***Flows in Network***. Princeton, N.J. Princeton University Press.

Gaussian R (1777-1855). ***A History of Mathematical Statistics*** (in Hald, A. 1998). Wiley- Interscience pp331-380.

Heumer,W.(2006). Fate and Justice. ***Grail World Magazine***. Stiftung Gralsbotschaft, Publishing Coy. Stuggart, pp. 28-34.

Heumer,W.(2007). A Path to the Recognition of God. ***Grail World Magazine.*** Stiftung Gralsbtschaft Publishing Coy. Stuggart. Pp18-19

Hogg R.V. and Craig, A.T.(1978). ***Introduction to Mathematical Statistics***. Collier Macmillan International Edition. P.112.

John, O.O. and Nduka E.C.(2007). Quantile Regression Analysis As a Robust Alternative to Ordinary Least Squares. 31st Ann.Conf. Nig. Stat. Assoc.

Kanji, G.K. (1993). ***100 Statistical Tests***. Sage Publications, London pp159-160.

King James Version of the Bible (Genesis 2: 7; James 2;26; Luke 2:1 Numbers 13: 17-20; Galatians 6.7)

Malchow, D.(2007). Genes: The Core of Life? ***Grail World Magazine.*** Pp12-14.

Mead, R.(1971). Plant Density and Crop Yield. Appl. Statist. 19, 64-81.

Mead, R. and Pike, D.J.(1975). A Review of Response Surface Methodology from a Biometric View Point, ***Biometrics*** 31, 803-851.

Meyer, P.L.(1977). 2nd Ed. ***Introductory Probability and Statistical Applications*****.** Addision- Welsey Pub.Coy. London. Pp.342-343.

Nabugoomu, F.(2005). Statistics for Food Product Development Processes. 9th Bi-annual Conf. Sub-saharan African Network, Addis-Ababa Ethiopia.

Nduka, E.C. (1986). The Interaction Between Politics and Population Census in Nigeria: A Statistical Problem: 10th Ann. Conf. Nig. Stat. Assoc.

Nduka, E.C. (1991). Students' Degree Project as an Efficient Test Discriminator. ***Int. J. Math. Ed. Sci. Tech***. 22, 3, 395-401.

Nduka, E.C. (1994). Inverse Polynomials in the Exploration of Response Surfaces. Unpublished Ph.D. Thesis Submitted to the University of Ibadan.

Nduka,E.C. (1995) Testing the Goodness of Approximation of the Mitscherlich Model via its Variants. ***Int. J. Math. Ed. Sci. Tech*****.** 26,2,213-217.

Nduka, E.C. (1997). Methods for Discriminating Between Models. ***Int. J. Math. Ed. Sci. Tech***. 28,3,317-32.

Nduka E.C. (1997). Statistics in Agricultural Research: The Nigerian Environment, 12th Ann. Conf. Farm Mgt. Assoc. Nig. Pp.129-133.

Nduka, E.C. (1999). ***Principles of Applied Statistics: Regression and Correlation Analyses***. Crystal Publishers, Owerri.

Nduka, E.C. (1999). Model Comparisons in Plant-Yield Relationships. ***Global J. Pure and Appl. Sci***. 5,3,417-419.

Nduka, E.C. (2007). 2006 Nigerian Population Census: Preliminary Analysis of Facts and Figures: Paper Presented at The School of Graduate Studies Forum, University of Port Harcourt.

Nduka,E.C. (2002). Obtaining Proportion of Optimum Yield when Full Yield is Unattainable ***Global J. Math. Sci.*** 1, 1 & 2, 21-25.

Nduka, E.C. and Bamiduro, T.A. (1997). A New Generalized Inverse Polynomial for Response Surface Designs. ***J. Nig. Stat. Assoc.*** 11, 1, 41-48.

Nduka, E.C. Bamiduro, T.A. and Atobatele,J.T. (1998). Obtaining Proportion of Optimum Yield Under An Inverse Polynomial Yield-Density Relationship. ***J.Sci. Res***. 4, 1, 1-2.

Nduka, E. C. and Consul, J. I. (2007). The Effects of Outliers In a Regression Model. 31st Ann. Conf. Nig. Stat. Assoc.

Nduka, E.C. and Igabari, J. N. (2007). A Modified Generalized Generating Function. ***Global J. Math. Sci***. (In Press).

Nduka, E.C. and Igabari, J.N. (2006) On the Existence, Uniqueness and Uniform Continuity of the Generalized Generating Function (ggf). 25th Ann. Conf. Nig. Math. Soc.

Nduka, E.C. and Ijomah, M.A. (2004). The Effects of Some Economic Indicators on Nigeria's Balance of Payment Regime. 28th Ann. Conf. Nig. Stat. Assoc.

Nduka, E.C. and Kalu, I. E. (2001). Strategies for Cost-Effective Disposal of Solid Wastes in Nigeria. ***J. Agric. Sci. Env. Mgt***. 5, 3, 5-8.

Nduka, E.C. and Kalu, I. E. (2002). Economic Analysis of Wastes Management in Nigeria. ***J. Agric. Sci. Env. Mgt***. 6, 1, 64-68.

Nelder, J.A. (1966). Inverse Polynomials, a Useful Group of Multi-Factor Response Functions. ***Biometrics*** 22, 128-141.

Nelder, J.A. (1968). Regression, Model Building and Invariance (with Discussion). ***J.R. Stat. Soc. A*** 131, 303-315.

Nwobi, F.N. and Nduka, E.C. (2003) ***2nd Ed. Statistical Notes and Tables for Research.*** Alphabet Nig. Publishers, Owerri. Pp.43-51.

Ogum, G.E.O. (1986). The Hide-and-Seek of Nigerian Census. 10th Ann. Conf. Nig. Stat. Assoc.

Okoh, J.D. (2005). The Risk of An Educational System Without a Philosophical Base. Inaugural Lecture Series, No. 38. University of Port Harcourt.

Onuoha, G.C., Adoki, A. Erondu, E.S. and Nduka, E.C. (1994). Microbial Profile of Organically Enriched Freshwater Ponds in South Eastern Nigeria. ***Int. J. Env***. Stud. 48, 275-282.

Onuoha, G.C. and Nduka, E.C. (2005). Simple Models for Determining Water Quality: Studies on Water Samples from Aba River – Nigeria 9th Bi-annual Conf. Sub-sahara African

Network of International Biometric Society held in Addis-Ababa. Ethiopia.

Onuoha, G.C. and Nduka, E.C. (2004). Application of Water Quality Indices for the Classification of the Bonny River-Nigeria. ***Scientia Africana*** 3, 2, 23-32.

Owate, I.O and Nduka,E.C. (2001). Essentials of Research Methods and Technical Writing. Minson Publishers, Port Harcourt.

Oyejola, B.A. (2006). Reasoning in the Realm of Uncertainty. Inaugural Lecture No. 80 University of Ilorin.

Reichmann, W.J. (1983). ***Use and Abuse of Statistics***. Penguin Books, U.K. p. 73.

Srinivansan, S.K. and Mehata, K.M. (1981). *Probability and Random Processes*. Tata McGraw-Hill Pub. Coy. Ltd. Pp.250-252.

Sugar, E.A., Wang, C.Y. and Prentice, R.L. (2007). Logistic Regression With Exposure Biomarkers and Flexible Measurement Error, ***Biometrics***, 63, 1, 143-151.

SYSTAT (2005). ***SSC Statistical Resources Handbook;*** The University of Reading, UK.

Torrie, J.H. (1998). ***Principles and Procedures of Statistics: A Biometrical Approach***. 8th Ed. McGraw Hill International Book Coy. London. P.2.

Ubeku, A. (2000). The Ladder of Life. How Old Are You and What Are You Doing? ***Sunday Vanguard*** June 18, 2000 p.19.

Udoidem, S.I. (2006). The Philosopher in the Market Place: Reflections on the Future of Nigeria. Inaugural Lecture Series No. 49. University of Port Harcourt.

Vasey C. (2007). Temperament and Health. *Grail World Magazine*. Stiftung Gralsbotschaft Publishing Coy. Stuttgart. Pp.6-8.

Vollmann, H. (1985). *A Gate Opens*. Stiftung Gralsbotschaft, Publishers Coy. Stuttgart.

www.SAS.com/software.

Wiggans, R.G.(1989). The Influence of Space and Arrangement on the Production of Soybean Plants. ***J. Amer.Soc. Agron***. 31, 314-321.

Winsor, C.P. (1982). The Gompertz Curve as a Growth Curve. ***Proc.Nat.Acad.Sci.*** 18, 1-18.

Zemroch, J.P. (1986). Cluster Analysis as an Experimental Design Generator, with Application to Gasoline Blending Experiments. ***Technometrics***. 28, 39-49.