

The First Step to Science Innovation: Down to the Basics

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Abstract: The purpose of this paper is to show the basic ideas about the basic knowledge needed to analyse scientifically the data collected on the field or generated in designed experiments. ANOVA (Analysis Of VAriance) is very used for this purpose. We analyzed just one case taken from some published documents found on the web: “On State Budget in the North Central of Nigeria: Analysis of Variance (ANOVA) Approach.” [56] This paper is especially written to settle the matter for the researchers who want to learn a basic statistical tool. Researchers must be alert in order to do a good job.... Many others cases should be shown: the paper should be 10 times longer the methods used are the Logic and the Scientific Theory (Mathematics, Probability, Statistics, Physics...). Several Professors do not practice them.

Keywords: ANOVA, Quality Methods, Scientific Approach, Intellectual Honesty

1. Introduction: “The Problem Outline”

The problem of Science and Quality was originated at least 40 years ago, when the author was working in big Corporations [General Electric, Siemens] and continued in [Fiat (now FCA, Fiat Chrysler Automobiles), Philco, IVECO] and at the Politecnico of Turin (Italy): many and many “false Scholars” were writing wrong papers that defeated the readers (managers, researchers and students) of their right of getting good ideas. UNFORTUNATELY the Peer-Reviewers were worse than the authors: very few of the readers took care of this big problem!

Fausto Galetto was ever fond of Scientific Management (i.e. the *Management to take sound decisions using Scientific Methods*) and tried to make the managers, professor, researchers, and students aware of their need of learning Scientific Ideas... He had little success: ignorance increased constantly.

If the reader acted sometime as a Peer-Reviewer he must admit that very few Journals asked him to evaluate the SCIENTIFIC content of the articles. The Journals prefer the “literature review of the problem” as though that is a symptom of Quality.... The author shows an example of how a superficial assessment of the quality of the methods had led to the publication in the literature of wrong information which might mislead inattentive readers (both young researchers and professors) and diffuse wrong ideas; the author shows the correct way to operate with respect to the concerned topic.

We do not present a literature review of the problem, because

it will need at least hundreds of pages to be settled, both for Quality, Reliability, Statistics, Confidence Intervals and for Design of Experiments that are subjects very little known by managers and professors; we list here only few docs in the references [1-6,12-16,19-23,29,31-38, 44-56], taken from the hundreds of papers read by F. Galetto in his 45 years of experience/activity in the Quality Field (big and medium Corporations and Universities).

We prefer to present the ideas about Science and the Scientific Attitude and Behavior (SAB).

Every “author’s opinion” is based on this long experience in the Quality Field: *they are not only opinions, they are hard facts*. See, for example, the figure 1, 2 and especially 3: Fausto Galetto during the “students’ defense of their final thesis” (to get their degree in Engineering) used to open the written thesis at a page and to ask the future graduate what he meant with some statements found in there. 90%-98% of the students did not know how to provide answer to the questions: moreover, 50%-60% said “*I copied it from the web!*” That was not the biggest problem: it always astonished me the fact that the (Professor) Referee of the thesis did not know the matter/answer himself! These are *hard facts*, not opinion; the same were for Deming and Gell-Mann..., and Einstein...

We start with the important statement of the great scientist Isaac Newton “*If I have seen farther than others, it is because I have stood on the shoulders of giants*”; the process of Science is such that the discoveries of one people generation serve for the next one, by knowledge accumulation. This is true for any

discipline (e.g. Logic, Mathematics, Physics, Probability, Statistics, Medicine, Economics, Reliability...): any building needs *sound foundations*.

When using other people words (like those of Newton, Galilei, Einstein, Deming, Gell-Mann...) the author tries to show that very great scholars have been providing correct hints to the readers in order to help them increasing their knowledge...

The Knowledge-Making process and the Knowledge itself must have Quality got through Quality Tools and Methods; this is depicted in the figure 1, *Quality Tools and Quality Methods to avoid the Disquality*.

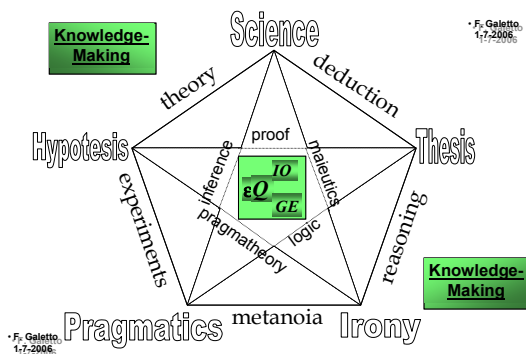


Figure 1. Quality Tools and Quality Methods to avoid the Disquality.

To build Science we need to deduce by Logic and Methods some results to be verified by Experiments in order to confirm our Hypotheses, with “high” Confidence Level: then we have the Theory [figure 2].

The word “science” is derived from the Latin word “scire” (to know for certain) {derived from the Greek words μάθησις, επιστημη, meaning learning and knowledge, which, at that time, were very superior to “opinion” [δόξα], while today opinion of many is considered better than the knowledge of very few! (See the “like attitude”: people now are used to push the like-dislike buttons, instead of using their own intelligence!)}; knowledge is strongly related to “logic reasoning” [λογικος νοος], as it was, for ages, for Euclid, who’s Geometry was considered the best model of “scientificness”. Common (good) sense is not science! Common sense does not look for “understanding”, while science looks for “understanding”! “Understanding” is related to “intelligence” (from the Latin verb “intelligere” ([intus+legere: read into]: “intellige ut credas” i.e. understand to believe. Unfortunately “none so deaf as those that won’t hear”).

Let us give a first example, the Pythagoras Theorem: “In a right triangle, the square of the length of the hypotenuse equals the sum of the squares of the lengths of the other two sides.” Is this statement scientific? It could be scientific because it concerns the science of Geometry and it can be proven true by mathematical arguments and *logic*. It is not-scientific because we did not specify that we were dealing with the “Euclidean Geometry” (based, among others, on the “parallel axiom”: from this only, one can derive that the sum of the interior angles of a triangle is always π): we did not deal “scientifically” with the axioms; we assumed them implicitly.

So we see that “scientificness” is present only if the set of statements (concerning a given “system”) are non-contradictory and deducible from stated principles (as the rules of Logic and the Axioms).

Let us give a second example, the 2nd law of Mechanics: “The force and the acceleration of a body are proportional vectors: $F=ma$, (m is the mass of the body)”. Is this statement scientific? It could be scientific because it concerns the science of Mechanics and it can be proven “true” by well-designed experiments. It is not-scientific because we did not specify that we were dealing with “frames of reference moving relatively one to another with constant velocity” [inertial frames (with the so called “Galilean Relativity”: the laws of Physics look the same for inertial systems)] and that the speed involved was not comparable with [i.e. not very near] the “speed of light in the vacuum [which is the same for all the observers]” (as proved by the Michelson-Morley experiment: in the Special Relativity (SR) Theory, $F=d(mv)/dt$ is true, not $F=ma$!) and not involving atomic or subatomic particles. We did not deal “scientifically” with the hypotheses; we assumed them implicitly. From the laws of Special Relativity we can derive *logically* the conservation laws of momentum and of energy, as could Newton for the “Galilean Relativity”.

The Special Relativity Theory had a problem: it gave to the inertial frames of reference a “special position”, assuming that the laws of Physics must have the same formulation in all the inertial frames of reference; this was unsatisfactory. So the General Relativity (GR) arose with the more general assumption that “the laws of Physics must have the same formulation in all the inertial frames of reference (equivalence principle)”. [Inertial motion provided by the geodesic of the Space-Time] Both SR and GR were great innovations, but that was not enough...

For atomic or subatomic particles “quantum Mechanics” is needed (with Schrödinger equation as fundamental law) [weak and strong forces act in the interior of atoms].

To conceal the four forces (two: gravitation and electromagnetic) of Relativity Theory and (two: weak and strong forces) of Quantum Theory something new is needed... Will that be the “the Strings Hypothesis”? Only if experiments will confirm it...

So we see that “scientificness” is present only if the set of statements (concerning a given “system”) do not contradict the observed data, collected through well-designed experiments [“scientific” experiments]: only in the XVII century, due to Galilei, Descartes, Newton... we learned that. Since that time only, science could really grow, using *LOGIC* (figures 1 and 2).

When we start trying to learn something, generally, we are in the “clouds”; reality (and truth) is hidden by the clouds of our ignorance, the clouds of the data, the clouds of our misconceptions, the clouds of our prejudices; to understand the phenomena we need to find out the reality from the clouds: we make hypotheses, then we deduct *logically* some consequences, predicting the results of experiments: if predictions and experimental data do match then we “confirm” our idea and if many other are able to check our findings we get a theory. To generate a theory we need Methods. Eric Berne, the

psychologist father of “Transactional Analysis”, stated that everybody interacts with other people through three states P, A, C [Parent, Adult, Child, (not connected with our age, fig. 2)]: the Adult state is the one that looks for reality, makes questions, considers the data, analyses objectively the data, draws conclusions and takes logic decisions, coherent with the data, methodically. Theory [θεωρία] comes from the Adult state! Methods [μεθοδος from μετα+οδος = the way through (which one finds out...)] used to generate a Theory come from the Adult state!

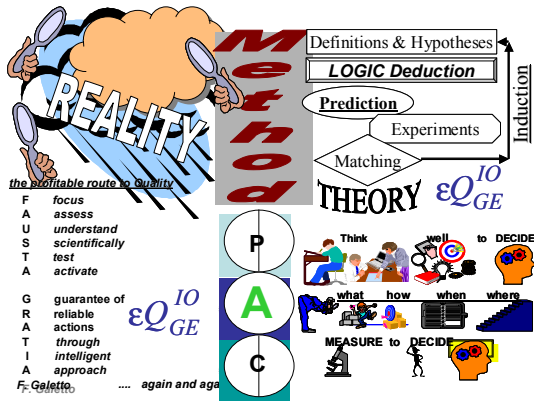


Figure 2. FAUSTA GRATIA for Quality in order to avoid the Disquality.

You can find a sample of anti Scientific Attitude and Behavior (aSAB) by looking at some very few cases, taken from some published documents found on the web: Montgomery, Rade, M. A. El-Damcese [paper 41], M. A. El-Damcese, et al. [paper 42] (and other from books [from 44 to 49, M. Xie, Y-S Dai, K-L Poh, (2004), T. Nakagawa, (2005), H. Pham, (2003), H. Wang, H. Pham, (2006), M. Lazzaroni, L. Cristaldi, L. Peretto, P. Rinaldi, M. Catelani, (2003), MONTGOMERY D.C. (2006)] and theses [35, 54]!). See also all the other cases in the references, about Design of Experiments [1-4, 10-29, 50-54]. The problem of ignorance is so huge [1-6, 12-16, 19-23, 29, 31-38, 44-54] that a profound change of mind (metanoia, Deming) [5, 6] is needed.

In this paper we use another case to show that "Professors and Referees (Peer-Reviewers) do not know the basics of ANOVA" and therefore take WRONG decisions [56]: «On State Budget in the North Central of Nigeria: Analysis of Variance (ANOVA) Approach. Journal of Investment and Management. Vol. 4, No. 6, 2015, pp. 296-300. doi: 10.11648/j.jim.20150406.12»

The paper [56] is to be considered «««Science Innovation»»»? Absolutely not!

My students are able to find the right solutions because they had the Sound Theory [17]! Muritala Abdulkabir, Raji Surajudeen Tunde did not have it.

Citing Muritala Abdulkabir, Raji Surajudeen Tunde, Fausto Galetto, WHO found them wrong, improves the indexes of Muritala Abdulkabir, Raji Surajudeen Tunde! Where is the Quality?

Fausto Galetto, in his 45 years of experience, met so many incompetents (managers, professors, researchers,) that he always was used to say to his students: «««IF a guy suggests

books and papers written by incompetents he is TWICE incompetent, because he does not recognize wrong ideas and suggests to read wrong ideas»»»». Unfortunately several Professors do not practice the two important methods used here, the Logic and the Scientific Theory (Mathematics, Probability, Statistics, Physics...). See the references...

Please see well the figures 1-5, and see IF ...

Researchers shall use their intelligence in order to make knowledge for the improvement of people and their life.

Researchers must not cheat people and act according to the figures 1 and 2.

Any Intellectually hOnest person that loves Quality and hates DISquality will Focus on the problems [potential and/or actual], Assess their importance (money, impact, consequences, risks, ...), Understand all the previous items SCIENTIFICALLY and SCIENTIFICALLY Test for finding the causes; when a solution is found anybody will Activate to implement the solution, in order to Guaranty that Reliable Actions (preventive and corrective) are taken Through an Intelligent Approach (approach that uses intelligence, ingenuity and science, avoiding misdeeds) [figure 2].

Eric Berne [32] devised the Transactional Analysis “Theory” [that actually is not a theory in the scientific sense] with the 3 EGO_States: Parent, Adult, Child.

The Parent ego_state is a set of thoughts, feelings, and behaviours that are learned or “borrowed” from our parents or other caretakers. Two parts are comprised: the Nurturing Parent ego_state soft, loving, and permission giving, and Prejudiced Parent, the part of our personality that contains the prejudged thoughts, feelings, and beliefs that we learned from our parents.

The Adult ego_state is our data processing centre. It is the part of our personality that formulate hypotheses to be verified by experiments, uses Logic and Science, invents Methods to test ideas and to process data accurately, that sees, hears, thinks, and can come up with solutions to problems [potential and/or actual] based on the facts and not solely on our pre-judged thoughts or childlike emotions: it denounces misdeeds. You can see its capacities on the right hand of the figure 2. Qualitatis FAUSTA GRATIA is related to the Adult ego_state.

In the excerpt 1 (from the paper [56]) you read the following statements [nonsense!]:

The research work was designed to investigate “The Comparative analysis of state budget in the north central of Nigeria”.

A review of related theories on comparative analysis of state budget in North central of Nigeria backed up with a related theoretical framework was carried out chapter four, hypothesis were stated for the research study.

A well structured data collected from the field while the sources used for the collected of data were secondary source. The data collected from the field were presented in a tabular form and expressed in randomized block design, while two ways (ANOVA) table was used to test the stated hypothesis at the significant level of 0.05 percent, with F-distribution V_1 , V_2 . And from the test it was obvious that comparative analysis of state budget in the North central of Nigeria is significant different.

Excerpt 1. Conclusions of [56]: analysis of budget data.

NOTICE the words «Significant different»!!! We will see that are NONSENSE!

2. The Data and the Analysis [56]

Any reader of a paper expects to find good analysis of data by sound Scientific methods.

States	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Benue	44.91	46.3	44.84	64.65	63.29	89.49	71.6	159.78	130.992	715.852
Kogi	31.31	33.89	45	52.37	78.669	78	80	126.411	132.6	658.25
Kwara	33.9	35.66	60	66.5	72.2	67	60.61	85.1	94.4	575.37
Nasarawa	25.42	29.05	35.46	55.7	58.3	87.5	81.506	104	108	584.936
Niger	33.79	42.08	50	55.45	69.09	111	129	94.05	83.7	668.16
Plateau	29.4	31.9	45	63.02	79.5	74.864	86.562	115	133.5	658.746
Total ne	198.73	218.88	280.3	357.69	421.049	507.854	509.278	684.341	683.192	3861.314

Excerpt 3. The data.

The authors (statisticians!) Muritala Abdulkabir and Raji Surajudeen Tunde make the ANOVA and generate the ANOVA table (excerpt 4)

Source of variation	Degree of freedom	Sum of freedom	Mean of square	Fratio
State	5	1596.039	319.208	5.446
Year	8	44484.968	5560.621	94.870
Error	40	2344.52	58.613	
Total	33	48425.527		

$$F_{5,40}^{0.05} = 2.45$$

$$F_{3,40}^{0.05} = 2.18$$

Excerpt 4. The ANOVA of the data (given in excerpt 3).

They used the following “additive model” (excerpt 5) to make the analysis

$$y_{ij} = \mu + \alpha_i + \beta_j + I_{ij}$$

Excerpt 5. The statistical model used for the ANOVA (of excerpt 4)

The authors (statisticians!) Muritala Abdulkabir and Raji Surajudeen Tunde through the ANOVA table (excerpt 4) draw the conclusion with 95% Confidence Level (excerpt 6).

“ H_1 : There is significant different in the state budgeting allocation within the years considered in the North central of Nigeria”

Excerpt 6. Conclusion from the ANOVA (excerpt 4)

WITHOUT making any calculation, from the ANOVA in the excerpt 4, any student can have doubts about the conclusion (excerpt 6) and make the following statements (the Peer-Reviewers could not!)

1. In the ANOVA (the excerpt 4), the “Degrees of freedom” (df) in the “Total” (last row) are wrong: they must be 53 (=5*9-1) NOT 33
2. In the excerpt 4, the F value 2.18 is with 8 and 40 df, NOT 3 and 40
3. In the ANOVA (the excerpt 4), the 3rd column “SUM of freedom” is ACTUALLY named, in all books and papers known to Fausto Galetto, «SUM of SQUARES» (SS); the software Minitab, used by the “statisticians” uses SS!

It’s not the case of Muritala Abdulkabir, Raji Surajudeen Tunde, in spite of their job working as in excerpt 2!

“Statistics Department, University of Ilorin, Ilorin, Nigeria

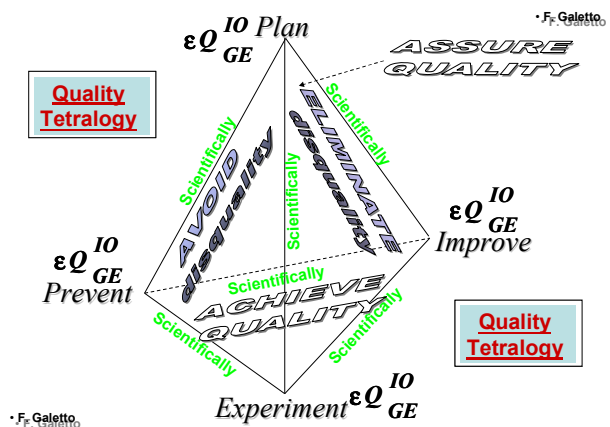
Mathematics and Statistics Department, Federal Polytechnic, Offa Kwara State, Nigeria”

Excerpt 2. Job of M. Abdulkabir and R. S. Tunde.

Later we will see the correct analysis of the data, using the Theory of the next paragraph.

3. The THEORY for Making the ANOVA

In order to overcome the huge problem of ignorance [1-6,12-16,19-23,29,31-38, 44-58] a profound change of mind (metanoia, Deming) [5,6] is NEEDED: therefore we present the Theory for analyzing Scientifically the data and making Scientifically the ANOVA [17].



Deming The result is that hundreds of people are learning what is wrong. I make this statement on the basis of experience seeing every day the devastating effects of incompetent teaching and faulty applications. Deming

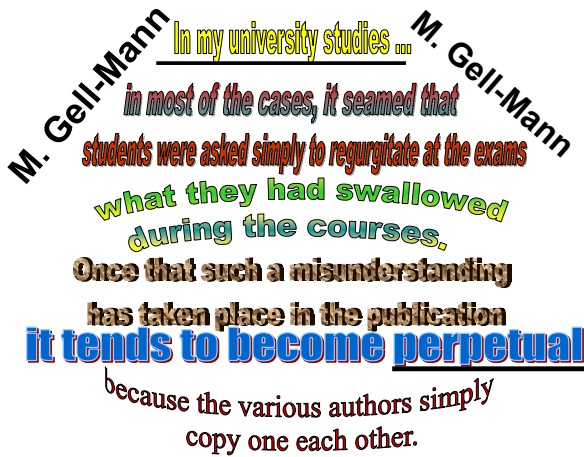


Figure 3. Statements from Deming, Gell-Mann, Galetto ideas.

When Fausto Galetto was in the Research Gate Questions&Answers forum (2014) there were two debate points: the Least Squares Estimates [LSE] and the Maximum Likelihood Method [MLM] to find the Maximum Likelihood Estimates [MLE]; it is important to have the correct ideas on the areas of applications, because there the ignorance was prevalent.

This is especially important for YOUNG Researchers: YOU, researcher, MUST be ALERT, in order NOT to be cheated! Please meditate on the figure 3.

Let's consider first the Least Squares Method [LSM] to find the Least Squares Estimates [LSE] [which includes the ANOVA Estimates from DOE (Design Of Experiments)].

We limit ourselves to the very simple case of two factors, as in the case of the Nigerian "statisticians"; we assume that any datum y_{ij} is defined as generated by the following model, [ADDITIVE model] (for A, B factors)

$$y_{ij} = \mu + \alpha_i + \beta_j + e_{ij}$$

where μ provides the influence of the mean μ of the random variables Y_{ij} , α_i provides the influence of the factor A, β_j provides the influence of the factor B [we do not consider $\alpha\beta_{ij}$ that provides the influence of the interaction AB (due to the factor A and the factor B)].

ALL the above quantities are the PARAMETERS of the model, while e_{ij} provides the influence of the "random errors" due to the random variables E_{ij} .

We write the model for two data only, leaving the others to the reader: the datum 44.91 = y_{11} comes from $\mu + \alpha_1 + \beta_1 + e_{11}$; the datum 55.45 = y_{54} comes from $\mu + \alpha_5 + \beta_4 + e_{54}$; ... and so on.

We can write the model in matrix form (using the Random Vectors Y and E) as

$$Y = X\beta + E$$

The vector Y has dimensions $n \times 1$ [in the case considered $n=54$ collected data]. The matrix X, the Design Matrix, is a known $n \times p$ matrix that contains only 0's and 1's (related to the presence of the parameter [in the case considered $\mu, \alpha_1, \alpha_2, \dots, \alpha_6, \beta_1, \beta_2, \dots, \beta_9$, 16 parameters]: be careful, the

matrix X has rank m, where $m < p \leq n$. β is a vector of the unknown parameters; we want to estimate them! E is a vector of the unknown random variables: we cannot observe them!

ALL we can OBSERVE is any datum y_{ij} from the random variable Y_{ij} . We write the vector product (inner product, where the (apex) symbol «'» means the operation transpose of the vector or the matrix) that provides the Sum of Squares of the "errors"

$$SS = E'E = (X\beta - Y)'(X\beta - Y)$$

Now we have to assume that the random variables E_{ij} are UNCORRELATED with Mean 0 AND Variance σ^2 .

We then derive the SS (Sum of Squares of the "errors") with respect to the elements of the vector β of the unknown parameters; then we set the derivatives equal to 0.

We get the Normal Equations (nothing to do with the "normal distribution") [17, 18, 29] This method is named G-Method:

$$X'X\beta = X'Y$$

TWO cases can arise:

1. either the matrix $X'X$ is of FULL rank, that is $m=p$ and therefore it has an inverse
2. or the matrix $X'X$ has not full rank (it is SINGULAR) and therefore there is no inverse

In the 1st case the Normal Equations have a unique solution vector $\hat{\beta}$ whose entries are the POINT estimators for the elements of the vector β of the unknown parameters.

In the 2nd case the Normal Equations there may be two situations [17, 18, 29]:

- (1) There is no vector $\hat{\beta}$ which satisfies the Normal Equations
- (2) Or there are an infinite number of vectors $\hat{\beta}$ which satisfies the Normal Equations

NOTICE that the case (2) is not very satisfactory: two experimenters with the same model and the same data get the same Normal Equations, BUT each of them gets a *different* estimate of the vector β of the unknown parameters. In this case there is NO unbiased estimator of the vector β of the unknown parameters. This is the case of the data of the Nigerian "statisticians" for which we will make the ANOVA (Analysis Of Variance).

To get the estimates of the parameters in a two factorial setting [named "two way table"] we have to write the following table 1.

Table 1. The layout of the data for a two way ANOVA.

A/B	Level 1	Level ...	Level ...	Level b	Row total	Row Mean
Level 1	y_{11}	.....	.....	y_{1b}	$y_{1.}$	$y_{1.}/b$
Level ...	.....	.....	.....	.....	.....	.....
Level a	y_{1a}	.....	.....	y_{ab}	$y_{a.}$	$y_{a.}/b$
Col. total	$y_{.1}$	.....	.....	$y_{.b}$	$y_{..}$	.....
Col. Mean	$y_{.1}/a$	.....	.....	$y_{.b}/a$	.....	$y_{..}/(ab)$

One solution of the Normal Equation (the estimates of the parameters) is

Table 2. The estimates for a two way ANOVA.

μ $y_{..}/(ab)$	α_i $y_{i.}/b$	β_j $y_{.j}/a$
------------------------	--------------------------	-------------------------

The *Sum of Squares of the “model”* is provided by the inner product of the vector “solution of the Normal Equations” with the vector $X'Y$. This is true for any solution with the G-Method. Any model has its own *Sum of Squares of the “model”*. The “Corrective Factor” is the *Sum of Squares of the “mean μ ”*.

The difference between $SS_{\text{of_model1}}$ and $SS_{\text{of_model2}}$ provides the $SS_{\text{of_the_parameters_}}(\text{model1-model2})$:

$$SS_{(\text{model1-model2})} = SS_{\text{model1}} - SS_{\text{model2}}$$

Therefore the importance of the factors A and B is found by the Sum of Squares

- due to factor A, SS_A =inner product of the vector ‘Row total’ with the vector ‘Row Mean’ minus the Corrective Factor, and
- due to factor B, SS_B =inner product of the vector ‘Column total’ with the vector ‘Column Mean’ minus the Corrective Factor.

With these information we can make the first part of the ANOVA table (table 3)

Table 3. Format for a two way ANOVA “additive model” (according to F. Galetto).

Source	df	SS	MS	Fc
Total	Ab	SS_{total}		
Mean	1	SS_{Mean}		
Corr_tot	ab-1	$SS_{\text{Corrtotal}}$		
A	a-1	SS_A	$MS_A = SS_A/df$	MS_A/MS_R
B	b-1	SS_B	$MS_B = SS_B/df$	MS_B/MS_R
Residual	(a-1)(b-1)	SS_{Residual}	$MS_R = SS_R/df$	

In order to decide if the factors A and B are “significant” we need to find the distribution of the “Fc, the computed ratios of the MS (Mean Square) to the MS_R ”.

Researchers must be clear about that!

Table 4. Data in matrix form for computing the SS (according to F. Galetto).

states\years	2005	2006	2007	2008	2009	2010	2011	2012	2013	Row Total	Row Mean
A	44.91	46.30	44.84	64.65	63.29	89.49	71.60	159.78	130.99	715.85	79.54
B	31.31	33.89	45.00	52.37	78.67	78.00	80.00	126.41	132.60	658.25	73.14
C	33.90	35.66	60.00	66.50	72.20	67.00	60.61	85.10	94.40	575.37	63.93
D	25.42	29.05	35.46	55.70	58.30	87.50	81.51	104.00	108.00	584.94	64.99
E	33.79	42.08	50.00	55.45	69.09	111.00	129.00	94.05	83.70	668.16	74.24
F	29.40	31.90	45.00	63.02	79.50	74.86	86.56	115.00	133.50	658.75	73.19
Column Total	198.73	218.88	280.30	357.69	421.05	507.85	509.28	684.34	683.19	3861.31	
Column Mean	33.12	36.48	46.72	59.62	70.17	84.64	84.88	114.06	113.87		71.51

The states are indicated with capital letters, A, B..., F; each row shows the data of one state. The last two columns in table 4 provide the totals and the means for each state.

The last two rows in table 4 provide the totals and the means for each year.

It was not so for the (statisticians!!!) Muritala Abdulkabir and Raji Surajudeen Tunde...

NOTICE that we wrote the table 3 WIHTOUT assuming any distribution.

To go farther, *now* we assume that the random variables E_{ij} are *normal* variables *uncorrelated* with Mean 0 AND Variance σ^2 . In this case we have the Likelihood function $L(e; \beta, \sigma^2)$ given by the formula

$$L(e; \beta, \sigma^2) \propto \frac{1}{\sigma^n} e^{-e'e/(2\sigma^2)} = (1/\sigma^n) e^{-(X\beta - Y)'(X\beta - Y)/(2\sigma^2)}$$

From the calculus we have the *maximum* of the $L(e; \beta, \sigma^2)$ when the exponent of the number e is *minimum*; in any case one gets the same *Normal Equations* we got before

$$X'X\beta = X'Y$$

Therefore we conclude that (NOTICE): for *complete samples and Normal distributed data* the MLE and the LSE are identical. [17, 18, 29]

Then, for *complete samples and Normal distributed data* the “Fc” ratios are related to the F distribution (with suitable degrees of freedom); to decide about factors significance we find the values F^* from the F distribution.

We must set a “*significance level*”, i.e. the risk we accept (BEFORE the analysis of the data!) to make an error when we state that «a factor is important (=significant) for explaining the effect of the factor on the response (the data we collected)».

Now we go back to the case of the (statisticians!) Muritala Abdulkabir and Raji Surajudeen Tunde...

4. The Scientific Analysis of the Data [56]

Now we analyse Scientifically, using the Theory of paragraph 3, the data of the budget. [excerpt 4, the case of the (statisticians!) Muritala Abdulkabir and Raji Surajudeen Tunde]

The data to analyse are in the excerpt 3.

Here we present them in matrix form to use the rule of “inner product of vectors”.

3861.31 is the “Grand Total” and 71.51 is the “Grand Mean”; their product is the “Corrective Factor”, i.e. $SS_{\text{Mean}}=276106.40$

The importance of the factors State and Year is found by the Sum of Squares

- due to factor State, SS_{State} =inner product of the vector 'Row total' with the vector 'Row Mean' minus the Corrective Factor, and
- due to factor Year, SS_{Year} =inner product of the vector 'Column total' with the vector 'Column Mean' minus the Corrective Factor.

$$SS_{State}=1596.04 \text{ and } SS_{Year}=44484.97$$

We state the "Significance Level" $\alpha=5\%$.

With these information we can make the ANOVA table (table 5)

Table 5. Two way ANOVA "additive model" (according to F. Galetto).

Source	df	SS	MS	Fc	F*	Signif
Total	54	331729.35		$\alpha=$	0.05	
Mean	1	276106.40				
Corr_tot	53	55622.95				
States	5	1596.04	319.21	1.39	2.45	
Years	8	44484.97	5560.62	23.31	2.18	**
Residual	40	9541.94	238.55			

It is clear from table 5 that

- the years have a Significant Effect on the Budget (i.e. the budget changed with the years)
- there is NO Significance Difference between the States [the *OPPOSITE* was found by the (statisticians!) Muritala Abdulkabir and Raji Surajudeen Tunde..., because they, using Minitab, computed *WRONGLY* the $SS_{Residual}=SS_{Error}$!!! Obviously we do not know why MINITAB computed *WRONGLY* the SS_{Error} !!!]
- the cause of the error was the wrong THEIR $SS_{total}=48425.527$, while it should be $SS_{Corr_tot}=55622.95$; obviously we do not know why MINITAB computed *WRONGLY* the SS_{Error} !!!

Only the authors (statisticians) perhaps can explain that.

5. Another Scientific Analysis of the Data [56]

Using the Theory of paragraph 3, the data of the budget [excerpt 4, the case of the (statisticians!) Muritala Abdulkabir and Raji Surajudeen Tunde], we can make another Scientific analysis (data in the excerpt 3).

We use the model "model with trend"

$$y_{ij} = \mu + \alpha_i + \beta \text{ year} + e_{ij}$$

where μ provides the influence of the mean μ of the random variables Y_{ij} , α_i provides the influence of the factor A (the States) and β provides the "common linear" influence of the factor B (the years).

We could, as well, use the model

$$y_{ij} = \mu + \alpha_i + \beta_i \text{ year} + e_{ij}$$

where μ provides the influence of the mean μ of the random variables Y_{ij} , α_i provides the influence of the factor A (the States) and β_i provides the "linear" influence of the factor B

(the years), for each state.

So we see how powerful is the Theory we presented in the paragraph 3.

ALL the above quantities are the PARAMETERS of the model, while e_{ij} provides the influence of the "random errors" due to the random variables E_{ij} .

We content ourselves to provide the analysis of the model with "common linear" influence β of the factor B (the years).

We write again the model in matrix form (using the Random Vectors Y and E) as

$$Y = X\beta + E$$

The vector Y has dimensions $n \times 1$ [in the case considered $n=54$ collected data]. The matrix X, the Design Matrix, is a known $n \times p$; be *careful*, the matrix X has rank m, where $m < p \leq n$. β is a vector of the 8 unknown parameters: $\mu, \alpha_1, \alpha_2, \dots, \alpha_6, \beta$; we want to estimate them! E is a vector of the unknown random variables: we cannot observe them!

We have to assume, as we did before, that the random variables E_{ij} are *uncorrelated* with Mean 0 AND Variance σ^2 . We derive the SS (Sum of Squares of the "errors") with respect to the elements of the vector β of the 8 unknown parameters; then we set the derivatives equal to 0. We get the *Normal Equations* (nothing to do with the "normal distribution"...) [17, 18, 29] for the new model

$$X'X\beta = X'Y$$

The G-Method assures that any solution of the Normal equations estimates the 8 unknown parameters; with them we compute the Sum of Squares for the States (factor A) and for the "common" slope β for the years: we find $\beta=10.951$

We state again the "Significance Level" $\alpha=5\%$ and make the ANOVA table (table 6)

Table 6. Two way ANOVA "model with trend" (according to F. Galetto).

Source	df	SS	MS	Fc	F*	Signif
Total	54	331729.35		$\alpha=$	0.05	
Mean	1	276106.40				
Corr_tot	53	55622.95				
States	5	1596.04	319.21	1.38	2.41	
Years_Lin	1	43172.60	5560.62	186.94	4.05	**
Residual	47	10854.30	230.94			

Compare the findings of table 5 and table 6.

It is clear from table 6 that (as we found in the table 5, with the "additive model")

- the years have a Significant *LINEAR* Effect on the Budget (i.e. the budget changed "linearly" with the years, with high confidence level)
- there is NO Significance Difference between the States [the *OPPOSITE* was found by the (statisticians!) Muritala Abdulkabir and Raji Surajudeen Tunde...]

Since the analysis was made to find the different behavior of the Nigeria states with their budget it is evident that the (statisticians!!!) Muritala Abdulkabir and Raji Surajudeen Tunde missed completely their job!

6. Conclusion

We presented two ways of analysing one single case [paper 56] (to show the Scientific way of making ANOVA, via the Least Squares Method):

«On State Budget in the North Central of Nigeria: Analysis of Variance (ANOVA) Approach. Journal of Investment and Management. Vol. 4, No. 6, 2015, pp. 296-300. doi: 10.11648/j.jim.20150406.12» (Muritala Abdulkabir, Raji Surajudeen Tunde)

My student are able to find the right solution because they had the Sound Theory! [17]

Without knowing the Basics of the discipline one wants to innovate it is very improbable (if not impossible) to improve the status of Science. Citations, impact factors, the various indexes are not a proof of Science. (see the Fausto Galetto experience in the Research Gate "database")

Citing Muritala Abdulkabir and Raji Surajudeen Tunde Fausto Galetto, WHO found them WRONG, improves the indexes of Muritala Abdulkabir, Raji Surajudeen Tunde! WHERE is the Quality?

We said that the problem of ignorance is so huge [1-6,12-16,19-23,29,31-38, 44-54] that a profound change of mind (metanoia, Deming) [5,6] is NEEDED.

See all the figures (mostly figures 1, 2, 3, 5).

The following statements of great scientists and managers are important for any person who wants to make QUALITY Decisions on QUALITY matters. They are not opinions; they are hard facts!

We think that the YOUNG Researchers MUST be ALERT if they want to LEARN: THEY MUST know the THEORY!

The author Galetto always invited people to be intellectually honest in teaching and taking decisions: THEORY is fundamental in both cases. [see the F. Galetto documents, in the references, in the RG database, and in his books]

From above we see that Fausto Galetto taking into account the following statements by great people, as always did, could provide a sensible advice for any Researcher, in any university, and any Manager, in any Company.

W. E. DEMING "It is a hazard to copy". "It is necessary to understand the theory of what one wishes to do or to make." "Without theory, experience has no meaning." "A figure without a theory tells nothing". <<<The result is that hundreds of people are learning what is wrong. I make this statement on the basis of experience, seeing every day the devastating effects of incompetent teaching and faulty applications. >>>

M. GELL-MANN "In my university studies ..., in most of the cases, it seemed that students were asked simply to regurgitate at the exams what they had swallowed during the courses." Some of those students later could have become researchers and then professors, writing "A_scientific" papers and books ... For these last, another statement of the Nobel Prize M. Gell-Mann is relevant: <<<<<"Once that such a misunderstanding has taken place in the publication, it tends to become perpetual, because the various authors simply copy one each other.">>>>> similar to "Imitatores, servum pecus"

[Horatius, 18 B.C.] and "Gravior et validior est decem virorum bonorum sententia quam totius multitudinis imperitiae". [Cicero]

P. B. CROSBY Paraphrasing P. B. CROSBY one could say "Professors may or may not realize what has to be done to achieve quality. Or worse, they may feel, mistakenly, that they do understand what has to be done. Those types can cause the most harm."

What do have in common Crosby, Deming and Gell-Mann statements? The fact that professors and students betray an important characteristic of human beings: rationality [the "Adult state" of E. Berne]

A. EINSTEIN "Only two things are infinite: the Universe and the Stupidity of people; and I'm not sure about the former".

GALILEO GALILEI Before EINSTEIN, GALILEO GALILEI had said [in the Saggiatore] something similar "Infinite is the mob of fools".

The scientific community as a whole must judge [κρίνω] the work of its members by the objectivity and the rigor with which that work has been conducted; in this way the scientific method should prevail. Any professor and any Statistical Consultant should know Probability Theory and Statistics!

I always was used to say to my students: ««««IF a guy suggests books and papers written by incompetents he is TWICE incompetent, because he does not recognize wrong ideas and suggests to read wrong ideas»»»». Unfortunately several Professors do not practice the two important methods used here, the Logic and the Scientific Theory (Mathematics, Probability, Statistics, Physics,...). See the references...

Please see well the figures and see IF ...

Researchers shall use their intelligence in order to make knowledge for the improvement of people and their life.

Researchers MUST not cheat people and act according to the figures 1, 2 and 3.

Remember that any Intellectually hOnest person that loves QUALITY and hates DISquality will Focus on the problems [potential and/or actual], Assess their importance (money, impact, consequences, risks, ...), Understand all the previous items SCIENTIFICALLY and SCIENTIFICALLY Test for finding the causes; when a solution is found anybody will Activate to implement the solution, in order to Guaranty that Reliable Actions (preventive and corrective) are taken Through an Intelligent Approach (approach that uses intelligence, ingenuity and science, avoiding misdeeds). [figures 1 and 4]

Remember also that the Parent ego_state is the set of thoughts, feelings, and behaviours that are learned or "borrowed" from our parents or other caretakers. Two parts are comprised: the Nurturing Parent ego_state soft, loving, and permission giving, and Prejudiced Parent, the part of our personality that contains the prejudged thoughts, feelings, and beliefs that we learned from our parents.

Remember also that the Adult ego_state is our data processing centre: it formulates hypotheses to be verified by experiments, using Logic and Methods to test ideas and to

process data accurately: it denounces misdeeds. You can see its capacities on the right hand of the figure 1. Qualitatis FAUSTA GRATIA is related to the Adult ego_state.

The Adult ego_state [17, 18, 29] is embodied in the εQ_{GE}^{IO} symbol (the epsilon-Quality, see also figure 4).

Intellectually hOnest people use as much as possible their rationality and Logic, in order not to deceive other people.

Deming, Einstein, Gell-Mann are beacons for the Quality Journey.



Figure 4. The epsilon-Quality to avoid the Disquality.

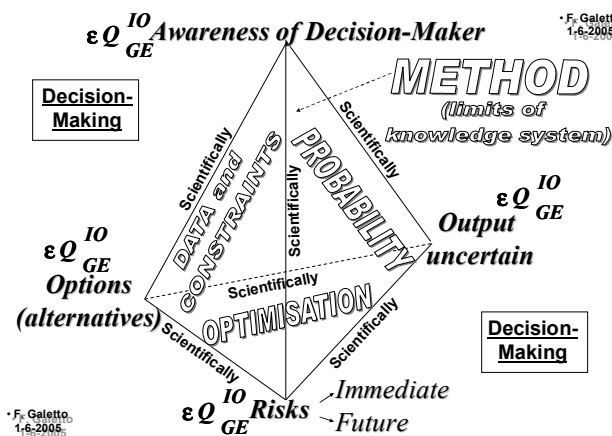


Figure 5. The Decision-Making Tetrahedron.

If we want to achieve Quality, MANAGERS (now students) NEED to be EDUCATED on Quality εQ_{GE}^{IO} by Quality Professors, EDUCATED on Quality.

I could, at last, paraphrase ST John "And there are also many other things, the which, if they should be written everyone, I suppose that even the world itself could not contain the books that should be written." [1-56]

Will someone want to see the truth? Only God knows that ...

The personal conclusion is left to the Intellectually Honest reader to whom is offered the Quality Tetralogy: Prevent, Experiment, Improve, Plan, SCIENTIFICALLY to avoid disquality, to eliminate disquality, to achieve Quality, to assure Quality, using Intellectual Honesty: we wish them to use correctly the Decision-Making Tetrahedron (fig. 5).

Quality Tetralogy and Decision-Making are much better than ISO 9004:2008 (and 2015, as well) because Quality Tetralogy and Decision-Making Tetrahedron take into account explicitly the need for scientific behavior either of people or of organizations that really want to make Quality. Moreover they

show clearly that prevention is very important for Quality and Good Management is strongly related to Good Knowledge for Business Excellence.

Brain is the most important asset: let's not forget it, IF we want that our students (Future Managers or Future Researchers) be better than their professors.

We repeat

YOUNG Researchers MUST be ALERT

if they want to LEARN:

THEY MUST know the THEORY!

««The truth sets you free»»

Professors and researchers who do not are Intellectually hOnest will not grow students and researchers fond of Quality (see all the figures and [32]).

If they want that the Science improve they must know at least the BASICS!

They can have a new proof of the need of knowledge of the basics, by reading the chapter 7 of the book [58] (published in September 2015: three professors made a mess of an application of DOE (case found on September 20, 2015).

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