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CONTENTS

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SANKHYA VIGNAN
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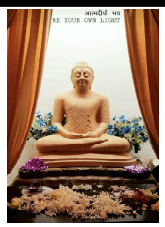
EDITORIAL



It is our pleasure to present before you this issue (NSV 17, Sept. 2021, No.3) in almost stipulated time. We express our sincere thanks to all our contributors, evaluators, readers and well wishers for their continuous and consistent support, which always helps us to achieve our goal.

This issue contains one paper for the section of Management and Statistics, two review articles, two research articles, one research note, one biography, two book reveiws and other sections of SV news letter and readers forum. You will find the details in the contents.

We are highly indebted to our following referees who have helped us for evaluation of the articles / papers submitted for this issue. **(Their names are given one by one in the order of their apperance.)**

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You can visit our website **www.sankhyavignan.org,** where you can give your feedback and suggestions.

We express our sincere thanks to our **Research Team** for this work. In particular we thank **Shree Dinesh Darji for DTP work and Shree Ashish Bhatt for website.**

All our contributors will get digital copy and official certificates.

Our best wishes and blessings to all of you for your health, progress and prosperity.

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GUJARAT STATISTICAL ASSOCIATION - FROM EDITOR'S DESK

SANKHYA VIGNAN is a peer reviewed refereed Bi-Annually journal that published empirical, conceptual and review papers of exceptional quality that contribute to Statistics Theory and enriched Applications of Statistical Techniques in various fields. The objective ofthe Journal is to disseminate knowledge, which ensures good practice of professional management and its focal point is on research and reflections relevant to academicians and practitioners in the field of Applied Statistics.

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   a) send the paper to two reviews, if the results were negative by one reviewer and positive by the other one; then the editor may send the paper for third reviewer or he take immediately the final decision by accepting/rejecting the paper. The Editor In Chielf will ask the selected reviewers to present the results within 7 working days, if they were unable to complete the review within the agreed period then the editor have the right to resend the papers for new reviewers using the same procedure. If the Editor In Chief was not able to find suitable reviewers for certain papers then he has the right to accept/reject the paper.
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6. Article should be typed in 12 point - Times New Roman Font English with a one and half space and single column with 1 Margin on a Standard A4 size paper. The page numbers should be at the center of every page. All headings & sub headings must be in bold letters.
7. Table should be numbered consecutively, the title of the table should be placed above the table. The source should be indicated at the bottom.
8. All the tables, charts, graphs, diagrams should be in black and not in colors.
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MANAGEMENT AND STATISTICS

ARTICLE

THE ROLE AND RESPONSIBILITIES OF THE RESEARCHERS, SPONSOR'S/CLIENT'S AND PARTICIPANTS IN BUSINESS RESEARCH.

A. C. BRAHMBHATT*

ABSTRACT

This paper discusses in brief the role and responsibilities of the research workers partaining to business research. Business research is a very important feature now adays and it needs precautions for maintaing quality of the research works undetaken. Some hints and suggestions are presented in this paper to safeguard and monitor the quality of the research works.

KEY WORKS

Participant, Sponsor, Responsibility, Confidential, Assertion.

1. INTRODUCTION

In any business research , mostly three parties are involved—researcher, sponsor/client and participants. Ideally it should be of very high standard in terms of research element involved in it, but at the same time, the high ethical standards should have been be maintained. Most of the researchers try to comply with ethical principles provided by American Psychological Association (APA).These principles focus on the general ethical principle of beneficence (i.e. avoiding harm and providing benefits). Each of the stakeholders has certain rights and responsibilities. They should have mutual respect to one another , maintaining amount of fair treatment and guarding against fabrication or falsification of data. Such ethically sound research enhances cooperation and promotes moral and social values. It builds public support. People are more likely to invest in or fund for such research. By maintaining high ethical standards in business research, values like social responsibility, human rights,

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compliance with law , health, human welfare etc. are strengthened.

2. RIGHTS OF RESPONDENTS:

Respondents are extremely important entities, in any business research project undertaken. It is their sheer willingness and preparedness to provide responses to the questions administered to them, help navigate the project smoothly and reach to its logical conclusions. The researcher therefore should protect their rights . The data may be gathered through any mode-survey, observation or an experiment, their rights are to be safeguarded.

(1) They should know the purpose of the study and they should be told everything, a reasonable person would want to know in order to arrive at decision as to whether they should participate or not.

(2) They should be very clearly told the benefits of the research, neither overstated nor understated. Researcher should introduce himself/herself, his/her past business research project work , if any.

(3) Researcher has to secure informed consent from the respondents. The informed consent is one of the founding principles of research ethics. The informed consent may be oral or even in a written form. In securing their informed consent, tell them the project theme, objectives, geographical extent, the name of sponsor etc. They should be clearly told that the participation is completely voluntary.

(4) Even after the data collection is over, they need be given the follow up information. Give them the brief report of findings. If it is experimental kind of research, inform them about the intervention that was tested.

(5) They have the right of anonymity and confidentiality .Anonymity means his/her name should never be disclosed . Confidentiality means the information of individual participants are not reported, even without names , unless explicit permission has been given. It should even extend to casual coffee room conversations.

(6) They have right to withdraw from a study at any time after the start of their

participation in the study. The participant who chooses to withdraw has the right to receive whatever benefits that were promised.

(7) They have right to privacy. They can refuse to be interviewed or can refuse to answer a particular question in personal interview or may not attend the telephonic call, in a telephonic interview, if they suspect that their privacy is invaded.

In observational studies, using hidden camera or observing through one-way mirror invade upon their privacy, especially in the case of women participants. In the household survey, the interviews of women participants, preferably should be conducted in the presence of the head of the family.

(8) They have the right to know when they have been deceived and why , during the research process ,if at all such incidence of deception may have occurred. If the deception seems to be unwarranted and unreasonable, they have right to withhold the data and even approach the appropriate authority .

3. RESPONSIBILITIES OF THE PARTICIPANTS

The participants have certain responsibilities too.

(1) Participants have a responsibility to take the research project seriously and cooperate with the researcher.

(2) They should provide honest and thoughtful answers to the questionnaire administered to them. Their commitment and dedication to providing truthful answers provides the researcher with invaluable knowledge of human behavior that could be useful to formulate right business strategies.

(3) They should be extremely punctual to attend sessions arranged by the researcher. If it is experimental kind of research, if they do not inform in advance their non-availability, it may jeopardize researcher's entire schedule.

(4) They should give their honest feedback after the completion of the project. Good researchers expect them not merely providing responses, but also receiving from them the relevant additional information that could be of great importance while

undertaking future business research.

(5) They should honor the researcher's request to not disclose the findings of the project with any outsider. Confidentiality works both ways.

The all above obligations of the participants are in a way, also the rights of the researcher.

4. SPONSOR'S RIGHTS

The sponsors have certain rights, especially those sponsors who do not wish to reveal themselves.

(1) Sponsor nondisclosure: Due to the sensitive nature of the management dilemma or the research question , the researcher has a responsibility to respect the sponsor's desire of safeguarding his identity.

(2) Purpose nondisclosure: A research sponsor may be testing a new product idea or may be contemplating a new public stock offering, he does want the competitor to know of his purpose and plans. In such cases , researcher should regard his wish of purpose nondisclosure.

(3) Findings nondisclosure: Most sponsors want research data and findings to be confidential, at least until the management decision is made. It is researcher's responsibility to honor it.

(4) Right to deliverables: The researcher after the completion of the business project should return entire data, CDs , questionnaires, monthly reports etc. to the sponsor.

(5) Right to quality research: The researcher should not compromise on quality. The sponsor wants that in carrying out the business research, appropriate research deign, appropriate, questionnaire design, appropriate sampling design, appropriate tools of analysis should have been employed. Researcher's role is fact finding, whereas sponsor's role is management decision making. Therefore the quality of the research should be such that helps him in sharpening and refining his decision making process.

5. SPONSOR'S RESPONSIBILITIES

Sponsor has several obligations towards the researcher and the participants as well.

(1) He should have transparent relationship with the researcher. There should be clear , unambiguous written statement with regard to money and time committed.

(2) He should not unduly try to justify a self-serving , political position that is not supported by the data .

(3) He should maintain the rights of privacy of both , participants and researcher, even the privacy on internet. He should resist the temptation of using all the demographic information of the participants.

(4) He should not alter data or create false data to meet his desired intent.

(5) He should not make recommendations beyond the scope of the data collected in the research project.

Thus, If the concerned parties in business research – the sponsor, researcher and the participants , mutually honor the rights of one another and render their responsibilities , the outcomes of the research would not only have promising managerial implications but also have high ethical standard.

6. ACKNOWLEDGEMENTS

I thank the referee for reviewing my paper.

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REVIEW ARTICLE

STATISTICS ARE OMNIPRESENT - A BRIEF REVIEW ON SOME APPLICATIONS OF STATISTICS[#]

M. N. PATEL*

ABSTRACT

Statistics has very wide area for its applicabilit not in different fields but almost everywhere. This feature can be described very honestly and honourably that statistics are omnipresent.

This paper discusses few interesting applications of statistics connected with different fields. It highlights an expanding universe so far as applicability of the subject is concerend.

KEYWORDS

Behaviour, Principle Component Analysis, Predictions, Decision Making Approach.

1. WHAT IS STATISTICS ?

Statistics can come forward in two ways: singular and plural. In plural form, statistics is quantitative as well as qualitative. In the plural sense, data is generally taken into account keeping in mind the statistical analysis.

Singularly, it is more like a scientific method that helps in presenting, collecting, as well as analyzing data. All of this brings some major characteristics into the limelight.

2. THE PURPOSE OF STATISTICS:

Statistics teaches people to use a limited sample to make intelligent and accurate

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This paper is based upon author's keypaper presented at the conference on celebration of World Statistics Day at H.K.C.C., Ashram Road, Ahmedabad on 20th October, 2020. (rcd. August '21 / rvd. Sept. '21)

conclusions about a greater population. The use of tables, graphs, and charts play a vital role in presenting the data being used to draw these conclusions.

Statistics is an extremely powerful tool available for assessing the significance of experimental data and for drawing the right conclusions from the vast amounts of data encountered by engineers, scientists, sociologists, and other professionals in most spheres of learning.

There is no study with scientific, clinical, social, health, environmental or political goals that does not rely on statistical methodologies. The most essential reason for this fact is that variation is ubiquitous in nature, and probability and statistics are the fields that allow us to study, understand, model, embrace and interpret this variation.

3. APPLICATIONS:

Uses and importance of statistics can be seen in fields as diverse as agriculture, mathematics, healthcare, engineering, decision making, geography, sports, sociology, marketing, government, nursing, planning, banking, economics, research, education, medicine, accounting, business, technology, psychology, business economics, business management, industry, physics, biology as well as educational research.

The financial market is not complete without statistical data. For a layperson, it is hard to understand the complicated scenario of share market and other financial sectors. It is easier to represent valuable data with the help of diagrams, charts, and other statistical tables. If you are holding some share in the market, with just one look at the data chart you will understand the market scenario. It was not possible without statistics.

You name any business sector; trading, manufacturing, production so on, every sector require statistics to monitor their growth.

In Multinational Companies, statistics is an integral part of their projects. They use charts and statistic parameters to monitor the performance of their employees.

Nowadays, Mobile Applications are incomplete without statistical data. For

example, booking a cab or checking how many calories you have burnt throughout the day or week; if you are on a diet you check your calorie intake with the help of some app that uses statistical data to present the result.

Another important sector where statistics used as the predominant form of information is the health and medicine sector. Doctors used percentage and charts to monitor the health of their patients. The data help them understand how you are improving.

Political sector is another platform where statistics uses extensively to predict the election result, progress and growth of the ruling party, and so on.

News Channels use statistical data to make everything understandable for its viewers. Statistical data plays a strong part in this sector. Without that, it will be tough for viewers to understand the important perspectives of today's' world.

Space science is another sector where statics is used extensively. With the help of statistical data, you will get valuable first-hand information about different planets of our solar system. Isn't it amazing!

Statistics are often used to support opinions or views. They show up on all forms of media, including the World Wide Web. Statistics prevent everything from getting complicated. It allows collecting information around the world. With the internet we can leverage the power of statistical data.

When used correctly, statistics can be used to predict the trend of things in the past or the future to justify the present. Here, we have come up with an infographic to highlight the different applications of statistics in daily life. Have a look.

4. APPLICATIONS OF STATISTICS IN DIFFERENT FIELDS OF OUR LIVES.

Application 1. To analyse the brand loyalty behavior of consumers for Detergents:

To analyse the long-term probabilities and brand loyalty behaviour of consumers for detergents, using Markov Chain model, the required data have been collected

randomly from 1100 households belonging to different levels of the society, for the month of June in the year 2013.

The four brands of detergents which are popular among the consumers have been brought for consideration and the other brands available in the market have been grouped together. i.e. They are D1, D2, D3, and D4(Others).

Data:

Customer No.	Brand used in May	Brand uses at present (in June)
1.	D1	D1
2.	D2	D4
3.	D2	D1
4.	D1	D3
5.	D3	D4
6.	D3	D2
7.	D4	D1
8.	D4	D2
9.	D1	D4
10.	D2	D3
11.	D3	D4
12.	D4	D1
13.	D2	D2
14.	D3	D3
15.	D4	D4
and many more...		

May\June	D1	D2	D3	D4	Total
D1	480	21	10	0	511
D2	105	70	10	85	270
D3	45	30	125	35	235
D4	12	10	12	50	84

The following transition probability matrix, calculated for the month of May-June.

May\June	D1	D2	D3	D4
D1	0.9393	0.0411	0.0196	0.0000
D2	0.3889	0.2593	0.0370	0.3148
D3	0.1915	0.1277	0.5319	0.1489
D4	0.1429	0.1190	0.1429	0.5952

The present proportions of the four brands in the month of June are respectively as 0.5836, 0.1191, 0.1427 and 0.1546 (i.e. 58%, 12%, 14% and 16% approximately).

Denote this present proportion as vector V_0 = (0.5836, 0.1191, 0.1427, 0.1546).

Then the proportion of the four detergents in the market after one month can be obtained as

$$V_1 = V_0P = (0.5836,\ 0.1191,\ 0.1427,\ 0.1546)\begin{pmatrix} 0.9393 & 0.0411 & 0.0196 & 0.000 \\ 0.3889 & 0.2593 & 0.0370 & 0.3148 \\ 0.1915 & 0.1277 & 0.5319 & 0.1489 \\ 0.14296 & 0.1190 & 0.1429 & 0.5952 \end{pmatrix}$$

$$= (0.6439,\ 0.0915,\ 0.1138,\ 0.1508)$$

We see that after one month (in July) detergent D1 capture the market more. i.e. from 58.36% to 64.39% and so on…

Application 2. Ranking the cricket captains using principal component analysis

The data considered by Shah and Patel(2018) on batting, bowling performance of each Captain and team performance under his captaincy in one day International

(from 2005 to April, 2018) who have captained the team for at least 40 matches is used for analysis.

Principal Component Analysis (PCA) is a nonparametric variable reduction technique well-suited for correlated data. It is used to determine the ranks (performance) of the Captains.

This analysis includes the batting measures like Runs, Batting Average (Ave), Batting Strike Rate (SR), Fours, Sixes, Hundreds and Fifty variables, bowling measures like Wickets, Bowling Average, Bowling Strike Rate, team performance like matches played, match won, match lost, discussed in below section, for all captains who have captained for at least 40 ODI matches. This accounts for 29 total captains.

The first principal component for Captain is calculated by the equation

L1 = 0.374* Matches + 0.198* Winning % + 0.339* (Fifty + Hundred) + 0.001* Batt_Avg - 0.030*Batt_S/R + 0.354* (Catches + Stumping) + 0.091* Overs + 0.099 * Wickets + 0.029*Bowl_Avg + 0.034* Bowl_S/R + 0.050 * Bowl_E/R.

Larger values indicate better Captain's performance. This justifies that we should rank (largest to smallest) the captains based on the first principal component. The results of first ten Captains are presented here.

Rank	Player	PCA
1	MS Dhoni (INDIA)	2.90117
2	RT Ponting (AUS)	2.64540
3	DPMD Jayawardene (SL)	1.42782
4	GC Smith (Afr/SA)	1.31151
5	AB de Villiers (SA)	0.67660
6	V Kohli (INDIA)	0.56460
7	MJ Clarke (AUS)	0.39754
8	DL Vettori (NZ)	0.15717
9	Shakib Al Hasan (BDESH)	0.13584
10	Misbah-ul-Haq (PAK)	0.02903

Application 3. Sex determination from the foot and/or shoe dimension in youngsters of Ahmedabad city.

Foot print/ shoe print is one of the valuable physical evidence encountered in the crime scene. The aim of the study was to develop a formula to determine the sex of an individual using foot and/or shoe dimensions.

This study is based on the stature, shoe size, left and right shoe dimensions, left and right foot length and width measurement (in Centimeter) of a target group of 500 youngsters of age 18 -23 years, randomly selected from the different colleges of Ahmedabad.

Of which 400 were again selected for data analysis and the remaining 100 were used to verify the formula of determining their sex.

The following abbreviations are used here.

ss – shoe size, lfw- left foot width, lsw-left shoe width, lfl- left foot length, lsl- left shoe length, rfw – right foot width, rsw- right shoe width, rfl-right foot length, rsl – right shoe length.

Logistic regression equation for sex determination

No.	Sex equation	Total Correct Prediction (%)
1	Sex = -62.207 + 0.489**(ss) - 0.395(lfw) + 0.4(lsw) + 0.106(lfl) + 0.285*(lsl) + 0.217(rfw) + 0.895*(rsw) + 0.642*(rfl) + 0.499**(rsl)	95.41
2	Sex = -53.174 + 0.873** (ss)- 0.057(lfw) + 1.093**(lsw) + 0.572**(lfl) + 0.601**(lsl)	98.41
3	Sex = -50.482 + 0.468**(lfw) + 1.210**(lfl)	87.71
4	Sex = -40.105 + 1.112**(lsw) + 1.203**(lsl)	100

5	Sex = -52.781 + 0.596**(ss) + 0.146(rfw) + 1.321**(rsw) + 0.599**(rfl) + 0.797**(rsl)	98.14
6	Sex = -42.242 + 1.333**(rfw) + 1.389**(rfl)	88.87
7	Sex = -47.504 + 1.17** (rsw) + 1.278**(rsl)	93.98
8	Sex = -65.596 - 0.348(lfw) + 0.209(lsw) + 0.264(lfl) + 0.427*(lsl) + 0.431(rfw) + 1.110*(rsw) + 0.531*(rfl) + 0.540**(rsl)	96.14
9	Sex = -53.448 + 0.079(lfw) + 1.219**(lsw) + 0.941**(lfl) + 0.749**(lsl)	98.14
10	Sex = -60.707 + 0.344(rfw) + 1.174**(rsw) + 0.743**(rfl) + 0.912*(rsl)	93.24
11	Sex = -49.447 + 0.731**(ss) + 0.109(lsw) + 0.474**(lsl) + 0.995*(rsw) + 0.699**(rsl)	95.14
12	Sex = -43.089 + 0.871**(ss) + 1.011**(lsw) + 0.918**(lsl)	95.14
13	Sex = -44.217 + 0.816**(ss) + 1.276**(rsw) + 0.889**(rsl)	90.43
14	Sex = -53.172 + 0.188(lfw) + 0.861**(lfl) + 1.007**(rfw) + 0.714**(rfl)	90.43

It was noticed that determination of sex could be done with 87.71 – 100% correctly. Because there may be differences between different societies in order to shoe size and people's shoe size. It was supposed that if any kind of shoe found on the spot, this study would lead the determination of sex. 93.98 to 100% correctly.

5. LIMITATIONS:

Limitations come a lot before directly applying the statistical methods. It is necessary to be aware of it in order to move ahead. Some of the primary limitations of statistics are:

In order to propose specific projections, i.e. sales, price, quantity and so on, there is a requirement of a set of conditions. So, if, by any chance, these conditions turn out to be wrong or are violated, there is a chance that the projections and its outcome will be inaccurate.

Statistical inferences make use of random sampling options. Hence, not following the rules for sampling would be a very bad idea as it can lead to wrong results. The conclusions coming off would have errors. So, the idea here is to consult the experts before hopping into the sampling scheme, directly.

6. ACKNOWLEDGEMENT:

I thank the referee for his review and comments on my paper which has help to revise it thoroughly.

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REVIEW ARTICLE

A STUDY ON THE EVOLUTION OF THE CONCEPT OF STATISTICAL QUALITY CONTROL AND ITS INCEPTION IN INDIA

RICHA SETH*

ABSTRACT

This study briefly sketches the historical dates of the events that have supported the evolution process of the concept of Statistical Quality Control and also illustrates how and when it got incepted in India. The study starts with mentioning the definition of quality and its dimensions. Then it talks about the relationship between quality assurance, quality control and continuous quality improvement. The study shows that the credit of initialization of the statistical quality control methods lies on the shoulders of the western world. The establishment of these procedures was initiated in US and subsequently, these procedures were adopted by Japan to recover from the World War II devastation. The study delves into the history and brings out the significant events that have supported in the evolution of the concept of Statistical Quality Control and its transformation to Six-Sigma techniques, leading to Total Quality Management and Continuous Quality Improvement. The study also shows that in India, the Statistical Quality Control methods were introduced and developed later, during the period of 1935 to 1946. The spread of the awareness of these procedures in India was due to the efforts made by the scientist and applied statistician P. C. Mahalanobis. The study mentions that the statistical quality control techniques have extended from manufacturing arena to many other sectors, like services, software, financial sector and health care industry. Most of the companies in various sectors are competing

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confidently and harvesting the benefits of attaining and managing quality standards.

KEY-WORDS:

Quality, Quality assurance, Statistical quality control, Quality improvement.

1. INTRODUCTION

Statistical tools and their use to analyze data have vast applications in any phenomenon related to life. Statistical data analysis can also be used to assess quality. How quality is measured and what statistical procedures can be adopted to examine and improve that measurement, is an area of interest. Even more interesting is to get aware about the meaning of quality and how it is being achieved. It makes us more curious to get into the depth of knowing about the evolution of the term Statistical Quality Control and what is its significance in the current scenario. This search of acquiring knowledge and understanding the concept of Statistical Quality Control leads to the following objectives of study.

2. OBJECTIVES OF THE STUDY

(i) To study how the concepts of Quality Control and Six-Sigma evolved over the period of time.

(ii) To know about the inception of Statistical Quality Control Methods in India.

(iii) To know the recent developments in the area of Statistical Quality Control.

3. CONCEPT OF QUALITY

Quality is the degree of excellence of the efforts made and as rightly said by A. P. J. Abdul Kalam, “Excellence is a continuous process and not an accident”. International Organization of Standardization (ISO 8402; 1986, p3) defines quality as: “The totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs.” (Gupta, 1994). Stated need can be understood for the product automobile, as a need of good quality metal body with wheels that can be driven and the implied need as a need of its ability to provide safe transportation. In general, quality has different levels of degree of customer satisfaction.

Quality can take many forms: Quality of Design, Quality of Conformance and Quality of Performance (Summers, 2009). Sood (2015) has defined all three of them as follows.

Quality of Design means the intentional inclusion or exclusion of features by designers in a product or service that characterizes the quality of the product or service. The design differences may arise due to the types of materials and their levels used in the construction, the specifications set by the designers and the amount of reliability built in the final product. For instance, "in manufacturing sector, the car manufacturers like Ford and BMW make cars which are fit for use but designed for a different set of customers. Both cars differ in their features, performance, size, quality and cost and the buyers who are not pleased with the overall quality of a car are encouraged to move up a class. Similarly, in service sector, like hotel industry, all hotels provide a place to sleep but many features of design quality such as comfort, luxury, ambience, services available, swimming pool and exercise rooms separate a normal hotel from a five star hotel".

Quality of Conformance means how well the product or service conforms to the specifications that are not only set by the designers but also required by the design. It may not be directly associated with consumers' perception of quality. It may be affected by the manufacturing processes that are employed, the methods of inspecting, testing and controlling of these processes and the training, supervision and motivation of the workforce to achieve quality. For instance, suppose a manufacturer sets the dimension of a product as 14.05±0.10 5Z5Z and suppose, in service industry a server sets the time limit to deliver food at home in 20-30 minutes. Then, if they are not meeting the specifications and going beyond the limits, they have poor quality of conformance.

Quality of Performance refers to reliability and robustness of the product or service. Reliability of a product or service means that it performs its intended function under a prescribed set of conditions for a long period of time. Robustness of the

product means the product or service can work under a broad range of conditions. The repeated sales of a product and its image are built by its performance and if the performance is poor then it may lead to legal implications. For instance, if a voltage stabilizer is designed to work within a voltage range of 185-275 volts then it would be reliable if it performs satisfactorily in this range for a long period of time and it would be robust if it works well even at 165 or 295 volts. Similarly, for service industry, say, in information technology industry, suppose an antivirus program is designed such that whenever it is updated it removes all viruses from computer hard disk and protects it. But if the computer is infected even after repeated antivirus updates then the antivirus has poor quality of performance.

3.1 ORGANIZATIONS FOR ASSESSING QUALITY

International Organization for Standardization (ISO) is a standard body for assessing quality. It consists of representatives from different countries. Each country has its own national standards body as a representative in ISO. The Indian representative to ISO is Bureau of Indian Standards (BIS). American National Standards Institute (ANSI) is the US representative to ISO (Gupta, 1994). ISO has a vast coverage including quality management, environmental management, country code, social responsibility, energy management, risk management, food safety management, information security management and occupational health and safety (ISO web page, 2015).

IEC, Electro-technical International Commission is another organization looking after international standards and conformity assessment of electrical, electronic and related technologies (IEC web page, 2015). "ISO and IEC operate as a single system. Their objective is to facilitate the development of international standards in order to reduce the 'barriers' effect of different national standards on international goods and services" (Gupta, 1994).

4. EVOLUTION OF CONCEPT OF QUALITY CONTROL AND SIX-SIGMA

Industrial Revolution in Western Civilization, during the 18th and 19th century,

approximately in the time period of 1760 to 1840, expanded with the help of creation of cotton gin. The use of cotton gin to separate cotton fibres from their seeds eased the mechanism and produced cotton fibres in abundance which led to the creation of machines, designed to spin and weave fabric in large amounts. Eli Whitney invented cotton gin in 1793. His idea of interchangeable parts emerged, when in 1798, due to ignition of French Revolution, new American government realized the need to prepare for war. Government awarded Whitney a contract of producing 10000 muskets. "Whitney demonstrated that machine tools - run by workers who did not require the highly specialized skills of gunsmiths – could make standardized parts to precise specifications and that any part made could be used as a component of any musket" (NewWorldEncyclopedia, 2017). Whitney's manufacturing of interchangeable components introduced his revolutionary "uniformity system". For about a century, the uniformity system was used to check whether the new produced items matched the original design of the item, without taking into account exact replication.

During the mid of the 19th century, with the introduction of go gages, consistency in the design of the items produced was made possible. Go gages verified the minimum dimension of the new part. About 30 years later no-go gages were introduced to verify the maximum dimension of a new part. These gages provided minimum and maximum tolerance limits to measure how much replicable a part is, to its original design. These minimum and maximum tolerance limits eventually evolved into specifications.

The world's first National Standards body was formed in 1901 by Sir John Wolfe-Barry. "Originally known as British Standard Mark, British Standards Institution has grown into one of Britain's most important and most recognized consumer quality marks" (BSIGroup, 2017). The time-line of major events in the evolution of concept of quality control is shown in the Table-4.1.

Table-4.1 Time-Line of Evolution of Concept of Quality Control

Century	Year	Event
18th Century	1798	Invention of Eli Whitney's revolutionary Uniformity System
19th Century	18401870	Introduction of Go GagesIntroduction of No-Go Gages
20th Century	1901	Establishment of British Standards Organization
	1913	Installation of Assembly Line for Mass Production by Henry Ford
	1924	Invention of Walter Shewhart's Control Charts
	1939-45	Happening of World War II and Prominent Use of Statistical Methods
	1945-50	The Advent of Japanese Quality Movement
	1946	Establishment of Indian Standards Institution
	1947	Establishment of International Organization for Stan0dardization
	1950-54	Visits of Deming and Juran to Japan for Introducing Quality Concepts
	1950	Establishment of Japan's Deming Prize by the Union of Japanese Scientists and Engineers (JUSE)
	1954-73	Japan Continuously Focused on its Quality Improvement Journey
	1973	Beginning of Oil Embargo
	1980's	Deming and Philip Crosby Promoted Quality Improvement Techniques in U.S.
	Early 1980's	Turning Around of Pocket Pager Business at Motorola by Implementing Bandit Project – Stealing Best Practices From the Best Companies

	1986	Implementation of Six Sigma Quality System at Motorola
	1987	Bureau of Indian Standards was Established to Broaden the Scope of Indian Standards Institution and Introduction of Malcolm Baldrige National Quality Award in USA, Motorola being First to Won this Award
	1992	Introduction of European Quality Award
	1994	Revision for the First Time of the Set of Standards Published at the Time of Establishment of ISO
	1996	Introduction of Indian Merchants' Chamber Ramakrishna Bajaj National Quality Award
21st Century till Current Period	2020-21	Emergence of Advanced Statistical Methods, Multivariate Symmetry and Asymmetry, Data Mining and Intelligent Computation Methods to Collect, Analyze and Report Real-Time Data for Assessing and Improving Quality.

An American industrialist, Henry Ford, the founder of the Ford Motor Company, continuously tried for years to increase his factories' productivity. In his desire to build automobiles more efficiently, he installed in 1913 the first moving assembly line for mass production of cars. The building of cars on assembly line reduced the time of production from more than 12 hours to just 2 hours and 30 minutes (History, 2017). This process of production also met the requirement of producing new products which would be similar to the original product or design.

As it was not practical, cost effective and time relevant to use the measure of go and no go gages to test each item, use of concept of sampling was the demand of the hour as against 100% inspection. The invention of control charts, based on the concept of sampling, by Walter Shewhart in 1924, while working for Western Electric Company, ushered an era of monitoring the stability of the process and

identifying when it changes. It was a refinement in the inspection procedure of identifying and sorting defective items after production.

4.1 INCEPTION OF THE IDEA OF STATISTICAL QUALITY CONTROL

The birth of Statistical Quality Control lays back to the first quarter of the 20th century just after the World War I ended. The seeds of this technique were sown by an American physicist, engineer and statistician Walter Andrew Shewhart, who is remembered as the father of Statistical Quality Control. After being awarded doctorate in physics from the University of California, Berkeley in 1917; he joined in 1918 Western Electric Company of America which manufactured telephones and associated equipments. The company was renamed as Bell Telephone Laboratories in 1925. The process of developing the concept of Statistical Quality Control started from the time when Shewhart joined the company's Inspection Engineering Department.

The initial job assigned to him at Western Electric Company was to develop a sound-proof aviation shield (Mahalanobis, 1948). He applied statistical knowledge for developing specifications for different sizes of heads by taking measurements of heads of 100 men of the company. In early nineteen twenties, it was found that the lack of quality in the products of the company lead to the rejection of large portions of the items. Since Walter was found to be interested in statistics, he was asked to search for the procedure of reducing the proportion of rejections. He was also asked to arrive at a sample size that would be appropriate for inspection purposes. To answer these queries, Shewhart prepared a report in 1924, explaining in detail the method of Statistical Quality Control and mentioning control chart in a diagram form which he later presented in his classical book "Economic Control of Quality of Manufactured Product". The book was published in 1931.

When United States entered the World War I in 1917, there was a huge demand of war materials. As there was not sufficient number of trained inspectors it was not possible for the war department to carry out 100% inspection of the war material.

As such the war department had to adopt the Sampling Inspection Plans proposed by Shewhart. Also the war production board realized the significance of using Statistical Quality Control during production processes. There onwards progress was made in the application of SQC in other industrial arenas.

During 1920's and 1930's the volume of production grew larger and more complex which required sophisticated quality assurance and control methods. During World War II, 1939 to 1945, the use of statistical methods became prominent. "The armed forces initially inspected virtually every unit of product, then to simplify and speed up this process without compromising safety, the military began to use sampling techniques for inspection, aided by the publication of military specification standards and training courses in Walter Shewart's statistical process control techniques" (AmericanSocietyforQuality, 2017).

After World War II, consumption increased drastically in U.S. The consumers were satisfied with marginal quality and so the manufacturers continued producing in mass volume and were not worried about cost reduction or quality improvement of the products. However, Japan was devastated by the war. When the war ended in the year 1945, Japan started the process of reconstructing itself and ended its enmity with United States.

Japanese leaders thought that the secret of success of allied forces in the war was knowledge and use of statistics. They wanted to gain more practical knowledge about the field of statistics. In this regard, the quality gurus, Shewhart, Deming and Juran visited Japan from time to time. They informed, explained and spread the knowledge of statistics and its application in quality improvement.

In the mean time, the Union of Japanese Scientists and Engineers (JUSE) got established in the year 1946. The JUSE pioneered the study of Statistical Quality Control in Japan and used it for research, educational and promotional activities (Tsutsui, 1996).

During 1955-1965 Japanese overcame the limitations that the economy and

industry was facing and conceptualized the synthesis of "top management involvement, statistical information and participative management practices" to develop the movement of Total Quality Control. This led to the progress of Japan's "quality miracle". Japan's quality revolution of the 1960's and 1970's was driven by the philosophy and methodology of Total Quality Control.

Initially quality management started with a simple inspection based system. It then passed through the revolutionary stage of quality control, followed by stage of quality assurance during World War II and then leading to the birth of Total Quality Management system in United States in response to the quality revolution in Japan following World War II.

In inspection based system, manufactured product was compared with product standard by a team of inspectors. The product testing and documentation was included in the quality control stage. During the quality assurance stage, there was shift in focus from product quality to systems quality by including preventive measures such as quality manuals, quality planning and advanced document control. The Total Quality Management environment sought continuous quality improvement integrating all organizational functions (marketing, finance, design, engineering, production, inter-departmental barriers, staff training, excellent customer relations etc.) to meet customer needs and organizational objectives.

4.2 TRANSFORMATION OF STATISTICAL QUALITY CONTROL INTO SIX-SIGMA MOVEMENT

The manufacturing companies of U.S. were struggling to survive in the competitive environment created by Japanese firms. The United States government in 1987 introduced Malcolm Baldrige National Quality Award for attaining business excellence. "Two key aspects of the Baldrige Award are the promotion of best practice sharing and the establishment of a benchmark for quality systems that focused on customer satisfaction as a primary driver of business design and execution" (Folaron & Chase, 2003). Motorola was the first company to win this award.

Bob Galvin, the son of the founder of Motorola, Paul Galvin, along with Dr. Mikal J Harry and Motorola engineer Bill Smith, implemented six-sigma quality system at Motorola. Six-Sigma approach was an in-house initiative by Motorola's engineers for reducing defects in manufacturing processes. In 1986, it began as statistically based method to reduce variation in electronic manufacturing processes. "Certain engineers – Bill Smith and Mikal Harry, felt that measuring defects in terms of thousands was an insufficiently rigorous standard. Hence they increased the measurement scale to parts per million, described as 'defects per million', which prompted the use of six-sigma terminology equating to 3.4 parts-or defects-per million" (BusinessBalls, 2017).

Six-Sigma needs to be implemented in an organization from top to bottom cutting across all organizational barriers to bring about improvement in the product and the processes.

5. ADOPTION OF STATISTICAL QUALITY CONTROL METHODS IN INDIA

In India, the spreading of awareness of Statistical Quality Control lays solely on the efforts of the scientist and the applied statistician P.C. Mahalanobis. Apart from writing reputed scientific papers, he contributed to the services of the country by setting up Indian Statistical Institute in 1931 and founding the Journal Sankhya (Mahalnobis Biography, 2015).

In 1935, Mahalanobis wrote a note to the government of India for the requirement of developing Quality Control methods in India (Mahalanobis, 1948). In 1942, he again made an effort to urge the government of India to use Quality Control methods in war production. In 1944, Prof. A. V. Hill, secretary of the Royal Society of London came to India for giving advice on the organization of scientific research. On his recommendation, Council of Scientific and Industrial Research appointed a committee on Statistics, Standards and Quality Control. P. C. Mahalanobis was made the chairman of this committee. Not much progress in application of quality control was made because of absence of contacts with industrial concerns and lack of industrial

experience. Moreover, industrialists were making large profits without being interested in Quality Control.

In May 1946, Mahalanobis met Walter A. Shewhart in New York. In November 1946, he was invited by Dr. Shewhart to deliver a lecture and attend a conference in the Bell Telephone Laboratories of America. At that time, Mahalanobis realized that lots needed to be done for improving Indian industry and for that Dr. Shewhart's assistance was required.

In December 1946, Mahalanobis wrote a note to the Government of India, suggesting to invite Dr. Shewhart to India, but the Government thought that the time was not yet ripe. So, in March 1947, Indian Statistical Institute took the initiative of inviting Dr. Shewhart. Later, he was also invited by Indian Standard Institution and Indian Science Congress. Under the sponsorship of Indian Statistical Institute, nine operating units for providing knowledge, training and consultancy on SQC were established at Bangalore, Baroda, Bombay, Calcutta, Coimbatore, Delhi, Ernakulum, Madras and Trivandrum. Interest in the application of SQC increased in the industry, especially in the private sector in India.

In India, after globalization and liberalization, process, product and service quality has been the demand of the hour to meet global competition, so Indian companies have also embraced six-sigma methodologies. Initially, large engineering and manufacturing companies of India have adopted six-sigma approach. Later, it has been implemented by small and medium sized organizations. Today, the use of six-sigma is not restricted to engineering and manufacturing sector only, but has benefited the organizations in software, business process outsourcing, service, financial, insurance sectors and more recently, healthcare industry. In relation to this, a large number of case studies of different Indian companies have been published in various international journals (Antony et al, 2016). Mumbai's Dabbawalas have been studied as a case study for six sigma approach in their operations. Wipro Technologies, Bharti Airtel, TATA Steel, ICICI Prudential Life are some of the Indian

companies that have adopted six-sigma practices for attaining and maintaining quality standards. Micro, Small and Medium enterprises in India still have a long way to go for understanding and meeting the challenges in implementation of six-sigma practices to reap the fruits of quality attainment (Malek & Desai, 2015).

6. RECENT DEVELOPMENTS AND ADVANCES IN STATISTICAL QUALITY CONTROL

As mentioned earlier, the application of statistical quality control methods has emerged to be of great significance in variety of sectors, such as, software development, healthcare industry, financial services, business process outsourcing services, engineering and manufacturing sectors. The studies in these areas require more sophisticated statistical methods, as the simplified assumptions of classical SQC may not be fruitful and valid. New procedures based on advanced statistical methods, multivariate symmetry and asymmetry, data mining and intelligent computation methods are emerging as the areas of interest. Some of these advanced techniques of statistical analysis - Design of Experiment Methods, Stream of Variation Analysis, Finite Element Modeling, Fuzzy Logic, Genetic Algorithm, Multi-Objective Optimization and Numerical Simulation are now used for analyzing data for the purpose of Statistical Quality Control (Symmetry, 2021).

7. CONCLUSION

This study presents a clear view of the evolution process of arriving at high production quality standards. Starting from the beginning of the 18th and 19th century, when, Industrial Revolution in western world led to the creation of machines till today's world, which uses sophisticated Statistical Process Control, where real time-data is analyzed and reports are housed in a Cloud (Modern Quality Control with SPC, 2021), the concept of Statistical Quality Control has travelled a long distance. Initially, the production of large number of parts on machines demanded the comparison of the original design of the item with that of the new produced items. Eli Whitney's Uniformity System revolutionized the manufacturing process and

introduced the checking system of the consistency of quality. To work upon this checking of consistency, Go-Gages and No-Go-Gages were introduced to verify the minimum dimension and the maximum dimension of a new part. Later, these minimum and maximum dimensions evolved into specifications. In 20th century, Walter A. Shewhart initiated the idea of Statistical Quality Control which revolutionized quality management in industrial arena in United States. Japan followed the footsteps and developed the movement of Total Quality Control which resulted in "Quality Miracle" in the manufacturing sector. Though India is a late entrant in this development process, it has been able to keep pace. Indian companies have embraced quality control methodologies and have become competitive in the global competition. Most of the Indian companies are now reaping the fruits of quality attainment. Now, Indian companies should take note of the recent advancement in Statistical Quality Control procedures where Statistical Process Control has been broadened to include real-time data collection, analysis and reporting.

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RESEARCH ARTICLE

REGRESSION ANALYSIS FOR SENSITIVITY INDICES CORRESPONDING TO NON-NEUTRAL CDPF FOR INDUSTRIAL SECTOR OF ALL INDIA

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ABSTRACT

A specific study for fitting Non-neutral CDPF was made for the entire industrial sector for all India during period 1981-82 to 2017-18. The model was well fitted both at current as well as at constant prices. Based upon the fitted model partial elasticities were examined for their sensitivity. In this paper a regression relation is established for these indices in order to provide further predictions for certain period.

KEYWORDS:

NON-NEUTRAL, TSI, PSI, REGRESSION, PREDICTION

1. INTRODUCTION

Production function models have their mathematical forms which are associated with several input factors of production which can affect the independent variable that can be output or profit or cost or value added by manufacturers (VAM). The relationships considered may be for a single individual unit or for a group of such units which means it may be at micro or macro level while considering industrial applications. In a similar way the production function approach is also much more popular in the case of agricultural production. But in that case the nature of variables are different with their requisite assumptions, which highlight some alternative pattern for the stipulated models concerned in their fields

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We want to highlight our study particularly for the industrial production and also for all industries in the entire industrial sector for all India. Earlier we have fitted non-neutral Cobb-Douglas production function (NNCDPF) for the industrial sector of all India during the period 1981-82 to 2017-18.

The model was very well fitted at current as well as constant prices and parametric sensitivity analysis was considered for total and partial elasticities of the model. While observing the model and the respective sensitivity indices it was really very surprising to find that these indices could be related with time in some way and graphical presentation ensured about linear relationships.

In this paper, data base considered is given in section 2, then the model approach with notations are give in section 3.1 and 3.2. The corresponding regressions are given in section 4 by means of tables 1 to 8, section 5 gives conclusions made based upon out analysis in which table 9 gives predictions for further periods 2018-19 to 2022-23. Sections 6 gives concluding remarks based upon our findings which is followed by acknowledgements and selected references in section 7 and 8.

2. DATA BASE

Here, data are used from Annual Survey of Industries and also from Census of Indian Manufacturers. The data are pertaining to all industries for all India during the period 1981-82 to 2017-18.

3. METHODOLOGY

3.1 MODELS

We consider different models for Partial sensitivity indices and Total sensitivity indices as per passage of time. The relevant equations are as under.

$$P_{1t}^{\delta} = a_0 + a_1 t + U_{1t}$$
$$P_{2t}^{\delta} = b_0 + b_1 t + U_{2t}$$
$$P_{3t}^{\alpha} = c_0 + c_1 t + U_{3t}$$
$$P_{4t}^{\alpha} = d_0 + d_1 t + U_{4t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(I)}$$
$$P_{5t}^{\beta} = e_0 + e_1 t + U_{5t}$$

$$P_{6t}^{\beta} = f_0 + f_1 t + U_{6t}$$

$$T_{7t}^{all} = g_0 + g_1 t + U_{7t}$$

$$T_{8t}^{all} = h_0 + h_1 t + U_{8t}$$

3.2 NOTATIONS

P_{1t}^{δ} = Partial sensitivity indices at time t when parameter δ is increased by 5%

P_{2t}^{δ} = Partial sensitivity indices at time t when parameter is decreased by 5%

P_{3t}^{α} = Partial sensitivity indices at time t when parameter is increased by 5%

P_{4t}^{α} = Partial sensitivity indices at time t when parameter is decreased by 5%

P_{5t}^{β} = Partial sensitivity indices at time t when parameter is increased by 5%

P_{6t}^{β} = Partial sensitivity indices at time t when parameter is decreased by 5%

T_{7t}^{all} = Total sensitivity indices at time t when all parameters are simultaneously increased by 5%

T_{8t}^{all} = Total sensitivity indices at time t when all parameters are simultaneously decreased by 5%

Here, $\alpha_0, \alpha_1, b_0, b_1, c_0, c_1, , d_1, e_0, e_1, f_0, f_1, g_0, g_1, h_0$ and h_1 are the regression coefficients and $U_{1t}, U_{2t}, U_{3t}, U_{4t}, U_{5t}, U_{6t}, U_{7t}$ and U_{8t} are the disturbance terms.

4. REGRESSION ANALYSIS

Using values of Partial sensitivity indices and Total sensitivity indices from our earlier paper, an attempt is made to consider regression analysis based upon above equations in (I). The results obtained are given in the following tables.

Table 1: Regression analysis when is increased by 5%

Model : $P_{1t}^{\delta} = \alpha_0 + \alpha_1 t + U_{1t}$

Regression Statistics						
Multiple R	0.999898404					
R Square	0.999796819					
Adjusted R Square	0.999791014					
Standard Error	0.049329184					
Observations	37					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	419.0875065	419.0875065	172225.2599	3.27188E-66	
Residual	35	0.085167894	0.002433368			
Total	36	419.1726743				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.094136453	0.015895994	-5.92202356	9.7812E-07	-0.12640704	-0.0618658
Time	0.315209334	0.00075954	415.0003132	3.27188E-66	0.313667386	0.3167512

Table 2: Regression analysis when is decreased by 5%

Model : $P_{2t}^{\delta} = b_0 + b_1 t + U_{2t}$

Regression Statistics						
Multiple R	0.999897888					
R Square	0.999795787					
Adjusted R Square	0.999789953					
Standard Error	0.044523005					
Observations	37					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	339.6767113	339.6767113	171355.0189	3.57512E-66	
Residual	35	0.06938043	0.001982298			
Total	36	339.7460918				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.08642029	0.014347236	-6.02348008	7.19049E-07	-0.11554673	-0.05729385
Time	-0.283778572	0.000685537	-413.950503	3.57512E-66	-0.28517029	-0.28238686

Table 3: Regression analysis when parameter is increased by 5%

Model : $P_{3t}^{\delta} = c_0 + c_1 t + U_{3t}$

Regression Statistics						
Multiple R	0.86769914					
R Square	0.7529018					
Adjusted R Square	0.74584185					
Standard Error	0.22776609					
Observations	37					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	5.532417076	5.532417076	106.6440887	3.62976E-12	
Residual	35	1.815708681	0.051877391			
Total	36	7.348125757				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95.0%*
Intercept	6.2394388	0.07339607	85.0105257	3.80823E-42	6.09043689	6.38844
Time	0.0362163	0.003507	10.32686248	3.62976E-12	0.02909671	0.04333

Table 4: Regression Analysis when parameter is decreased by 5%

Model : $P_{4t}^{\delta} = d_0 + d_1 t + U_{4t}$

Regression Statistics						
Multiple R	0.87418315					
R Square	0.76419618					
Adjusted R Square	0.75745893					
Standard Error	0.19771659					
Observations	37					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	4.434128822	4.434129	113.4285	1.5896E-12	
Residual	35	1.368214763	0.039092			
Total	36	5.802343585				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-5.877780484	0.063712828	-92.2543	2.2E-43	-6.0071244	-5.7484366
Time	-0.032422826	0.003044317	-10.6503	1.59E-12	-0.038603117	-0.0262425

Table 5: Regression analysis when parameter is increased by 5%

Model : $P_{5t}^{\delta} = e_0 + e_1 t + U_{5t}$

Regression Statistics							
Multiple R	0.8556400						
R Square	0.7321198						
Adjusted R Square	0.7244660						
Standard Error	0.27957509						
Observations	37						
ANOVA							
	df	*SS*	*MS*	*F*	*Significance F*		
Regression	1	7.4766417	7.476642	95.655429	1.51103E-11		
Residual	35	2.735678082	0.078162				
Total	36	10.21231982					
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*
Intercept	12.386637	0.0900911	137.49	1.972E-49	12.20374	12.5695	12.20374
Time	0.0421017	0.0043047	9.780359	1.511E-11	0.033362	0.05084	0.033362

Table 6: Regression analysis when parameter is decreased by 5%

Model : $P_{6t}^{\delta} = f_0 + f_1 t + U_{6t}$

Regression Statistics						
Multiple R	0.86074355					
R Square	0.74087945					
Adjusted R Square	0.73347601					
Standard Error	0.21733474					
Observations	37					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	4.726852442	4.726852	100.07227	8.39837E-12	
Residual	35	1.653203601	0.047234			
Total	36	6.380056043				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-11.018747	0.070034643	-157.333	1.774E-51	-11.1609245	-10.87657
Time	-0.0334759	0.003346385	-10.0036	8.398E-12	-0.04026946	-0.026682

Table 7: Regression analysis when all parameters are increased by 5%

Model : $T_{7t}^{all} = g_0 + g_1 t + U_{6t}$

Regression Statistics						
Multiple R	0.993882142					
R Square	0.987801712					
Adjusted R Square	0.987453189					
Standard Error	0.577926592					
Observations	37					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	946.6387704	946.6387704	2834.255068	4.36069E-35	
Residual	35	11.68997009	0.333999145			
Total	36	958.3287405				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	19.20450031	0.186232917	103.1208695	4.53489E-45	18.82642739	19.58257323
Time	0.473738691	0.008898553	53.23772223	4.36069E-35	0.455673668	0.491803714

Table 8: Regression analysis when all parameters are decreased by 5%

Model : $T_{8t}^{all} = h_0 + h_1 t + U_{8t}$

Regression Statistics						
Multiple R	0.995682113					
R Square	0.99138287					
Adjusted R Square	0.991136666					
Standard Error	0.297311139					
Observations	37					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	355.9337	355.93373	4026.676933	9.941E-38	
Residual	35	3.0937869	0.0883939			
Total	36	359.0275				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-16.37148962	0.0958064	-170.88079	9.88265E-53	-16.565987	-16.1769920
Time	-0.290490066	0.0045778	-63.456102	9.94096E-38	-0.2997835	-0.28119661

5. CONCLUSIONS

From above table : 1, we find that the value of R is 0.99 which indicates that there is strong association between Partial sensitivity indices with time. We also find that 99% variation is explained by the model. Adjusted R^2 is also 0.99 which also indicates similar behavior. F value from ANOVA is highly significant.

From above table :2, we observe that again 99% variation is explained by the model. Value of R^2 is 0.99 which shows strong association between Partial sensitivity indices and time. From the table of regression coefficients it is observed that all regression coefficients are statistically significant at 5% level of significance. F value is also highly significant which shows that regression model may be consider as good fit for the data.

Similarly from Table : 3, 4, 5, 6, 7 and 8 , we observe that values of R are 0.87,0.87, 0.86, 0.86, 0.99 and 0.99 respectively, which show strong association between respective sensitivity indices and time. Also 75%, 76%, 73%, 74%, 98%, 99% variations are explained by the different models respectively. All values of R^2 are highly significant. From tables of regression coefficients, it is also clear that all regression coefficients are statistically significant at 5% level of significance. We also found that all F- values are also highly significant which indicate that all regression models may be considered to be good fit for the data.

We are employing above models for prediction purpose. The predicted values of Partial sensitivity indices and Total sensitivity indices for subsequent years are given in the Table : 9 below.

Table 9: Predicted values of Total Sensitivity indices and Partial Sensitivity indices for the years 2018-19 to 2022-23

Year	P_{1t}^{δ}	P_{2t}^{δ}	P_{3t}^{α}	P_{4t}^{α}	P_{5t}^{β}	P_{6t}^{β}	T_{7t}^{all}	T_{8t}^{all}
2018-19	11.5609	-10.5944	7.5784	-7.0768	13.9447	-12.2545	36.89	-27.138
2019-20	11.8759	-10.8784	7.6146	-7.1092	13.9868	-12.2879	37.368	-27.429
2020-21	12.1909	-11.1624	7.6508	-7.1416	14.0289	-12.3213	37.846	-27.72
2021-22	12.5059	-11.4464	7.687	-7.174	14.071	-12.3547	38.324	-28.011
2022-23	12.8209	-11.7304	7.7232	-7.2064	14.1131	-12.3881	38.802	-28.302

6. CONCLUDING REMARKS

This research study highlights the significance of the total and partial sensitivity indices for the fitted non-neutral CDPF model. As seen above, all linear models are almost closely fitted for the data series considered by us. The surprising linear relationships are envisaged and they may be useful for further prediction based upon our analysis.

It may be worthwhile here to place assertion that the partial and total indices for the parametric study may induce the corresponding labour, capital and growth pattern of the data based upon our model. This may help for further planning objectives for the managements as well as for government organizations.

7. ACKNOWLEDGEMENTS

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8. COMMENTS BY REFEREE :

This research study is a linear trend observed for the timeseries data considered by researchers. Authors have tested the original model fitted for having non constant

returns to scale. it is surprising how the sensitivity indices for the partial elasticities have lineartity. This large time series could have been split up in two or three time series and then model testing exercise might give some interesting conclusions.

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RESEARCH ARTICLE

EDUCATION, ECONOMIC GROWTH AND ECONOMIC DEVELOPMENT IN INDIA

Himanshu Desai[(1)], Manish Thaker[(2)], Parul I. Patel[(3)]

ABSTRACT

The education, infra-structural facilities, health, banking, finance are the basic factors that determine the economic growth, development and economic progress of the nation. The variables listed here, in most of the cases are exogenously determined. It is only possible to make efficient use of the existing resources in such a way that the economic growth is speedy, economic development is total and it is achieved in such a way that economic welfare is maximized.

The economic change is observed in terms of a significant change in structure of the economy. The role and the share of the primary sector gradually decline and the share of other two sectors rises. In the later phase of economic development the share of service sector in the national income rises remarkably. The important aspect for the study is to know [1] whether the expansion of education, banking and other infra structural facilities are capable to provide equal opportunities to every body in the society.[2] the impact of education, banking and other infra-structural facilities on income and other macro variables.

The focus of this study is to examine [1] The benefit of economic development on GENDER at two point of time [1] 1991 and [2] 2001. [2] The influence of

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education and other variable on economic development. The data covered in the present study is from HUMAN DEVELOPMENT REPORT published by Gandhi Labour Institute Ahmedabad.

An attempt is made here to link the role of education, health and other infrastructural facilities with economic development and economic growth. It is considered that when economic activity expands the role of secondary and the tertiary sector gradually increases. This also assumes that when the education medical and other infrastructural facilities expands government policy make such an attempt that the economic opportunities are available in equal way to every one in the society. The analysis presented here shows that there is a considerable disparities between the rich and the poor states and the gender disparities is observed.

There are few positive points in terms of rise in the literacy rate, rise in the female literacy and the decline in the drop out ratio. The picture is still not very rosy. The econometric results highlight that the impact of education on economic development shows positive sign in 2001, which was negative in the 1991 period but still the results are not significant. We spend hardly 4.0% of our GDP on education. This must rise to provide better economic opportunity to people in the society.

I. INTRODUCTION

The education, infra-structural facilities, health, banking, finance are the basic factors that determine the economic growth, development and economic progress of the nation. The variables listed here, in most of the cases are exogenously determined. It is only possible to make efficient use of the existing resources in such a way that the economic growth is speedy, economic development is total and it is achievd in such a way that economic welfare is maximized.

The economic change is observed in terms of a significant change in structure of the economy. The role and the share of the primary sector gradually decline and the share of other two sectors rises. In the later phase of economic development the share of service sector in the national income rises remarkably. The important aspect

for the study is to know [1] whether the expansion of education, banking and other infra structural facilities are capable to provide equal opportunities to every body in the society.[2] the impact of education, banking and other infra-structural facilities on income and other macro variables.

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[1] 1991 and [2] 2001. [2] The influence of education and other variable on economic development. TE he data covered in the present study is from GUJARAT HUMAN DEVELOPMENT REPORT.*2004.

The economic development should be designed in such a way that it provides benefits to each state in the almost equally, depending on the economic and human resource allocation and their uses. However planner must provide such situation that the fruits of development and growth are available to each state and each individual.

The economic growth of the INDIAN ECONOMY and the relative share pattern of primary, secondary and tertiary sector are viewed in the first section. Here a brief review of role of education in economic development is covered. The economic status of 15 selected states and in 1991 and 2001 is explained. The absolute disparities in terms of economic growth indicators and education and health indicators are compared. The second section emphasis on the gender disparities and the effect of education on economic development and economic growth.

2. THE SECTORAL SHARE OF G.D.P:

In the process of economic development in the initial stage the decline in the share of primary sector can be fast and the rise in the share of the secondary and tertiary sector remains slow .The process of shifting from primary to the other sector.

TABLE 1.0 SECTORAL SHARE OF G.D.P.: INDIA

	primary	secondary	Tertiary	*pri	*sec	*ter
50-51	59.2	13.3	27.5	--	--	--
60-61	54.7	16.6	28.7	-0.45	0.33	0.12
70-71	48.1	19.9	32.0	-0.66	0.33	0.33
80-81	41.8	21.6	36.6	-0.63	0.17	0.46
90-91	34.9	24.5	40.6	-0.69	0.29	0.40
91-92	34.1	23.9	42.0	-0.80	-0.06	1.4
92-93	34.2	23.7	42.1	-0.01	-0.2	0.1
93-94	33.5	23.7	42.8	-0.07	0.0	0.7
94-95	32.9	24.4	42.7	-0.6	0.07	-0.1
95-96	30.6	25.5	43.9	-2.3	1.1	1.2
96-97	30.9	25.4	43.7	0.3	-0.1	0.02
97-98	29.0	25.2	45.8	-1.9	-0.2	2.1
98-99	29.0	24.5	46.5	00	-0.7	0.7
***[yearly changes]**						

The above results indicate that there is a decline in the share of the primary sector share in G.N.P. And a corresponding rise in the share of secondary and tertiary sector in G.N.P In INDIA during 1950-1980 the share of the primary sector decline at slow and steady rate. In 1950-51 the share of primary sector was 59.2% which declined to 34.1% in 1990-91.This decline is of [24.3%].In the same period the secondary sector share rises by[11.2%] The tertiary sector share rises by [13.1%] In this phase it is observed that the sectoral shift is almost even but when we take the entire period of 1950-1999 the decline in the share of the primary sector was[30.2%] and the rise in the share of the other two sectors was 11.2% and 19.0% respectively. This reflects that the sectoral shift is more in favour of the Tertiary sector.

It is stated that in the process of economic development the growth of banking, finance, education, health, infrastructural development increases at speedy rate and

as a result the economic growth will be faster. The planning process must emphasis on these sectors in such a way that it has a positive impact on the development and growth process.

3. EDUCATION, DEVELOPMENT AND GROWTH

When education facilities expand it provides more opportunities to earn at the economy level and also at the state level. This must generate gender equality at all level. The government must give due importance to education in their expenditure plans. The education expenditure /GDP ratio is given in the table given below

TABLE 2.0: EDUCATION EXP/GDP %

1951	0.64	1971	2.25	1991	3.80
1952	0.73	1972	2.33	1992	3.72
1953	0.74	1973	2.15	1993	3.62
1954	0.94	1974	2.20	1994	3.56
1955	1.15	1975	2.49	1995	3.56
1956	1.08	1976	2.51	1996	3.53
1957	1.19	1977	2.83	1997	3.49
1958	1.23	1978	3.00	1998	3.85
1959	1.40	1979	3.07	1999	4.25
1960	1.48	1980	2.98	2000	4.33
1961	1.52	1981	2.92	2001	3.84
1962	1.52	1982	3.25	2002	3.79
1963	1.50	1983	3.14	2003	3.76
1964	1.51	1984	3.25		
1965	1.69	1985	3.49		
1966	1.68	1986	3.41		
1967	1.73	1987	3.73		
1968	1.80	1988	3.72		
1969	1.92	1989	3.93		
1970	2.11	1990	3.84		

TABLE 3.0 DROP OUT RATIO

PERIOD	CLASS 1-5	CLASS 1-8	CLASS 1-10
1960-61	64.9	78.0	—
1970-71	67.0	77.9	--
1980-81	58.7	72.7	82.5
1990-91	42.6	60.9	71.3
2000-01	40.7	53.7	68.6
2003-2004	31.47	52.32	62.69

TABLE 4.0 LITERACY RATE

PERIOD	MALE	FEMALE	TOTAL
1951	24.95	7.93	16.67
1961	34.44	12.95	24.02
1971	34.45	18.69	29.45
1981	56.56	29.85	43.67
1991	64.13	39.29	52.21
2001	75.85	54.16	65.37

The above tables that indicate the role of education expenditure in GDP and the other two indicators such as drop out ratio and gender literacy and total literacy rates. The education expenditure /GDP ratio from 1951-2003 point out that the education is been given a least importance and due to that from 1955-1969 it has remained at less than 2.0% level. During 1983-1997 it has remained at less than 4.0% level. Even after 2000-01 the expenditure /GDP ratio has fallen to less than 4.0%.This strongly advise to give more weight age to grow education expenditure/ GDP ratio.

There are **several positive points** in the case of literacy rate and the drop-out ratio point out that there is some positive impact of education expenditure on enhancing

the literacy rate and specifically the female literacy advances from 7.93% to 54.16% which is not a bad achievement. The total literacy boost up from 16.67% to 65.37% in the span of five decades.

The biggest investment on education expenditure is to reduce wastage of vital human resources. The high drop- out ratio at the school level actually enhances the frustration among youth. The progress in this is still not very significant. In Std.1-5; drop out ratio reduced from 64.95 to 31.47%. In the case of Std 1-8, it has dropped from 78.3% to 52.32% and for Std 1-10 it fall from 82.5% to 62.69% from 1971 to 2004.The drop out ratio of 62.69% is still shows alarming sign for the planners and policy makers.

Amartya Sen and J. Dreze argues that investment in human capital enhances the human capabilities which have both intrinsic and instrumental value; growth of GNP per- head must be seen as having only instrumental importance.

Education and health can be seen to be valuable to the freedom of a person *at least* five distinct ways.

1. Intrinsic importance. For themselves to have effective freedom.2.Instrumental personal value. to get a job and to make use of economic opportunity..3. Instrumental social role. This expands the facilities that the public enjoys and it leads to better utilization of the available services.4.Instrumental process role. Through explicitly formal education it broadens their horizons, and this can particularly important for young girls. 5. Empowerment and distributaries role. The disadvantaged group can increase their ability to resist. These influences need not work only for the person who receives education or health care. There are interpersonal effects. It expands the scope for the social opportunities.

Through these various interconnections, education and health can be variables of global strategic importance in the process of economic development. India's failure to have adequate public policy in educational and health matter can be, thus, of profound significance in assessing the limited success of Indian

development efforts over the last half a century. [**A.Sen 1995**] A policy reform that concentrates just on liberalization and deregulation cannot deal with this part of failure of past planning. The removal of counterproductive government control may indeed expand social opportunities for many people.

TABLE 5.0 1990

GENDER DISPARITY [F/M%]

	PCY	**AD.LT**	**SCH**	**IMR**
KER	12.34	92.04	95.54	62.00
MAH	44.83	68.33	86.68	100.00
PUN	5.93	76.77	90.40	126.53
T.N	41.42	69.60	89.83	98.24
KAR	46.48	65.20	81.90	95.65
GUJ	41.60	66.53	82.00	100.00
W.B	20.68	68.86	84.67	103.00
HAR	18.99	58.56	79.61	121.00
A.P	44.34	59.35	74.76	81.40
ASS	34.93	69.54	86.94	100.00
M.P	55.46	49.38	70.84	100.00
RAJ	48.81	37.17	37.51	98.70
ORI	3.09	54.96	75.26	8.59
U.P	22.19	45.41	62.28	114.00
BIH	27.47	43.60	60.67	105.00
AVE	31.23	61.68	77.25	94.27
C.V%	53.12	22.96	19.2	28.07

With the expansion of the education, the economic development becomes steady and significant but if failed to break the gender disparity in terms of per capita income to the female in 1991 and 2001, in highly human developed states like Kerala the

gender income disparity continue to remain very high. The expansion of the education and economic development failed to generate per capita income parity to the female in the economy. The disparities are also observed in terms of other health indicators.

The technical relation between economic demographic and development indicators is explained with the help of regression relationship is presented in the following section.

4. ECONOMETRIC STUDY:

The linear and exponential functions have been estimated to estimate per-capita income as a function of adult literacy rate, percentage of households with all three facilities, and percentage of main workers to total population.

The linear model $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + u$ … (1)

Where Y = per- capita Income

X_1 = Adult Literacy Rate

X_2 = Percentage of house holds having all three facilities (1. Drinking water, 2 Sanitation and 3. Electricity)

X_3 = percentage of main workers to total population

u = Error term

is estimated for the cross section data over the 15 states for the years 1991 and 2001, and the results are tabulated below

Table-1 Results of model 1 (eq. 1) for human development measure

	1991	2001
β_0	2445.022(0.477)	-22693.7* (3.657)
β_1	60.024 (1.503)	348.016* (4.584)
β_2	20.969 (0.96)	387.967* (3.586)
β_3	-18.861 (0.134)	298.075** (1.873)
R^2	0.214 (2.014)	0.861* (22.628)

* indicate significant at 5% level of significance.

** indicate significant at 10% level of significance.

The same model is estimated as a measure of gender development and economic growth and the results are tabulated below

Table-2 Results of model 1(eq. 1) for gender development measure

	1991		2001	
	Male	Female	Male	Female
β_0	-1505.049 (0.124)	34.120(0.055)	-55217.7* (2.58)	-3321.7 (1.42)
β_1	69.751 (1.129)	-9.956 (0.984)	692.355* (3.319)	45.441 (1.14)
β_2	332.705* (3.532)	72.141* (3.234)	393.664 (1.561)	367.879* (5.47)
β_3	-2.193 (0.01)	115.939* (5.908)	393.789 (0.92)	258.994* (3.34)
R^2	0.637* (6.429)	0.787* (13.574)	0.694* (8.32)	0.848* (20.42)

* indicate significant at 5% level of significance.

** indicate significant at 10% level of significance.

The another exponential type model is also estimated to measure human development and economic growth as given in the equation (2) below and the results are tabulated in the table 3

$$Y = e^{\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+u} \quad \ldots (2)$$

Where Y = Per-capita Income

X_1 = Adult Literacy Rate

X_2 = Percentage of house holds having all three facilities (1. Drinking water, 2. Sanitation, and 3. Electricity)

X_3 = percentage of main workers to total population

u = Error term

Table-3 Results of model 2(eq. 2) for human development measure

	1991	2001
β_0	7.741* (9.251)	6.645* (17.962)
β_1	0.012** (1.831)	0.026* (5.756)
β_2	0.004 (1.04)	0.024* (3.797)
β_3	0.003 (0.128)	0.027* (2.8)
R^2	0.286 (1.471)	0.901* (33.526)

* indicate significant at 5% level of significance.

** indicate significant at 10% level of significance.

The same model given by (2) is estimated for the estimation of per capita income as a measure of gender development and economic growth and the results are tabulated in the table-4

Table-4 Results of model 2 (eq. 2) for gender development measure

	1991		2001	
	Male	Female	Male	Female
β_0	7.285* (6.438)	6.903* (22.328)	5.792*(6.212)	7.375* (28.551)
β_1	0.012** (2.039)	-0.007 (1.45)	0.034* (3.802)	0.008** (1.867)
β_2	0.034* (3.841)	0.026* (2.287)	0.019 (1.769)	0.042* (5.63)
β_3	0.007 (0.353)	0.048* (4.85)	0.027 (1.479)	0.033* (3.92)
R^2	0.72* (9.437)	0.71* (8.969)	0.769* (12.175)	0.873* (25.28)

* indicate significant at 5% level of significance.

** indicate significant at 10% level of significance.

5. OBSERVATIONS:

From the table-1 the model 1 (eq. 1) is not good fit for the year 1991 but fits well for the year 2001 and all the parameters are significant at 5% level of significance except the coefficient for the percentage of main workers to total population. Table 3 gives the results for the exponential model as explained in eq. 2. Which gives better estimates for the parameters? For the year 1991 the model

is not well fitted but for the year 2001 all the parameters are significant at 5% level of significance including the value of R2 indicates sthat the model is a good fit.

From the above analysis it can be concluded that as compared to 1991 the economic growth is very high in the year 2001.

Further estimating the same models 1 and 2 for the gender development, the results in the tables 2 and 4 shows interesting results that in 1991 the coefficient of adult literacy rate for female was negative for both the models, which becomes positive in 2001 for model 1 though not significant but for model 2 it is positive and significant at 10% level of significance.

6. CONCLUSIONS:

An attempt is made here to link the role of education, health and other infrastructural facilities with economic development and economic growth. It is considered that when economic activity expands the role of secondary and the tertiary sector gradually increases. This also assumes that when the education medical and other infrastructural facilities expands government policy make such an attempt that the economic opportunities are available in equal way to every one in the society. The analysis presented here shows that there is a considerable disparities between the rich and the poor states and the gender disparities is observed.

There are few positive points in terms of rise in the literacy rate, rise in the female literacy and the decline in the drop out ratio. The picture is still not very rosy. The econometric results highlight that the impact of education on economic development shows positive sign in 2001, which was negative in the 1991 period but still the results are not significant. We spend hardly 4.0% of our GDP on education. This must rise to provide better economic opportunity to people in the society.

7. ACKNOWLEDGEMENT

We thank the referee for the review of our paper which has helped to revise it.

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RESEARCH NOTE

ON METZLER INVENTORY MODELS FOR BUSINESS CYCLES

H. M. DIXIT*

ABSTRACT

This paper describes briefly a very pertinent application of inventory models as used for business cycle. Two forms of famous METZER models are discussed - one is simple and the other one is its modifed version. Both of them are useful for business research.

KEYWORDS

MPC, Lag Equation, Homogenous Equation, Equilibrium Solution

1. INTRODUCTION

For any business organization however large or small it may be, it is always necessary to consider the problem of inventory control in order to run the business smoothely and efficiently. In this context, it is necessary to consider the regulation of stock supply from time to time. A businessman has to keep his cycles of production and inventory so that the requirements are met with.

There are many types of models related to the problems of inventory control and management. Here an attempt is done to highlight some specific types of economic models which are in practical use.

2. METZLER SIMPLE VERSION OF THE MODEL

Let us consider the following equations for this model

$\gamma_t = U_t + V_0$ ...(1)

$U_t = \beta \gamma_{t-1}$ ...(2)

At t = 0, $\gamma_t = \gamma_0$ ...(3) $0 < \beta < 1$

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(rcd. June '21 / rvd. July '21)

Where γ_t = Income produced at time t

U_t = Number of units produced for sale at time t

V_0 = Constant non-induced investment.

β = Marginal propensity to consume one year's consumption w.r.t. previous year's income.

Equation (1) gives a relation between current period income in terms of the units produced in that period and also in terms of the fixed non-induced investment.

Equation (2) gives the current year produced units in terms of the income in the preceding period and it is related by m.p.c. .

Now from (2) and (1) we get

$$\gamma_t = \beta\,\gamma_{t-1} + V_0$$

When t = 1, $\gamma_1 = \beta\gamma_0 + V0$

t = 2, $\gamma_2 = \beta\gamma_1 + V0$

$$= \beta(\beta\,\gamma_0 + V_0) + V_0$$

$$= \beta^2\,\gamma_0 + \beta\,V_0 + V_0$$

t = 3, $\gamma_3 = \beta\gamma_2 + V_0$

$$= \beta(\beta^2\gamma_0 + \beta\,V_0 + V_0)$$

$$= \beta^3\gamma_0 + \beta^2\,V_0 + \beta\,V_0$$

Hence $\gamma_t = \beta^t\gamma_0 + V_0(1 + \beta + \beta^2 + ... + \beta^t)$

$$\gamma_t = \beta^t\gamma_0 + V_0\left(\frac{1-\beta^t}{1-\beta}\right) \qquad ...(4)$$

Hence from (1), $\gamma_t = U_t + V_0$

$$U_t = \beta^t\gamma_0 + V_0\left(\frac{1-\beta^t}{1-\beta}\right) - V_0$$

So that $U_t = \beta^t\gamma_0 + V_0\left(\frac{\beta-\beta^t}{1-\beta}\right)$

Hence $U_t = \beta^t\left(\gamma_0 - \frac{V_0}{1-\beta}\right) + V_0\left(\frac{\beta}{1-\beta}\right)$ ...(5)

This equation determines the solution for the number of units produced for sale at time t in terms of the income produced initially, constant non-incluced investment and m.p.c.

The above time dependent relationship exhibits a decreasing trend for Ut and it can be represented graphically. Initially the series decreases and then it becomes almost steady after some period.

3. METZLER MODIFIED VERSION OF THE MODEL

The above simple version for the economic model can further be modifed as under

$$\gamma_t = U_t + S_t + V_0 \qquad ...(6)$$

$$U_t = \beta\,\gamma_{t-1} \qquad ...(7)$$

$$S_t = \beta\left(\gamma_{t-1} - \gamma_{t-2}\right) \qquad ...(8)$$

$$0 < \beta < 1$$

Where γ_t = Total income produced at time t

U_t = Consumer's goods produced for sale in period t.

S_t = Consumer's goods produced for inventories in period t.

V_0 = Constant non induced net investment.

The bove representation by way of eaquations of the model states that the total income produced in any period is equal to the total production of consumer's goods plus net investment.

Sales in any period are a constant proportion of the income in the preceding period. Production for inventory is equal to the difference between the actual and anticipated sales of the preceding period. i.e. there is an attempt to keep inventory at a constant level. It is assumed that tinventories are sufficient to meet differences between production and consumer demand.

If we substitute equation (7) and (8) into equation (6), we get

$$\gamma_t = \beta\,\gamma_{t-1} + \beta\left(\gamma_{t-1} - \gamma_{t-2}\right) + V_0$$

Hence, $\gamma_t - 2\beta\,\gamma_{t-1} + \beta\,\gamma_{t-2} = V_0$ ...(9)

If we change the suffix t-2 into t and so on then we get the equation

$\gamma_{t+2} - 2\beta\,\gamma_{t+1} + \beta\,\gamma_t = V_0$ ...(10)

This is second order non homegenous difference equation.

To solve this equation, the auxilliary equation of the homogenious difference equation corresponding to (10) above gives

$m^2 - 2\beta m + \beta = 0$

and the two roots for this quiadratic equation are given by

$$m_1 = \frac{2\beta + \sqrt{4\beta^2 - 4\beta}}{2} = \beta + \sqrt{\beta^2 - \beta}$$

and $m_2 = \dfrac{2\beta - \sqrt{4\beta^2 - 4\beta}}{2} = \beta - \sqrt{\beta^2 - \beta}$

using the standard methodology for solving the quation, since $0 < \beta < 1, \beta^2 - \beta < 0$ and the roots are complex number given by

$m_1 = \beta + i\sqrt{\beta(1-\beta)}$

and $m_2 = \beta - i\sqrt{\beta(1-\beta)}$ ... (11)

thus $r = \sqrt{\beta^2 + \beta(1-\beta)} = \sqrt{\beta}$ ... (12)

we get $\cos\theta = \dfrac{\beta}{\sqrt{\beta}} = \sqrt{\beta}$

then $\sin\theta = \dfrac{\sqrt{\beta(1-\beta)}}{\sqrt{\beta}} = \sqrt{1-\beta}$ ...(13)

Hence the general solution of the homogenious equation

$Y_{t+2} - 2\beta\,Y_{t+1} + \beta\,t_t = 0$ ...(14)

is thus given by $Y_t = \left(\sqrt{\beta}\right)^t \cdot \left[c_1 \cos(\theta t) + c_2 \sin(\theta t)\right]$ ...(15)

Here c_1 and c_2 are constants. A particular Solution of the non-homogenious equation

$Y_{t+2} - 2\beta\,Y_{t+1} + \beta\,Y_t = V_0$ gives

$\gamma_p = \dfrac{V_0}{1-\beta}$ ... (16) Since $0 < \beta < 1,\ 1 - \beta \neq 0$

Hence the general solution of the non-homogenious equatio has the form

$$\gamma_t = \left(\sqrt{\beta}\right)^t [c_1 \cos(\theta t) + c_2 \sin(\theta t)] + \frac{V_0}{1-\beta} \qquad ...(17)$$

The term involving sines and cosines oscillates between positive and negative values and results in cyclical fluctuations. These fluctuations are damped by the factor $\left(\sqrt{\beta}\right)^t$ and since $0 < \beta < 1$.

$\left(\sqrt{\beta}\right)^t [c_1 \cos(\theta t) + c_2 \sin(\theta t)] \to 0$ as $t \to \infty$ and

as $t \to \infty$, $\gamma_t \to \frac{V_0}{1-\beta}$ ... (18)

Which is the equailibrium value. Thus the long term equilibrium solution for the model is specified by the ratio of initial non-induced investment to the speed of mpc ratio.

There can be further modified versions for this model and the solutions of the equations deal with more complicated types of expressions. Some econimetric version of these models can also be considered.

4. ACKNOWLEDGEMENTS

I thank Dr. B. B. Jani for his help in preparing this paper. I also thank the referee for reviewing my paper which has helped me to revise it.

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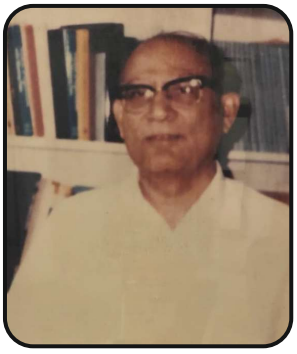
BIOGRAPHY

PROFESSOR DR. C. G. KHATRI

H. S. MEDIWALA*



It gives me immense pleasure and gratitude for my **GURUJI Prof. C. G. Khatri** to express my feelings by writing this small, article in the form of a brief. biographical sketch for our Sankhya Vignan Sept. 2021 issue. Before that I write anything here, first of all my pranams to him.

॥ सद्गुरुम त्वं नमामि ॥

Chinubhai Ghelabhai Khatri (very commonly now known as **C. G. Khatri - Our Khatri Sir)** was born on 4th August 1931 at Patan in the Mehsana District. His father had the profession of handwooven textile which was not very sound and economically viable. Thus his childhood faced days of poverty. Evetnough he completed his matriculation (S.S.C.) studies from a highschool in Patan. In 1948 he joined Gujarat College, Ahmedabad for his college education. He was a very brilliant student right from the beginning but could not go for engineering or medical education due to poor economic conditions of the family. Thus he studied for B.Sc. degree in Mathematics from Gujarat College in 1993 and obtained first class first with distinction and recived Gold Medal.

In those day a specialisation course for masters degree in statistics subject was available only at Mumbai University. He joined Mumbai Universitis department of Statistics as P.G. Student and obtained M.Sc. degree in Statistics in 1955 with flying colours. **Dr. M. C. Chakrabarty** was professor and Head of Statistics Dept., Mumbai University. He was much impressed by the capacity and interlligence of Khatri and

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he knew his talents, so that he recommended **Prof. N. M. Bhatt,** Prof and Head, Statistics Dept., M. S. University, Baroda to offer him lecturer's position in the university.

Prof. Khatri was much interested in multivariate analysis and during his works at Baroda, he could solve very difficult problmes pertaining to multivariate analysis. Dr. N. M. Bhatt knew about the intelligence and abilities of Khatri and registered him for Ph.D. degree in Statistics subject. Khatri did his research work very eminently and his Ph.D. examiner **Dr. A. C. Aitken at U.K.** was highly impressed by his work. Khatri received Ph.D. Degree in 1960.

Thereafter in 1962, he was selected for the post of Reader in Department of Statistics at Gujarat Univeristy and became head of department. He developed this Department by means of rigorous teaching and research work and gradually he as well as the department became very famous in the country and aborad. In 1964, he was invited as **post doctoral fellow to work with Prof. S. N. Roy in the field fo multivariate analysis at North Carolina University, USA.** He came back from USA as Prof. Roy had expired, but continued his research work that he started with him.

In 1967, he was invited to work as a visiting professor in I.S.I. Calcutta by the world renown statistician **Prof. C. R. Rao.** He came in close contact with **Prof. D. Basu, Prof. S. K. Mitra** etc. He worked for research in Mathematical Statistics also. During 1967 and **thereafter he became very famous and established himself as one of the leading statisticians of India and abroad.**

He had internal intution whcih gave him inspiration to tackle with research problems. In classrooms with students he was versatile and he liked to teach even latest research papers that he has studied from reputed journals. **In that sense, he was a very unique teacher.** His ability in matrix algebra and other mathematical tools was enormous and praiseworthy. His research areas were **extended in distribution theory particularly contagious and power series distributions, characterisation problmes, design of experiments, econometric theories and applications, statistical inference, linear and non liner models classical and**

bayesian Statistical inference etc.

He had tremendous concetration when he was reading or writing journal articles. When any problem was given to him, he could immediately go very deeply in the problem and solve it soon.

We were his students in P.G. with him and often we have found him seeting in a chair (Muda) and reading latest journals, making notes, solving very pertinent and difficult problems. We were at that time wondering why our teacher has to read all these things, but this also became a source of inspriation giving us guidence that **TEACHER MUST BE UPTODATE IN KNOWLEDGE.**

His own personality was superb, very fairly looking, sincere, loving and always helping nature.

Somethimes he appeared to be very harsh, but the next moment he would be very friendly with students as well as colleagues. His deep sense of understanding the problems made him very famous both academically as well as in administrative routines.

He was very tough task master also. He would not allow any error or discrepancies in the work - whether he is a student or colleague or anyone else. That way he was very particular but would not keep any sort of enemity with anyone. His childlike smile was everlasting in all situations.

Besides statistics, he was also interested in Mathematics. He often discussed mathematical theories with **Dr. P. C. Vaidya, Dr. A. M. Vaidya, Prof. H. N. Raval and Prof. Darshansingh of Mathematics Department.** For somethimes both Maths and Statistics departments were working jointly in Gujarat University, with **Prof. P. C. Vaidya** heading both the departments.

Later on Statistics department was Separated and started working independently, but the unity, brothrhood and knowledge transmission remained for ever. Prof. Khatri was also much interested in **theory of numbers, topology, functional analysis** etc. He also wrote papers in these fields and guided research students for further work. **Prof. Khatri has published more than 200 research papers in very reputed jounrlas at national level and abroad.**

In 1970 he was awarded fellowship at Americal Statistical Association and in 1973 he was made Fellow of Institute of Mathematical Statistics. In 1980. He was offered National Lecturer from UGC and in 1983 he was awarded fellowship by Indian National Science Academy. These are the highest rank honours that can be given to any academic dignitory. **BY ALL HIS ACHIEVEMENTS, HE BROUGHJT GUJARAT UNIVERSITY ON WORLD MAP IN THE FIELD OF STATISTICS.** In 1985, he was appointed as sectional president of statistics section of Indian science congress held at B.H.U. Banaras. He has also rendered his services at different universities abroad and also worked as honourary members in many reputed journals and associations.

Prof. Khatri has published two versalite books - one is on **Matrix Algebra in Gujarati Language** published by Gujarat Granth Nirman Board. It is one of the very unique books on the subject and has reputation abroad also. Other book is on **Multivariate analysis. It is the work started with Prof. S. N. Roay initially and then co-authored with Prof. M. S. Srivastav and it was published by North Holland Publishign house at USA.** It is considered as a very famous textbook on multivariate analysis.

Under the guidance of Prof. Khatri some brilliant students received Ph.D. degree. Some names are **Dr. M. C. Jaiswal, Dr. A. V. Gajjar, Dr. R. T. Ratani, Dr. K. S. Shah, Dr. I. D. Patel, Dr. C. B. Bhavsar** etc. Prof. Khatri established a unique association named as **Gujarat Statistical Association (GSA)** in the year 1969. It was for promoting research activities from the college and university teachers as well as from the research students working in the field of statistics.

Many regular meetings were held for GSA and almost every year an annual conference was organised at different places for ineraction with the teachers and research students in the subject.

A journal named as **Gujarat Statistical Reveiw (GSR) was started on behalf of GSA. Dr. Khatri was the first founder editor of the journal.** Due to his famous name, many research papers came for this journal - Dr. Khatri took immediate spot decisions for the papers and GSR became a very high ranked journal at national

as well as at international level.

Later on, jointly with Prin. D. G. Vashi, the **founder academician of Statistics dept. G.U.**, it was decided to bring out another journal named **Sankhya Vignan (SV)** which was for the field of applied statistics. Both GSR and SV have been eaqually popular among the research workers.

Prof. Khatri was spiritually attached with Shri Aurobindo Philosophy. His aim was to spend his life in Pondicherry Ashram with Mother, but he was inspired to work further in the areas selected by him and that gave him strength, vigour and inspiration. **Dr. Khatri's Ph.D., guide Dr. N.M.Bhatt describes him as a versatile eminent personality which can be placed in the rank with the class of statisticians like P.C.Mahalanobis, S. N.Roy, R.C.Bose, C.R.Rao** etc.

Due to his very high level recognitions earned by Khatri sir, the statistics department was considered as an august platfrom for determining common national level syllabi in statistics from all the different faculties and in the meetings held some eminent statisticians were present at the department of Statistics.

Later on after some years the department was offered cosist and other programmes by UGC. Also department was considered for giving refresher as well as orientation courses for teachers in statistics. These are all due to the global image of Khatri Sir.

In statistics department of G.U. every faculty member had to work hard for teaching as well as research work. Mostly after every 3 years, the teacher's teaching portion was changed - not the same for all for all the times. This was revolutionary. **Even syllabus was changed oft and often.** This dynamic stituation helped teachers to be allert and by that the department as well as faculty members developed their potential.

Unfortunately such a big versatile personality could not live more, otherwise the status of the department as well as university would be different and beyond our imagination. On 31st March 1989, Prof. Khatri passed away immediately due to very massive heart attack. This unasuming catastrophical event made all of us orphans.

In the memory of Khatri Sir, **GSA published a memorial volume to honour him.** This contains the detailed works by Prof. Khatri along with many other particulars. This was edited by **Dr. Shreehari** of M.S.Uni., Baroda.

GSA has also established a Separate trust (linked with GSA) under the name of late Prof. **Dr. C. G. Khatri, memorial trust.** The main purpose of this trust is to keep a **national level lecture** int he honour of Khatri sir and also to accelerate different academic activities linked with GSA. Prof. Khatri will always be remembered for ever in the field of statistics.

We can rarely find such a personality even once in a lifetime who lightens the Lamp of knowledge, gives inspirations and stimulate our aspirations for perpatual growth and then suddenly passes away like a shining star fading away suddenly and placing ourselves in the deep darkness of sorrows. We can not forget his ever smiling face, unassuming personality with unusual intelligence. Such dignitories rarely come to us and awakens all of us to hunt for the quest of knwoledge.

We do remember him as **PURN GURU**. I recite here in memory of our Khatri Sir few lines of **GURUSTROTTAM**.

न गुरोरधिकं सत्त्वं, न गुरोरधिकं तपः ।
तत्वज्ञानात्परं नास्ति तस्मैः श्री गुरवे नमः ॥
गुरोपरतरं नास्ति तस्मैः श्री गुरवे नमः ॥

ACKNOWLDGEMENTS :

I thank Dr. B. B. Jani for his help and suggestions to prepare this article. I also thank the referee for reviewing this article.

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BOOK REVIEW

Book Review on **"Sustainable Development and Quality of Life: Through Lean, Green, and Clean Concepts"** by **Prof. K. Muralidharan, Department of Statistics, Faculty of Science, The Maharajah Sayajirao University of Baroda, Vadodara- 390 002, India.**

Dr. (Mrs.) Mangala Shah

Associate Professor of Statistics, Faculty of Science

The Maharajah Sayajirao University of Baroda, Vadodara- 390 002, India.

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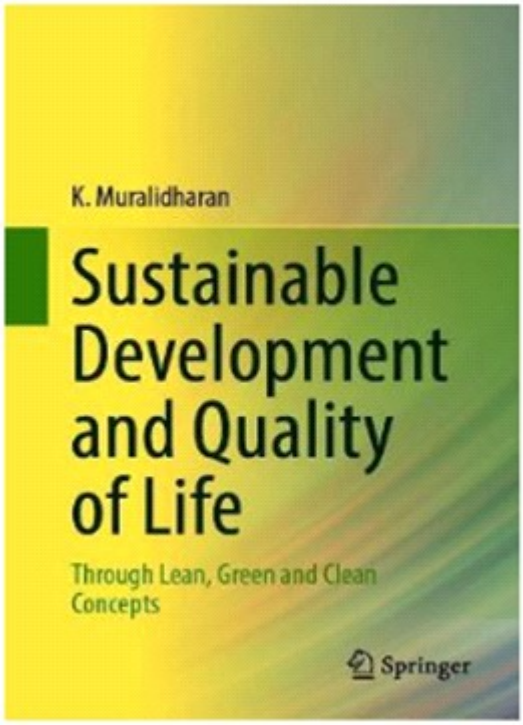
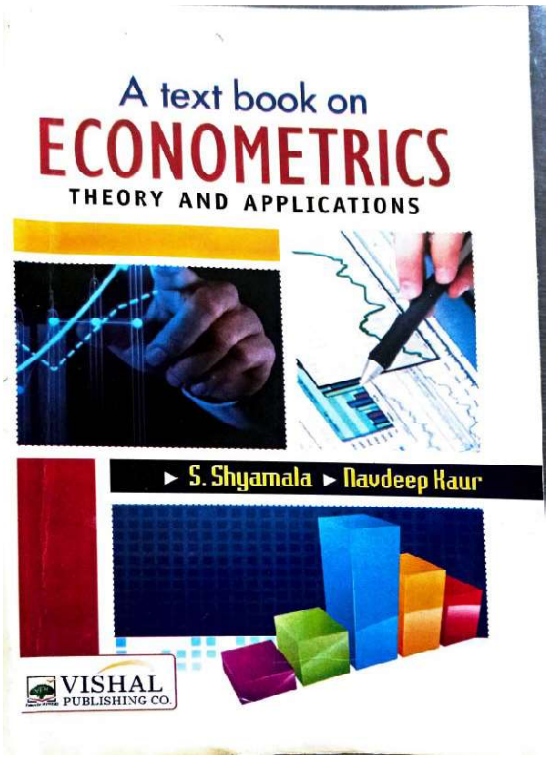
As the title suggests, the book helps the readers to observe and understand the concept of sustainable development through Lean, Green nd Clean (LGC) initiatives and make them aware about adaptation, implementation and maintenance of these developments so as to achieve a high quality level in every aspects of life. As the author believes 'everything in excess is a waste' (be it qualitative or quantitative), the book focuses on how LGC concepts are applicable in many spheres of life to avoid 'waste' through project management and measurement based assessment methods.

The book accompanies 10 chapters with 85 numerical illustration, 82 tables and more than 100 figures to understand the ideas in a better and easier way. Chapter 2 introduces the LGC quality concepts and chapter 3 discusses LGC ideas in science and technologies. Chapter 4 focuses on LGC quality improvement models. Remaining chapters discusses in length about LGC quality assessment methods, Green Statistics, how to achieve and promote LGC quality objects, how to control and monitor LGC activities etc. Chapter 9 is completely devoted to case studies, to give readers a precise idea about implementation of all earlier ideas. Chapter 10 is like cherry on the cake, which guides the readers how to move forward towards sustainable quality life.

All the chapters are well supported by appropriate statistical tools and techniques along with real life examples making the concepts well understandable to the readers. The entire concept/ theme of the book is a real need of the time to come.

The motto 'sustainable quality life' is explained in a very simple but effective manner through statistical principles. The book is a must read for all those who care about mother earth. I strongly, recommend the book for every institution library. The book is published by Springer Nature, Singapore and is available in most of the online platforms.





The present review address the book on econometrics titled ***"A textbook on Econometrics-Theory and Applications by S. Shyamala and Navdeep Kaur (Vishal Publishing Co.)".*** This book seems generic in content. However first feel no longer sustain as reader go through this book gradually chapter by chapter. The purpose of this book is to facilitate students who choose the course of Econometrics though they may not have enough back ground of mathematics and statistics. many books available on Econometrics, bu handful of them, designed for students, who are beginners and aspire to pursue career in economics. Present book is figured in that list. This textbook comprised 25 cahpters and they cover almost all topics on econometrics, prescribed in syllabus on Indian Universities. In econometrics researcher frequently trapped into problems like multicollinearity auto correction, heteroscedasticity, errors in variables etc. with insufficient knwoledge of techniques of dealign with such

problems, researcher may not puruse his/her projects. This book provides such techniques in lucid manner.

The most appealing feature of this text is its easily understandable language and sufficient matter in each chapter followed by chapter end exercise and multiple choice questions.

At last this book attempts to serve at an entry level and with the help of this book the students can comfortably mov efrom basics of econometrics to more advanced study in one or more specified area.

Date : 28 August, 2021

H. M. Dixit
H.O.D., Stastics Dept.,
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Manish B. Thaker*

* Dr. R. G. Bhatt has resigned from her post as president of GSA due to her health problems. It was accepted in the executive committee meeting of GSA. In her place, Dr. N. D. Shah will be working temporarily as acting president of GSA.
* Dr. R. G. Bhatt has also sent her resignation from the post of editor of Gujarat Statistical Review (GSR) journal. This journal will now be under **Dr. D. K. Ghosh as Chief Editor of the Journal**. Dr. Ghosh has framed new committee for the journal GSR, which is given in this SV News letter.
* Dr. R. G. Bhatt has also retired from her position as managing editor of Prof. C. G. Khatri memorial trust. The new proposed committee names are presented elsewere in this issue.
* Dr. R. G. Bhatt has expressed her desire to resign as joint editor of Sankhya Vignan Journal. We have requested her to continue unitil 31st Decemeber 2021 (Till Dec. '21 issue of SV). Dr. R. G. Bhatt has given execmplary services for all her works and commitments.
* S. P. Uni. is starting M.Sc. with Applied Statistics course. A brocher is presented for guidance of the students and teachers.

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Gujarat Statistical Association

Established : 1969

[Registered under Public Trust Act of 1950 (Bombay)]

R. No. E2502 A'bad - 1974

The objective of the association is primarily to promote statistical ideas in pure and applied fields in the form of study, teaching and research in statistics. The membership of GSA consists of Life / institutional / ordinary members.

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	In India	Abroad
Institutional Member (for 3 years)	Rs. 2,000/-	US $ 500
Life Member	Rs. 1,500/-	US $ 300
Ordinary Member (p.a.)	Rs. 500/-	US $ 50

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Call for Research Papers in Gujarat Statistical Review

Dear Professor

Professor(late) C. G. Khatri founded an association named as Gujarat Statistical Association and kept its headquarter at Department of Statistics, Gujarat University, Ahmedabad. He even started the publication of a Journal, Gujarat Statistical Review (GSR) biannually. This journal is a standard journal as it has published quality research papers. Journal has published referred original research papers, reviews and case studies related to any branch of applied and theoretical Statistics. Since last seven-eight years, publication of GSR is discontinued due to some unavoidable reasons. The members of the management committee of the association has decided to continue the publication of GSR as per meeting held on 24 July, 2021. GSR is a peer reviewed journal in Statistics and was published twice in a year in past. However, it will begin the publication of journal annually. The next issue of the journal is expected to be published in March 2022.

I would like to invite you with humble request to submit your research papers/ articles for possible publication in GSR. The research papers will be reviewed by two referees and then it will be considered for possible publication. However, the final decision of the publication of the research paper will be considered by Editorial board members only.

Yours Sincerely
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Author should submit their manuscript as softcopy either directly to the Chief Editor (ghosh_dkg@rediffmail.com) or through the Editors (bikassinha1946@gmail.com) and (amsseng@gmail.com).

How to prepare manuscript ?

Authors should prepare their manuscript using MS WORD 2010 with Times New Roman font of size 12 pt with double margin. However, MS-WORD equation editor will be preferred for mathematical equations.

The manuscript should be organized as Title of the paper, Author(s) name, E-mail address, Abstract (not more than 250 words) without reference, key word (not more than six), AMS subject classification, complete articles which includes Tables, Figure, graph (if any required), conclusion, acknowledgement, appendices (if required) and finally, the references.

The complete articles will be organized as appropriate number of sections, subsections, Equations, Figures, Tables. Equations, Figures and Tables should be numbered continuously starting with 1 irrespective of their subsections etc.

Reference list and citation of reference in the complete paper should be agree.

References for research article and book should follow the following:

RESEARCH PAPER:

1. Ghosh, D.K. and Karmakar, P. (1988) Some series of efficiency balanced designs. Aust. Jour. Statist. 30(1), 47-51.

2. Ghosh, D.K. (1989). Construction of confounded designs for mixed factorial experiments, Jour. Statist. Planning and Inference., 23, 253- 261.

BOOK:

1. Das, M. N. and Giri, N. C. (1973). Design and Analysis of Experiments. Third Edition, New Age International Publishers.

It is the policy of the journal that no submission, or substantially overlapping submission, be published or be under review at another journal or conference at any time during the review process. Submission of a manuscript implies that it has been

approved by all authors as well as by the responsible authorities tacitly or explicitly at the institute where the work has been carried out. The publisher and the editors will not be held legally responsible should there be any claims for compensation.

DECISION AFTER REVIEW:

After considering the Reviewer's reports, the Editorial Board Members will make one of the following decisions:

(i) Accept the paper for possible publication

(ii) Request for a minor/major revision

(iii) Reject the publication of the paper

The peer-review process of the journal is a double-blind process. While submitting the revised manuscript, the authors should clearly explain point-by-point as to how the reviewer's comments have been addressed. If the authors disagree with reviewer's comments, the reason(s) should be explained. Decision of the editorial board will be final. Those papers recommended by two reviewers will be accepted for publication.

The peer review process may be completed within 4 months, but it depends on the response of the peer reviewers.

STOP PRESS (BREAKING NEWS)

Gujarat Statistical Review (GSR) will be renamed under new rules and new committee as under GUJARAT JOURNAL OF STATISTICS AND DATA SCIENCES (GJSDS)

READERS FORUM

Ashvin J. Patel*

* **U. B. Gothi (Ahmedabad)**
SV is doing exemplary work by devoting some issues in the loving memory of Dr. A.V. Gajjar, Dr. Y. K. Shah and now Prin. A. M. Patel (Dec. 2020 issue). I welcome these efforts. My best wishes to the team.

* **Dr. M. C. Jaiswal (USA)**
My very close student (now just like my younger brother) does this work of SV. I feel happy and proud for the efforts made by team. Wish you further progress.

* **Bipin Mehta (Ahmedabad)**
SV team is doing good work indeed, but this decision for digital copies is not appropriate. Certainly I would like to read hard copy, as we are habituated that way.

* **Prin. M. C. Patel (Mehsana)**
More focus is needed for applciation oriented papers, as this is a journal for applied statistics. Dec. 2020 issue was very good as it contained almost half of the issue in memory of my very close and beloved friend Ambubhai (AMP).

* **Bhavin Shah (Indore)**
These days, analytics is becoming very important. So is data science. SV issues should contain the papers pertaining to them.

* **Pinakin Jani (Industry)**
SV issues fall short of actual industrial applications. In place of very highly oriented theoretical articles, applications must be given more focus.

* **Pradeep P. Prajapati (Ahmedabad)**
Earlier it was decided for some bifercation into different areas. This is not maintained in March and June issues.

* **P. Mariappan (Trichi)**
SV team is doing good examplary work. 4 issues are welcome. My best wishes.

* **Hiten Parekh (Ahmedabad)**
Congrats and best wishes to the team. Welcome digital copies.

* Head, Statistics Dept., R. H. Patel Arts & Commerce College, Vadaj, Ahmedabad.

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RESEARCH TEAM

PROFESSOR DR. C. G. KHATRI*

Professor Chinubhai Ghelabhai Khatri (Very commonly known as **C. G. Khatri** or rather **Khatri Sir**) was born on 4th August 1931 at Patan in Mehsana District of Gujarat State, India. Right from beginning he was extremely brilliant student. He studied in highschool at Patan and obtained matriculation (S.S.C.) keeping high records. He continued graduation studies from **Gujarat College, Ahmedabd** and obtained B.Sc. degree in Mathematics with top most rank in 1953 and **won gold medal.** He joined **university of Bombay** for his further post graduate studies under **Prof. M. C. Chakrabarty of Statistics Dept., B.U**. and received M.Sc. degree in 1955 **as the first ranker**. Prof. Chandrabarty knew extraordinary capacity and intelligence of Khatri Sir and recommended him for Lecturer's position in statistics Dept. of M. S. University, Baroda under **Prof. N. M. Bhatt.** He also did his Ph.D. under his guidance. Later on, he was appointed as Reader and Heal of Statistics Dept of Gujarat University and also became Prof. of Statistics Dept. of Gujarat University. His study and research areas are **Multivariate Analysis, Linear and Non Linear Models, Distribution Theory, Design of Experiments, Matrics, Number Thory, Classical and Bayesian Statistical Inference, Decision Theory, Econometric Models** etc. He worked with **Prof. S. N. Roy** for post doctoral work in **North Cardolina University, USA.** He was a visiting Lecturer at I.S.I. Calcutta and also very close to **Prof. C. R. Rao.** After 1967, he became **very famous and was regarded as leading statistician in India and abroad.** He was founder president of **Gujarat Statistical Association (GSA)** and started a very famous journal - **Gujarat Statistical Review.** His two books-one on **Matrix Algebra** and the other on **Multivariate Analysis** are very famous everywhere. In 1970, he was appointed as **Fellow of American Statistical Association.** In 1985, he was made **sectional president at Indian Science Congress**. In 1980, he became **national Lecturer as appointed by UGC.**

He was also made **fellow of Institute of Mathematical Statistics USA**. **Dr. Khatri can be placed in the rank of high level statisticians like P. C. Mahalanobis, S. N. Roy, R. C. Bose, C. R. Rao** etc.

His extra ordinary career and research works have placed Gujarat University on world map.

Unfortunately he expired suddenly due to a massive heart attack. On 31st March 1989. Only at the age of 58 years. His sudden demise was a tremendous blow to the Statistical fraternity.

॥ सद्गुरुम् त्वं नमामि ॥

***Brief biographicasl sketch is given inside the journal.**

Printed Matter
(Journal of GSA, Ahmedabad)

BOOK-POST

To,

From : **Dr. B. B. Jani**
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