

# INTERNATIONAL JOURNAL OF RESEARCH IN COMMERCE, IT & MANAGEMENT

I  
J  
R  
C  
M



A Monthly Double-Blind Peer Reviewed (Refereed/Juried) Open Access International e-Journal - Included in the International Serial Directories

*Indexed & Listed at:*

Ulrich's Periodicals Directory ©, ProQuest, U.S.A., EBSCO Publishing, U.S.A., Cabell's Directories of Publishing Opportunities, U.S.A., Google Scholar,

Open J-Gate, India [link of the same is duly available at Infilbnet of University Grants Commission (U.G.C.)],

Index Copernicus Publishers Panel, Poland with IC Value of 5.09 & number of libraries all around the world.

Circulated all over the world & Google has verified that scholars of more than 4767 Cities in 180 countries/territories are visiting our journal on regular basis.

Ground Floor, Building No. 1041-C-1, Devi Bhawan Bazar, JAGADHRI – 135 003, Yamunanagar, Haryana, INDIA

<http://ijrcm.org.in/>

# CONTENTS

Sr. No.	TITLE & NAME OF THE AUTHOR (S)	Page No.
1.	IMPACT OF FACEBOOK USAGE ON STUDENT ACADEMIC PERFORMANCE: THE CASE OF WOLLEGE UNIVERSITY <i>V.P.S. ARORA &amp; SARFARAZ KARIM</i>	1
2.	A STUDY ON THE IMPACT OF EMOTIONAL INTELLIGENCE ON QUALITY OF WORK LIFE AMONG WOMEN EMPLOYEES OF ITES COMPANIES WITH SPECIAL REFERENCE TO SELECTED COMPANIES IN COIMBATORE DISTRICT <i>DR. S. GANESAN &amp; SUKANYA.L</i>	7
3.	IMPACT OF VILLAGE INFRASTRUCTURE INITIATED BY KORBA COALFIELDS OF CHHATTISGARH (INDIA) ON VILLAGERS' WAY OF LIVING <i>A S BABU &amp; SUKANTA CHANDRA SWAIN</i>	11
4.	REVENUE MANAGEMENT: A CASE STUDY OF BHARAT SANCHAR NIGAM LIMITED <i>DR. U. PADMAVATHI</i>	18
5.	DIGITAL MARKETING – WAY TO SIGNIFICANCE <i>SEMILA FERNANDES &amp; VIDYASAGAR A.</i>	22
6.	PERFORMANCE MANAGEMENT IN SUGAR INDUSTRIES <i>M. SARADADEVI &amp; K. YASODA</i>	28
7.	FOREIGN DIRECT INVESTMENT INFLOWS, TECHNOLOGICAL INNOVATION, SUSTAINABLE DEVELOPMENT AND SKILLED HUMAN BEHAVIOR: A MULTIVARIATE GRANGER CAUSALITY STUDY – EVIDENCE FROM FRANCE <i>DR. BHUMIKA GUPTA &amp; DR. JASMEET KAUR</i>	32
8.	CONSTRUCTION OF INTER QUARTILE RANGE (IQR) CONTROL CHART USING PROCESS CAPABILITY FOR STANDARD DEVIATION <i>DR. C. NANTHAKUMAR &amp; S.VIJAYALAKSHMI</i>	35
9.	EQUITY SHARE PERFORMANCE OF AUTO MOBILE INDUSTRY IN BSE <i>M. NIRMALA &amp; P. PAVITHRA</i>	39
10.	TURN OF THE MONTH EFFECT IN INDIAN METAL SECTOR WITH SPECIAL REFERENCE TO BSE METAL INDEX <i>J. SUDARVEL &amp; DR. R. VELMURUGAN</i>	43
11.	ROLE OF MAHILA SAHKARI BANK IN WOMEN EMPOWERMENT <i>DR. R. P. AGRAWAL &amp; AJITA SAJITH</i>	46
12.	STRESS AMONG IT SECTOR EMPLOYEES <i>SABARI GHOSH</i>	49
13.	MOBILE BANKING IN INDIA: A COMPARATIVE STUDY ON HDFC BANK AND AXIS BANK <i>N. NEERAJA</i>	54
14.	LEADERSHIP REQUIREMENTS TO MANAGE GLOBAL BUSINESS <i>DEEPA NATHWANI</i>	58
15.	A STUDY ON EMOTIONAL INTELLIGENCE AMONG TEACHERS IN PRIVATE SCHOOLS OF DINDIGUL DISTRICT <i>DR. R. RADHIKA DEVI &amp; SOUNDARYA.N.</i>	63
16.	A STUDY ON CONSUMERS OPINION TOWARDS ECO-FRIENDLY PRODUCTS WITH SPECIAL REFERENCE TO COIMBATORE CITY <i>NITHYA M &amp; T. RAHUL PRASATH</i>	67
17.	AN EVALUATION OF SERVICES BY DOCTORS PROVIDED BY PHARMACEUTICAL COMPANIES <i>MENKA TRIPATHI &amp; DR. PRATIBHA JAIN</i>	74
18.	OPPORTUNITIES AND CHALLENGES TO TOURISM INDUSTRY: A CASE STUDY OF JAMMU AND KASHMIR <i>MUNEER A KHAN, SHAHNEYAZ A BHAT, SUHAIL A BHAT &amp; MUDASIR AHMAD WAR</i>	79
19.	PERCEPTION OF STUDENT TOWARDS FATE AND LOCUS OF CONTROL AT HIGHER SECONDARY LEVEL: A STUDY IN PERCEPTION <i>P. THANGARAJU</i>	83
20.	SOCIO ECONOMIC CONDITIONS OF HANDLOOM WEAVERS: A STUDY OF KARIMNAGAR DISTRICT <i>ANKAM SREENIVAS &amp; KALAKOTLA SUMAN</i>	85
	REQUEST FOR FEEDBACK & DISCLAIMER	96

## CHIEF PATRON

**PROF. K. K. AGGARWAL**

Chairman, Malaviya National Institute of Technology, Jaipur

(An institute of National Importance & fully funded by Ministry of Human Resource Development, Government of India)

Chancellor, K. R. Mangalam University, Gurgaon

Chancellor, Lingaya's University, Faridabad

Founder Vice-Chancellor (1998-2008), Guru Gobind Singh Indraprastha University, Delhi

Ex. Pro Vice-Chancellor, Guru Jambheshwar University, Hisar

## FOUNDER PATRON

**LATE SH. RAM BHAJAN AGGARWAL**

Former State Minister for Home & Tourism, Government of Haryana

Former Vice-President, Dadri Education Society, Charkhi Dadri

Former President, Chinar Syntex Ltd. (Textile Mills), Bhiwani

## FORMER CO-ORDINATOR

**DR. S. GARG**

Faculty, Shree Ram Institute of Business & Management, Urjani

## ADVISORS

**PROF. M. S. SENAM RAJU**

Director A. C. D., School of Management Studies, I.G.N.O.U., New Delhi

**PROF. M. N. SHARMA**

Chairman, M.B.A., Haryana College of Technology & Management, Kaithal

**PROF. S. L. MAHANDRU**

Principal (Retd.), Maharaja Agrasen College, Jagadhri

## EDITOR

**PROF. R. K. SHARMA**

Professor, Bharti Vidyapeeth University Institute of Management & Research, New Delhi

## CO-EDITOR

**DR. BHAVET**

Faculty, Shree Ram Institute of Engineering & Technology, Urjani

## EDITORIAL ADVISORY BOARD

**DR. RAJESH MODI**

Faculty, Yanbu Industrial College, Kingdom of Saudi Arabia

**PROF. SANJIV MITTAL**

University School of Management Studies, Guru Gobind Singh I. P. University, Delhi

**PROF. ANIL K. SAINI**

Chairperson (CRC), Guru Gobind Singh I. P. University, Delhi

**DR. SAMBHAVNA**

Faculty, I.I.T.M., Delhi

**DR. MOHENDER KUMAR GUPTA**

Associate Professor, P. J. L. N. Government College, Faridabad

**DR. SHIVAKUMAR DEENE**

Asst. Professor, Dept. of Commerce, School of Business Studies, Central University of Karnataka, Gulbarga

***ASSOCIATE EDITORS***

**PROF. NAWAB ALI KHAN**

Department of Commerce, Aligarh Muslim University, Aligarh, U.P.

**PROF. ABHAY BANSAL**

Head, Department of I.T., Amity School of Engineering & Technology, Amity University, Noida

**PROF. A. SURYANARAYANA**

Department of Business Management, Osmania University, Hyderabad

**PROF. V. SELVAM**

SSL, VIT University, Vellore

**DR. PARDEEP AHLAWAT**

Associate Professor, Institute of Management Studies & Research, Maharshi Dayanand University, Rohtak

**DR. S. TABASSUM SULTANA**

Associate Professor, Department of Business Management, Matrusri Institute of P.G. Studies, Hyderabad

**SURJEET SINGH**

Asst. Professor, Department of Computer Science, G. M. N. (P.G.) College, Ambala Cantt.

***FORMER TECHNICAL ADVISOR***

**AMITA**

Faculty, Government M. S., Mohali

***FINANCIAL ADVISORS***

**DICKIN GOYAL**

Advocate & Tax Adviser, Panchkula

**NEENA**

Investment Consultant, Chambaghat, Solan, Himachal Pradesh

***LEGAL ADVISORS***

**JITENDER S. CHAHAL**

Advocate, Punjab & Haryana High Court, Chandigarh U.T.

**CHANDER BHUSHAN SHARMA**

Advocate & Consultant, District Courts, Yamunanagar at Jagadhri

***SUPERINTENDENT***

**SURENDER KUMAR POONIA**

## **CALL FOR MANUSCRIPTS**

We invite unpublished novel, original, empirical and high quality research work pertaining to recent developments & practices in the areas of Computer Science & Applications; Commerce; Business; Finance; Marketing; Human Resource Management; General Management; Banking; Economics; Tourism Administration & Management; Education; Law; Library & Information Science; Defence & Strategic Studies; Electronic Science; Corporate Governance; Industrial Relations; and emerging paradigms in allied subjects like Accounting; Accounting Information Systems; Accounting Theory & Practice; Auditing; Behavioral Accounting; Behavioral Economics; Corporate Finance; Cost Accounting; Econometrics; Economic Development; Economic History; Financial Institutions & Markets; Financial Services; Fiscal Policy; Government & Non Profit Accounting; Industrial Organization; International Economics & Trade; International Finance; Macro Economics; Micro Economics; Rural Economics; Co-operation; Demography; Development Planning; Development Studies; Applied Economics; Development Economics; Business Economics; Monetary Policy; Public Policy Economics; Real Estate; Regional Economics; Political Science; Continuing Education; Labour Welfare; Philosophy; Psychology; Sociology; Tax Accounting; Advertising & Promotion Management; Management Information Systems (MIS); Business Law; Public Responsibility & Ethics; Communication; Direct Marketing; E-Commerce; Global Business; Health Care Administration; Labour Relations & Human Resource Management; Marketing Research; Marketing Theory & Applications; Non-Profit Organizations; Office Administration/Management; Operations Research/Statistics; Organizational Behavior & Theory; Organizational Development; Production/Operations; International Relations; Human Rights & Duties; Public Administration; Population Studies; Purchasing/Materials Management; Retailing; Sales/Selling; Services; Small Business Entrepreneurship; Strategic Management Policy; Technology/Innovation; Tourism & Hospitality; Transportation Distribution; Algorithms; Artificial Intelligence; Compilers & Translation; Computer Aided Design (CAD); Computer Aided Manufacturing; Computer Graphics; Computer Organization & Architecture; Database Structures & Systems; Discrete Structures; Internet; Management Information Systems; Modeling & Simulation; Neural Systems/Neural Networks; Numerical Analysis/Scientific Computing; Object Oriented Programming; Operating Systems; Programming Languages; Robotics; Symbolic & Formal Logic; Web Design and emerging paradigms in allied subjects.

Anybody can submit the **soft copy** of unpublished novel; original; empirical and high quality **research work/manuscript** **anytime** in **M.S. Word format** after preparing the same as per our **GUIDELINES FOR SUBMISSION**; at our email address i.e. [infoijrcm@gmail.com](mailto:infoijrcm@gmail.com) or online by clicking the link **online submission** as given on our website ([FOR ONLINE SUBMISSION, CLICK HERE](#)).

## **GUIDELINES FOR SUBMISSION OF MANUSCRIPT**

### 1. **COVERING LETTER FOR SUBMISSION:**

DATED: \_\_\_\_\_

**THE EDITOR**

IJRCM

**Subject:** SUBMISSION OF MANUSCRIPT IN THE AREA OF \_\_\_\_\_.

(e.g. Finance/Mkt./HRM/General Mgt./Engineering/Economics/Computer/IT/ Education/Psychology/Law/Math/other, please specify)

**DEAR SIR/MADAM**

Please find my submission of manuscript entitled ' \_\_\_\_\_ ' for possible publication in one of your journals.

I hereby affirm that the contents of this manuscript are original. Furthermore, it has neither been published elsewhere in any language fully or partly, nor is it under review for publication elsewhere.

I affirm that all the co-authors of this manuscript have seen the submitted version of the manuscript and have agreed to their inclusion of names as co-authors.

Also, if my/our manuscript is accepted, I agree to comply with the formalities as given on the website of the journal. The Journal has discretion to publish our contribution in any of its journals.

<b>NAME OF CORRESPONDING AUTHOR</b>	:	
Designation	:	
Institution/College/University with full address & Pin Code	:	
Residential address with Pin Code	:	
Mobile Number (s) with country ISD code	:	
Is WhatsApp or Viber active on your above noted Mobile Number (Yes/No)	:	
Landline Number (s) with country ISD code	:	
E-mail Address	:	
Alternate E-mail Address	:	
Nationality	:	

**NOTES:**

- a) The whole manuscript has to be in **ONE MS WORD FILE** only, which will start from the covering letter, inside the manuscript. **pdf. version is liable to be rejected without any consideration.**
  - b) The sender is required to mention the following in the **SUBJECT COLUMN of the mail:**  
**New Manuscript for Review in the area of** (e.g. Finance/Marketing/HRM/General Mgt./Engineering/Economics/Computer/IT/ Education/Psychology/Law/Math/other, please specify)
  - c) There is no need to give any text in the body of mail, except the cases where the author wishes to give any **specific message w.r.t.** to the manuscript.
  - d) The total size of the file containing the manuscript is expected to be below **1000 KB**.
  - e) **Abstract alone will not be considered for review** and the author is required to submit the **complete manuscript** in the first instance.
  - f) **The journal gives acknowledgement w.r.t. the receipt of every email within twenty four hours** and in case of non-receipt of acknowledgment from the journal, w.r.t. the submission of manuscript, within two days of submission, the corresponding author is required to demand for the same by sending a separate mail to the journal.
  - g) The author (s) name or details should not appear anywhere on the body of the manuscript, except the covering letter and the cover page of the manuscript, in the manner as mentioned in the guidelines.
2. **MANUSCRIPT TITLE:** The title of the paper should be **bold typed, centered and fully capitalised**.
  3. **AUTHOR NAME (S) & AFFILIATIONS:** Author (s) **name, designation, affiliation (s), address, mobile/landline number (s), and email/alternate email address** should be given underneath the title.
  4. **ACKNOWLEDGMENTS:** Acknowledgements can be given to reviewers, guides, funding institutions, etc., if any.
  5. **ABSTRACT:** Abstract should be in **fully italicized text**, ranging between **150 to 300 words**. The abstract must be informative and explain the background, aims, methods, results & conclusion in a **SINGLE PARA**. **Abbreviations must be mentioned in full.**
  6. **KEYWORDS:** Abstract must be followed by a list of keywords, subject to the maximum of **five**. These should be arranged in alphabetic order separated by commas and full stop at the end. All words of the keywords, including the first one should be in small letters, except special words e.g. name of the Countries, abbreviations.
  7. **JEL CODE:** Provide the appropriate Journal of Economic Literature Classification System code (s). JEL codes are available at [www.aeaweb.org/econlit/jelCodes.php](http://www.aeaweb.org/econlit/jelCodes.php), however, mentioning JEL Code is not mandatory.
  8. **MANUSCRIPT:** Manuscript must be in **BRITISH ENGLISH** prepared on a standard A4 size **PORTRAIT SETTING PAPER**. **It should be free from any errors i.e. grammatical, spelling or punctuation. It must be thoroughly edited at your end.**
  9. **HEADINGS:** All the headings must be bold-faced, aligned left and fully capitalised. Leave a blank line before each heading.
  10. **SUB-HEADINGS:** All the sub-headings must be bold-faced, aligned left and fully capitalised.
  11. **MAIN TEXT:**

**THE MAIN TEXT SHOULD FOLLOW THE FOLLOWING SEQUENCE:****INTRODUCTION****REVIEW OF LITERATURE****NEED/IMPORTANCE OF THE STUDY****STATEMENT OF THE PROBLEM****OBJECTIVES****HYPOTHESIS (ES)****RESEARCH METHODOLOGY****RESULTS & DISCUSSION****FINDINGS****RECOMMENDATIONS/SUGGESTIONS****CONCLUSIONS****LIMITATIONS****SCOPE FOR FURTHER RESEARCH****REFERENCES****APPENDIX/ANNEXURE****The manuscript should preferably range from 2000 to 5000 WORDS.**

12. **FIGURES & TABLES:** These should be simple, crystal **CLEAR, centered, separately numbered** & self explained, and **titles must be above the table/figure. Sources of data should be mentioned below the table/figure.** *It should be ensured that the tables/figures are referred to from the main text.*
13. **EQUATIONS/FORMULAE:** These should be consecutively numbered in parenthesis, horizontally centered with equation/formulae number placed at the right. The equation editor provided with standard versions of Microsoft Word should be utilised. If any other equation editor is utilised, author must confirm that these equations may be viewed and edited in versions of Microsoft Office that does not have the editor.
14. **ACRONYMS:** These should not be used in the abstract. The use of acronyms is elsewhere is acceptable. Acronyms should be defined on its first use in each section: Reserve Bank of India (RBI). Acronyms should be redefined on first use in subsequent sections.
15. **REFERENCES:** The list of all references should be alphabetically arranged. **The author (s) should mention only the actually utilised references in the preparation of manuscript** and they are supposed to follow Harvard Style of Referencing. **Also check to make sure that everything that you are including in the reference section is duly cited in the paper.** The author (s) are supposed to follow the references as per the following:
  - All works cited in the text (including sources for tables and figures) should be listed alphabetically.
  - Use (ed.) for one editor, and (ed.s) for multiple editors.
  - When listing two or more works by one author, use --- (20xx), such as after Kohl (1997), use --- (2001), etc, in chronologically ascending order.
  - Indicate (opening and closing) page numbers for articles in journals and for chapters in books.
  - The title of books and journals should be in italics. Double quotation marks are used for titles of journal articles, book chapters, dissertations, reports, working papers, unpublished material, etc.
  - For titles in a language other than English, provide an English translation in parenthesis.
  - **Headers, footers, endnotes and footnotes should not be used in the document.** However, **you can mention short notes to elucidate some specific point**, which may be placed in number orders after the references.

**PLEASE USE THE FOLLOWING FOR STYLE AND PUNCTUATION IN REFERENCES:**

#### **BOOKS**

- Bowersox, Donald J., Closs, David J., (1996), "Logistical Management." Tata McGraw, Hill, New Delhi.
- Hunker, H.L. and A.J. Wright (1963), "Factors of Industrial Location in Ohio" Ohio State University, Nigeria.

#### **CONTRIBUTIONS TO BOOKS**

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

#### **JOURNAL AND OTHER ARTICLES**

- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

#### **CONFERENCE PAPERS**

- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–23

#### **UNPUBLISHED DISSERTATIONS**

- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

#### **ONLINE RESOURCES**

- Always indicate the date that the source was accessed, as online resources are frequently updated or removed.

#### **WEBSITES**

- Garg, Bhavet (2011): Towards a New Gas Policy, Political Weekly, Viewed on January 01, 2012 <http://epw.in/user/viewabstract.jsp>



# CONSTRUCTION OF INTER QUARTILE RANGE (IQR) CONTROL CHART USING PROCESS CAPABILITY FOR STANDARD DEVIATION

**DR. C. NANTHAKUMAR**  
**ASSOCIATE PROFESSOR**  
**DEPARTMENT OF STATISTICS**  
**SALEM SOWDESWARI COLLEGE**  
**SALEM**

**S. VIJAYALAKSHMI**  
**HEAD**  
**DEPARTMENT OF MATHEMATICS & STATISTICS**  
**AVS ARTS & SCIENCE COLLEGE**  
**SALEM**

## ABSTRACT

Any course of action examine by control charts is a quite popular practice in statistical process control. In this research article a new control chart based on robust IQR using process capability for standard deviation is proposed instead of Shewhart chart for standard deviation when the underlying normality assumption is not met and it enables easier detection of outliers. Furthermore, the performances of these charts compared based on numerical examples under the assumptions of normal and exponential distributions. The proposed robust control chart using IQR shows to a better performance than the Shewhart control chart for standard deviation with moderate sample sizes.

## KEYWORDS

control chart, control limit interval, interquartile range and process capability.

## I. INTRODUCTION

Statistical process control has been used to great effect in the manufacturing industry to increase productivity in processes by specifically identifying and reducing variation (Deming, 1982). In such a way that the variation fluctuates in a natural or expected manner, a stable pattern of many chance causes of variation develops. Chance causes of variation are inevitable. When an assignable cause of variation is present, the variation will be excessive, and the process is classified as out of control or beyond the expected natural variation. Determination of the common or assignable causes of variation in control chart is possible with the use of control limits. Shewhart (1931) control chart which is one of the most widely used statistical process control technique developed under the normality to monitor the process in order to control the process variability. In this research article a new control chart based on robust IQR using process capability for standard deviation is proposed instead of Shewhart (1931) chart for standard deviation when the underlying normality assumption is not met and shows to a better performance than the Shewhart control chart for mean using range.

### A. Robust methods

This is one of the most commonly used statistical methods when the underlying normality assumption is violated. These methods offer useful and viable alternative to the traditional statistical methods and can provide more accurate results, often yielding greater statistical power and increased sensitivity and yet still be efficient if the normal assumption is correct (Moustafa Omar Ahmed Abu-Shawiesh, 2008). The standard deviation measures spread about the mean. Therefore, it is not practical to calculate the standard deviation when using the median as the measure of central tendency. Other statistics may be more useful when calculating the spread about the median. One statistic that is often used to measure the spread is to calculate the range. The range is found by subtracting the smallest value in the sample,  $y_1$ , from the largest value,  $y_n$ . The problem with the range is that it shares the worst properties of the mean and the median. Like the mean, it is not resistant. Any outlier in any direction will significantly influence the value of the range. Like the median, it ignores the numerical values of most of the data. That is not to say that the range does not provide any useful information and it is a relatively easy statistic to compute. In order to avoid the problem of dealing with the outliers, however, we can calculate a different measure of dispersion called the interquartile range (IQR). The interquartile range can be found by subtracting the first quartile value ( $q_1$ ) from the third quartile value ( $q_3$ ). For a sample of observations, we define  $q_1$  to be the order statistic below which 25% of the data lies. Similarly,  $q_3$  is defined to be the order statistic, below which 75% of the data lies.

The population IQR for a continuous distribution is defined to be  $IQR = Q_3 - Q_1$ , where  $Q_3$  and  $Q_1$  are found by solving the following integrals  $0.75 = \int_{-\infty}^{Q_3} f(x)dx$  and  $0.25 = \int_{-\infty}^{Q_1} f(x)dx$ . The function  $f(x)$  is continuous over the support of  $X$  that satisfies the two properties, (i)  $f(x) \geq 0$  and  $\int_{-\infty}^{\infty} f(x)dx = 1$ .

### B. Terms and concepts

#### a. Upper specification limit (USL)

It is the greatest amount specified by the producer for a process or product to have the acceptable performance.

#### b. Lower specification limit (LSL)

It is the smallest amount specified by the producer for a process or product to have the acceptable performance.

#### c. Tolerance level (TL)

It is a statistical interval within which, with some confidence level, a specified proportion of a sampled population falls. It is the difference between USL and LSL,  $TL = USL - LSL$ .

#### d. Process capability ( $C_p$ )

Process capability compares the output of an in-control process to the specification limits by using capability indices. The comparison is made by forming the ratio of the spread between the process specifications to the spread of the process values, as measured by 6 process standard deviation units. i.e.  $C_p = \frac{TL}{6\sigma} = \frac{USL - LSL}{6\sigma}$ .

#### e. Interquartile range (IQR)

The interquartile range (IQR) is a measure of variability, based on dividing a data set into quartiles. These quartiles divide a rank-ordered data set into four equal parts. The values that divide each part are called the first, second, and third quartiles; and they are denoted by  $Q_1$ ,  $Q_2$ , and  $Q_3$ , respectively.

- $Q_1$  is the "middle" value in the first half of the rank-ordered data set
- $Q_2$  is the median value in the set
- $Q_3$  is the "middle" value in the second half of the rank-ordered data set

The interquartile range is equal to  $Q_3$  minus  $Q_1$ .



**f. Robust quality control constant**

The quality control constant  $\sigma_{RPC}$  introduced in this research article to determine the robust control limits based on IQR using process capability for standard deviation chart.

**II. CONSTRUCTION OF IQR CONTROL CHART USING PROCESS CAPABILITY FOR STANDARD DEVIATION**

In this division a method to build an IQR control chart using process capability for standard deviation and suitable Table – A (APPENDIX I) is also obtained and presented for the companies to take quick decisions. Fix the tolerance level (TL) and process capability ( $C_p$ ) to find out the process standard deviation ( $\sigma_{RPC}$ ).

Apply the value of  $\sigma_{RPC}$  in the control limits  $c_4\sigma_{RPC} \pm \left\{ \left[ 3\sqrt{1-c_4^2} \right] \sigma_{RPC} \right\}$ , to get the robust control limits using process capability for standard deviation (Radhakrishnan et al., 2011), where  $\sigma_{RPC}$  is replaced instead of  $\sigma$  from the Shewhart 3-Sigma.

The quality control constant  $\sigma_{RPC}$  is coined by the control limits of Inter quartile range (IQR) in the course of “z-score” that corresponds to the areas under the normal curve of 0.25 and 0.75 respectively. Thus we have  $Q_3=0.6745+\mu$  and  $Q_1=-0.6745+\mu$  implies that  $IQR_{norm}=1.3490\sigma$  because of the central limit theorem motivates the use of the normal distribution  $f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$ ,  $-\infty < x < \infty$ .

**III. ASSUMPTIONS FOR THE STUDY**

- Production managers involved in the study will be willing and able to learn the principles of evaluating control charts
- Production managers involved in the study will have adequate knowledge and experience to make adjustments to an activity to improve the productivity of a process based on the data conveyed in the control charts
- The activities to be studied will feature crews comprised of the same labourers and operators during the pre-intervention and intervention periods

**IV. CONDITIONS FOR APPLICATION**

- Robust control limits will be used if the data is found to be non-normal
- Companies adopt the concept of IQR using process capability in its processes

**V. DETERMINATION OF CONTROL CHARTS**

The example provided by Acheson J. Duncan (1958, Page No. 303) is considered here. The following data are measurements of inside diameters. The measurements are taken in sample groups of 5 each.

**TABLE 1: MEASUREMENTS OF INSIDE DIAMETERS**

Sample	x1	x2	x3	x4	x5	S	IQR <sub>zs</sub>
1	15	11	8	15	6	4.06	5.19
2	14	16	11	14	7	3.51	2.22
3	13	6	9	5	10	3.21	2.97
4	15	15	9	15	7	3.90	4.45
5	9	12	9	8	8	1.64	0.74
6	11	14	11	12	5	3.36	0.74
7	13	12	9	6	10	2.74	2.22
8	10	15	12	4	6	4.45	4.45
9	8	12	14	9	10	2.41	2.22
10	10	10	9	14	14	2.41	2.97
11	13	16	12	15	18	2.39	2.22
12	7	10	9	11	16	3.36	1.48
13	11	7	16	10	14	3.51	2.97
14	11	7	10	10	7	1.87	2.22
15	13	9	12	13	17	2.86	0.74
16	17	10	11	9	8	3.54	1.48
17	4	14	5	11	11	4.30	4.45
18	8	9	6	13	9	2.55	0.74
19	9	10	7	10	13	2.17	0.74
20	15	10	12	12	16	2.45	2.22
						$\bar{S} = 3.03$	$\bar{IQR}_{zs} = 2.37$

**A. Shewhart control chart for standard deviation**

The  $3\sigma$  control limits suggested by Shewhart (1931) are  $\bar{S} \pm \left\{ \left[ 3\sqrt{1-c_4^2} \right] \left( \frac{\bar{S}}{c_4} \right) \right\}$

$$UCL_S = \bar{S} + \left\{ \left[ 3\sqrt{1-c_4^2} \right] \left( \frac{\bar{S}}{c_4} \right) \right\} = 3.03 + \left\{ \left[ 3\sqrt{1-(0.94^2)} \right] \left( \frac{3.03}{0.94} \right) \right\} = 6.33$$

$$CL_S = \bar{S} = 3.03$$

$$LCL_S = \bar{S} - \left\{ \left[ 3\sqrt{1-c_4^2} \right] \left( \frac{\bar{S}}{c_4} \right) \right\} = 3.03 - \left\{ \left[ 3\sqrt{1-(0.94^2)} \right] \left( \frac{3.03}{0.94} \right) \right\} = -0.27$$

However, the control limit interval hereafter refers to as CLI, is the difference between the control limits value. Therefore, for the IQR control chart for standard deviation, the control limit interval will be determined using the expression:

$$CLI_S = \left[ 6\sqrt{1-c_4^2} \right] \left( \frac{\bar{S}}{c_4} \right) = \left[ 6\sqrt{1-0.94^2} \right] (3.03/0.94) = 6.60$$

From the result, it is clear that the process is in control, since the entire sample numbers lie inside the control limits and the control limit interval is 6.60 for  $n=5$ .

**B. Inter quartile range (IQR) control chart for standard deviation**

The  $3\sigma$  control limits based on IQR are  $c_4\bar{IQR}_{zs} \pm \left\{ \left[ 3\sqrt{1-c_4^2} \right] (\bar{IQR}_{zs}) \right\}$

$$UCL_{S,Rob} = c_4\bar{IQR}_{zs} + \left\{ \left[ 3\sqrt{1-c_4^2} \right] (\bar{IQR}_{zs}) \right\} = (0.94 \times 2.37) + \left\{ \left[ 3\sqrt{1-(0.94^2)} \right] (2.37) \right\} = 4.65$$

$$CL_{S,Rob} = c_4\bar{IQR}_{zs} = (0.94 \times 2.37) = 2.23$$

$$LCL_{S,Rob} = c_4\bar{IQR}_{zs} - \left\{ \left[ 3\sqrt{1-c_4^2} \right] (\bar{IQR}_{zs}) \right\} = (0.94 \times 2.37) - \left\{ \left[ 3\sqrt{1-(0.94^2)} \right] (2.37) \right\} = -0.20$$

However, the control limit interval hereafter refers to as CLI, is the difference between the control limits value. Therefore, the IQR control chart for standard deviation, the control limit interval will be determined using the expression:

$$CLI_{S,Rob} = \left[ 6\sqrt{1 - c_4^2} \right] (IQR_{z_5}) = \left[ 6\sqrt{1 - (0.94^2)} \right] (2.37) = 4.85$$

From the result, it is clear that the process is in control, since the entire sample numbers lie inside the control limits and the control limit interval is 4.85 for  $n=5$ .

### C. Proposed inter quartile range (IQR) control chart using process capability for standard deviation

Difference between upper specification and lower specification limits is 4.45 ( $USL - LSL = 5.19 - 0.74$ ), which termed as tolerance level (TL) and choose the process capability ( $C_p$ ) is 2.0, it is found from the Table - A (APPENDIX I) that the value of  $\sigma_{RCP}$  is 0.37. The control limits of inter quartile range (IQR) using process capability for standard deviation, a specified tolerance level with the control limits  $c_4\sigma_{RCP} \pm \left\{ \left[ 3\sqrt{1 - c_4^2} \right] \sigma_{RCP} \right\}$

$$UCL_{S,RPC} = c_4\sigma_{RCP} + \left\{ \left[ 3\sqrt{1 - c_4^2} \right] \sigma_{RCP} \right\} = (0.94 \times 0.37) + \left\{ \left[ 3\sqrt{1 - 0.94^2} \right] \times 0.37 \right\} = 0.73$$

$$CL_{S,RPC} = c_4\sigma_{RCP} = (0.94 \times 0.37) = 0.35$$

$$LCL_{S,RPC} = c_4\sigma_{RCP} - \left\{ \left[ 3\sqrt{1 - c_4^2} \right] \sigma_{RCP} \right\} = (0.94 \times 0.37) - \left\{ \left[ 3\sqrt{1 - 0.94^2} \right] \times 0.37 \right\} = -0.03$$

However, the control limit interval hereafter refers to as CLI, is the difference between the control limits value. Therefore, the IQR control chart using process capability for standard deviation, the control limit interval will be determined using the expression:

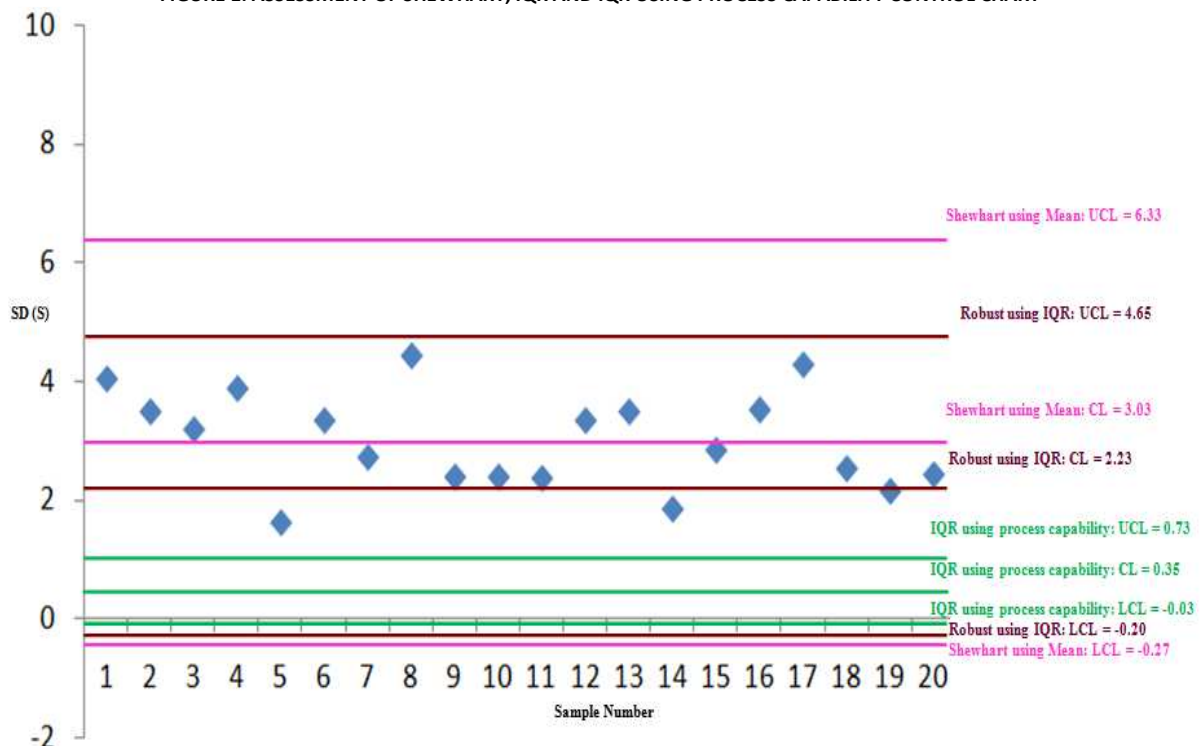
$$CLI_{S,RPC} = \left[ 6\sqrt{1 - c_4^2} \right] \sigma_{RCP} = \left[ 6\sqrt{1 - 0.94^2} \right] \times 0.37 = 0.76$$

From the result, it is clear that the process is out of control, since the entire sample numbers lie outside the control limits and the control limit interval is 0.76 for  $n=5$ .

TABLE 2: ASSESSMENT OF SHEWHART, IQR AND IQR USING PROCESS CAPABILITY CONTROL CHARTS

Control limits	Shewhart control chart	IQR	IQR using process capability
LCL	-0.27	-0.20	-0.03
CL	3.03	2.23	0.35
UCL	6.33	4.65	0.73
CLIs	6.60	4.85	0.76

FIGURE 1: ASSESSMENT OF SHEWHART, IQR AND IQR USING PROCESS CAPABILITY CONTROL CHART



It is found from the Figures 1 that the process is in control when the control limits of Shewhart 3 – Sigma and IQR are adopted and also the process is out of control when the control limits of IQR using process capability are used. The control limits interval of IQR using process capability is smaller than the control limits interval of Shewhart and IQR. It is clear that the product/service is not in good quality as expected, accordingly a modification and improvement is needed in the process/system.

## VI. CONCLUSION

Usually, Shewhart (1931) standard deviation control chart for monitoring the process variability is based on some assumptions with standard deviation ( $\sigma$ ) which is not a robust estimator. For this cause, we offered the control chart based on robust IQR using process capability for standard deviation. The outcome of numerical example and randomly selected data under exponential show that the proposed robust method leads better to the performance in the presence of normality and exponential, such as many points fall outside the control limits than the existing control charts and the control limits interval of IQR using process capability is smaller than the control limits interval of Shewhart and IQR. It is clear that the product/service is not in good quality as expected, accordingly a modification and improvement is needed in the process/system. Furthermore, in the case of non-normality, it is recommended to use proposed robust control charts as an alternative to Shewhart control chart for standard deviation. The proposed control chart based on IQR using process capability for standard deviation will not only assist the producer in providing better quality but also increase the fulfilment and self-assurance of the consumers. Furthermore, this procedure is designed not only to the manufacturing industries alone, but also to the other industries such as Health care, Software, E-commerce industry and so on.

## REFERENCES

1. Acheson j. Duncan, 'Quality Control and Industrial Statistics', Richard D. Irwin, Inc. Homewood, Illinois (sixth printing), pp. 280-282. 1958.
2. B.C. Michael Khoo and S.Y. Sim, "A Robust Exponentially Weighted Moving Average Control Chart for the Process Mean", Journal of Modern Applied Statistical Methods, Vol. 5, No. 2, 2006, pp.464-474.
3. Deming, W. Edwards, "Quality, Productivity, and Competitive Position", MIT Center for Advanced Engineering Study (CAES), Cambridge, Mass, 1982.
4. Dewey L. Whaley III, "The Interquartile Range: Theory and Estimation", School of graduate studies, East Tennessee State University, United states, 2005.
5. Moustafa Omar Ahmed Abu-Shawiesh, "A Simple Robust Control Chart Based on MAD", Journal of Mathematics and Statistics 4 (2): 2008, pp.102- 107.
6. Nuri Celik, "Control Charts Based on Robust Scale Estimators", American Research Journal of Mathematics, Volume 1, Issue 1, 2015.
7. R. Radhakrishnan and P. Balamurugan, "Construction of control charts based on six sigma Initiatives for Fraction Defectives with varying sample size", Journal of Statistics & Management Systems (JSMS), Volume 15, Issue 4-5, 2012, pp. 405-413.
8. W.A. Shewhart, "Economic Control of Quality of Manufactured Product", Van Nostrand, New York, 1931.

## WEBSITE

9. <http://www.mathwave.com/>

## APPENDIX

TABLE- A:  $\sigma_{RPC}$  VALUES FOR A SPECIFIED  $C_p$  AND TL

TL $C_p$	0.0001	0.0002	....	0.001	0.002	....	1	2	....	50	100	200
1	0	0	....	0.0002	0.0003	....	0.17	0.33	....	8.33	16.67	33.33
1.1	0	0	....	0.0002	0.0003	....	0.15	0.30	....	7.58	15.15	30.30
1.2	0	0	....	0.0001	0.0003	....	0.14	0.28	....	6.94	13.89	27.78
1.3	0	0	....	0.0001	0.0003	....	0.13	0.27	....	6.41	12.82	25.64
1.4	0	0	....	0.0001	0.0002	....	0.12	0.24	....	5.95	11.90	23.81
1.5	0	0	....	0.0001	0.0002	....	0.11	0.22	....	5.56	11.11	22.22
1.6	0	0	....	0.0001	0.0002	....	0.10	0.21	....	5.21	10.42	20.83
1.7	0	0	....	0.0001	0.0002	....	0.10	0.20	....	4.90	9.80	19.61
1.8	0	0	....	0	0.0002	....	0.09	0.19	....	4.63	9.26	18.52
1.9	0	0	....	0	0.0002	....	0.09	0.18	....	4.39	8.77	17.54
2	0	0	....	0	0.0002	....	0.08	0.17	....	4.17	8.33	16.67
2.1	0	0	....	0	0.0002	....	0.08	0.16	....	3.97	7.94	15.87
2.2	0	0	....	0	0.0002	....	0.08	0.15	....	3.79	7.58	15.15
2.3	0	0	....	0	0.0001	....	0.07	0.14	....	3.62	7.25	14.49
2.4	0	0	....	0	0.0001	....	0.07	0.14	....	3.47	6.94	13.89
2.5	0	0	....	0	0.0001	....	0.07	0.13	....	3.33	6.67	13.33

## **REQUEST FOR FEEDBACK**

**Dear Readers**

At the very outset, International Journal of Research in Commerce, IT & Management (IJRCM) acknowledges & appreciates your efforts in showing interest in our present issue under your kind perusal.

I would like to request you to supply your critical comments and suggestions about the material published in this issue, as well as on the journal as a whole, on our e-mail [infoijrcm@gmail.com](mailto:infoijrcm@gmail.com) for further improvements in the interest of research.

If you have any queries, please feel free to contact us on our e-mail [infoijrcm@gmail.com](mailto:infoijrcm@gmail.com).

I am sure that your feedback and deliberations would make future issues better – a result of our joint effort.

Looking forward to an appropriate consideration.

With sincere regards

Thanking you profoundly

**Academically yours**

Sd/-

**Co-ordinator**

## **DISCLAIMER**

The information and opinions presented in the Journal reflect the views of the authors and not of the Journal or its Editorial Board or the Publishers/Editors. Publication does not constitute endorsement by the journal. Neither the Journal nor its publishers/Editors/Editorial Board nor anyone else involved in creating, producing or delivering the journal or the materials contained therein, assumes any liability or responsibility for the accuracy, completeness, or usefulness of any information provided in the journal, nor shall they be liable for any direct, indirect, incidental, special, consequential or punitive damages arising out of the use of information/material contained in the journal. The journal, neither its publishers/Editors/ Editorial Board, nor any other party involved in the preparation of material contained in the journal represents or warrants that the information contained herein is in every respect accurate or complete, and they are not responsible for any errors or omissions or for the results obtained from the use of such material. Readers are encouraged to confirm the information contained herein with other sources. The responsibility of the contents and the opinions expressed in this journal are exclusively of the author (s) concerned.

## ABOUT THE JOURNAL

In this age of Commerce, Economics, Computer, I.T. & Management and cut throat competition, a group of intellectuals felt the need to have some platform, where young and budding managers and academicians could express their views and discuss the problems among their peers. This journal was conceived with this noble intention in view. This journal has been introduced to give an opportunity for expressing refined and innovative ideas in this field. It is our humble endeavour to provide a springboard to the upcoming specialists and give a chance to know about the latest in the sphere of research and knowledge. We have taken a small step and we hope that with the active co-operation of like-minded scholars, we shall be able to serve the society with our humble efforts.

### *Our Other Journals*

