ISSN: 2147-5121 / E-ISSN: 2717-7610

İstanbul Nişantaşı Üniversitesi Sosyal Bilimler Dergisi

Bilimsel Hakemli Dergi

Yıl: 2023 Cilt: 11 Sayı: 2

İSTANBUL NİŞANTAŞI UNIVERSITY NEW

NUSBD

Yayın Aralığı: Yılda 2 Sayı - Başlangıç: 2013

İstanbul Nişantaşı University Journal of Social Sciences

Scientific Refereed Journal

Year: 2023 Vol.: 11 No: 2

D E R L E M E M A K A L E / R E V I E W A R T I C L E

**DOI:** 10.52122/nisantasisbd.1256691

# A BIBLIOMETRIC ANALYSIS OF QUALITY CONTROL CHARTS

**Arş. Gör. Fatmanur GÖÇER***

*İstanbul Nişantaşı Üniversitesi, Mühendislik Mimarlık Fakültesi, Endüstri Mühendisliği Pr.

e-posta: fatmanur.gocer@nisantasi.edu.tr

ORCID 0000-0001-8063-2566

**Dr. Öğr. Üyesi Sinem BÜYÜKSAATÇI KİRİŞ***

*İstanbul Üniversitesi-Cerrahpaşa, Mühendislik Fakültesi, Endüstri Mühendisliği Bölümü

e-posta: s.buyuksaatcikiris@iuc.edu.tr

ORCID 0000-0001-7697-3018

**ABSTRACT**

In order to recognize research directions, monitor research hot spots and directions for further researches, this work evaluates the bibliometric analysis of quality control charts. So, based on the following analysis—chronological distribution, country distribution, keyword co-occurrence and author co-occurrence—a summary of quality control chart studies from 2002 to 2023 was obtained using VOSviewer software. A total of 2702 research papers published were examined. The findings indicate that the topics of "engineering", "management sciences & statistics" and "materials science & automation control systems" are of particular interest in quality control chart researches. In addition, the keywords “statistical process control”, “average run length” and “control charts” have seen a sharp increase in recent years in term of citations. Besides, William H. Woodall, Douglas C. Montgomery and Matthew R Reynolds were identified as the highly referenced authors. The USA, China, Pakistan, Saudi Arabia, and Malaysia were found to have the highest influence on quality control charts researches among the 76 nations studied in this study, with 618, 485, 260, 202, and 140 publications, respectively.

**Keywords:** quality control charts, bibliometric review, co-citation analysis

**Jel Kodları:** L26, O18, R11, B21.

# KALİTE KONTROL ÇİZELGELERİNİN BİBLİYOMETRİK ANALİZİ

**ÖZ**

Bu çalışma, kalite kontrol çizelgeleri konusunda araştırma yönlerini belirlemek, araştırma sıcak noktalarını ve sonraki araştırmalar için yönelimleri izlemek için kalite kontrol çizelgelerinin bibliyometrik analizini değerlendirmektedir. Bu nedenle; kronolojik dağılım, ülke dağılımı, anahtar kelime birlikte kullanımı ve yazar birlikte kullanımı analizlerine dayanarak ve VOSviewer yazılımı kullanılarak 2002'den 2023'e kadar kalite kontrol çizelgeleri çalışmalarının bir özeti elde edilmiştir. Yayınlanmış toplam 2702 araştırma makalesi incelenmiştir. Bulgular, "mühendislik", "yönetim bilimleri ve istatistik" ve "malzeme bilimi ve otomasyon kontrol sistemleri" konularının kalite kontrol şeması araştırmalarında özellikle ilgi çekici olduğunu belirtmektedir. Ayrıca “istatistiksel süreç kontrol”, “ortalama çalışma uzunluğu” ve “kontrol çizelgeleri” anahtar kelimeleri atıf açısından son yıllarda keskin bir artış göstermiştir. Ayrıca William H. Woodall, Douglas C. Montgomery ve Matthew R Reynolds da en çok atıf yapılan yazarlar olarak belirlenmiştir. Bu çalışmada incelenen 76 ülke arasında sırasıyla 618, 485, 260, 202 ve 140 yayınla ABD, Çin, Pakistan, Suudi Arabistan ve Malezya'nın kalite kontrol çizelgeleri araştırmalarında en yüksek etkiye sahip olduğu bulunmuştur.

**Keywords:** kalite control çizelgeleri, bibliyometrik analiz, ortak alıntı analizi

**Jel Codes:** L26, O18, R11, B21.

**Geliş Tarihi/Received:** 06.02.2023 | **Kabul Tarihi/Accepted:** 21.12.2023 | **Yayım Tarihi/Printed Date:** 30.12.2023

**Kaynak Gösterme:** Göçer, F. ve Büyüksaatçı Kiriş, S. (2023). “A Bibliometric Analysis of Quality Control Charts”. *İstanbul Nişantaşı Üniversitesi Sosyal Bilimler Dergisi*, 2(11) 00-00.

## INTRODUCTION

One of the most crucial considerations for consumers when choosing between competing goods and services is quality. Quality also correlates with a linear rise in production in another way. Reducing variability in processes and products is a key component of quality improvement. (Montgomery D.C, 2020). Quality is a set of systems that have gained meaning in many sectors with different measurement methods. On the other hand, quality control of commercial products and services has a very significant place in providing competitive advantage, gaining customer loyalty, and obtaining a higher quality, value, and success control of manufacturers. The essential purpose of quality control should be to improve the variance between the perceived value and the measured value.

The development of the principle of quality began in the early 20th century with the testing methods of products and materials in AT&T laboratories. W.S. Gosset introduced t-distiribution during quality control improvement in 1908. The quality department, which attaches importance to the testing, inspection and reliability of the products, was established in AT&T laboratories. W.A. Shewart introduced the concept of the control scheme while working in these laboritories. Acceptance sampling was also developed at labs. W.A. Shewart published economic control in product quality. Statistical quality control forms quality communities during this time and spreads throughout the industry through training (Vadori, 2020).

Shewhart explained statistical quality with three precisions and quality control in three steps in his book “Statistical Methods”. These three steps in quality control processes are the examination of what is specifically requested, whether the production with this specified specification meets the indicators, and whether the manufactured products meet the specifications. When Statistical Quality is examined under four basic functions, it is possible to combine the functions as follows: monitoring process parameters and process outputs, distinguishing the variances caused by special reasons during the process, ensuring continuous improvement by separating the variances caused by common reasons, and deciding how the process can cope with the specifications.

Statistical process control (SPC) is a sophisticated collection of tools used to inspect, manage, and improve the quality of processes (Silpakob et.al., 2023). By removing specific reasons of variation in processes, such as tool wear, operator error, measurement mistakes, use of unsuitable raw materials, etc., it is a potent way to manage, control, analyze, and enhance the performance of a process (Abtew et.al., 2018). Statistical Process Control (SPC) is the use of statistical techniques to oversee and regulate a process to make sure it runs as efficiently as possible and results in a conforming product (Madanhire & Mbohwa, 2016). A considerably greater range of tasks are included in statistical process control, such as designing sample and inspection plans, performing Pareto analyses, designing experiments, and performing multivariable analyses (Harris & Ross, 1991). Firms with high production demands use SPC tools to maintain stability (Hrvacic, 2018). In addition, since the application of SPC provides fewer defective products and improved production time, SPC has become essential in large mass production companies. SPC is used to ensure that the final product's quality will meet predetermined requirements (Koutras et.al., 2007). SPC aims to provide higher-quality products and services by reducing variation. 7 basic tools comprise SPC. These are histogram, Pareto chart, cause and effect diagram, stem and leaf chart, control sheet, defect concentration diagram, scatter diagram, and control charts (Hrvacic, 2018). Monitoring processes with these techniques at every stage of production and service is seen as an effective tool. Because all processes have some inherent normal variability in

performance, consistency does not imply that the same results will be obtained every time. Instead, the results will shift (Jalote & Saxena, 2002). The process is under control when there are variations between the upper and lower control levels identified in the control charts. Monitoring unpredictable errors and situations outside the specified limits and controlling the process is a crucial factor of SPC. One can classify control charts into the following three major types based on their statistical underpinnings: Control charts using Shewhart, Cumulative Sum (CUSUM), and Exponentially Weighted Moving Average (EWMA) (Koutras et.al., 2007). These charts come under the category of the Control chart for variables.The oldest and most popular known control charts were introduced by Shewhart in 1931 and called by his name.

The use of statistical process control charts has spread over a wide area. Manufacturing processes are the environments where these charts are used the most due to the inherent variation. Apart from this, one of the application areas is the healthcare sector. One of them is the healthcare sector. Error rates rise in tandem with increased human engagement in healthcare. Statistical control charts can be used to identify the special and common causes of variances, which can assist in detecting the source of errors. Initially used in laboratories, control charts were later used in hospitals to manage patient-level data. The mortality rate, door to reperfusion time, door to needle time, length of stay, processing time, admission time, complications, surgical site infections, and the percentage of errors in almost every department have all decreased dramatically with the use of control charts (Suman & Prajapati, 2018).

While continuous quality gained importance, SPC tools that reduce variation and keep the process stable have also shown themselves in the food industry. Technology, sensory (flavor, color, texture, smell, and taste), physical attrıbutes, microbiological safety, chemical composition, and nutritional value are all strongly tied to quality control in the food industry. Moreover, the food industry has had to take into account important aspects of the manufacturing process, the distribution procedures, and the product-market systems as indications of overall quality in addition to the customer's impression of a product's quality. SPC implementations revealed that food industry was mainly due to its compliance with food laws and regulation (Lim et.al., 2014). Unlike other industries, SPC applications in the food industry are at a very low level in the literature because of the special characteristics of food products (Halim Lim, 2017). Rai (2008) addressed the problem of weight (over or under) variation in the tea package encountered in tea production with the help of a control diagram. Alfatiyah et al. (2020) analyzed the number of errors of nugget products with the p diagram and investigated when and for what reason the errors outside the control limit occurred. González Álvarez et al. (2022) assessed the stability and conformity to quality standards of a firm that produces pasta within the food industry sector. Losses resulting from poor quality of the product have necessitated monitoring various quality characteristics such as humidity and acidity with X-R quality control diagrams.

Another area where SPC applications are frequently used is the textile industry. Das (2013) explained different statistical techniques and their applications in textile industry with relevant examples. Suryoputro et al. (2017) implemented seven tools including control charts at the Batik Company to reduce and prevent defects in textile products. Abdulghafour et al. (2021) conducted a study to help textile manufacturers and enable them to focus on reducing quality costs in their relevant unit operations, especially in a competitive market or recession environment. $\bar{X}$-R and $\bar{X}$-S control charts for variables have been applied and implemented to monitor the yarn quality variations.

There are also review studies on control charts in the literature. Nasiri and Darestani (2016 examined a number of control chart research studies that used fuzzy logic between 1990 and

2012. They examined the researches under 7 headings, assumptions of the data model, type of the control charts, type of variables, input representation techniques, type of membership function, type of validation, performance criteria. The non-standard uses of SPC charts documented in the literature from 1989 to 2000 were examined by MacCarthy and Wasusri in 2002. The application domain, data sources, and control chart approaches utilized in non-standard applications were all analyzed. Aykroyd et. al. (2019's goal was to pinpoint existing, forthcoming, and hot themes that would be studied in control chart research in 2015 and early 2016 using bibliometric analysis technique. They also presented industrial and non-industrial applications and cases which were monitored by control charts. Another subject covered by this paper is the potential impact of the big data revolution on control charts.

This bibliometric analysis seeks to further these earlier reviews by charting the evolution of quality control charts between 2002 and 2023. Below research questions guided the review.

RQ 1: What is the total number of papers published globally, their development trajectory, and their distribution throughout the countries in the quality control charts knowledge base?

RQ 2. What are the most frequently studied topics in the quality control charts literature in recent years?

RQ 3. Which authors and research papers have had the greatest impact on quality control charts research?

Accordingly, the paper is structured as follows. The next section describes the steps performed through the VOSviewer program used for bibliometric analysis. Chapter 2 presents the findings of the study respect to co-occurrence keywords. co-citation authors, co-citation documents, and co-citation countries. The conclusion part provides a summary and final descriptions.

## 1. Application

Bibliometric analysis, which has been used in an increasing trend recently, is a well-known quantitative and rigorous method that helps to perform a comprehensive literature review and identify research trends and hot topics. This analysis provides quantitative statistics, allowing visual data from an extensive perspective while examining a large amount of publications. Through this method, researchers can provide a comprehensive definition for future studies by visualizing the relationships between articles, journals, keywords, and prevalent citation networks (Ranjbari et al., 2021). In this study, the bibliometric analysis was carried out using the VOSviewer program on the information obtained from the Web of Science (WOS) core collection data set. The WOS core collection database is regarded as the most reliable data source for researching publications across a wide range of areas because it contains the most respectable and significant journals (Zhao et al., 2019). Although Scopus has a broad data extent, it has a high connection with the WOS database. The WOS core collection database allows researchers to reach various fields such as management and social sciences, apart from engineering and science. This is one of the reasons why it was chosen in this study.

VOSviewer visually expresses to the researchers the authors who have participated in the joint work on the subject, the interaction of the studies with each other, through the keywords, countries, and references, in the form of cluster analysis through the research unit. While word analysis examines the keywords and terms used together, in co-citation analysis, the author examines the common occurrences between journals and studies. In particular, the studies that have common references are handled with cluster analysis, and the high citation relationships between the studies are also examined. Some important issues may not be considered because

they are not cited (Zhao et al., 2019). The analysis progressed in a 5-stage process. The research was started by using the "quality control charts" keyword and approximately 10709 articles were included in the process as definitions. In the first stage, citation topics were primarily limited to "Statistical Methods", "Management", "Automation & Control Systems", "Design and Manufacturing", "Supply Chain and Logistics", "Manufacturing", and finally "Operation Research and Management Science". After this limitation, the number of articles decreased to 4956. In the second stage, the articles with publication years from 2002 to 2023 were included in the analysis. With this time interval, the last two decades were taken into account. After the year limitation, the number of articles was reduced to 4310. In the third stage, in order to increase the depth of the study in the WOS category, "Engineering Industrial", "Operations Research Management Science", "Engineering Multidisciplinary", "Statics Probability", "Engineering Manufacturing", "Computer Science Interdisciplinary Applications", "Automation Control Systems", "Management", "Social Sciences Interdisciplinary", "Computer Science Information Systems", "Mathematics Interdisciplinary Applications", "Multidisciplinary Sciences", "Business", "Instrumentation", "Mathematics", "Mathematics Applied", and "Material Science Multidisciplinary" topics were preferred and the number of articles to be analyzed was reduced to 3804. The fourth stage is the stage where the publishers were restricted. In this study, articles published by Wiley, Taylor & Francis, Elsevier, Spring Nature, Emerald Group Publishing, and IEEE. In this way, the number of sample articles was further narrowed down to 2845. Eventually, SCI-E, SSCI, and CPCI-S were preferred within the scope of the WOS index, and the data set to be used in VOSviewer was determined with 2702 articles. The systematic stages of the search process used in this study are shown in Figure 1.

## 2. Findings

### 2.1. Evolution of Publications

Figure 2 depicts the trend in research publications on quality control charts from 2002 to 2023. Studies on quality control charts have shown an increasing trend over the years. In particular, the time period between 2019-2021 is seen as the most productive years in terms of published articles on quality control charts.

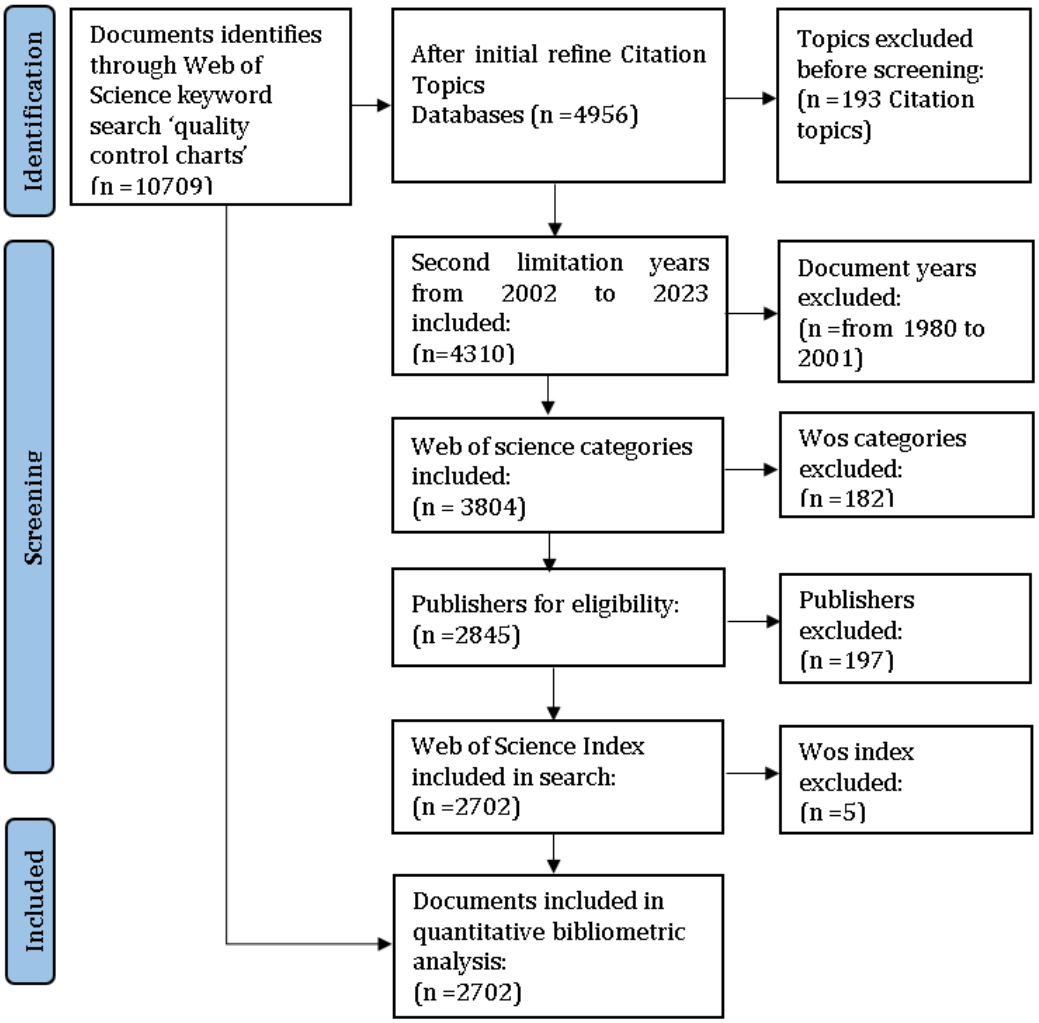


**Figure 1**. PRISMA Diagram Describing the Collection of Quality Control Charts Documents from the Web of Science Database

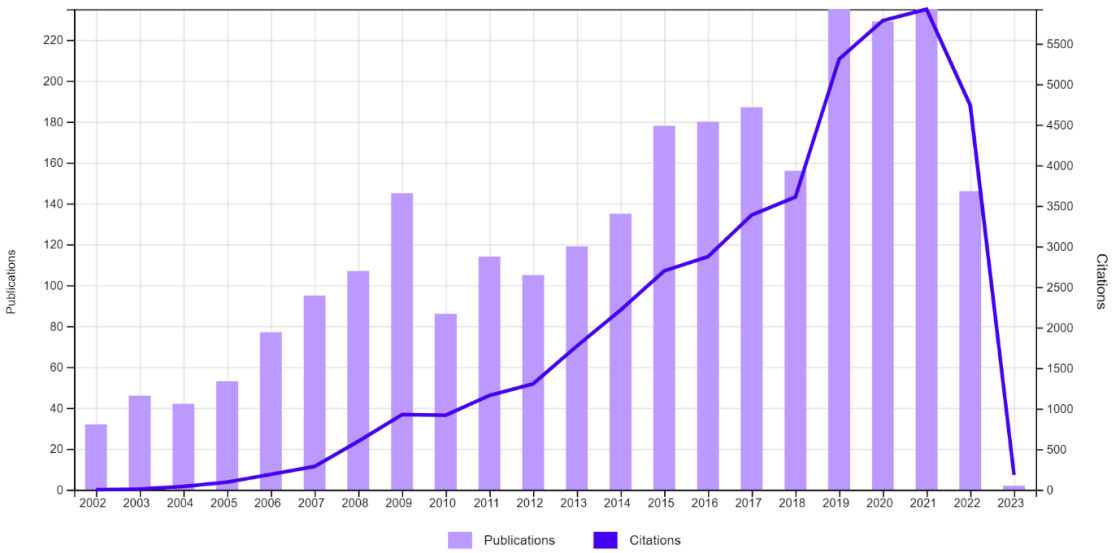


**Figure 2.** Publications Evolution for Quality Control Charts Researches Qver Time 2002-2023

## 2.2. Analysis of Citations

A citation is a reference to a source. If an article has a large number of citations, this can show its importance. Table 1 below summarizes the fifteen most cited articles on quality control charts in the WOS database.

**Table 1.** The Top 10 Most Cited Articles in WOS Database

| No | Authors | Title | Citation | Type |
|---|---|---|---|---|
| 1 | Jensen et al., 2006 | Effects of parameter estimation on control chart properties: A literature review | 412 | Review |
| 2 | Hazen et al., 2014 | Data quality for data science, predictive analytics, and big data in supply chain management: An introduction to the problem and suggestions for research and applications | 404 | Article |
| 3 | Bersimis et al., 2007 | Multivariate statistical process control charts: An overview | 390 | Review |
| 4 | Woodall, WH., 2006 | The use of control charts in health-care and public-health surveillance | 344 | Review |
| 5 | Nichols and Padgett, 2006 | A bootstrap control chart for Weibull percentiles | 256 | Article |
| 6 | Lee et al., 2004 | Fault detection of batch processes using multiway kernel principal component analysis | 218 | Article |
| 7 | Mahmoud et al., 2007 | A change point method for linear profile data | 205 | Article |
| 8 | Woodall and Montgomery, 2014 | Some Current Directions in the Theory and Application of Statistical Process Monitoring | 197 | Article |
| 9 | Williams et al., 2007 | Statistical monitoring of nonlinear product and process quality profiles | 188 | Article |
| 10 | Colledani et al., 2014 | Design and management of manufacturing systems for production quality | 169 | Article |

## 2.3. Keyword co-occurrence network

The authors' keywords should express their research's essential impression and extent. Analysis of terms together can enable us to discover significant points about the subject while researching the same areas. Keyword co-occurrence analysis was performed using the VOSviewer program. The smallest quantity of circumstances of a keyword has progressed by making 10 keyword matches in this study. 5332 keywords have been reduced to 149 with this limitation. The restricted words were split into 9 clusters Each node in this network specifies a keyword. The nodes, which have a larger and brighter appearance, indicate the frequency of the keywords. The distance between the nodes would specify the relationship of the keywords to each other. It is accepted that the reduced range between two nodes, the higher the relationship between them. As given in Figure 3, "Shewart control charts" and "quality control" keywords received the most attention while "statistical process control" while "ewma," "markov chain" and "average run

length" have a great link. Based on the data in Figure 3 researchers could realize the novelest and effective keywords.

Among the 2702 articles we considered in the study, 15 of the keywords with the highest frequency of occurence are "statistical process control", "average run length", "control chart", "control charts", "quality control", "EWMA", "Markov chain", "exponentially weighted moving average", "profile monitoring", "CUSUM", "monte carlo simulation", "average run length(arl)", "phase II", "spc" and "phase I". Their occurence and total link values are shown in Table 2. Moreover, these fifteen keywords have the maximum amount of cross-references to alternative expressions in the dataset.

**Table 2.** Top 15 Co-occurrence Keywords in the Quality Control Chart Literature

| No | Keyword | Occurrences | Total link strength |
|---|---|---|---|
| 1 | Statistical process control | 633 | 1178 |
| 2 | Average run length | 491 | 1059 |
| 3 | Control chart | 340 | 745 |
| 4 | Control charts | 269 | 502 |
| 5 | Quality control | 242 | 449 |
| 6 | EWMA | 130 | 333 |
| 7 | Markov chain | 123 | 256 |
| 8 | Exponentially weighted moving average | 67 | 189 |
| 9 | Profile monitoring | 97 | 188 |
| 10 | CUSUM | 65 | 182 |
| 11 | Monte carlo simulation | 58 | 171 |
| 12 | Average run length(arl) | 93 | 162 |
| 13 | Phase II | 39 | 119 |
| 14 | Spc | 65 | 117 |
| 15 | Phase I | 40 | 114 |

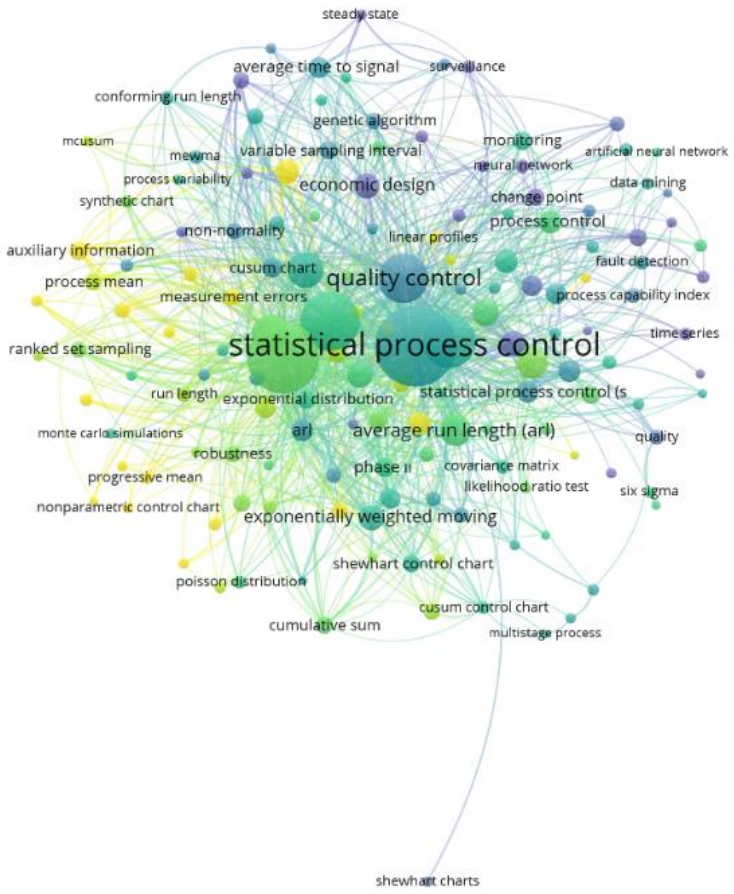


**Figure 3.** Co-occurrence Network of Keywords Generated by VOSviewer Based on Quality Control Charts

## 2.4. Co-Citation Analysis

Co-citation analysis examines whether two documents cite together and presents the amount cited together each other. In addition, co-citation analysis uses the ability of journals to visualize similar studies, keywords used, as well as visual associations of related studies under the identified compilation. In this study, three sorts of co-citation analysis as the co-author, co-citation cite references, and co-citation country were considered. Furthermore, the co-citation cite references approach with cluster analysis analyzes the occurrence of recent research trends and relevant variation after a certain time and detects the research attention at a time point. The visual network diagram reveals lines or "links" associating each of the authors, is based on their co-citation by other academics. Looking at the semantic relationship between the links provides insights to help understand the breadth and place of knowledge that scientists have about that field. Ultimately, the network diagram view arranges the authors toward colored "clusters" by co-citation patterns.

### 2.4.1. Co-Citation Author Network

Author co-citation analysis looks into how research societies emerged and whose works were referenced together in related domains. The author co-citation structure is shown in Figure 4 with 343 nodes, whose volume corresponds to the frequency of author co-citations. In addition, 37110 links consider the indirect collective associations shaped by co-citations. Accordingly, the bulk of highly referenced authors were identified, including William H. Woodall (frequency = 1136, USA), Douglas C. Montgomery (frequency = 1387, USA), Matthew R Reynolds (frequency = 932, USA), Zhang Wu (frequency = 736, Singapore), and Chang-Ling Zou (frequency = 636, China). In

addition, the top 20 co-cited authors in the quality control chart literature are presented in Table 3. Considering the positions of the exceedingly cited authors, it is fair to say that examination of quality control charts has been strongly commenced in America, Singapore, and China.

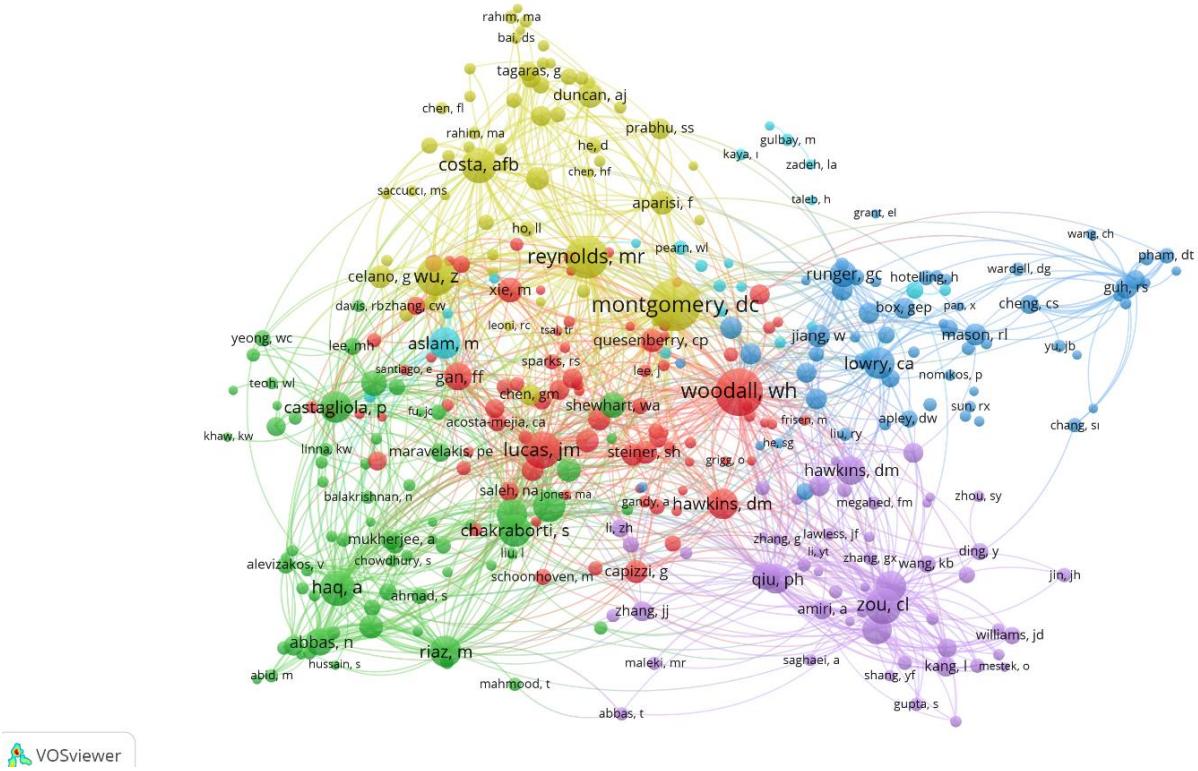


**Figure 4.** Author Co-citation Visual Network for Researches on Quality Control Charts in 2002–2023 Date Range (n = 15011 include the number of authors in the co-citation map; restriction is 40 citations each author, this meets 343 authors

**Table 3.** Highest Ranked 20 Co-cited Authors in the Quality Control Chart Literature in 2002–2023 Date Range

| No | Author | Citation | Total link strength |
|---|---|---|---|
| 1 | Woodall, WH | 1136 | 29882 |
| 2 | Montgomery, DC | 1387 | 28836 |
| 3 | Reynolds, MR | 932 | 25059 |
| 4 | Wu ,Z | 736 | 18983 |
| 5 | Zou, CL | 636 | 18168 |
| 6 | Haq, A | 600 | 17382 |
| 7 | Lucas, JM | 696 | 17368 |
| 8 | Costa, AFB | 605 | 16357 |
| 9 | Noorossana, R | 467 | 15085 |
| 10 | Riaz, M | 476 | 14504 |
| 11 | Chakraborti, S | 521 | 13658 |
| 12 | Page, ES | 515 | 13363 |

| | | | |
|---|---|---|---|
| 13 | Castagliola, P | 497 | 13078 |
| 14 | Lowry, CA | 485 | 12023 |
| 15 | Hawkins, DM | 459 | 11982 |
| 16 | Roberts, SW | 448 | 11972 |
| 17 | Mahmoud, MA | 416 | 11908 |
| 18 | Qiu, PH | 415 | 11669 |
| 19 | Gan, FF | 378 | 10880 |
| 20 | Abbas, N | 370 | 10846 |

### 2.4.2. Co-Citation Cite References

The co-citation network diagram reveals the bibliographic structure in accordance with co-citation examination and shows the conceptual essential of investigation. Considering the number of 210 documents,12957 linked research were identified and the top 20 co-cited documents as shown in Table 4 were determined. To simplify the description of the clusters, we confined this study target to citations with 30 repetitions or more. Accordingly, 6 clusters formed for the structure of this research are shown in Figure 5. Each separate cluster contains common citation references that indicate the specified references. The breadth range among corners resembles the probability of co-citation, the nearer two corners are situated simultaneously in the network map, the further apparently such references will be cited in collaboration. In this context, studies in a cluster are more apparent to be cited mutually than either association of studies from distinct clusters.

**Table 4.** Top 20 Co-cited Documents on Quality Control Chart in 2002–2023 Date Range

| No | Article | Citation | Total link strength |
|---|---|---|---|
| 1 | Anscombe, F. J., & Page, E. S. (1954). Sequential tests for binomial and exponential populations. Biometrika, 41(1-2), 252-253. | 367 | 3375 |
| 2 | Lucas, J. M., & Saccucci, M. S. (1990). Exponentially weighted moving average control schemes: properties and enhancements. Technometrics, 32(1), 1-12. | 324 | 3313 |
| 3 | Lowry, C. A., Woodall, W. H., Champ, C. W., & Rigdon, S. E. (1992). A multivariate exponentially weighted moving average control chart. Technometrics, 34(1), 46-53. | 284 | 2783 |
| 4 | Kang, L., & Albin, S. L. (2000). On-line monitoring when the process yields a linear profile. Journal of quality Technology, 32(4), 418-426. | 199 | 2218 |
| 5 | Kim, K. M. Mahmoud, and W. Woodall. (2003). On the monitoring of linear profiles. Journal of Quality Technology, 35(3), 317-28. | 173 | 2023 |
| 6 | Montgomery, D. C. (2007). Introduction to statistical quality control. John Wiley & Sons. | 281 | 1788 |
| 7 | Woodall, W. H., & Montgomery, D. C. (2014). Some current directions in the theory and application of statistical process monitoring. Journal of Quality Technology, 46(1), 78-94. | 157 | 1745 |
| 8 | Jensen, W. A., Jones-Farmer, L. A., Champ, C. W., & Woodall, W. H. (2006). Effects of parameter estimation on control chart properties: a literature review. Journal of Quality technology, 38(4), 349-364. | 181 | 1531 |
| 9 | Crosier, R. B. (1988). Multivariate generalizations of cumulative sum quality-control schemes. Technometrics, 30(3), 291-303. | 156 | 1787 |

| | | | |
|---|---|---|---|
| 10 | Mahmoud, M. A., & Woodall, W. H. (2004). Phase I analysis of linear profiles with calibration applications. Technometrics, 46(4), 380-391. | 129 | 1778 |
| 11 | Roberts, S. W. (2000). Control chart tests based on geometric moving averages. Technometrics, 42(1), 97-101. | 183 | 1723 |
| 12 | Montgomery, D. C. (2005). Introduction to statistical quality control. John Wiley & Sons. | 208 | 1577 |
| 13 | Lowry, C. A., & Montgomery, D. C. (1995). A review of multivariate control charts. IIE transactions, 27(6), 800-810. | 172 | 1551 |
| 14 | Mahmoud, M. A., Parker, P. A., Woodall, W. H., & Hawkins, D. M. (2007). A change point method for linear profile data. Quality and Reliability Engineering International, 23(2), 247-268. | 115 | 1495 |
| 15 | Woodall, W. H., & Montgomery, D. C. (1999). Research issues and ideas in statistical process control. Journal of Quality Technology, 31(4), 376-386. | 153 | 1230 |
| 16 | Duncan, A. J. (1956). The economic design of X charts used to maintain current control of a process. Journal of the American statistical association, 51(274), 228-242. | 204 | 1178 |
| 17 | Pignatiello Jr, J. J., & Runger, G. C. (1990). Comparisons of multivariate CUSUM charts. Journal of quality technology, 22(3), 173-186. | 116 | 1166 |
| 18 | Zou, C., Tsung, F., & Wang, Z. (2007). Monitoring general linear profiles using multivariate exponentially weighted moving average schemes. Technometrics, 49(4), 395-408. | 86 | 1127 |
| 19 | Reynolds, M. R., Amin, R. W., Arnold, J. C., & Nachlas, J. A. (1988). Charts with variable sampling intervals. Technometrics, 30(2), 181-192. | 133 | 1076 |
| 20 | Williams, J. D., Woodall, W. H., & Birch, J. B. (2007). Statistical monitoring of nonlinear product and process quality profiles. Quality and Reliability Engineering International, 23(8), 925-941. | 89 | 1070 |

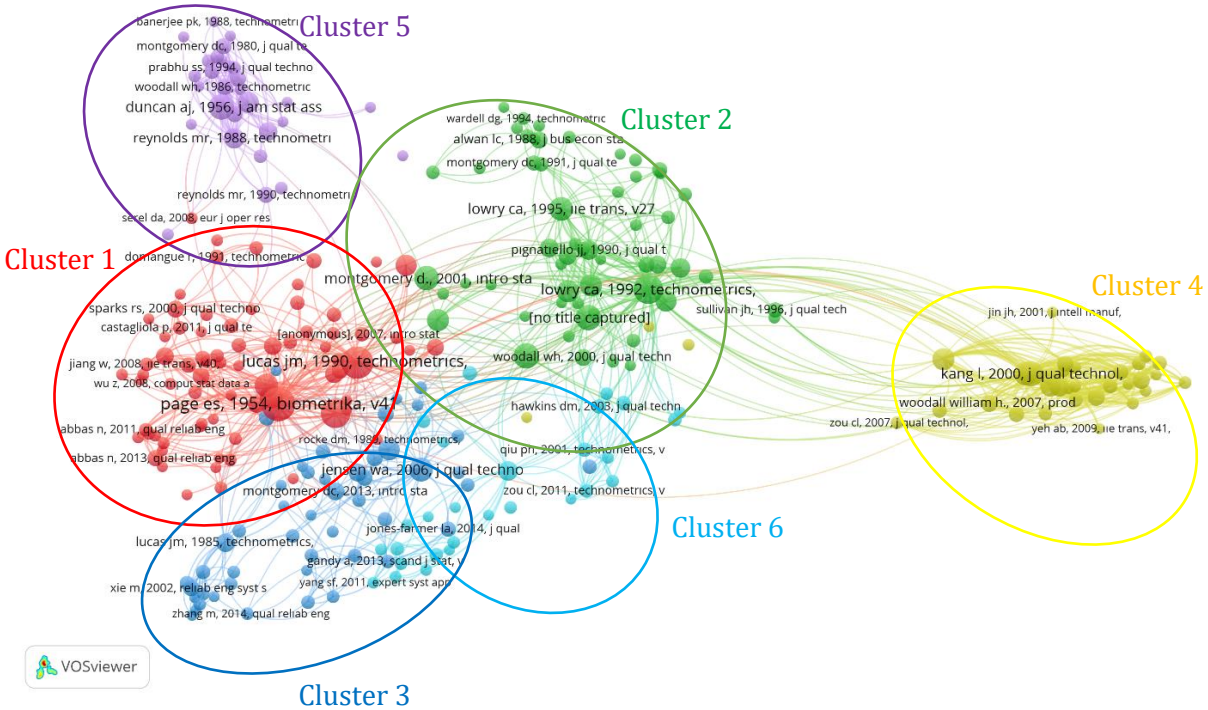


**Figure 5**. Co-citation Visual Map of References Cited by Quality Control Charts Researches from 2002 to 2023. The Examination Areas, or Theoretical Bases are Connected Mutually

### 2.4.3. Country Citation Network

Figure 6 represents certain locations and Table 5 supplied the top topic out of that research 76 countries. The VOSviewer network diagram shown in Figure 6 indicates the number of publications abounding in a certain country. In this study, among the 76 countries, The USA, China, Pakistan, Saudi Arabia, and Malaysia were determined as the countries with the most impact on quality control charts research with 618, 485, 260, 202, and 140 publications, respectively. In addition, the top 20 co-cited countries are presented in Table 5. On the other hand, if the contributions to research were evaluated, Iran, France, Greece, Taiwan, and Italy are among the top 10 contributors.

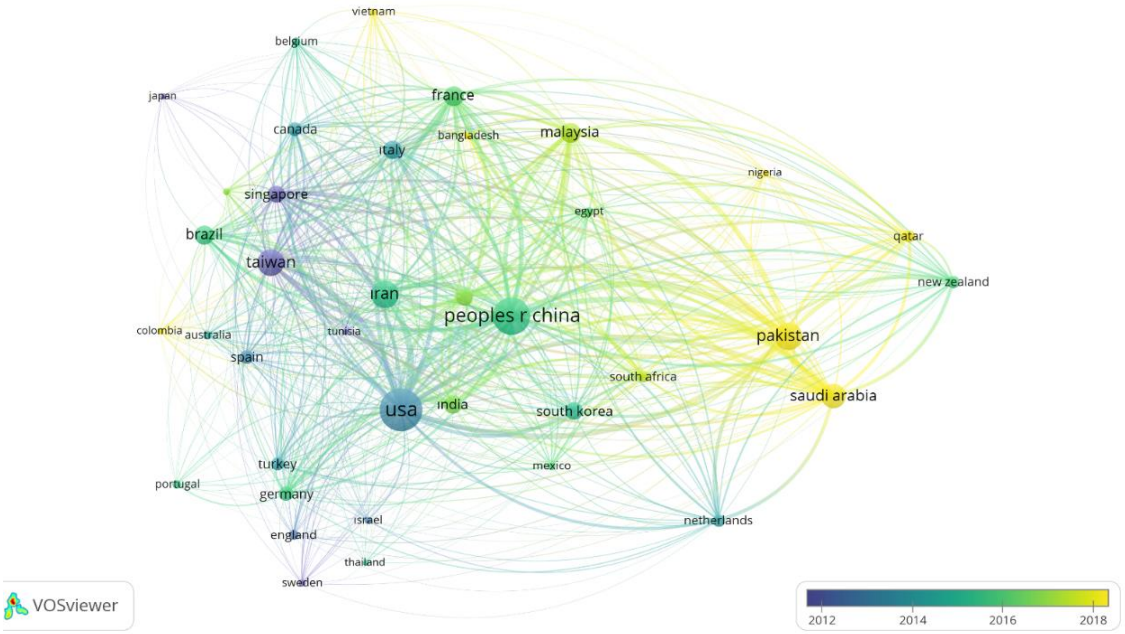


**Figure 6.** Country Co-citation Network

**Table 5.** Top 20 Co-cited Countries for the Quality Control Charts Literature in 2002–2023 Date Range

| No | Country | Documents | Citations | Total Links Strength |
|---|---|---|---|---|
| 1 | USA | 618 | 13715 | 9096 |
| 2 | China | 485 | 7524 | 8343 |
| 3 | Pakistan | 260 | 4013 | 6402 |
| 4 | Saudi Arabia | 202 | 3399 | 5138 |
| 5 | Malaysia | 140 | 2095 | 3845 |
| 6 | Iran | 261 | 3653 | 3609 |
| 7 | France | 134 | 3081 | 3605 |
| 8 | Greece | 99 | 2081 | 2897 |
| 9 | Taiwan | 239 | 3510 | 2761 |
| 10 | Italy | 112 | 2129 | 2268 |
| 11 | Singapore | 102 | 2359 | 2209 |

| | | | | |
|---|---|---|---|---|
| 12 | India | 119 | 1619 | 2141 |
| 13 | Brazil | 126 | 1562 | 1678 |
| 14 | South Korea | 103 | 1986 | 1481 |
| 15 | New Zealand | 50 | 883 | 1432 |
| 16 | Netherlands | 54 | 1181 | 1374 |
| 17 | Qatar | 52 | 542 | 1330 |
| 18 | South Africa | 45 | 830 | 1330 |
| 19 | Canada | 65 | 1210 | 1256 |
| 20 | Germany | 73 | 913 | 1198 |

## CONCLUSIONS

The bibliometric analysis method provides researchers a convenience and permit for the recognition of fresh approaches for future investigation. In this bibliographic analysis, we systematically reviewed the last two decades of the literature on quality control chart research. The VOSviewer software was utilized to evaluate and the number of journal papers, the network of authors, the network of countries, and future improvement management of quality control chart research. As a result of the specific limitations made on the VOSviewer software for the purposes, 2702 studies were obtained.

The essential finding from the view of the number of articles is that quality control chart research is enhancing exponentially. The essence of research in this subject began in 1980 and has continued to increase until today. Research hotspots comprise statistical quality control, average run length, markov chain, and exponentially weighted moving average.

Considering the subject categories, it was determined that the quality control charts have a significant degree of importance in the subjects of management sciences and automation systems. In addition, quality control charts have a wide range of use in a wide variety of fields. Health Care Science Services, Economics, Neurosciences, Water resources, Pediatrics, Health Policy Services, Surgery, Chemistry Analytical, Oncology, Optics and Agricultural Engineering some of these fields.

In the common word analysis, statistical process control, average run length, exponentially weighted moving average and markov chain were the keywords with the highest frequency, USA, China, Pakistan, Saudi Arabia, and Malaysia were the first 5 countries with the highest citation rate in the country citation network.

In the co-citation cite references section, the studies were gathered in 6 clusters. The studies collected in each cluster have the highest citation rates among themselves. It is very likely that the studies shown in different colours are on a common denominator. The citation trends of future studies may change over time in line with the limitations determined and the foresight of potential researchers.

While doing bibliometric analysis, some limitations may occur because of the caharacteristic of the research. Vosviewer only uses the Scopus database for the analyses. Although Scopus is the largest database, not all papers associated with quality control charts may be included in it. This may limit the subject depth, geographic coverage etc. Second limitation is that this study only evaluates published articles. For a more comprehensive knowledge of the evolution of this scientific subject, comparable analysis may be carried out for other document categories, such as conference papers. Another limitation is to say with certainty that a highly cited article is actually

highly influential. Authors may cite articles for many reasons. For example, to refer to a particular methodology, to point out examples of other work done on the same topic, to reinforce a point theymake in the text, to give credit to their mentors or experts in the field, or even to discuss examples of flawed methods or misleading results. However, the bibliometric analysis performed count all citations equally, regardless of the reason for the citation.

In this study, we did not include gray literature (eg, boks, conference papers) as mentioned in limiations. In future studies, the search scope can be broaden to explore more relevant studies to enrich the literature.

## REFERENCES

Abdulghafour, A. B., Omran, S. H., Jafar, M. S., Mottar, M. M., & Hussein, O. H. (2021, August). Application of statistical control charts for monitoring the textile yarn quality. In Journal of Physics: Conference Series (Vol. 1973, No. 1, p. 012158). IOP Publishing.

Abtew, M. A., Kropi, S., Hong, Y., & Pu, L. (2018). Implementation of statistical process control (SPC) in the sewing section of garment industry for quality improvement. AUTEX Research Journal, 18(2), 160-172.

Alfatiyah, R., Bastuti, S., & Kurnia, D. (2020, July). Implementation of statistical quality control to reduce defects in Mabell Nugget products (case study at Pt. Petra Sejahtera Abadi). In IOP Conference Series: Materials Science and Engineering (Vol. 852, No. 1, p. 012107). IOP Publishing.

Aykroyd, R. G., Leiva, V., & Ruggeri, F. (2019). Recent developments of control charts, identification of big data sources and future trends of current research. Technological Forecasting and Social Change, 144, 221-232.

Anscombe, F. J., & Page, E. S. (1954). Sequential tests for binomial and exponential populations. Biometrika, 41(1-2), 252-253.

Bersimis, S., Psarakis, S., & Panaretos, J. (2007). Multivariate statistical process control charts: an overview. Quality and Reliability engineering international, 23(5), 517-543.

Colledani, M., Tolio, T., Fischer, A., Iung, B., Lanza, G., Schmitt, R., & Váncza, J. (2014). Design and management of manufacturing systems for production quality. Cirp Annals, 63(2), 773-796.

Crosier, R. B. (1988). Multivariate generalizations of cumulative sum quality-control schemes. Technometrics, 30(3), 291-303.

Das, A. (2013). Testing and statistical quality control in textile manufacturing. In Process control in textile manufacturing (pp. 41-78). Woodhead Publishing.

Duncan, A. J. (1956). The economic design of X charts used to maintain current control of a process. Journal of the American statistical association, 51(274), 228-242.

González Álvarez, R., Barrera García, A., Guerra Morffi, A. B., & Medina Mendieta, J. F. (2022). Stability assessment and process capability analysis in a food pasta company. Visión de futuro, 26(1), 231-251.

Halim Lim, S. A., Antony, J., Arshed, N., & Albliwi, S. (2017). A systematic review of statistical process control implementation in the food manufacturing industry. Total Quality Management & Business Excellence, 28(1-2), 176-189.

Harris, T. J., & Ross, W. H. (1991). Statistical process control procedures for correlated observations. The canadian journal of chemical engineering, 69(1), 48-57.

Hazen, B. T., Boone, C. A., Ezell, J. D., & Jones-Farmer, L. A. (2014). Data quality for data science, predictive analytics, and big data in supply chain management: An introduction to the problem and suggestions for research and applications. International Journal of Production Economics, 154, 72-80.

Hrvacic, I. (2018). Design and implementation of SPC systems in defense industry manufacturing process. Periodicals of Engineering and Natural Sciences (PEN), 6(1), 27-40.

Jalote, P., & Saxena, A. (2002). Optimum control limits for employing statistical process control in software process. IEEE Transactions on Software Engineering, 28(12), 1126-1134.

Kang, L., & Albin, S. L. (2000). On-line monitoring when the process yields a linear profile. Journal of quality Technology, 32(4), 418-426.

Kim, K. M. Mahmoud, and W. Woodall. 2003. On the monitoring of linear profiles. Journal of Quality Technology, 35(3), 317-28.

Koutras, M. V., Bersimis, S., & Maravelakis, P. (2007). Statistical process control using Shewhart control charts with supplementary runs rules. Methodology and Computing in Applied Probability, 9(2), 207-224.

Lee, J. M., Yoo, C., & Lee, I. B. (2004). Fault detection of batch processes using multiway kernel principal component analysis. Computers & chemical engineering, 28(9), 1837-1847.

Lim, S. A. H., Antony, J., & Albliwi, S. (2014). Statistical Process Control (SPC) in the food industry–A systematic review and future research agenda. Trends in food science & technology, 37(2), 137-151.

Lowry, C. A., & Montgomery, D. C. (1995). A review of multivariate control charts. IIE transactions, 27(6), 800-810.

Lowry, C. A., Woodall, W. H., Champ, C. W., & Rigdon, S. E. (1992). A multivariate exponentially weighted moving average control chart. Technometrics, 34(1), 46-53.

Lucas, J. M., & Saccucci, M. S. (1990). Exponentially weighted moving average control schemes: properties and enhancements. Technometrics, 32(1), 1-12.

MacCarthy, B. L., & Wasusri, T. (2002). A review of non-standard applications of statistical process control (SPC) charts. International Journal of Quality & Reliability Management, 19(3), 295-320.

Madanhire, I., & Mbohwa, C. (2016). Statistical Process Control (SPC) Application in a Manufacturing Firm to Improve Cost Effectiveness: Case study. In Int. Conf. Ind. Eng. Oper. Manag (pp. 2298-2305).

Mahmoud, M. A., & Woodall, W. H. (2004). Phase I analysis of linear profiles with calibration applications. Technometrics, 46(4), 380-391.

Mahmoud, M. A., Parker, P. A., Woodall, W. H., & Hawkins, D. M. (2007). A change point method for linear profile data. Quality and Reliability Engineering International, 23(2), 247-268.

Montgomery, D. C. (2007). Introduction to statistical quality control. John Wiley & Sons.

Montgomery, D. C. (2020). Introduction to statistical quality control. John Wiley & Sons.

Nasiri, M., & Darestani, S. A. (2016). A literature review investigation on quality control charts based on fuzzy logic. International Journal of Productivity and Quality Management, 18(4), 474-498.

Nichols, M. D., & Padgett, W. J. (2006). A bootstrap control chart for Weibull percentiles. Quality and reliability engineering international, 22(2), 141-151.

Pignatiello Jr, J. J., & Runger, G. C. (1990). Comparisons of multivariate CUSUM charts. Journal of quality technology, 22(3), 173-186.

Rai, B. K. (2008). Implementation of statistical process control in an Indian tea packaging company. International Journal of Business Excellence, 1(1-2), 160-174.

Ranjbari, M., Saidani, M., Esfandabadi, Z. S., Peng, W., Lam, S. S., Aghbashlo, M., ... & Tabatabaei, M. (2021). Two decades of research on waste management in the circular economy: Insights from bibliometric, text mining, and content analyses. Journal of Cleaner Production, 314, 128009.

Reynolds, M. R., Amin, R. W., Arnold, J. C., & Nachlas, J. A. (1988). Charts with variable sampling intervals. Technometrics, 30(2), 181-192.

Roberts, S. W. (2000). Control chart tests based on geometric moving averages. Technometrics, 42(1), 97-101.

Silpakob, K., Areepong, Y., Sukparungsee, S., & Sunthornwat, R. (2023). A New Modified EWMA Control Chart for Monitoring Processes Involving Autocorrelated Data. Intelligent Automation & Soft Computing, 36(1).

Suman, G., & Prajapati, D. (2018). Control chart applications in healthcare: a literature review. International Journal of Metrology and Quality Engineering, 9, 5.

Suryoputro, M. R., Sugarindra, M., & Erfaisalsyah, H. (2017, June). Quality Control System using Simple Implementation of Seven Tools for Batik Textile Manufacturing. In IOP Conference Series: Materials Science and Engineering (Vol. 215, No. 1, p. 012028). IOP Publishing.

Vadori, R. (2020). Quality control and standards in manufacturing of medical devices. In Metallic Biomaterials Processing and Medical Device Manufacturing (pp. 549-568). Woodhead Publishing

Williams, J. D., Woodall, W. H., & Birch, J. B. (2007). Statistical monitoring of nonlinear product and process quality profiles. Quality and Reliability Engineering International, 23(8), 925-941.

Woodall, W. H. (2006). The use of control charts in health-care and public-health surveillance. Journal of Quality Technology, 38(2), 89-104.

Woodall, W. H., & Montgomery, D. C. (1999). Research issues and ideas in statistical process control. Journal of Quality Technology, 31(4), 376-386.

Woodall, W. H., & Montgomery, D. C. (2014). Some current directions in the theory and application of statistical process monitoring. Journal of Quality Technology, 46(1), 78-94.

Zhao, X., Zuo, J., Wu, G., & Huang, C. (2019). A bibliometric review of green building research 2000–2016. Architectural Science Review, 62(1), 74-88.

Zou, C., Tsung, F., & Wang, Z. (2007). Monitoring general linear profiles using multivariate exponentially weighted moving average schemes. Technometrics, 49(4), 395-408.

**EXTENDED ABSTRACT**

*GENİŞLETİLMİŞ ÖZET*

## A BIBLIOMETRIC ANALYSIS OF QUALITY CONTROL CHARTS

Bu çalışmanın amacı, kalite kontrol çizelgeleri konusunda araştırma yönlerini belirlemek, araştırma sıcak noktalarını ve sonraki araştırmalar için yönelimleri izlemek için kalite kontrol çizelgelerinin bibliyometrik analizini değerlendirmektedir. Bu nedenle; kronolojik dağılım, ülke dağılımı, anahtar kelime birlikte kullanımı ve yazar birlikte kullanımı analizlerine dayanarak ve VOSviewer yazılımı kullanılarak 2002'den 2023'e kadar kalite kontrol çizelgeleri çalışmalarının bir özeti elde edilmiştir. Çalışma 5 aşamalı bir süreçte ilerlemiştir. Araştırmaya "kalite control çizelgesi" anahtar kelimesi kullanılarak başlanmış ve yaklaşık olarak 10709 makale tanımlama olarak sürece dahil edilmiştir. Öncelikli olarak kalitede kullanılan süreç control diyagramlarını elde edebilmek için ilk aşamada alıntı konuları "İstatistiksel Yöntemler", "Yönetim", "Otomasyon ve Kontrol Sistemleri", "Tasarım ve İmalat", "Tedarik Zinciri ve Lojistik", "İmalat" ve son olarak "Yöneylem Araştırması ve Yönetim Bilimi" olarak sınırlandırılmıştır. Bu sınırlandırmadan sonra makale sayısı 4956'ya düşmüştür. İkinci aşamada yayın yılı 2002'den 2023'e kadar olan makaleler analize dahil edilmiştir. Bu zaman aralığı ile son yirmi yıl dikkate alınmıştır. Yıl sınırlamasının ardından makale sayısı 4310'a düşürülmüştür. Üçüncü aşamada, çalışmanın derinliğini arttırabilmek amacıyla, Web of Science kategorisinde "Endüstriyel Mühendislik", "Yöneylem Araştırması Yönetim Bilimi", "Mühendislik Multidisipliner", "Statik Olasılık", "Mühendislik İmalat", "Bilgisayar Bilimleri Disiplinlerarası Uygulamalar", "Otomasyon Kontrol Sistemleri", "Yönetim", "Sosyal Bilimler Disiplinlerarası", "Bilgisayar Bilimleri Bilgi Sistemleri", "Matematik Disiplinlerarası Uygulamalar", "Çok Disiplinli Bilimler" , "İşletme", "Enstrümantasyon", "Matematik", "Uygulamalı Matematik" ve "Malzeme Bilimi Multidisipliner" konuları tercih edilerek makale sayısı 3804'e getirilmiştir. Dördüncü aşama yayımcıların sınırlandırıldığı aşamadır. Bu çalışmada Wiley, Taylor & Francis, Elsevier, Spring Nature, Emaral Group Publishing ve IEEE tarafından yayımlanan makaleler dikkate alınmıştır. Bu sayede örnek makale sayısı daha da daraltılarak 2845 makaleye indirgenmiştir. Son aşamada Web of Science indeksi kapsamında SCI-E, SSCI ve CPCI-S tercih edilerek, VOSviewer'da kullanılacak veri seti 2702 makale olarak belirlenmiştir. Yayınlanmış toplam 2702 araştırma makalesi incelenmiştir. Bulgular; "Mühendislik", "Yönetim Bilimleri ve İstatistik" ve "Malzeme bilimi" ve "otomasyon kontrol sistemleri" konularının kalite kontrol çizelgeleri araştırmalarında özellikle ilgi çekici olduğunu belirtmektedir. Ayrıca "istatistiksel süreç kontrol", "ortalama çalışma uzunluğu" ve "kontrol çizelgeleri" anahtar kelimeleri atıf açısından son yıllarda keskin bir artış göstermiştir. Bunların dışında; William H. Woodall, Douglas C. Montgomery ve Matthew R Reynolds da en çok atıf yapılan yazarlar olarak belirlenmiştir. Bu çalışmada incelenen 76 ülke arasında ABD, Çin, Pakistan, Suudi Arabistan ve Malezya'nın sırasıyla 618, 485, 260, 202 ve 140 yayınla kalite kontrol çizelgeleri araştırmalarında en yüksek etkiye sahip olduğu bulunmuştur. Ortak kelime analizinde "istatistiksel süreç kontrol" ve "ortalama çalışma uzunluğu" sıklığı en fazla olan kelimeler olurken, ABD ve Çin ülke alıntı ağında en yüksek atıf alan ülkeler olmuşlardır. Ortak alıntı referanslar kısmında çalışmalar 6 küme içerisinde toplanmıştır. Her bir küme içinde toplanan çalışmalar, kendi aralarında alıntılanma oranları en yüksek olan çalışmalardır. Burada farklı renkle gösterilen çalışmaların ortak bir payda üzerinde olma ihtimalleri çok yüksektir. Konu kategorileri göz önünde bulundurulduğunda; ulaşılan sonuçlar neticesinde kalite kontrol çizelgelerinin "Mühendislik", "Yönetim Bilimleri ve İstatistik" ve "Malzeme bilimi" ve "otomasyon kontrol sistemleri" başlıkları altında azımsanmayacak derecede önem derecesine sahip olduğu ortaya çıkmıştı. Bu konu başlıklarının dışında kalite kontrol çizelgeleri çok çeşitli alanlarda ve çok geniş kullanım aralığına sahiptir. Web of Science kısıtlamamız haricinde "Sağlık Bilimleri Hizmetleri", "Ekonomi", "Sinir Bilimleri", "Su kaynakları", "Pediatri", "Sağlık Politikası Hizmetleri", "Cerrahi", "Analitik Kimya", "Onkoloji", "Optik" ve "Ziraat Mühendisliği" gibi daha birçok farklı alanda da kalite control çizelgelerine ait çalışmalar bulunmaktadır.

# KATKI ORANI BEYANI VE ÇIKAR ÇATIŞMASI BİLDİRİMİ

| | |
|---|---|
| **Sorumlu Yazar**<br>*Responsible/Corresponding Author* | Fatmanur Göçer |
| **Makalenin Başlığı**<br>*Title of Manuscript* | A BIBLIOMETRIC ANALYSIS OF QUALITY CONTROL CHARTS |
| **Tarih**<br>*Date* | 26.02.2023 |
| **Makalenin türü (Araştırma makalesi, Derleme vb.)**<br>Manuscript Type (Research Article, Review etc.) | Derleme/Review |

**Yazarların Listesi /** *List of Authors*

| *Sıra No* | **Adı-Soyadı**<br>*Name - Surname* | **Katkı Oranı**<br>*Author Contributions* | **Çıkar Çatışması**<br>*Conflicts of Interest* | **Destek ve Teşekkür (Varsa)**<br>*Support and Acknowledgment* |
|---|---|---|---|---|
| 1 | Fatmanur Göçer | Makaleye eşit oranda katkı sağlanmıştır | Çıkar çatışması bulunmamaktadır | |
| 2 | Sinem Büyüksaatçı Kiriş | Makaleye eşit oranda katkı sağlanmıştır | Çıkar çatışması bulunmamaktadır | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |