# Cost of Quality: Literature Review Based on Meta-Analysis

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## Abstract

Measurement of Cost of Quality (COQ) appears to be an important component for organizations to maintain or develop their market share in today's competitive business environment. Quality is a critical point and customer expectations of quality are always changing. Reducing quality costs decreases total organizational costs, which leads to lower prices for goods manufactured or services provided, increased customer satisfaction, and improved organizational performance. The purpose of this research is to show the development of the quality cos model during the previous fifty years, as illustrated in 446 real-data studies. A meta-analysis of these publications is carried out in order to show how the variables utilized in the research of Quality Costing have evolved through time, in connection to the date of publication, the business sector, and the geographical origin of each paper. Research methodologies approach the cost components were analyzed using Multiple Correspondence Analysis integrated Vos Viewer and N-Vivo12 plus, which is a valuable approach for exploring the interrelationships among all aspects with the goal of identifying the dominant and most significant patterns in their structure. The findings of this research are the theme on Cost of Quality which covers 5 clusters and has five main topics. It is shown that there were in the 496 papers, 446 from database Scopus and 150 form databases DOAJ (Directory of Open Access Journals). The result of the Vos viewer showed that there are five concept clustery, namely: Cluster 1 related the concept of cost; cluster 2 highlights the concept of cost-effectiveness, and cluster 3 emphasizes the concept of humans. Furthermore, cluster 4 features a quality control philosophy, while cluster 5 focuses on risk. Based on meta-analysis with N-Vivo, shown that in Meta-Analysis using N-Vivo include cost (17.59 %), quality (17.59%), and quality cost (10.12 %), Quality Model (5,17 %). The limitation of this study is that the article reviewed sources from Scopus dan DOAJ. Furthermore, the topic about the cost of quality based on Failure Mode Effect Analysis is needed for application and development.

## Keywords
Cost, Meta – Analysis, Quality, Quality Cost, Quality Model.

## 1. Introduction

Measurement of Cost of Quality (COQ) appears to be an important component for organizations in order to maintain or develop their market share in today's competitive business environment. Quality is a critical point and customer expectations of quality are always changing. Reducing quality costs decreases total organizational costs, which leads to lower prices for goods manufactured or services provided, increased customer satisfaction, and improved organizational performance (W. H. Tsai, 1998). The term "cost of quality" refers to a method of calculating the entire cost of quality-related efforts and flaws. The "cost of quality" does not refer to the expense of producing a high-quality product or service (Surange et al., 2013). In a project, the cost of quality (COQ) allows you to measure and document project quality using the cost of quality analysis in order to produce better and more effective resource utilization and invest in preventative and evaluation activities to reduce the cost of the project (Omar & Murgan, 2014).

Internally, the COQ has been measured practically primarily. To create a mathematical model and combine it with key variables, researchers were using the conventional PAF (Prevention-Appraisal-Failure) model classification. The previous researcher has studied and reported using the PAF Model finding the cost of conformity (66 %) and the cost of non - conformance (34 %). The appraisal charges accounted for 46% of the entire cost. Managers need to investigate its appraisal processes. There is a significant chance to cut some expenditures, particularly those associated with inspection and testing (Aniza et al., 2013).

The purpose of this research is to show the development of the quality cos model during the previous fifty years, as illustrated in 446 real-data studies. A meta-analysis of these publications is carried out in order to show how the variables utilized in the research of Quality Costing have evolved through time, in connection to the date of publication, the business sector, and the geographical origin of each paper. Based on Scopus data from 1967-2022. Several 446 journals related to the cost of quality were reviewed. The bibliometric research approach and bibliographic display maps were investigated using VOS viewer software. The bibliometric analysis is a method of identifying the most influential writers, their connections, the keywords they use, and, more significantly, how these traits connect one work to the next (Syed, 2021; Zahra et al., 2021). NVivo is a set of device-specific tools for studying literature (Hafidhah & Yandari, 2021).

## 2. Literature Review

Quality of costs (CoQ) is charged due to a variety of operations involving several departments, all of which have an impact on the product/service quality. The costs of avoiding, detecting, and correcting poor work are known as quality costs (Jaju et al., 2009). COQ is a concept created to support and improve the quality management process (Merino, 1991a). Quality costing can be used as a lever to gain top management commitment to initiate an improvement project (Hwang & Aspinwall, 2010). COQ consists of non-conformance and conformance costs. Non-conformance costs arc failure costs, and conformance costs arc the costs to appraise and prevent non-conformance costs (Merino, 1991b; Rosenfeld, 2009; Vaxevanidis & Petropoulos, 2008). Quality cost categories based on PAF Model generally consist of: (1) Prevention costs, i.e., costs incurred to keep appraisal and failure costs to a minimum, such as a process control, process design, and preventive maintenance; (2) Quality costs, i.e., costs incurred to keep appraisal and failure costs to a minimum, such as a process control, process design, and preventive maintenance; (3) Quality costs, i.e., costs incurred (2) Appraisal expenses encompass all expenditures associated with ensuring that a product or service meets requirements, such as in-process inspection, raw material inspection, and quality audit; (3) Internal Failure Expenses, i.e., costs incurred by-products or services that are rejected before being provided to customers and fail to satisfy their expectations, such as scrap, rework, and equipment repair; (4) The cost of failure linked with quality flaws in the product or service after it is delivered to the user is known as external failure(Burgess, 1996; Carson, 1989; Chatzipetrou & Moschidis, 2017; Chen & Weng, 2002; Czuchry et al., 1999; Dror, 2010; Harrington, 1999; Kim & Nakhai, 2008a; Mahanty et al., 2012; Sturm et al., 2019a; Trehan et al., 2015; W. Tsai, 2011; Zimwara et al., 2013).

The Crosby quality cost model consists of conformance and non-conformance cost elements. (Duarte et al., 2018; Goulden & Rawlins, 1995, 1997; Schiffauerova & Thomson, 2006; Vaxevanidis & Petropoulos, 2008b). When calculating the Risk Priority Number (RPN) using the Failure Mode and Effects Analysis (FMEA) approach, commonly known as the cost of quality based on FMEA, the quality cost model (table 1) is constructed based on the financial consequences of failure. Using a Life cost-based FMEA concept approach, FMEA uses a cost of quality to assess the cost of the repercussions of a possible failure mode. (Ahsen, 2014; Guinot et al., 2017; Omar, 2014; Rhee et al., 2009; Rhee & Ishii, 2003; Spencer et al., 2003)

Table 1. Comparison of the Cost of Quality Model

| No | Author (Year) | CoQ Model | Expected Visible Quality Cost ($E(C_{VQC})$) | | | | Expected Production Invisible Quality Cost ($E(C_{PIQC})$) | Expected Opportunity Cost ($E(C_{OC})$) |
|---|---|---|---|---|---|---|---|---|
| | | | Preven-tive Cost (P) | Appraisal Cost (A) | Failure Cost (Internal) | Failure Cost (external) | | |
| 1 | (Bamford & Land, 2006; Carson, 1989; Chatzipetrou & Moschidis, 2017; Dale & Wan, 2002; Dror, 2010; Goulden & Rawlins, 1997; Harrington, 1995; Kim & Nakhai, 2008b; Krishnan, 2006; Liu, 2007; Margavio et al., 1994; Schiffauerova, 2017; Setijono & | PAF | v | v | v | v | x | x |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Dahlgaard, 2008; Sharma et al., 2007; Sturm et al., 2019b; Trehan et al., 2015; W. Tsai, 1998; Vaxevanidis & Petropoulos, 2008b) | | | | | | | |
| 2 | (Mahmood et al., 2014) | COPQ | x | x | x | x | v | x |
| 3 | (Schiffauerova & Thomson, 2006; Sturm et al., 2019a; Vaxevanidis & Petropoulos, 2008b) | PAF + Opportunity Cost | v | v | v | v | x | v |
| 4 | (Guinot et al., 2017; Omar & Murgan, 2014; Rhee et al., 2009; Spencer et al., 2003; Von Ahsen, 2008) | Cost Based FMEA on Production Process | v | v | v | v | v | v |

## 3. Method

Because there is so much study on CoQ, the researchers found all the relevant studies. The researchers chose to do an online search in six databases and track specific sites that produce peer-reviewed journals and conference papers. Based on Figure 1, there are four stages: 1) Identification stage; 2) Bibliographic Classification and Mapping Stage: 3) Screening and exclusions stage; and 4) Eligibility and inclusion. Based on figure 1, there are have four-phase phases for meta-analysis cost of quality. Phase 1, the identification phase. In this phase, a paper search is carried out according to the theme, namely cost of quality using the Scopus database and DOAJ database with the publish or perish. Based on the search results in the Scopus database, there are 446 documents. From the DOAJ database, there are 250 documents with the theme of cost of quality, so the total number of papers that will be analyzed using Vos viewer and N-Vivo is 696 documents. Then, in the second phase, the results of the two databases are stored in the form of CSV and RIS. The next stage is a bibliographic classification and mapping tool using the Vos viewer for bibliometric mapping. After proceeding to the third stage, namely the screening phase. In this phase, document screening is carried out, which discusses the cost of quality. The screening results obtained 56 documents. The last stage is the fourth stage, namely eligibility, and inclusion. This stage is carried out by analyzing the literature with a qualitative approach using N-Vivo 12 plus. The outcome of N-Vivo is to do a literature review with the output framework, char from each theme, and auto codes from each author based on the keywords that have been analyzed.

## 4. Data Collection

Data collection and paper searching are done following the theme, namely the cost of quality, with Scopus and DOAJ databases, and publish or perish. There are 446 documents with the theme of cost of quality in the Scopus database, and 250 documents with the piece of the cost of quality in the DOAJ database, for a total of 696 papers that will be analyzed using Vos viewer and N-Vivo. The results of the two databases are then saved in CSV and RIS format.

## 5. Result and Discussion

### 5.1 Performance Analysis from Scopus

According to Figure 2, there were 446 documents published in the Cost of Quality area of research between 1905 and 2022, indicating a rise in academic interest. The publication rate rose substantially between 2004 and 2021, averaging 1589 works per year. From 2016 to 2021, there has been significant growth.

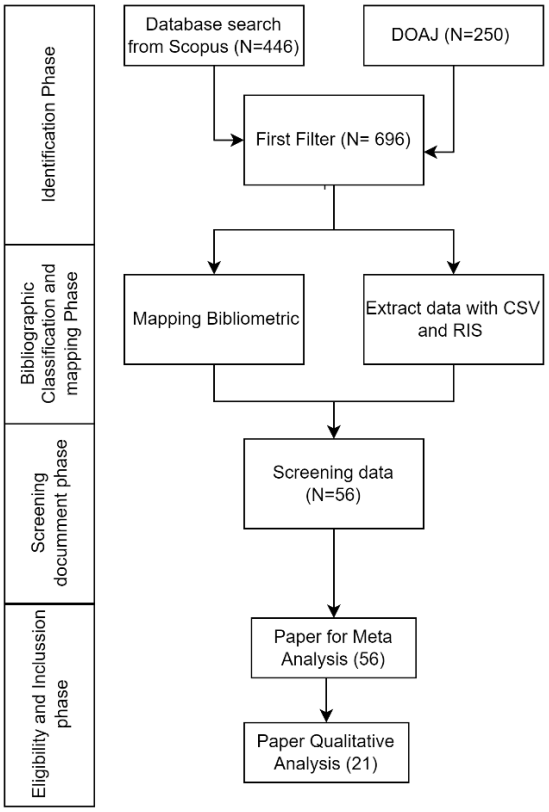


Figure 1. Flow diagram Meta - Analysis Cost of Quality

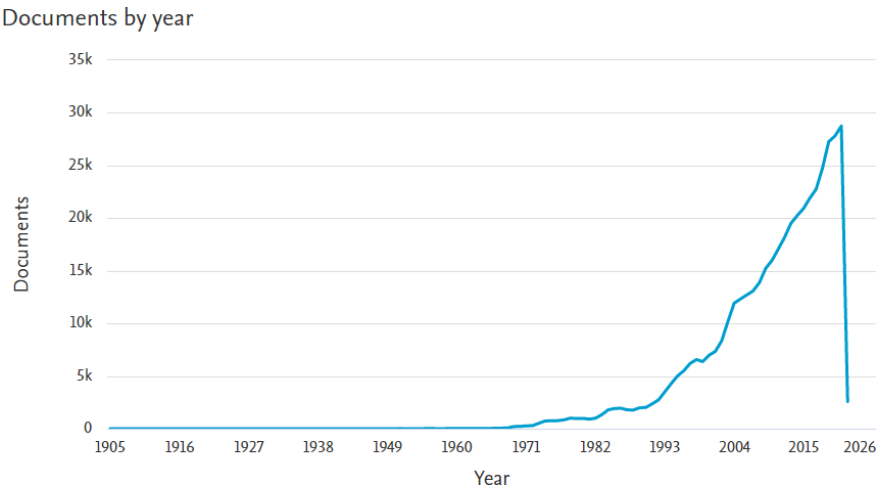


Figure 2. Growth of Scientific Production Relating Cost of Quality

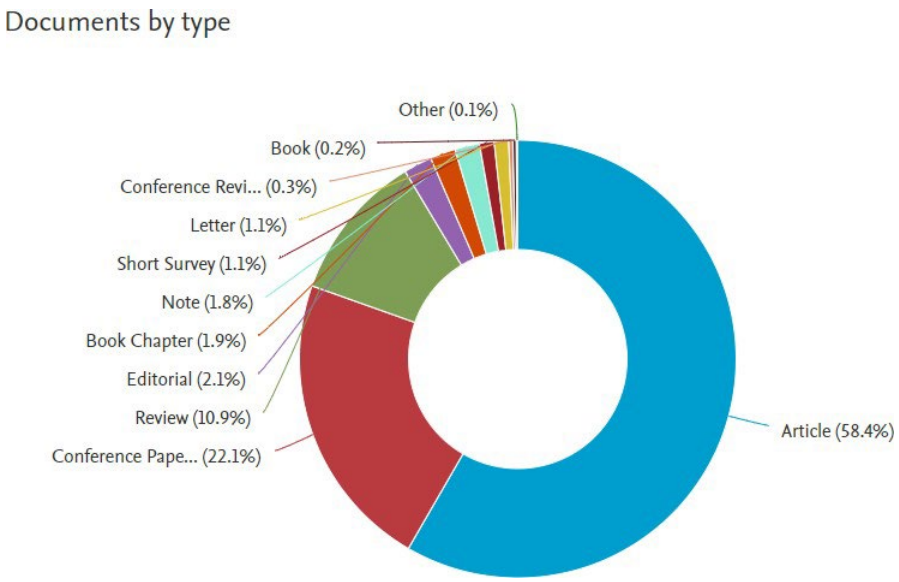


Figure 3 Percentage of Publication Cost of Quality in Different Document Type

According to Figure 2, the data between 1905 to 2021, a total of 446 scientific documents met the exclusion and inclusion criteria. According to Figure 3, the type of document Cost of Quality topic was separated into four groups: article 57,4% %); Conference Paper (22,1 %); Review (10 %), and Book Editorial (10.9%).

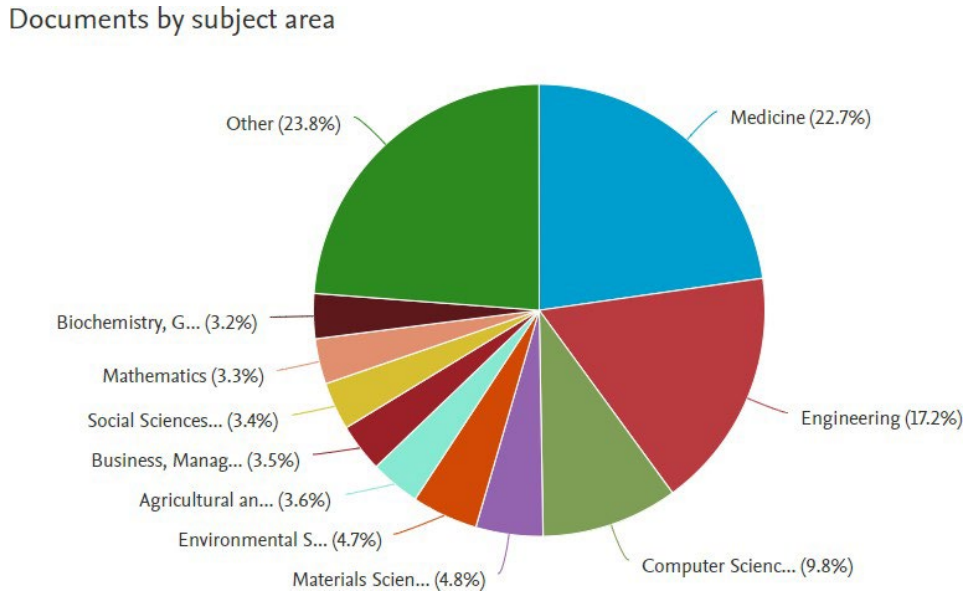


Figure 4. Document based on Subject Area

According to Figure 4, four areas have a lot of great subject area. Other (23,8%), Medicine (22,7 %); Engineering (17,2%) and Computer Science (9,8%) are the top four.

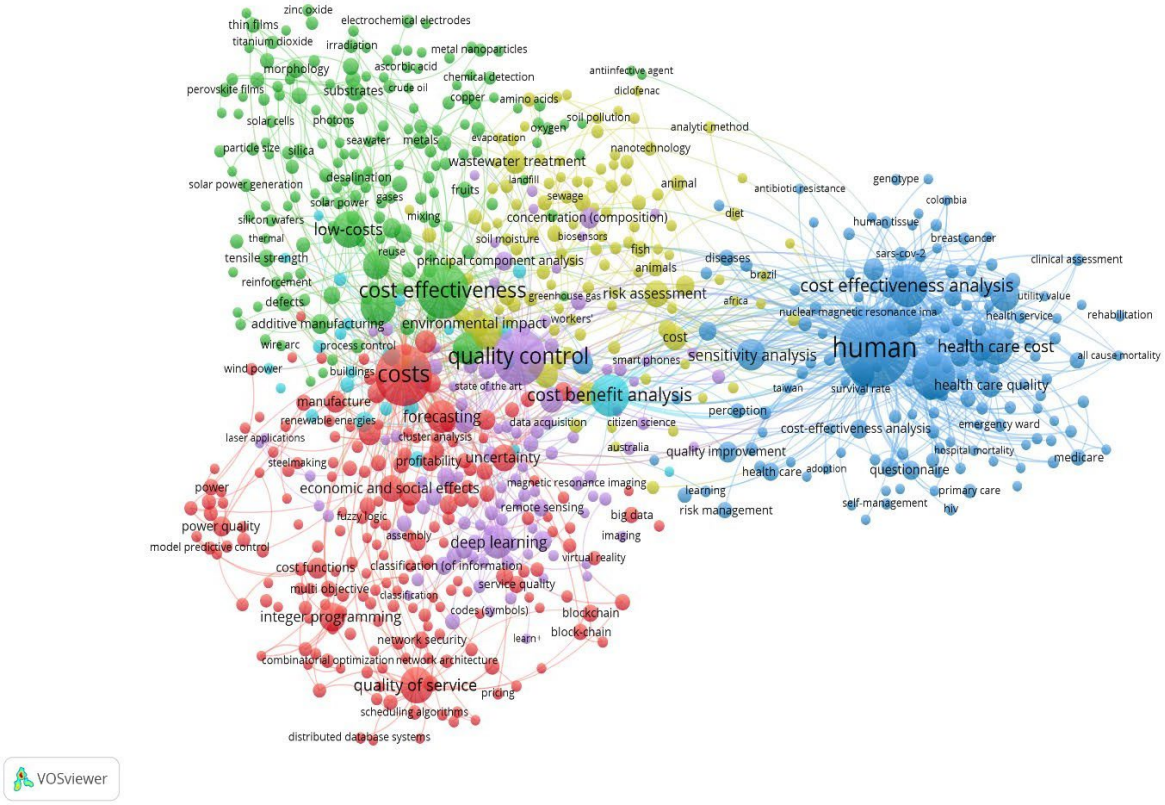


Figure 5. Co-accurances Network of author keywords

According to Figure 5, Cluster 1 is the most extensive study topic, with 446 idea papers on Cost of Quality-related topics. There are three cost considerations: cost-effectiveness, human, and cost-effectiveness. It can also assist novice researchers in beginning their research by examining topics connected to the theme. It assists new researchers in locating intriguing topics and according to their competencies by mapping the keywords that the author compiled. Figure 5 shows that there are five clusters. Cluster 1 stresses the concept of cost; cluster 2 highlights the concept of cost effectiveness; and cluster 3 emphasizes the concept of human. Furthermore, cluster 4 features a quality control philosophy, while cluster 5 focuses on risk.

Figure 6 shows that themes can be interrelated between authors with one another. The relationship is based on the theme used in this study, namely Scopus and DOAJ. Based on the picture, the relationship between author one and others is due to the similarity of keywords. The keywords have cost, the object taken in the research and quality. For example, Czajkowski's paper (2017) discusses Managing SME with an innovative hybrid Cost of the Quality model.", Measuring Business Excellence is connected with Omar's (2014) paper, namely "an improved model for the cost of quality," which is about the types of costs using the approach PAF Models.

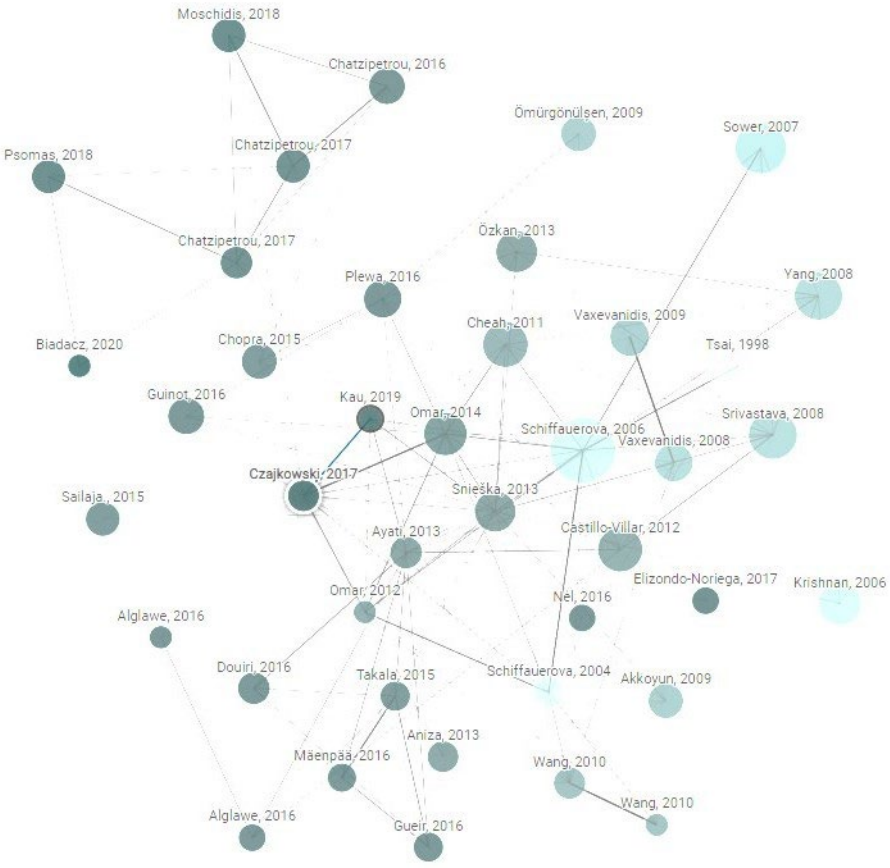


Figure 6 Connected Papers related Cost of Quality

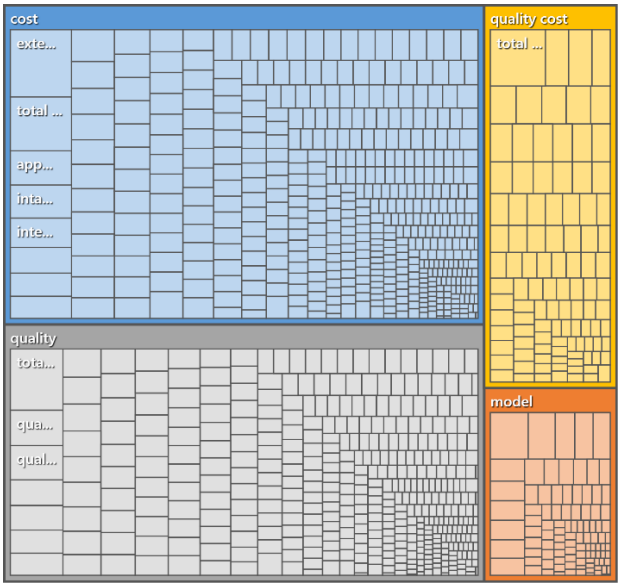


Figure 7. Compared by number of coding references

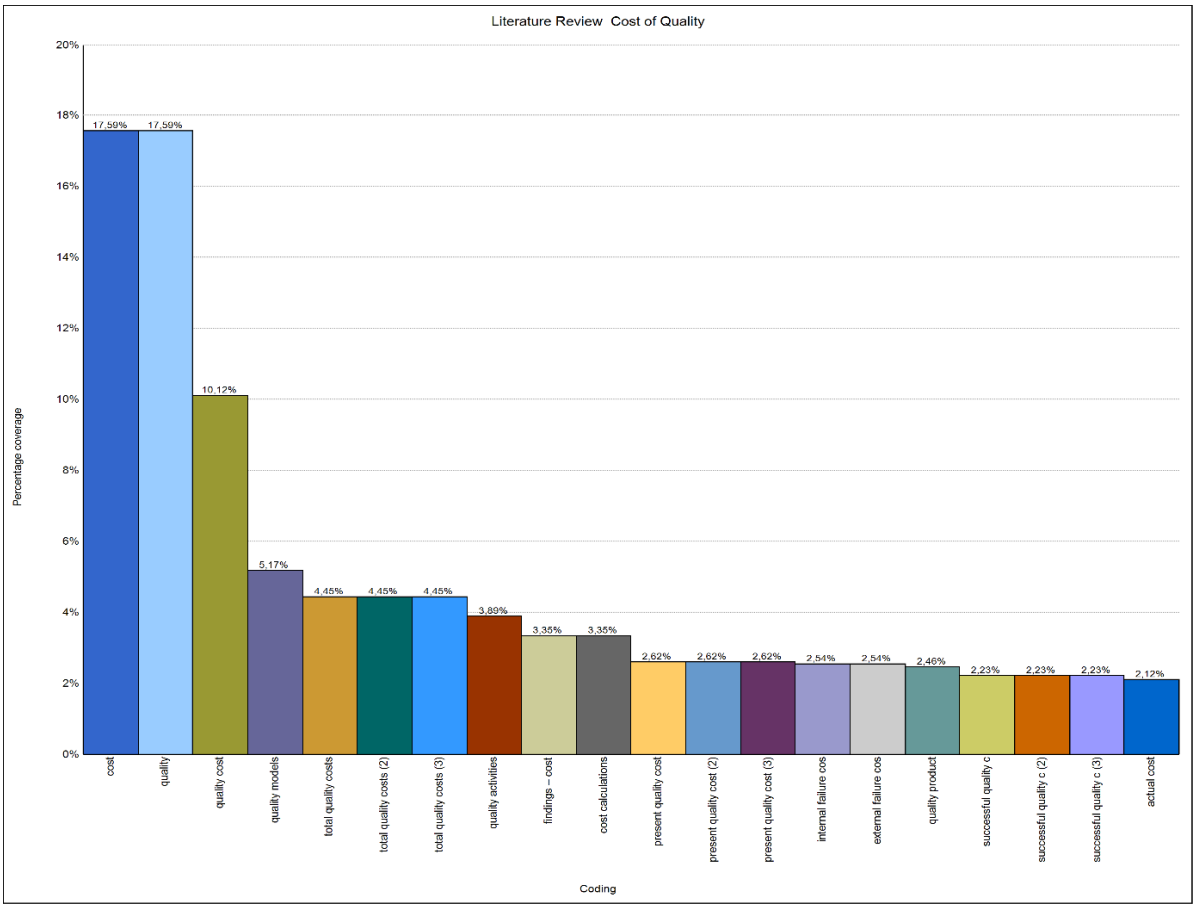


Figure 8 . Chart of Literature Review Cost of Quality

According to Figure 7 and 8, data processing using N-Vivo, the keywords employed in Meta - Analysis using N-Vivo include cost (17.59 %), quality (17.59%), and quality cost (10.12 % ), Quality Model (5,17 %).

Table 2 Framework cost of quality based on N-Vivo Meta-analysis

| Author (year) | A: cost | B: model | C: quality | D: quality cost |
|---|---|---|---|---|
| Abbas, Syed Nadeem; Ahmed, Javed; Salman, Muhammad; Ashraf, Syed Rehan (2015) | v | v | v | v |
| Duarte, Belmiro P.M.; Oliveira, Nuno M.C.; Santos, Lino O. (2016) | v | v | v | v |
| Duarte, Patricia; Low, Jwen Fai; Schiffauerova, Andrea (2018) | v | v | v | v |
| Dumitrascu, Adela-Eliza; Nedelcu, Anisor (2012) | v | v | v | x |
| Harrington, H. James (1999) | v | v | v | v |
| Kau, Lawrence; Nel, Hannelie (2019) | v | v | v | v |
| Kim, Seokjin; Nakhai, Behnam (2008) | v | v | v | v |
| Liu, Yumin (2007) | v | v | v | v |
| Mahmood, Shahid; Ahmed, Syed M.; Panthi, Kamalesh; Kureshi, Nadeem Ishaque (2014) | v | x | v | v |
| Modhiya, Shubhangan; Desai, Darshak (2016) | v | v | v | v |

| | | | | |
|---|---|---|---|---|
| Nikoomaram, Hashem; Fard, Hamidreza Vakili; Roodposhti, Fraydoon Rahnamay (2011) | v | v | v | v |
| Omar, Mohamed Khaled; Murgan, Sharmeeni (2014) | v | v | v | v |
| Rhee, S; Spenser, C (2009) | v | v | v | x |
| Schiffauerova, Andrea; Thomson, Vince (2006) | v | v | v | v |
| Sturm, Sebastian; Kaiser, Gernot; Hartmann, Evi (2019) | v | v | v | v |
| Surange, Vinod G.; Teli, S. N.; Halankar, Ankur M.; Saroj, Dinesh S.; Rane, Siddhesh S.; Adak, Datta D. (2013) | v | v | v | v |
| Surange, Vinod G.; Teli, S.N.; Majali, Vijay; Bhushi, Umesh (2013) | v | v | v | v |
| Von Ahsen, Anette (2008) | v | v | v | v |
| Vredenburg, Jessica; Bell, Simon J. (2014) | x | v | v | x |
| Wang, Michael H. (2011) | v | v | v | x |
| Wen-Hsien Tsai (2012) | v | v | v | v |

Based on table 2, almost 80.99% of published papers discuss costs, models, quality, and quality costs. There is 19.01 % which only discusses the model and quality cost; besides, it only concerns the price, model, and quality. Of the 56 documents used in the meta-analysis, only 21 were analyzed by developing a literature review framework regarding the cost of quality. Based on the 56 papers that have been auto coded, a research gap can be drawn. It can be in the form of scope or variables discussed in the cost of quality.


Figure 9. The dominant theme in Cost of Quality

Word frequency queries explore a word that appears most frequently in research data. Based on figure 9, the result of data analysis sourced from 56 articles, the dominant theme studied by previous researcher quality, cost of quality, and cost.

## 6. Conclusion

The review study on Cost of Quality covers 5 clusters and has five main topics. It is shown that there were in the 496 papers, 446 from database Scopus and 250 form databases DOAJ. The result of the Vos viewer showed that there are five concept clustery, namely: Cluster 1 related the concept of cost; cluster 2 highlighted the concept of cost-effectiveness, and cluster 3 emphasized the idea of humans. Furthermore, cluster 4 features a quality control philosophy, while cluster 5 focuses on risk. Based on meta-analysis with N-Vivo, shown that in Meta-Analysis using N-Vivo include cost (17.59 %), quality (17.59%), quality cost (10.12 %), Quality Model (5,17 %). The limitation of this study is that the article reviewed sources from Scopus dan DOAJ. Furthermore, the cost of quality based on Failure Mode Effect Analysis is needed for application and development.

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