Factor Analysis of Cost of Quality to Determine the Adoption of Economics of Quality as a Measure of Quality Management Performance in South African Companies

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Abstract – **The current disruptive business environment forces companies to constantly search for improved ways of meeting customer requirements. South African companies are not excluded from daily business challenges. This research assesses the adoption of cost of quality practice as the measure of quality management performance. The study uses the snowball sampling approach to identify the target sample members. It collected information from 45 companies around the Johannesburg area. The convergent validity and discriminant validity were used as the measure of study construct validity. The study identifies preventive cost and appraisal cost as two costs of quality categories which receive high attention from South African companies. The failure cost was identified to be in third place. The opportunity cost was identified as the ignored cost of quality (CoQ) category. Hence, it was recommended that the companies start to pay attention to their opportunity cost and it was also recommended that further research should focus on identifying the challenges experienced by companies in the implementation of cost of quality.**

Keywords – cost of quality, factor analysis

I. INTRODUCTION

The disruptive business environment of today makes it impossible for the companies to rely on their previous successes and traditional approaches of doing business. The internet, globalisation, and technology development force companies to understand the cost of their operations and expenses of creating value to the customers. The internet has also placed all information at the fingertips of the customers to demand more for their money. South African companies are not excluded from today's business challenges. Mc Camel [1] found power supply, skills and the cost of running a manufacturing enterprise as the major challenges in South Africa. The other challenges facing the companies include access to financial resources. However, if companies control the effectiveness of their processes and strategies to improve the performance, the risk associated with the challenges would be mitigated. This research assesses the adoption of cost of quality (CoQ) as a measure of quality performance in South African industries. The study was conducted in the Gauteng province, specifically around the Johannesburg area, to achieve three objectives. The first objective was to formulate the framework from the literature to measure the concept of cost of quality. The second objective was to collect sufficient data and use the factor analysis as the measure of construct validity. The third objective was to assess the level of cost of quality practice in South African industries.

A. Cost of quality

As early as the 1930s, the authors in the field of quality management identified that a bigger percentage on the cost of running the business was due to quality issues [2]. The concept of cost of quality or economic of quality is generally defined as the cost of ensuring that the objectives are met less the cost of failing to meet the intended goal [3]. Although the concept first appeared in the 1930s, the scarcity of resources during the 1950s made it famous and led to a more structured approach of managing and reporting cost related to quality [4]. Since then the enlightened companies invested in the cost of quality practice and reported a positive result in their investments [5]. However, Mantri and Jaju [6] maintain that the concept of cost of quality is not well recognised in industries.

Kaur [5] conducted the study in India, where the study found that only 21% of the companies report the cost of quality. Rasamanie and Kanapathy [7] led similar research in Malaysia where 61% of manufacturing companies indicated that they were not using the cost of quality as one of their key performance indicators. The case study [8], conducted in Malaysia has also shown that the hidden cost of quality was far more than the company's profit margin. The study [9], conducted in a Turkish manufacturing company found that the company's financial information was not comprehensive enough to fit in any cost of quality model. The company was mainly dependent on accounting reports as a form of reporting financial position. Hence, there is a need to assess the adoption and practice of CoQ in South African companies.

B. Cost of quality categories

According to Schiffauerova and Thomson [10], there are four generic models to group the cost of quality. The first framework includes the summation of prevention, appraisal and failure cost, this approach is also known as P-A-F model. In the P-A-F model, the failure cost is further divided into internal failure cost and external failure cost. The internal failure cost refers to the failure occurring during the production line or while the product is still in the hands of the manufacturer. The external failure costs refer

to the cost incurred as a result of a failure in the hands of the customer. The second framework involves two categories which are conformance and non-conformance costs. This framework is only different from the P-A-F model, in that prevention and appraisal costs are grouped into conformance costs and failure costs to non-conformance. The third approach involves grouping cost of quality into the tangible and intangible cost of quality. The tangible cost of quality refers to the prevention, appraisal and failure cost, while the intangibles refer to the income not earned or opportunity cost. Tsai [11], presents the frameworks which include the summation of value-added and non-value-added cost. This model is also known as the activity-based cost model (ABC). According to [4], the ABC model is different from other costs of quality models because it takes into account the overhead cost.

C. *Challenges in the implementation of cost of quality*

Sower, Quarles and Broussard [2] surveyed about 3200 manufacturing companies in the United States of America where the respondents provided the range of reasons in the implementation and tracking to cost of quality. Some of the reasons identified include lack of leadership support, lack of resources to invest in the cost of quality assessment, the lack of know-how and lack of software or tools to track cost of quality. Rasamanie and Kanapathy [7] surveyed a total of 84 manufacturing companies in Malaysia to identify the challenges experienced during the cost of quality implementations. The authors identified a lack of leadership support, mapping of cost of quality items, lack of knowledge to analysis, cost of quality data and lack of buy-in from departments.

D. *The benefit of cost of quality implementation*

The cost of quality is credited with the ability to translate technical challenges into financial terms which is the language better understood by managers [10]. According to Aniza [12], the cost of quality practice discloses the expenses which are not available in any financial report. Some of the expenses disclosed by the cost of quality practice include the cost of inefficiencies, underutilisation of resources, failure costs and cost of scrap. According to Teli, Jagtap and Chanewar, [13], the cost of quality also provides the basis for improvement, provide the motivation to invest in quality improvement and provide the link between business strategy and operations.

II. METHODOLOGY

The research investigates the adoption of the concept of cost of quality in South African industries. The research targets the companies and industries operating in South Africa, specifically in the Gauteng province, around the Johannesburg area, as the unit of analysis. The research methodology included four structured phases: (1) phase one was the formulation of the problem, (2) phase two has the literature review from conference papers, journal articles, books, and published thesis. The literature review led to the formation of the theoretical framework which was used in the development of the survey questionnaire. (3) Phase three encompasses survey questionnaire design and data collection. (4) Phase four included data analysis, which involves reliability assessments of the theoretical framework, factor analysis, reliability of the imperial framework, and construct validity. The next subsection covers phase three and phases four in detail.

A. *Questionnaire*

The concept of cost of quality cannot be measured using the standard measuring tools like the rulers, temperature sensors and other similar tools. It is hidden in people's experience, behaviour, and knowledge within their organisations. Justyna [14], classified this type of variables as latent variables and suggested the survey questionnaire as the tool to observe the elements of such variables. The survey questionnaire for the current research was constructed from the literature and divided into two main sections. The first section asks for general information about the respondent. This information was important to understand the character of the respondents. The second section assesses the concept of cost of quality using the prevention, appraisal, failure and opportunity cost categories using five-point Likert scale items. The respondents were requested to provide their views on the items in Table 1 using 1 = strongly disagree, 2 = disagree, 3 = neutral, 4= agree and 5= strongly agree [12]. TABLE I indicates the theoretical framework and items constructed to assess the concept of cost of quality for the current research.

TABLE I
COST OF QUALITY THEORETICAL FRAMEWORK [2, 4, 5, 12]

Category	Label	Does the organisation assess the following cost items?
Prevention cost	Item 1	Marketing research activities
	Item 2	Document review
	Item 3	Supplier review
	Item 4	Quality planning
	Item 5	Quality training
	Item 6	Product or service design
Appraisal cost	Item 7	Product or service inspection
	Item 8	Product or service testing
	Item 9	Materials testing
	Item 10	Process control or measurement
	Item 11	Maintenance or calibrations
	Item 12	Depreciation of equipment
	Item 13	Qualification of the product supplier
Failure cost	Item 14	Design corrections
	Item 15	Rework due to design
	Item 16	Scrap due to poor quality
	Item 17	Rejected orders
	Item 18	Uncontrolled material losses
	Item 19	Re-inspection and retest
	Item 20	Product or service recalls
	Item 21	Warranty claims
Opportunity cost	Item 22	The organisation assessed the price associated with loss of income
	Item 23	There is a system in place to estimate the price of resource utilisation
	Item 24	There is an automated system to assess the cost related to quality activities

Category	Label	Does the organisation assess the following cost items?
	Item 25	The company has a system in place to trace the cost of delays from one branch to another.
	Item 26	The corporation has a system in place to estimate the cost related to delays from the suppliers

The study uses the principle of the snowball sampling method [15]. The first process was to send the emails to the companies, requesting participation in the study and the distribution of the survey link to their network. The study received a total of 45 responses (26 from service companies and 19 from manufacturing sectors).

III. RESULTS

TABLE II shows the characteristic of the respondents in the current research. The majority (40%) of the respondents had 6-10 years in their industry. Most (38%) of the respondents were between the age of 26-30 years. The majority (58%) of the respondent indicate to have a Baccalaureate Degree as their highest educational qualification. Most (27%) regarded themselves as managers and the majority (58%) come from the service industry. The respondents had sufficient capacity to understand and respond to the questionnaires.

TABLE II
DEMOGRAPHIC INFORMATION

Questions	N	Frequency (%)	Cumulative (%)
How long have you been in the industry?			
Less than One year	1	2%	2%
1-5 years	17	38%	40%
6-10 years	18	40%	80%
11-15 years	5	11%	91%
16-20 years	2	4%	96%
More than 20 years	2	4%	100%
Total	45	100%	
How would you describe your current Age?			
20-25 years old	1	2%	2%
26-30 years old	17	38%	40%
31-35years old	15	33%	73%
36-40 years old	5	11%	84%
41-45 years old	5	11%	96%
More than 50 years old	2	4%	100%
Total	45	100%	
What is your highest qualification?			
Baccalaureate Degree(s)	22	58%	58%
Postgraduate Degree (s)	8	21%	79%
Post Matric Diploma or Certificate	7	18%	97%
Grade 12 (Matric, STD 10)	1	3%	100%
Total	38	100%	
How would you describe your current position?			
Other	7	16%	16%
Technician	7	16%	32%
Engineer	9	20%	52%
Manager	12	27%	80%
Supervisor	7	16%	95%
Specialist	2	5%	100%
Total	44	100%	
Which of the following best describes the principal industry of your organizations?			
Manufacturing industry	19	42%	42%
Service industry	26	58%	100%
Total	45	100%	

A. *Factor analysis*

Factor analysis is a statistical tool for measuring the latent variables and refining the theory [16]. There are two main types of factor analysis - the exploratory factor analysis and the confirmatory factor analysis. In the exploratory factor analysis, the researcher does not assume any previously known correlation between observed variables and their respective latent factors [17]. As the name suggests in the confirmatory factor analysis the researcher attempts to confirm the theory. The current research used both the exploratory factor analysis and confirmatory factor analysis. The exploratory factor analysis was employed to group the observed variables into fewer factors and also to refine the theoretical framework. Confirmatory factor analysis was used to identify the construct validity.

Williams, Onsman and Brown, [16] cited the discussion from different authors about sample requirements for factor analysis and reached the conclusion that there is no agreed minimum sample size for factor analyses. The author suggested the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's Test of Sphericity as the measure of data's suitability for factor analysis. The KMO index is the number ranging from 0 to 1, the KMO value of 0.5 and Bartlett's Test of Sphericity significant at p-value less 0.05 indicate the suitability for factor analysis. This research had the KMO index of 0.768 and Bartlett's Test of Sphericity (Chi-Square = 279.323, degree of freedom = 91, p-value < 0.05) which shows that the study did not have the sample problem.

B. *Exploratory factor analysis*

The current research used the five-step process defined in [16], to perform the exploratory factor analysis in SPSS. The current research used the principal axis factoring as the method of extraction and the eigenvalue greater than one as the criteria for extraction. The Promax was used due to the fact that the cost of quality factors are related.

The study also followed the guidance provided in [18], to analyse the output from SPSS. The first process includes identifying the items which had low measure of sampling adequacy (MSA) <0.6, loading lower than 0.3 from their respective factors and items causing double loading. The exploratory factor analysis removed 13 items from the theoretical frame and returned only 13 items for further analysis. TABLE III shows the empirical framework from exploratory factor analysis.

TABLE III
COST OF QUALITY EMPIRICAL FRAMEWORK

Variables	Factors			
	Preventive cost	Opportunity cost	Appraisal cost	Failure cost
Item 6	0,811			

Variables	Factors			
	Preventive cost	Opportunity cost	Appraisal cost	Failure cost
Item 4	0,797			
Item 3	0,756			
Item 5	0,513			
Item 23		0,862		
Item 24		0,797		
Item 25		0,783		
Item 17		0,352		
Item 10			0,989	
Item 8			0,841	
Item 20			0,415	
Item 14				0,934
Item 13				0,656
% of Variance	42,407	11,280	9,263	7,868
Cumulative %	42,407	53,687	62,95	70,818
Cronbach's Alpha	0,831	0,842	0,792	0,742

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

The extracted factors explained the total of 70.818% of the total variance and had the internal consistency, greater than the recommended 0.7 [19]. The empirical framework was further used for confirmatory factor analysis presented in the next section.

C. Confirmatory Factory analysis

Awang [20], recommended the structural equation modeling as an approach to perform confirmatory factor analysis. The current research followed the recommendation and used the IBM AMOS version 25 software for structural equation model. TABLE IV shows the model fit indices adopted for the current research.

TABLE IV
STRUCTURAL EQUATION MODEL FIT INDICES [20]

Fit indices	Criteria	Observed values
Chi-square		76.714
Degree of freedom (DF)		59
P-value	>0.05	0.060
Relative chi-square (CMIN/DF)	≤ 2 or 3	1.300
Comparative fit index (CFI)	≥ 0.90	0.920
Root mean square error of approximation (RMSEA)	< 1.0	0.084

The result shows that the overall fit indices were within the acceptable chi-square = 76.714 (DF = 59) and p-value >0.05, CMIN/DF = 1.300, CFI = 0.92, and RMSEA = 0.084 [20]. Fig.1. shows the structural equation modelling result. The result shows that the latent factors (preventive cost, opportunity cost factor, appraisal cost factor) were correlated below 0.7 which indicates that the factors were not measuring the same things [18]. The observed variables were also measuring their respective factors well with the factor loading ranging from 0.60 to 0.90. All the latent factors explained the high variance on their respective observed variables for example preventive cost factor explained the total variance ranging from 0.39 to 0.75 on the respective items.

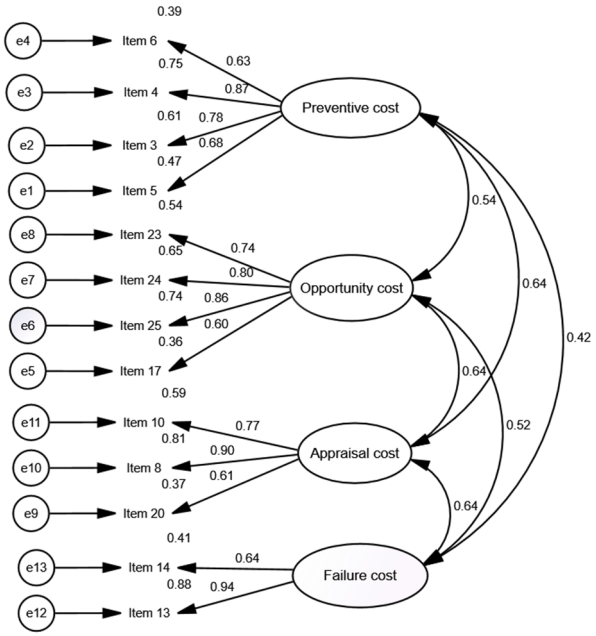

Fig. 1. Cost of quality structural equation model result

TABLE V shows the measure of composite reliability of the constructed model, converged validity, and discriminate validity. As indicated in [20] composite reliability (CR) is a measure of reliability based on the factor loading. The formulas below were used to calculate the CR and average variance extracted (AVE):

$$CR = \frac{\sum \Lambda^2}{[\sum(\Lambda)^2 + (\sum 1 - \Lambda^2)]} \quad (1)$$

$$AVE = \frac{\sum \Lambda^2}{n} \quad (2)$$

Where Λ = factor loading and n = number of items in a model. The result shows that the study had both composite reliability and Cronbach's Alpha greater 0.7 which observed variables had a good internal consistency and converge to measure their latent factors.

TABLE V
RELIABILITY, CONVERGENT AND DISCRIMINANT VALIDITY

Latent variables	CR >0.7	MSV	AVE >0.5	MSV < AVE
Preventive cost	0,83	0,41	0,56 > 0.5	0,41 < 0,56
Opportunity cost	0,84	0,41	0,57 > 0.5	0,41 < 0, 57
Appraisal cost	0,81	0,41	0,59 > 0.5	0,41 < 0,59
Failure cost	0,78	0,41	0,65 > 0.5	0,41 < 0,65

As suggested in [20], the study used Maximum shared variance (MSV) and average variance extracted (AVE) as a measure of discriminate validity and convergent validity. The AVE which is the percentage of variance shared by

observed variables to measure the unobserved variables is a measure of convergent validity. The AVE > 0.5 shows the presence of convergent validity. In the current research, all the factors four factors had the AVE>0.5 which means the model had convergent validity.

Maximum shared variance (MSV) which is defined as the measure of the variance of the unobserved variable explained by other latent variables in the model is used to judge the discriminant validity [20]. The discriminant validity is present when AVE > MSV. All the four factors had the AVE > MSV which proves that the model had the discriminate validity. The presence of convergent validity and discriminate validity confirmed that the model had the construct validity. Therefore, the results generated from this research can be trusted because they are generated from the validated framework.

D. Level of cost of quality practice

The study used the mean scores of the factors from confirmatory factor analysis result to identify the level of cost of quality practice in South African companies. Preventive cost factors had the highest mean score of 3.556 followed by appraisal cost factor with the mean score of 3.535 reported on the five-point Likert scale items. The failure cost factor had the mean score of 3.50 and opportunity cost factors scored the lowest mean score of 2.954. The opportunity cost was identified as the less managed cost of quality category from the respondents' companies. This confirmed the claims by [6] suggesting that companies are managing the cost of quality but they are not publishing their strategies.

IV. CONCLUSION

This study investigated the adoption of cost of quality in South African companies. The data were collected in the companies around the Johannesburg area using the online survey platform. The study collected a total of 45 respondents - 19 from manufacturing companies and 26 from service companies. The study used the factor analysis to refine the theoretical framework developed from the literature. The reliability of the framework was confirmed using Cronbach's Alpha and composite reliability. The construct validity was assessed using convergent validity and discriminant validity. The research found the South African companies around Johannesburg were highly concerned about the prevention cost and appraisal cost. The failure cost received the third highest score, an opportunity cost was identified as an ignored cost of quality category in the South African companies. Hence, it is recommended that companies start to pay attention to the opportunity cost of quality. Further research should identify the challenges experienced in the implementation of cost of quality programme in South African companies.

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