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Quantification of Cost of Quality: A Case Study in an Ethiopian Apparel Manufacturing Factory

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ABSTRACT

Cost of quality (CoQ) is considered as a key metric and an important hidden component during the calculation of the actual cost of a garment, which generally goes unnoticed as it is considered to be untraceable by many. The reason for its un-traceability is a complete absence of literature related to models that relate to the garment industry. The objective of this case study was to develop a framework for quantification of the CoQ and its implementation in a representative export-oriented small-scale factory based out of Addis Ababa, Ethiopia, which was on the verge of losing export buyers because of its high operational cost and unacceptable quality standards. The researchers conducted an in-depth study of the quality-related activity costs incurred to produce a product right from the product development stage to the final packing stage. The costs were segregated as per the sub-activities falling under the purview of COGQ (Cost of good quality) and COPQ (Cost of poor quality) following the guidelines as provided in the ABC (Activity Based Costing) model of CoQ calculation. The results were startling, with 23 % of the sales revenue incurred against the CoQ. The preventive cost, appraisal cost, internal failure cost, and external failure cost were 4.8 %, 10.2 %, 7.4 %, and 0.54 %, respectively. The quantification of quality-related costs can prove a beacon light for factories who want to be competitive globally.

Keywords: Cost of Quality, garment industry, Cost of good quality, Cost of poor quality, ABC Model, PAF model, Ethiopia

Introduction

Quality and cost are considered the essential factors to be competitive in today's challenging business atmosphere. Therefore, organizations are required to balance the quality and costs to improve consumer satisfaction by delivering valuable products/services to the market (Özkan & Karaibrahimoğlu, 2013). Quality costs are a significant component of an organization's overall cost (Giakatis et al., 2001). Quality costs are the expenses that occurred in assuring as well as confirming quality along with the losses that occurred when quality not achieved (ASQC, 1970; BS-6143, 1990) Since 1951, Dr. Juran introduced the quality concept, the economics of quality, and the graphical form on the CoQ model in his quality control Handbook. He highlighted in the book that the estimation of the cost of quality as one of the primary requisites for estimating and reducing the cost of non-conformance (Juran, 1951). Most of the companies seem to be ignorant of the amount of profits they are actually losing via bad quality (Plunkett & Dale, 1983; Porter &

Rayner, 1992). Crosby states that he has not seen a single business that had its cost of quality used appropriately in his thirty years of working experience as being a quality professional (Crosby, 1998). Smaller firms do not monitor quality costs as they do not possess the budget allocated for the same (Plunkett & Dale, 1983; Porter & Rayner, 1992). In the case of larger firms, even though they claim to access quality costs (Allen & Oakland, 1987; Chen, 1992; Schmahl et al., 1997) and declare quality as the top priority of theirs, just a few amongst them access the results of the quality improvement program (Morse, 1991; Tatikonda & Tatikonda, 1996).

Ethiopia is fast growing to be one of the major sourcing destinations for major apparel brands viz. GAP, H&M, PVH, Decathlon, to name a few. In order to sustain itself in the gruelling global competition with countries like Cambodia, Vietnam, and Kenya, it must be price competitive, keeping up with the global quality standards. The Ready-made garment (RMG) sector of Ethiopia is considered the biggest foreign exchange, massive employment generator, while being the biggest contributor to its Gross Domestic Product (GDP). It is the biggest exporting sector in Ethiopia that experienced remarkable growth during the last ten years. Trade incentives (AGOA, EBA, COMESA, GSP & TFTA), availability of cheap and readily trainable labor, low cost of power, export promotion schemes launched by the government, proliferation of world-class industry parks, and rapid development of rail-road-air networks are the main contributory factors which would help Ethiopia in its growth path to be one of the major global apparel sourcing destinations. However, the major trade incentive, AGOA, has been proposed to come to an end in 2025. Therefore, it is high time the Ethiopian Readymade Apparel industry can gear up to optimize productivity and quality.

Quality is among the significant areas that may give considerable internal savings and a real-time boost to profitability. The Ethiopian apparel industry remains at its infancy phase than competitive countries. It is not able to participate in the global market as a result of the failure to produce quality products (Demissie et al., 2017). On the other hand, most of the apparel factories in Ethiopia do not have any well-laid-out quality management system as per world-class principles like Total Quality Management (TQM). Most of the apparel manufacturers do not know the actual price they spend on ignoring quality. The cost occurred because of bad quality is aptly termed as CoQ. 'This is simply because the information required for the cost of quality analysis is usually not maintained in the apparel business, or even if the data is there, it is seen as way too confidential to share'(Bheda, 2015).

Though several researchers have written about the cost of quality for years, there has been almost no research on the topic, particularly in the apparel/garment industry, in Ethiopia.

This paper, to the best of the author's knowledge, is the first attempt to publish COQ implementation efforts by developing a CoQ calculation framework in the SME garment sector.

Cost of Quality (CoQ)

The CoQ is not a broadly used concept as confirmed by abundant research studies and industry surveys, for example, (Duncalf & Dale, 1985; Kumar et al., 1998; Plunkett & Dale, 1986; Plunkett & Dale, 1987; Wheldon & Koss, 1998). There is no single uniform definition of COQ (Machowski & Dale, 2018). Different authors or quality gurus have given different definitions of quality costs. The different definitions of quality are given below:

"CoQ is defined as all the resources required to ensure quality requirements by avoiding losses results from failure"(Bohan & Homey, 1991).

Cost of conformance or Cost of Good Quality (COGQ), and non-conformance cost or Cost of Poor Quality (COPQ) can be summed together to formulate the Cost of Quality. The amount spent to avoid bad quality, i.e., *inspection & quality appraisal, is known as COGQ, and the amount spent against costs incurred due to processes deviating from the specified standards, i.e., rework and returns, are termed as cost of non-conformance or COPQ (Machowski & Dale, 2018)*

Prevention cost and appraisal cost falls under COGQ, whereas Internal Failure Costs (IFC), External Failure Costs (EFC) comes under COPQ.

CoQ is categorized into 4 types concerning garment business. These are:

Prevention Cost:

"The cost of all activities designed specifically to avoid poor quality in products or services. Examples are the costs of new merchandise review, quality planning, supplier capability surveys, process capability evaluations, quality improvements, staff meetings, quality improvement projects, quality education, and training" (Campanella, 1999).

Appraisal Costs:

"The costs related to measuring, evaluating, or auditing apparel merchandise, services, or production-related in the factory to assure conformance to quality standards and performance requirements." These include the costs of incoming & sources inspection of purchased material (for example, fabric, accessories), in-process or in-line, end-line checking in sewing line, final inspection of the garment, product, process, or service audits, calibration & test equipment, and the cost of related supplies and materials (Campanella, 1999).

Internal Failure Costs (IFC):

"The costs occurring before delivery or shipment of the product to the customer. A few examples of the IFC cost are the costs of scrap, rework, re-inspection, re-testing, material review, downgrading, and returning garment for rework" (Campanella, 1999)

External Failure Costs (EFC):

"The costs occur after delivery or shipment of the product, and during or after furnishing of service, to the customer." Examples are the costs of processing customer complaints, customer returned garments, product recalls, warranty claims, and loss of goodwill (Campanella, 1999).

Background of study

This case study was undertaken in one small-scale factory based out of Addis Ababa, who had been doing job-work for a U.S. buyer and the domestic market for the last 14 years. The factory has a total of 208 machines with 299 employees. The reason why the researcher chose this factory was because even though they had the best possible technology, they were struggling to make profits from domestic and international markets. This issue was found to be very common in other Ethiopian factories (Sorri, 2010). Therefore, it was felt that this factory could represent other small-scale factories in Ethiopia.

Objectives

This case study focuses on the development of a framework and its implementation for the quantification of CoQ in one of the manufacturing lines, which was producing men's shirts.

General objective

- To formulate a framework for gathering the data and calculate the total CoQ for an order of 7000 pieces of shirts in the apparel industry and compare against the standards as laid out by the quality gurus.

Specific objectives

- To formulate a framework to compute the total CoQ for the apparel industry, which incorporated all the cost components related to all activities.
- To identify the macro and micro activities associated with CoQ in the apparel manufacturing chain right

from the sampling to the final finishing of the product.

- To quantify the CoQ components and segregate them as the COPQ (IFC, EFC) as well as COGQ (prevention & appraisal cost).
- To compare the COPQ and COGQ against the industry best practices.

Literature Review

CoQ helps an organization to identify and measure the quality cost, therefore letting the target be set for the reduction of CoQ. Some businesses lack the CoQ measurement system, along with its proper implementation methodology (Schiffauerova & Thomson, 2006). Therefore, to better understand it, the managers need additional practical education to gain full benefits and save money. Several researchers who have written on the cost of quality also talk about its degree of severance. 'Sale percentage,' which explains about the revenue generated through sales during a certain period, has been considered by many researchers as a basis for computation for cost of quality.

Several authors (Campanella, 1999; Crosby, 1967; Giakatis et al., 2001; Harrington, 1987; Juran, 1951; Rodchua, 2006; Superville & Gupta, 2001) reported that quality costs are somewhere between 5-30% of an organization's annual earnings through sales. They are further based on the nature of the business, size of the company, the duration of the quality program, etc. (Tye et al., 2011; Uyar, 2008; Williams et al., 1999). (Feigenbaum, 1956; Harrington, 1987) argues that any quality cost value that exceeds 6%-10% of sales (without considering the costs of poor quality of administrative areas) should concern the company management. Desai (2008) has additionally mentioned that the CoQ of an enterprise can reach up to 5-35 % revenue for manufacturing businesses, and twenty-five to forty % of operating expenses for service organizations (Desai, 2008), whereas (Corradi, 1994) stresses that 20-30% of annual sales of a company lost in bad quality, i.e., internal and external failures. Bell et al. estimate that the cost of quality in the manufacturing sector falls between 5 % - 25 % of sales (Bell et al., 2012). In Crosby's viewpoint, they would total up to a much substantially greater percentage, up to forty % when it comes to the service businesses (Crosby, 1998).

The researchers found very few studies on COQ has conducted in the garment industry through a literature survey. A study conducted by Bheda, in 61 Indian apparel factories found that loss on account of CoQ was an average of 14.05 % of their annual sales (Bheda, 2015). In another study, COPQ contributed to 39.76% of conversion cost and an annual loss of 171.7 Million in a 1200 machines Indian garment factory (Gowda & Babu, 2014). Mukhopadhyay reported that estimation of cost of quality-related data of 3 financial years assisted an Indian textile industry in lessening its non-conformance cost to a considerable extent (Mukhopadhyay, 2004). As per Cheah (2011), a major portion of cost of quality is invisible and can be controlled by implementing programs related to cost of quality (Cheah & Shah, 2011). (Heldt, 1994) stated that the gain could be multiplied by four times only by eliminating the failures without increasing the sales. Ideally, for a business to thrive, COPQ should not cross 10 to 15 percent of the operating cost (Crosby, 1967).

Organizations that understand how to conduct efficient quality planning, can manage to decrease the quality cost from thirty-six % to just three % of sales in a few years (Andrijašević, 2008). This can only happen when the company follows a structural framework or model to identify the activities associated with the cost of quality and measure them accordingly. Different models have been developed for identifying the cost related to different activities.

COQ models

CoQ quantification is considered seriously by organizations who want to be market competitive. Surprisingly, there is a lack of considerable work on the cost of quality. There are only a few publications on COQ models. Numerous models are used to collect related quality cost data. However, some of the models are considered uncertain and imprecise on what should be the level of cost of quality to consider it as optimum (Plunkett & Dale, 1987).

In the literature, the CoQ models are divided into four models. These are Crosby's model or P-A-F (Prevention-Appraisal-Failure), ABC (Activity-Based Costing) models, Process cost models, and intangible or Opportunity cost models, as shown in Table 1. Most CoQ models are based on the P-A-F model (Machowski & Dale, 2018; Plunkett & Dale, 1987; Sandoval-Chávez & Beruvides, 1998).

Table 1. Generic CoQ models and cost categories, Source: (J. Plunkett & Dale, 1987)

Generic model	**Cost/Activity categories**
P-A-F model	(Prevention + appraisal + failure)
Crossby's model	(Prevention + appraisal + failure + opportunity)
Opportunity or intangibles cost models	(Conformance + non-conformance) (Conformance + non-conformance + opportunity + Tangibles + intangibles) (P-A-F (Failure cost includes opportunity cost)
Process cost models	(Conformance + Non-conformance)
ABC models	(Value-added + non-value-added)

Feigenbaum categorized the cost of quality into appraisal, prevention, and failure (internal and external) costs (Feigenbaum, 1956). In the **P-A-F or Crosby model,** investment in prevention and appraisal-related activities can lessen failure costs. Further appraisal activity-related costs can be decreased by investment in prevention activities (Feigenbaum, 1956; Juran, 1951; Masser, 1957; Plunkett & Dale, 1987). In the **Intangible or Opportunity cost model**, intangible costs are losses incurred due to non-conformance and lost customers (Sandoval-Chávez & Beruvides, 1998). Production services are focused more in the Process cost model created by (Ross, 1977). The cost of conformance and non-conformance is summed together to get the process cost (Marsh, 1989).

Although PAF is widely accepted as a model for quantifying the cost of quality, it has been under criticism. "Loss of sales" and "Loss of customer goodwill" are not included under the PAF model (Oakland, 1993; Porter & Rayner, 1992). Opportunity losses were incorporated into traditional P-A-F quality expenses by Sandoval et al. incorporated opportunity losses into traditional P-A-F expenses (Sandoval-Chávez & Beruvides, 1998). Opportunity cost is the loss, which is caused by poor delivery service.

The biggest challenge faced while calculating the quality costs is the logging of time spent by indirect workers (Dale & Plunkett, 1991) . (Cooper & Kaplan, 1988) developed the Activity-based costing (ABC) model, which is not primarily a quality model, but a cost accounting method. It focuses on the allocation of activity costs over products and services after the identification of production-related activities and resources consumed by them.

COQ measurement under ABC

Tsai proposed a framework with the integration of COQ and ABC systems, where a mutual database is shared for getting different cost and nonfinancial information. The main agenda is to promote productivity, quality continuously by eliminating non-value-added tasks such as waste and costs. Therefore, it enables to manage the quality costs more efficiently (Tsai, 1998).

There is simply no concurrence system to assigning the overhead expenses to CoQ elements and absolutely no satisfactory technique for tracing quality costs to their sources. These deficiencies can be solved by activity-based costing.

In the ABC system, the overhead cost is split into several cost centers, and wherein each cost center is responsible for the cost of related activities proportionately utilized by goods. During the first stage of the ABC model's cost assignment process, the overheads' cost is connected to activities using resource drivers. In the second stage, the activity costs are tracked to their sources or cost objects using activity drivers. The overhead cost or indirect share factor (percentage) is allocated to the percentage of the indirect time incurred on each activity.

ABC is well-thought-out and much more suitable for quantifying the cost of quality compared to traditional accounting. The study carried out by Sailaja (2013) reported that the ABC model is better and accurate for COQ calculation in comparison to the PAF because it keeps a log of all the activities which contribute the cost, including the indirect or overhead cost such as human resources, machine costs, which are not effectively measured in the PAF model (Sailaja et al., 2013).

The following steps are followed under CoQ-ABC framework:

- Identify the CoQ related activities in a different department
- Categories activities under different CoQ components
- Quantify and allocating the costs, including the indirect cost to their respective activities in a different department

The authors, after a comprehensive overview of the existing quality cost models, found the CoQ-ABC framework to be most suited for the apparel manufacturing industries as they consist of a unique aggregation of a sequence of smaller activities or jobs and then assigning overhead/indirect cost based on time spent on activity by labor. It was also found that insufficient work has been done to properly understand and utilize ABC costing model in the apparel manufacturing industry.

Therefore, the authors' prime motivation was to formulate a tracing mechanism, which would cover all the macro and micro activities on the shop floor while being guided by the ABC costing model. This paper also proposes a framework/algorithm that offers an organized method of calculating CoQ.

Work Methodology

Although much information is available about CoQ, only a few have been published with detailed practical examples on the cost components of quality costing with the procedure of data collection. The elements/components of CoQ models differ from company to company. Precisely the same components are located in various cost components or even described differently as per the company's requirements. As per the quality experts, CoQ programs must be customized for every company instead of simply getting hired (Campanella, 1999; Johnson, 1995; Pursglove, 1996; Sörqvist, 1997).

The authors formulated framework/algorithms for calculating the different CoQ components, which would cover all the macro and micro activities required to complete an order of apparel merchandise starting from sample development till final packing on the shop floor. Data were calculated for an order of 7000 men's shirt by the following steps:

Project Charter:

First, the Project charter was prepared, as shown in table 2, on the lines of a six-sigma project. Its purpose to list down the objective, scope, and time frame of the project.

Table 2. Project Charter

<u>**Project Information**</u>	<u>**Project scope**</u>
Project Title: Cost of Quality	**In scope** Setting up the framework for GMM factory
Project Head: Monika Panghal	
Facilitator: Mr. Zweledi Tecleab	
Project Time Frame: Project start: 07 June, 2018 Project end: 20 August, 2018	
Team members: Mr. Sandeep Prasad, Mr. Shumet Tilahun	<u>**Problem and Goal**</u> **Problem statement:** Not-availability of framework for capturing of quality at GMM factory
Business case: Optimizing the cost of quality	**Goal:** To setup the framework to capture COQ

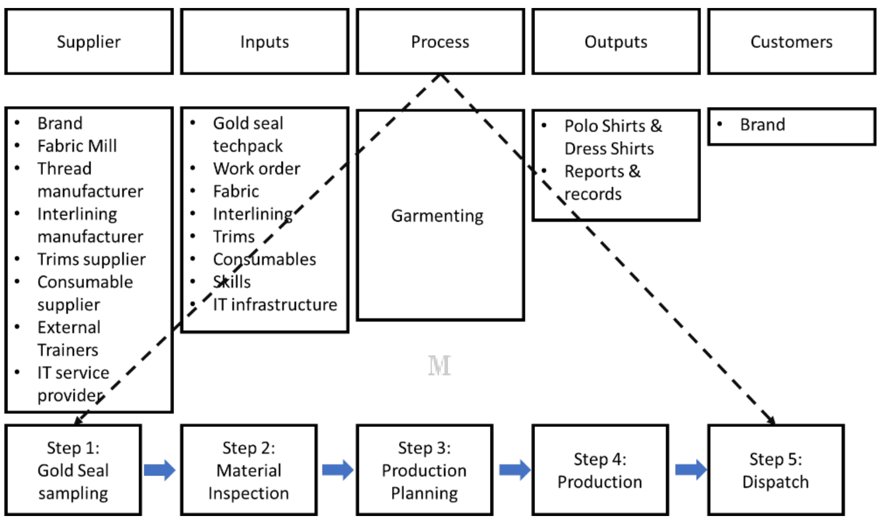

Figure 1. SIPOC

CoQ-SIPOC:
SIPOC (Supplier, Input, Process, Output, & Customer) is a tool prepared by the team to determine all relevant components of the order fulfilment before work begins (Fig. 1).

Creation of a model for CoQ components calculation

After a detailed literature analysis, researchers did not find a single publication on the calculation of CoQ components in the apparel industry. Therefore, the researchers developed algorithms to calculate the CoQ component for the apparel industry, as shown in Table 3. In this model, overhead expenses were included, unlike PAF model. The overhead cost seriously distorts the product cost in a business where product diversity with low volume, for example a garment manufacturing industry, overheads are a big portion of the product cost.

In this model, the researchers considered the distribution of indirect cost in a proportionate manner to each cost of quality components because it plays a great amount of contribution to the total cost of an organization. This model can prove as a ready reference guide for manufacturers who want to explore the quantum of CoQ in their factories.

Table 3. Framework/Algorithm for calculation of quality cost component

Cost components	Quantified formula	Source information
Prevention cost	• No of direct manpower = A • Hours spent by manpower = B • Average hourly wages = C • Average % share of indirect cost = D • Cost of direct consumables = E • Cost of equipment calibration = F *Cost for each activity under prevention component = {(A* B* C)* (1 + % D) + E + F}*	i) Number of concerned people ii) Avg. hourly wage rate iii) Time spent by concerned people iv) Indirect cost percentage occurred for activities from the finance department v) Cost of consumables materials from the purchasing department vi) Calibration cost
Appraisal cost	• No. of inspector/quality checker = A • Hours spent by an inspector/quality checkers = B • Average hourly wages of inspectors/quality checkers = C • Average % share of indirect cost = D • No. of inspection/testing m/c ran = E • Hourly rate of inspection/testing m/c = F • Cost of material supplies = G *Cost for each activity under appraisal component = [{(A* B* C)* (1 + % D)} + (E* F) + E]*	i) Number of inspectors/ quality checkers ii) Avg. hourly salary rate of inspectors/ quality checkers iii) Time input by inspectors/quality checkers iv) Data regarding different test done by the quality control department v) Cost of consumables materials from the purchasing department vi) Equipment calibration cost
Internal Failure Cost (IFC)	*Rework cost + Cost of Material Loss* Rework cost: {(A + B + C)* (1+ % E)} • Average man-hours spent for sewing rework (hours required for repairing like opening seams, re-cutting) = A • Average man-hours spent on finishing rework = B • Average man-hours consumed due to re-inspection of internal audit failures = C • Average hourly wages = D • Average % share of indirect cost = E *Cost of Material Loss = {(A* B) + (C* D)}* • Per Unit Price of material (Fabric/ Trims) = A • Excess consumption of material (Fabric/Trims) concerning Standard Allowance = B • Cost per apparel = C	i) Data regarding the defect's quantity obtained from the quality department (Daily Quality MIS) ii) Time spent by concerned people for re-screening, re-processing, and re-inspection iii) Average hourly wage of concerned people iv) Amount/quantity of material loss v) Average Cost occurred because of material loss

	• Count of apparel loss under Q3 (3rd quality) & scrap category = D	
External Failure Cost (EFC)	*Rework cost + Cost of Replacements* $Rework\ Cost = \{(A*B)+(C*D)\}*(1+\%E)$ • Man-hours consumed for rework & repairing = A • Average hourly wage of operator = B • Man-hours consumed for re-testing = C • Average hourly wage of checker/inspector = D • Average % share of indirect cost = E $Cost\ of\ Replacements\ under\ External\ Failure/Customer\ Complaints = (D*E)+F$ • Average cost of apparel replaced = D • Number of apparels replaced = E • Logistic cost = F	i) Time and cost occurred in rework ii) Cost occurred in rework iii) Cost occurred in re-processing iv) Number of samples replaced or returned v) Cost of the replaced product vi) Logistic cost
Cost of opportunity loss (EFC)	$Cost\ of\ Opportunity\ Loss = [\{A*(R-S+T)\} - (B*T) - C + D]$ • No. of pieces as per marketing Plan = R • Average revenue per apparel = A • Average revenue loss per apparel due to Q2 (2nd quality) = B • Amount debited by the buyer if any = C • Average operating cost of warehouse & logistics for Q2 = D • No. of pieces dispatched as Q1 (1st quality) = S • No. of pieces dispatched as Q2 (2nd quality) = T	i) Total no. of products as per marketing plan ii) Number of products dispatched under quality category 1st and 2nd iii) Average revenue and revenue loss per product for the different quality category iv) Quantity of returned product v) Operating cost of warehouse vi) Logistic cost

Data collection

The apparel manufacturing industry consists of a unique aggregation of a sequence of smaller activities or jobs**.** The researchers developed a Microsoft Excel template to track and record the quality-related activity costs incurred to produce a product right from the product development stage to the final packing stage. All the quality-related activities carried out by the key personnel in different departments like sampling, merchandising, designing, fabric & trim store, cutting room, sewing room, I.E. department, finishing & packing department, etc., who were responsible for the completion of the order, were logged in. The activities were traced by using different activity drivers to measure the consumption of activities by cost objects. For example, man-hours are used as the activity driver to analyze the specification sheet given by customers, inspect the product, or scheduling & controlling. The overhead costs were apportioned into different cost centers based on their activity as well as resource drivers, as advocated in the ABC model. Overhead/indirect cost was assigned based on time spent on activity by labor.

Subsequently, activities thus logged were identified, categorized, and quantified under different quality cost components. The researchers recorded the activities cost in the Sampling until the Finishing Department. A detailed description of activities under different CoQ components are:

Preventive Cost: The data related to the prevention cost was collected along with the following details (table 4):

- Input/Activity Details
- Process Description
- Manpower cost
- Consumables Cost

Appraisal Cost: Appraisal cost-related data were collected with the following details (table 5 & 6):

- Input/Activity Details
- Process Description
- Manpower cost
- Consumables Cost (table 6)
- Calibration cost
- External Services/ Training/ Projects

Table 4. (partial): Preventive activities in different departments and related manpower, consumables cost spreadsheet

		Product: Shirt								
	Process	Manpower Cost							Consumables	
Department	**Activities description**	**Designation**	**No of People (1)**	**Avg. Cost / Person/ Hour (2)**	**Man-Hours Spent/ Day (3)**	**No of Days (4)**	**Total Hours Utilized {(1)*(3)*(4)}= (5)**	**Cost (ETB) {(2)*(5)}=(6)**	**Name of Report/ Records**	**Cost Per Month**
Sampling	Tech Pack / Risk Analysis	Sampling In-charge	1	19	8	10	80	1520		
		Line supervisor	1	13	8	2	16	208		
		Pattern master	1	215	8	10	80	17200		
Sew Assembly	Line PP Meeting	Production Head	2	26	8	4	64	1664		
		Quality Checker	2	9	8	4	64	576	Line PP Meeting Format	150
		Line supervisor	4	13	8	4	128	1664		
		Quality Supervisor	4	22	8	4	128	2816		
		Quality checker	8	9	8	4	256	2304		
Maintenance	Preventive maintenan	In-charge	1	27	4	25	100	2700	Preventive	

ce								Maintenance Card	200
	Mechanics	3	24	8	25	600	14400		

Table 5. (partial): Appraisal activities in different departments and related manpower, consumables cost data spreadsheet

Total hours spent, Manpower Cost								
Department	**Activities description**	**Designation**	**No of People (1)**	**Average Cost/Person / Hour (2)**	**Hours Spent /Day (3)**	**No of Days (4)**	**Hours utilized {(1)*(3)*(4)}=(5)**	**Cost (ETB) {(5)*(2)}=(6)**
Sampling	Inspect Fit / Proto Sample	Quality checker	1	9	2	15	30	270
	Inspect P.P. Sample	Quality checker	1	9	4	10	40	360
	Inspect Trade Show Sample	Sampling In charge	1	19	2	25	50	950
		Quality checker	1	9	4	25	100	900
Fabric Inspection	Inspection Report, Shrinkage Report, CSV Report	Quality Line supervisor	1	12	1	22	22	264
		Quality Checker	1	9	0.5	25	12.5	113
Cutting room	Marker Checking	Quality checker	1	9	8	25	200	1800
	Spreading & Cutting Quality Check	Quality checker	1	9	6	25	150	1350
	Bundle Audit	Quality checker	1	9	8	25	200	1800
Maintenance	Breakdown Maintenance	Mechanics	2	24	1	25	50	1200
Sewing and Finishing	In-Line - CTQ Check	Quality Checker	8	9	8	25	1600	14400
	End of Line Check	Quality Checker	8	9	8	25	1600	14400
	Internal / Final Audit	Quality Checker	8	9	7	25	1400	12600

Table 6 (partial). Consumables cost data spreadsheet for Appraisal activities

Department	Name of records/ reports	Cost
Fabric store	Marker inspection report	700
	Bundle Audit report	400
Sewing	In-line inspection report	840
	End-line inspection report	1000
Washing	Before wash AQL report	1555
Finishing	Finishing Checking report	1725
Packing	Internal Audit report	1255
=	**Total**	**7475**

Internal Failure Cost: Following IFC related cost were collected:

- Raw Material *(scraps) and Finished good*s *loss*es (table 7)
- Rework cost *(table 8)*
- Internal failure Audit *(table 9)*

External Failure Cost: Following EFC related costs were collected:

- *Rework cost (*Total cost incurred for re-screening and re-inspection, resulting out of returned or rejected shipments/goods from existing customers) *(Fig 10)*
- *Replacements cost (*Total cost incurred due to replacements against defective products returned by the customers) *(Fig 11)*
- *Opportunity Loss (Loss of sales due to defective pieces)*

Table 7 (partial). Internal Failure cost data spreadsheet – Raw material & finished goods loss

Date	**11-July**	**12-Jul**	**13-Jul**	**14-Jul**
Product	Shirt	Shirt	Shirt	Shirt
Raw material cost/meter	180	180	180	180
Cost/product	350	350	350	350
Planned consumption	2.25	2.25	2.25	2.25
Order quantity	500	-	350	-
Cut quantity	505	-	355	-
Final consumption	2.3	-	2.8	-
% Excess consumption	0.02	-	0.24	-
1st quality (Q 1)	498	-	348	-
2nd quality (Q 2)	0	0	0	2
3rd quality (Q 3)	0	0	0	4
Un-Accounted	7	0	7	6
Standard allowance for excess consumption	0.03	0.03	0.03	0.03
Excess Process Loss	0	0	0.21	0
Raw Material Loss Value	-	-	30831.7	-
Value loss due to Q3, scraps & unaccounted	2450	-	2450	-
Total loss	2450	-	33281.7	-

Table 8 (partial). Internal Failure Cost- Re-Screening (inspection of rework product)

Date	Product	Quantity	Man-hours for Re-screen (1)	Man-hours for Re-inspection (2)	Manpower Cost/hour (3)	Cost of Rescreen & Repair (ETB) {(1) + (2)}* (3)
8-Jul	Shirt	200	8	6	9	126
9-Jul	Shirt	300	12	10	9	198
	Total cost					**324**

Table 9 (partial). Screenshot of Internal Failures Cost data spreadsheet – Rework

Date	Product	Sewing Defect Count	Man-hours spent for rework on sewing defects	Manpower cost for rework on sewing defects (1)	Finishing Defect Count	Man-hours spent for rework on finishing defects	Manpower cost for rework on finishing defects (2)	Total Rework Cost (ETB) (1)+(2)
11-Jul	Shirt	288	19.2	172.8	384	18	180	352.8
12-Jul	Shirt	308	25.6	230.4	698	31	310	540.4
	Total rework cost							**893.2**

Table 10 (partial). External Failures Cost data spreadsheet – Rework due to returned materials

Date	Product	Pack Quantity	Man-hour for Re-screen (1)	Man-hour for Repair (2)	Man-hour for Re-inspection (3)	Cost per person per hour (4)	Cost of Re-screen, Repair & re-inspection {(1)+(2)+(3)}* (4)
23-Jul	Shirt	3613	40	6	3	9	164

Table 11 (Partial). External Failures Cost data spreadsheet - product returns & Customer Complaints

Date	Product	Cost/Piece	No. of Pcs Returned	Loss (ETB)
30-Jul	Shirt	280	20	5600

The quality-related activities as well as their costs under different cost components like preventive, appraisal, and failure based on the model, were calculated and summarized using the algorithm, as shown in Table 1.

Data analysis and research findings

Based on the excel template and unique algorithms developed by the researchers, the cost elements such as COGQ and COPQ were recorded. After that, separate cost elements for all the activities were calculated and summarized using the model. ABC, together with other techniques such as work sampling, can trace resource costs (including overhead costs) to various activities in a rational way. As can been seen from Table 12 that the amount of COGQ and COPQ in USD were 9,184.7 and 4,847.2, respectively, for an order of 7000 pieces. The total amount of CoQ in USD was 14,031.9. The amount of total revenue generated from the order tracked and followed for CoQ calculation was USD 61,075.

The total CoQ incurred was 23 % of the product sales revenue, which was remarkably high. The percentage of COPQ and COGQ was 7.94% and 15% of the sales revenue, respectively, as shown in Table 12. The percentage of failure cost was 7.94%, whereas the cost of good quality was 15% of product sales revenue.

The percentage of Preventive cost, Appraisal cost, IFC, and EFC was 4.8 %, 10.2 %, 7.4 %, and 0.54 % of the sales revenue, respectively, as shown in Fig. 2. As per (Juran et al., 1951), prevention costs amount to lower than 10% of the total cost of quality. The external failure cost was not high in this case study. It was lesser because the company was catering to the local market.

The preventive cost was only 4.8% of the total CoQ, and failure cost was 7.94%. As per industry standards, the Failure cost should be maintained at half the Preventive cost for optimum profitability, whereas it was 1.64 times the Preventive costs in this study.

There is a possibility of eradication of the cost of non-conformance if the cost-based non-value-added activities are identified. Contrary to the most common initiative of increasing appraisal cost budget by many to keep a check on the quality cost, focusing on prevention costs are always considered a better option according to the 1/10/100 rule. Even though the Return on investment (ROI) might take more time, investing in prevention activities finally help in reducing the failure costs.

Table 12. CoQ Summary Report

Product - Shirt		Order quantity - 7000	Total revenue (USD)		61075
Quality Cost Summary report		Month June -Aug	Expenses (USD)	Total expenses including indirect cost share (0.39) %	Percentage of revenue
Preventive Cost					
Department	Sampling	Activities: Tech Pack / Risk Analysis; Proto Inspection / Risk Analysis	1006.0	1408.4	
Department	Maintenance and training	Preventive Maintenance; Staff / Supervisor Training	233.5	326.9	
Department	Cutting room	Cutting PP Meeting	20.1	28.1	
Department	Sewing and finishing	Line PP Meeting	843.2	1180.5	
	Consumables	Line PP Meeting Format; Preventive Maintenance Card	11.9	12	
		Total prevention cost	**2114.6**	**2955.7**	**4.8%**
Appraisal Cost					
Department	Sampling	Activities: Inspect Trade Show Sample; Inspect Gold Seal Sample; Inspect Fit / Proto Sample; Inspect PP Sample; Inspect Pilot Run	249.1	348.7	
Department	Maintenance and training	Preventive Maintenance; Breakdown Maintenance	41.1	57.6	
Department	Industrial engineering & planning	Batch setting; Planning DCDS sheet	121.4	170.0	
Department	Fabric store	Inspection Report; Shrinkage Report; CSV Report; Raise FRA, if Inspection Fail; Raise FDR, if reject	60.5	84.7	
Department	Cutting	Marker Checking; Spreading & Cutting Quality Check; Panel Replacement in cutting; Fusing Bond Test / Glue Line Temperature Test; Bundle Audit	153.5	214.9	
Department	Sewing and finishing	In Line - CTQ Check; End of Line Check; Before Wash AQL; Finishing Quality Check - 100%; Internal / Final Audit; 100% Audit	3607.3	5050.2	
	Consumables		303.1	303.1	
		Total appraisal cost	**4535.9**	**6229.0**	**10.2%**
Failure Cost					
	Internal Failure Cost				
Activities	Internal Rework - Defects	Sub-Activities: Cutting rework; Sewing rework; Finishing rework	1053	1474	
Activities	Inspection of rework product	Re-screen; re-inspection	116	163	
Activities	Cost of raw material and finished goods loss	Value Loss (Fabric, finished goods) due to poor quality (Q2, Q3); Scraps & Unaccounted material	2881	2881	
		Total internal failure cost	**4050.1**	**4517.7**	**7.4%**
	External Failure Cost				
Activities	Rework cost due to returned materials	Sub-Activities: Re-screen; re-inspection	30		
Activities	Cost of product returns	No. of product returns	175		
Activities	Opportunity loss	Amount debited by buyer; revenue loss due to Q2 product	124		
		Total external failure cost	**329.5**	**329.5**	**0.54%**
		Total Failure cost (COPQ)		**4847.2**	**7.94%**
		Total cost of quality (CoQ)		**14032.0**	**23.0%**

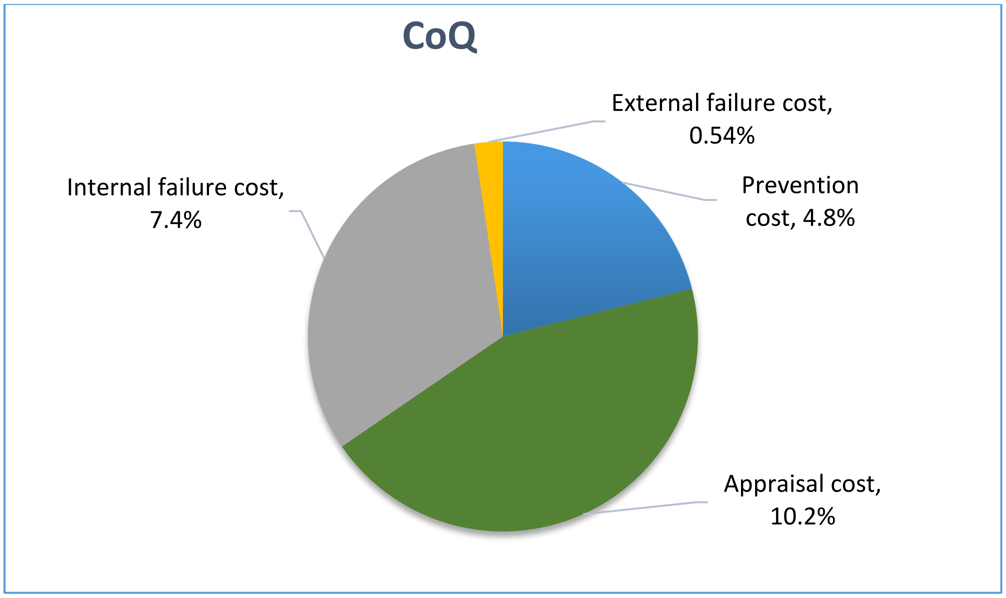

Figure 2. Cost of Quality

Conclusion

This case study was conducted in one of the leading exporting factories based out of Ethiopia, brings about many insights into the current status of high-quality costs. The ABC model for conducting CoQ programs offered a great means for measuring and identifying quality costs in a rational, logical path and therefore let precise action for minimizing CoQ. The cost of poor quality was 23 % of the sales revenue. The above mentioned CoQ figures would be an eye-opener for the factory management and pave the path for future researchers who strive to calculate CoQ for any garment manufacturing factory. The quantification of quality-related costs can prove a beacon light for factories that want to be competitive globally. It is highly believed that reducing the cost of poor quality would directly impact the bottom line and improve quality standards. Therefore, it is highly believed that by following the ABC model of quantification of cost of quality and Six Sigma tools for its optimization, Ethiopian apparel manufacturers can greatly benefit by being more competitive in the global sourcing market both in terms of costs and quality.

Recommendation

The competitiveness and success of any company are measured by the deliverance of its product quality, which is deemed to be central to achieving consumer satisfaction. The goal of a continuous improvement program led by the company should not only be focused on improving product quality for the fulfilment of customer demands but also to keep the associated costs at its minimum. Identification and measurement of the quality cost components are essential steps for the achievement of this goal. Therefore, managers have an important responsibility for identifying, calculating, and reporting the CoQ.

Limitation of the Study

Because of the scarcity of time, the researchers could not take up corrective actions towards reducing the cost of non-conformance. This activity can be taken up further by researchers, and also the impact of using 6 sigma tools in the optimization of cost of quality can be studied and examined.

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The authors planned and carried out the work. All authors read and approved the final manuscript.

Abbreviations
ABC — Activity Based Costing
CoQ — Cost of Quality
COGQ — Cost of Good Quality
COPQ — Cost of Poor Quality
EFC — External Failure Cost
IFC — Internal Failure Cost
P-A-F—Prevention Appraisal Failure
SAM — Standard Allowed Minutes
AQL- Acceptance Quality Level

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