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Cost of quality: Literature review, correspondence between models, and a call for a paradigm shift

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ABSTRACT

Quality costing is a useful tool for companies. According to the literature, it has an important role in enhancing quality; strengthening competitiveness, and satisfying the customer. The aim of this article is to examine this subject from an unusual angle. We conducted a literature review of the main existing Cost of Quality (COQ) models, where we highlighted the differences and similarities in the terminologies used for COQ classifications. In addition, this work identified the criticisms of the COQ models in the literature; a comparative diagram of the main COQ models is also built to illustrate the correspondence between them. The article investigates an inductive and critical analysis approach to demonstrate the relationship between the dominant paradigm and the various COQ models; the conclusion drawn is that the main purpose of the COQ models is the profit of the shareholders at the expense of the third parties. To integrate the needs of the customer, the employee, and the environment as key stakeholders, we believe that a new COQ classification is a must. Such profound change implies a shift from the profit-centered paradigm toward a new one that should be capable to provide answers to the challenges solely for the sake of human well-being. The outcome of this study will pave the way toward a new better COQ classification. Hence, we expect the company to be at the service of human beings in a fine balance. To the best of our knowledge, the way we dealt with the COQ has never been done previously.

1. Introduction

In order to maximize their profits, companies, nowadays, not only try to boost their sales, but they look at how to rationalize their expenditures as well. For this to be achieved, quality-related costs constitute an interesting opportunity. In fact, to identify the money leaks caused by any cost and in particular those related to quality, companies conduct an exercise of classification of quality-related costs and target the ones judged excessively high to drive them down. The primary goal of this exercise, obviously, is to enhance profitability as announced.

The direct link between the reduction of quality-related costs and the increased profitability of the organization has been widely discussed by many researchers, Jorgenson and Enkerlin (1992) and Wood (2013) are some of them. They all evoke the positive impact brought by the assessment and the reduction of the quality-related cost on companies regardless of their sizes, in a way that they take advantage of profit, and competitiveness, and also of ensuring to their customer satisfying products and services at the lowest cost for the company (Goodstadt and Marti, 1990; Schiffauerova and Thomson, 2006).

Giakatis et al. (2001) claimed that the costs related to quality ranged from 5 to 30% of the company sales, which means that they are too important to be ignored. Quality-related cost analysis is indeed an important management tool, it allows evaluation of the effectiveness of the quality management system of the company, identifying the problem areas, the available opportunities, the economics to bring, and the priorities of the actions to be taken (Oakland, 2014). Having said that, is there, anyhow, a unique classification of the quality-related cost or plenty? And is there any

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correspondence between them? And above all what are the areas of research within this topic?

2. Literature review

2.1. Terminology: What a confusion

By conducting a comprehensive review of the literature on the commonly used terms relevant to quality-related costs, one can remarkably conclude that there is no unanimity among researchers on the terms used to imply these costs. Multiple nomenclatures have been identified and grouped into three categories as below:

a. Terms that revolve around "Cost of Quality" (COQ). These are: "Cost of quality," "quality costing" and "quality cost."
b. The term "Economics of Quality."
c. Terms that are connected to "Cost of Non-Quality" (CONQ) such as "Cost of Poor Quality" (COPQ) and "Poor Quality Cost" (PQC).

The three terms "cost of quality," "quality cost," and "quality costing" are employed to mean the sum of the cost of conformance and non-conformance. In some cases, the term "quality costing" is employed to express the tool or technique used by any organization to implement the Total Quality Management program (TQM). This tool gives an indication of the efficiency of the quality system and provides an opportunity to improve the profit (Trehan et al., 2015).

In regards to the term "the economics of quality," it's often employed as a synonym for the first category of terminology. Nevertheless, it is a broad term that is used to define the economics behind quality achievement strategies in manufacturing and service industries (Sailaja et al., 2014).

Regarding the terms COPQ and PQC, they have the same meaning. PQC, which was introduced by Harrington (1987), signifies all the costs incurred by the company and the customer when the product delivered is out of specifications or the customer's expectations, in addition to the costs incurred to train the employers and control the output. Harrington (1987) would prefer to use the term PQC rather than quality cost and his classification of cost of quality are based on the term PQC. This term is less used in the literature than COQ, but confusion still exists between them (Chiadamrong, 2003; Harrington, 1999; Mahmood et al., 2014). In fact, the similarity in the definition of COQ and PQC found in the works of several authors leads us to conclude that the term PQC and COQ are nothing but synonyms (Yang, 2008). However, there are authors who consider that COPQ and PQC represent only the failures in quality, whereas COQ concerns both failures and the part of costs to achieve quality (Sörqvist, 1997; Krishnan, 2006).

For Crosby (1980), it's not a question of costs related to poor quality or high quality, but the costs incurred due to deficiencies since it's nonconformance that wastes the assets (Crosby, 1980). French Standard X50-126 (AFNOR, 1986) calls them the costs resulting from the non-quality instead of poor quality costs or costs of quality. Up to this point, one has to raise a fair question about the reason for all that number of terminologies and why such confusion exists.

We believe this is due mainly to the myriad definitions of costs of quality that the literature is replete with. In that sense, Kau and Nel (2019) have inventoried 26 definitions of them. In fact, some authors such as Chiadamrong (2003), and Goodstadt and Marti (1990) defined quality-related cost as being the costs of non-conformance. Others consider these costs as the sum of all expenses spent to obtain quality (Bohan and Homey, 1991; Giakatis et al., 2001); whereas, the third category affirms that quality-related costs are the sum of costs of conformance and non-conformance (BSI, 1990; Juran and Godfrey, 1999; Machowski and Dale, 1998; Mukhopadhyay, 2004).

In such confusion, what is the proper term to use? The terms COPQ, PQC, and CONC deal only with the non-conformance part of quality-related cost according to some authors. The term "economics of quality" also creates some ambiguity about the real economic value of quality management, at the point that there are two opposite views: The one that it is never economical to ignore quality, and the second is the extreme view when managers believe it is uneconomical to have 100% quality (Wood, 2013). In the development of this paper, and to avoid any misunderstanding, the proper term that will be adopted is COQ due to its large meaning and the fact that it is widely used among the scientific community; so hereafter COQ means the cost of achieving quality with both components of conformance and non-conformance costs.

2.2. Costs of quality classifications

In order to promote quality as a central value and a key factor for the success of companies, they do not only seek quality, but they also do it at the lowest price (Schiffauerova and Thomson, 2006). To do so, companies scrutinize all their expenses analyze and rationalize them. Among these costs, one can cite costs of quality which represent a significant proportion of the whole costs of the company. Many classifications of COQ have been put in place by specialists to make the operation of costs analysis easier as the ones of Crosby (1980), Feigenbaum and Feigenbaum (2005), Juran et al. (1974), Harrington (1987), Sandoval-Chávez and Beruvides (1998), Taguchi et al. (2005), and Kélada (1992), the standards BS 6143 and X50-126, the ABC method, and the cost Benefit model are also used for the same reason though they aren't considered as a real COQ classification.

Before developing the different classifications of COQ, two preliminary remarks should be made; the first concerns the number of classifications regarding the number of publications on the subject.

For example, when the keywords quality+cost+model are typed on Google scholar the output result is more than six million. In fact, most of the subject-published documents counted in the literature are based on the above-cited classification viewed from different angles. For instance, let's look at the recent following works: Jaju et al. (2010) attempted to develop a mathematical model enabling to study of the correlation effect of each PAF cost component with the Total Quality Cost. Wang et al. (2010) reviewed comprehensively the COQ models in the literature: Prevention Appraisal and Failure model (PAF), process cost model called also Process Cost Analysis (PCA), opportunity cost model (Oc), Activity Based Cost (ABC), Quality Loss Function (QLF) and cost-benefit model, then, the authors arrived to the conclusion that the majority of the failure costs in the tangible industries like manufacturing came from internal failure costs, whereas those failure costs are generated from external failure in the intangible industries like service, or the work of Chopra and Garg (2011) who tried to find the relationship between the different categories of COQ in the PAF model (Prevention Appraisal Failure) when Snieska et al. (2013) created a methodology for calculating hidden external failure costs. Omar and Murgan (2014) have suggested an empirical mathematical model based on two compounds function: The costs of the traditional PAF model and the hidden opportunity cost component. Mijoč et al. (2014) gave an overview of Contemporary Cost Management (CCM) methods such as Target Costing (TC), Activity Based Cost (ABC), and TQM, then they studied the relationship between these methods and financial performance. Trehan et al. (2015) provided insight into the COQ technical models and the case studies conducted in different organizations, their conclusion was the involvement and support of the top management as well as the interdepartmental coordination are the keys to the success of COQ implementation or Lim et al. (2015) who proposed a COQ optimization model under PAF framework. Alglawe et al. (2019) studied the impact of opportunity costs on the level of quality. Finally, Rogošić (2021) indicated through his study that the more quality managers use accounting information for reporting the more mature quality costing becomes. At last but not the least, is the study where the concept of cost of quality is applied to an anti-counterfeiting product, this idea enables companies according to the authors to assess the return on investments in anti-counterfeiting over time (Wilson et al., 2022).

The second remark is related to the criteria by which these classifications have been made: Essentially the breadth of the spectrum of costs covered by the classification and also the ease of its implementation in the company.

The British standard BS 6143 is divided into two parts; The first part BS 6143-1: 1992 (BSI, 1992) withdrawn in March 2017 highlighted the process cost model (PCA), while the second part BS 6143-2: 1990 (BSI, 1990) also withdrawn in March 2017 which was initially published by the British Standard Institute in 1981 (BSI, 1981), classifies these costs under the PAF model.

BS 6143-1:1992 (BSI, 1992) explained how to implement the COQ system into any process or service and emphasizes two elements: The process measurement and the process pilot. In order for the COQ classification to be simple and easily applicable in any type of company, the COQ classification under process, inspired apparently by Crosby's (1980) research, identified only two costs: Costs of conformance and cost of non-conformance. Costs of conformance are the cost of operating the process to provide a product or a service to specifications, but the costs of non-conformance encompass all the costs of inefficiency associated with the process functioning, that's to say the whole non-essential costs incurred by the company for that specific process like Waste of time, overexploiting human resources, materiel or machines, mistakes… and so on. The standard identifies 4 components of the cost associated with the process: Manpower, material, machine, and environment, so the process pilot is expected to undertake all the necessary changes with the aim of bringing to a minimum level both the costs of conformance and of non-conformance. It's noteworthy to remind that the management by process approach is a condition for the implementation of the process cost model in the organization, so after listing all the process activities, the costs of conformance and the costs of non-conformance could be identified. The detailed method for the assessment of the quality costs, in that case, consists of identifying all the process input/output, controls, and resources employed, whether costs are real or only estimated derived by interpolation from other costs without forgetting to mention the costs data sources for any later checking.

Regarding the second part of the standard, BS 6143-2: 1990 (BSI, 1990) inspired apparently mainly by Feigenbaum (1961), Masser (1957), and Juran et al. (1974) works, it points out the traditional classification of quality costs called PAF, this method basing on this standard splits the quality costs into four categories:

1. Prevention costs
2. Appraisal costs
3. Internal failure costs
4. External failure costs

This standard draws attention to the fact that increased awareness of the failure quality costs within a company leads to a rise in appraisal costs; however, as time and effort are invested in failure prevention activities, both costs of failure and appraisal decrease. This result is an opportunity for the company to perform the quality of its product or service, increase its profitability, and enhance its competitiveness.

The French standard NF X50-126 (AFNOR, 1986) withdrawn in 2008 is considered a guide helping to

evaluate the costs resulting from the non-quality, it invites companies to quantify the costs of the whole failures and anomalies or mistakes in order to be able to reduce their costs and so develop their turnover, this is illustrated by the Fig. 1.

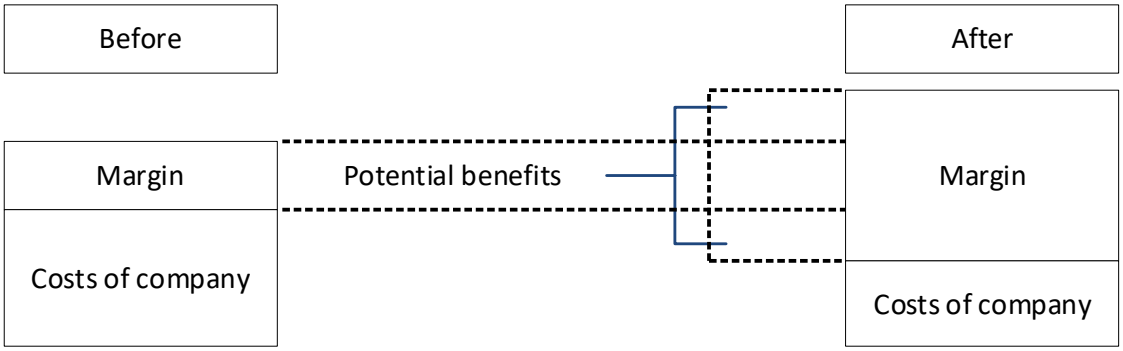

Fig. 1: Enhanced simplified layout of potential benefits due to COQ absorption (NF X50-126: 1986 (AFNOR, 1986))

The company cost reduction by means of dealing with the non-quality costs, according to NF X50-126 (AFNOR, 1986), generates many benefits especially when the company margin is increased Fig. 1 in addition to a turnover increase thanks to customers' satisfaction.

The NF X50-126 (AFNOR, 1986), like the English standard BS 6143-2, differentiates the four following quality-related costs:

1. Internal Failure Costs (IFC): Defined by the incurred costs when the product is out of specifications before shipping to the customer.
2. External Failure Costs (EFC): The incurred costs when the product is out of specification after delivering to the customer.
3. Detection Costs (DC): Costs incurred to check the product conformity to quality requirements; in other words, costs for financing the research of the failures.
4. Prevention Costs (PC): The human and material investment incurred to check, prevent and reduce failures; in other words, costs for financing the actions that help to identify and avoid the causes of the failures.

ISO 8402, published in 1986 and revised in 1994 but canceled later, defined those costs as being the costs incurred by the quality system in addition to the losses inflicted on the company when the quality is not achieved (opportunity costs). But no classification was given through this standard.

In addition to the PAF and PCA classifications, widely discussed in the literature, other such important classifications or methods exist:

- Tangible and intangible classifications elaborated by Juran (1951).
- Opportunity costs of Sandoval-Chávez and Beruvides (1998).
- Hidden costs developed by Taguchi et al. (2005).
- Activity Based Cost method was initiated by Cooper and Kaplan (1998).
- PQC model of Harrington (1987).
- Quality Benefit Cost model was introduced by Bajpai and Willey (1989).

Tangible and intangible costs*:* For Juran, the classification of the quality cost elements between prevention and appraisal, as is the case in the PAF model, creates ambiguity. He considers both prevention and appraisal costs as unavoidable and not necessary to be included in the classification. However, he recognizes the importance of the intangible elements that are usually more essential in the long term, so he suggests the following classification (Juran et al., 1974):

1. Tangible factory costs: They are measurable costs such as scrap.
2. Sales tangible costs: The measurable costs related to customer complaints treatment and warranty costs.
3. Intangible costs: These costs can't be evaluated; for example, in the case of the loss of the customer's purchasing willingness.

Juran (1951) considered intangible quality costs as "gold in the mine" and invites companies to explore them.

The opportunity model of Sandoval-Chávez and Beruvides (1998) defined opportunity costs as being the loss caused by opportunity factors and are broken down into 3 components:

- Underutilization of installed capacity.
- Inappropriate material handling.
- Poor delivery service.

This categorization enables the company to identify beneficial strategies and discover improvement paths. For them, the costs in the PAF model are only a minority of COQ, whereas opportunity costs, called opportunity factors, are the real costs to be determined, which are none other than profits not earned.

These opportunity costs are a part of the intangible cost and could be combined with PAF or PCA model to allow the identification of opportunity factors not covered by these two models.

Taguchi et al. (2005) hidden cost model: The hidden quality costs, or intangible costs, are

generally difficult to evaluate; they are similar to the immersed part of the iceberg hidden under the water's surface. While this unseen part of the iceberg is the origin of the sinking of the majority of the ships that hit it, the hidden quality cost carries most often negative effect on the company's profit (Campanella, 1999). This negative effect continues over time until the company faces serious financial difficulties in addition to the deterioration of its brand image.

Hence, Taguchi et al. (2005) have developed a statistical method to come up with a quantitative approximation of those hidden costs or losses caused by the functional variation of the product. According to Taguchi et al. (2005), hidden costs are the ones that contribute the most to the total cost of quality, since more opportunity costs come with more deviation from target value; Taguchi et al. (2005) used for the QLF function (Quality Loss Function), which is an approximation of the Taylor series around a target value.

ABC Model (Activity-based costing): In the traditional accounting system, it is not possible to break down the overhead costs related to quality on the unit prices of different products; neither the PAF model nor the PCA provides an answer to this in a quality system (Tsai, 1998). The ABC model was elaborated by Cooper and Kaplan (1998) to be able to allocate each activity cost of the company to the product and service so as to assist the managers in making the appropriate decisions whether for the costing, purchase, or improvement strategies. This method has been applied in the management of quality costs in view of its performance.

Harrington model: Harrington (1987), as seen previously in the terminology section, thinks it is more suitable to replace the concept of cost of quality (COQ) with the poor quality cost commonly called the non-quality (Poor Quality Cost: PQC). The model implemented by Harrington (1987) aims to correct the idea that a higher quality product means higher cost, and to change the managers' attitude toward quality, when it was believed that better-quality products cost more to produce, reminding that whatever it is called it doesn't affect the objective of reducing the cost associated with poor quality (Harrington, 1999). The system set up by Harrington (1987) is split into two categories:

1. Direct costs: These include the controllable costs (prevention and appraisal), the resultant costs (costs of internal and external errors), and the equipment PQC.
2. Indirect costs: These are the non-measurable costs. These are divided into four sub-categories: PQC costs inflicted on the customer, customer dissatisfaction costs, loss of reputation PQC (brand image), and opportunity loss costs.

Kélada model: Kélada (1992), through the model he proposed, attempts to overcome the limitations of the PAF model allowing only the direct tangible and visible costs relating to the quality of the product or service provided by the company to be represented. For Kélada (1992), the quality-related costs that the author named costs-quality include direct costs and indirect costs, tangible, calculable costs, and intangible costs that can only be estimated. His classification is not far from that of Harrington (1987) and goes as follows:

- The direct costs of non-quality:

1. Quantifiable costs: Such as the costs of resuming poorly done work or penalties for late delivery.
2. Non-quantifiable costs: Among these costs, one can list, for example, the loss of an order or a customer following the sale of a product of insufficient quality.

- Indirect costs relating to quality: These costs are indirectly linked to the quality of the product or service sold, they are of two types:

1. Quantifiable costs: Such as the overhead costs and the labor costs of correcting non-conforming items.
2. Unquantifiable costs: Such as the costs of the negative effects on the image of the company, on its competitiveness, or on its whole value due to poor quality.

Quality benefit model: Some authors believe that it is necessary to develop a quality tool so that quality is seen and evaluated in terms of benefit rather than cost (Bajpai and Willey, 1989). This is why we should speak about the quality benefit model instead of quality cost as long as the costs due to improvement and prevention activities are a form of investment, with a return on investment through reduced quality costs (Porter and Rayner, 1992). Nevertheless, this model still requires further research for modeling the real benefits in the long term regarding the investment in quality management instead of assessing only the effect in the short term on the quality costs of a product, service, or process (Wang et al., 2010).

2.3. Criticisms identified in the literature on COQ classifications

The literature review enabled us to identify several criticisms regarding the dominant classifications of COQ. These criticisms can be divided into two categories: General criticism of all the classifications, and criticism that mainly targets the PAF model.

General criticisms focused on the difficulty of implementing the COQ models and exploiting the generated information. In fact, the program COQ represents an administrative nightmare due to its heaviness to the point that some professionals consider it as an obstacle to quality, which pushes companies to abandon it (Johnson, 1995). Montgomery (2013) asserted that among the reasons why companies ignore these COQ models is

the difficulty of using COQ information as a tool to generate opportunities. In addition, top management underestimates the necessary involvement for the prevention quality measurements, for which the investment must be not less than 5 to 6% of turnover.

Moreover, analysis of the data by the accounting system often requires significant time. In this direction, Merino (1990) noticed the incompatibility of the conventional accounting system with the new environment of production highly automated and continuously evolving. As an example, he specified the inability of the accounting system to measure the benefits of the improvement of quality. This discrepancy is perpetual for Dale and Plunkett (1991).

Regarding the PAF model, some authors mention the confusion that may arise when classifying the different costs. For instance, there are authors who consider testing to be part of the production process that shouldn't be classified with appraisal costs, but still, others think that all the test operations should be included in the appraisal costs to be a long-term reduction target (Carson, 1986).

Whereas Dale and Plunkett (1991) question whether the tests should be viewed as being part of the COQ, in which case the question arises whether they are prevention costs or appraisal costs, or considered as production operations. This confusion is not limited only to the test tasks, because according to Oakland (2014), it is difficult to identify the activities that fall under the prevention category since everything that a well-run company does is linked directly to the prevention of quality problems (Oakland, 2014).

In fact, for Oakland, there is a whole category of prevention activities in industry or service that is an integral part of the quality insurance, which could never fit into the report of the quality costs. Moreover, he asserts that this model implies a level of quality where the quality/cost ratio is optimal and beyond which there is a compromise between the investment in preventive actions and the failure costs, which is not in line with the TQM philosophy, that's to say the PAF model has a limited application in the case of TQM program (Tsai, 1998).

Among the criticisms regarding these classifications is the fact that they don't take into account either the intangible costs (Porter and Rayner, 1992) or the opportunity costs (Sandoval-Chávez and Beruvides, 1998). Along the same line, Juran et al. (1974) thought that the PAF model is only adapted to individual projects and that the prevention and appraisal costs are inevitable and therefore to be neglected and suggested integrating the intangibles costs. Johnson (1995) stated that some costs incurred by the failures can't be effectively quantified such as the loss of the intention for purchasing. In addition, it seems that the components of the PAF model aren't suitable for all kinds of activities which leads some companies to set up their own elements of quality costs (Dale and Plunkett, 1991).

3. Results

It has been seen before that the PAF model can be broken down into costs of prevention, appraisal, and internal and external failure costs. The PCA model only contains two categories: Cost of conformance and cost of non-conformance. The first category encompasses the cost of prevention and appraisal (PAF model); whereas, the latter includes internal and external failure costs (PAF). The prevention and appraisal cost of the PAF model as well as their equivalence in the PCA model could be grouped into the category of costs of achieving quality, and those of internal and external failure could be grouped into the category of costs of the poor quality (Freiesleben, 2004). So the two models PAF and PCA can respectively be illustrated as follow in item (4) and item (1) in Fig. 2, noting that the PAF model (item 4) is used as a common reference for comparison with other classifications.

In the tangible and intangible cost model, the most important costs for the company are the intangible costs (item 5) which can only be estimated such as the loss of brand image, and the escape of customers (Juran and Godfrey, 1999). These costs go beyond external failures as defined by the PAF model (given its limit with regard to the incorporation of such costs (Freiesleben, 2004), and may also include a part of internal failure costs, for example, the decrease in staff motivation in the case where products have to be remade following customer rejection. While tangible costs include the costs of prevention and appraisal and almost the totality of tangible internal failure costs.

The opportunity costs (item 3) as defined by Sandoval-Chávez and Beruvides (1998) are illustrated by a small bar intersecting both with a part of internal failure costs and another part with external failure costs (PAF model). The poor handlings of equipment inside the plant or a breakdown in a machine in the production line are some examples of internal failure while delivering poor service is an example of external failure. The second bar, in item 3, integrates the other opportunity costs that go far beyond the classical failures issued from the PAF model, they are intangible costs derived, for example, from delivering a poor product or service causing the loss of customer goodwill. These may have serious consequences in terms of not only losing the specific customer and all their sales but losing the company's reputation and the customers that go with it as well (Alglawe et al., 2019). The opportunity costs may value more than expected, they simply represent the not earned benefit resulting from customer dissatisfaction and the reduction of business income (Wang et al., 2010).

In Harrington's (1987) model (item 7), The indirect costs, as defined, correspond to the aforementioned opportunity costs as well as some intangible costs such as costs of customer dissatisfaction and loss of reputation, thus they have been illustrated, as being a part of intangible costs, in

Fig. 2 by a bar slightly longer than the bar of opportunity costs model, whereas the direct costs, which are the controllable costs as well as equipment PQC, cover the area of prevention and appraisal costs of the PAF model as well as the area of internal and external failure costs, these last costs are considered as resultant costs in the Harrington's (1987) model, in other words, the direct costs according to Harrington (1987) are equivalent to equipment PQC added to PAF model, this is why the bar representing these costs is a bit larger than the one of the PAF model.

Taguchi et al. (2005) proposed a different view of quality, one that is related to costs and loss of money, not just to the manufacturer at the time of production but both to the consumer and society. So, Taguchi et al.'s (2005) model (item 6) does concern only the finished failed product shipped to the customer and just covers the hidden part of the external failure costs (PAF model) or even a part of the intangible costs.

With regards to the ABC method (item 2), it makes it possible to identify all the costs of the activities of production processes as well as the raw material. Activities in this context are of two types, those that create added value and which influence the quality of the business process or the product (Mijoč et al., 2014), their costs can be assimilated, in our opinion, into the prevention and appraisal costs of the PAF model. The second type is about the non-added value activities, whose costs can be identical to failure costs according to Mijoč et al. (2014) (PAF model). The company is, basically, in a constant struggle to eliminate the non-added value activities.

Kélada (1992), although his works are barely cited, still be a pioneer in the field of quality; through the model he proposes, the quantifiable part of the costs directly linked to the quality of the product or service could be assimilated into all the costs of prevention and evaluation including a part of indirect costs that are always quantifiable (item 8). This extends to failure costs mainly external ones, while its non-quantifiable part (direct and indirect costs) is similar to an important portion of intangible costs of the Juran model (model 5) such as loss of customers or the negative effect on the company's reputation, without neglecting another portion of non-quantifiable direct quality-related costs which reflects internal failures like staff demotivation because of the job to be redone. One can deduce then that the non-quantifiable costs, either direct or indirect ones, go beyond the costs considered by the PAF model, and may intersect with opportunity cost (item 3), with intangible costs (item 5), with indirect costs of Harrington (1987) (item 7) or even with a good portion of the cost-benefit model (item 9) that will be seen later.

It is important to remind that the Cost Benefit Model as represented hereafter in item 9 of Fig. 2, is distinguished by comparing it to the other models by the fact that the costs of quality through it are considered as being an investment for which the company expects to have benefits over time (Wang et al., 2010). Such benefits include namely the reduction of failure and appraisal costs, improvement of productivity, market share growth thanks to quality enhancement and a price cut, business stability, etc. as stated in the chain reaction of Deming (2000). All these benefits a priori exceed the intangible costs of Juran et al. (1974), the unmeasurable costs of Kélada (1992), the indirect costs of Harrington (1987), and the opportunity costs of Sandoval-Chávez and Beruvides (1998). This is what explains the length of the horizontal bar (Fig. 2) of the benefit in the Cost Benefit Model which is greater than all the other bars. Nevertheless, it seems to be difficult for companies to assess the real benefits harvested over time (Bajpai and Willey, 1989). In that case, the calculation of the return on investment only makes it possible to evaluate a part of the benefits of the investment through the TQM program. For this reason, the cost-benefit model requires much more development for a better evaluation over time of the quality-related benefits.

Thereby, Fig. 2 illustrates the different correspondences between the COQ models discussed above. The ultimate target of all these classifications is given vertically by the acronym PROFITS KB, where each letter stands for a model; that could mean, for easy memorization; «PROFIT is Key to Business» which best expresses the finality of the business in the dominant paradigm.

If the spectrum of costs covered by each model, is considered, as a criterion of evaluation, it is obvious that the Cost Benefit Model is the best (item 9), it exceeds Kélada (1992) as long as it seeks the long-term benefits of the costs of quality investments, not just the cost aspect as defined by Kélada (1992) and others due to quality or non-quality or even over-quality. Notwithstanding, if we consider operationality as a second criterion, the Kélada (1992) model would be the best model among all because it is suitable for practical application, unlike the cost-benefit model with no detailed practical categorization. The Kélada (1992) model (item 8) is then followed by the intangible cost model (item 5) and the Harrington (1987) model (item 7). Yet the combination of the PAF (item 4) or PCA model (item 1) with the opportunity cost model (item 3) occupies also an important rank.

4. Discussion

As previously seen, the literature is replete with criticisms of the different COQ models. All the criticisms follow the same path, whether the difficulty of implementation in the company or the failure to take intangible costs into consideration. In the end, it is nothing else than the maximization of the company's profit. Feigenbaum and Feigenbaum (2005) in this sense considered that quality is not only a set of techniques but also a means of federating, inspiring, and integrating efforts of managing for profitability and growth; The COQ models then are not an exception to this rule, because they have all been designed for the sake of

reducing quality costs and so maximizing the profit of the company (He, 2010). So, it's quite legitimate to ask this question: Is it wrong for companies to seek to minimize their costs and maximize their profits?

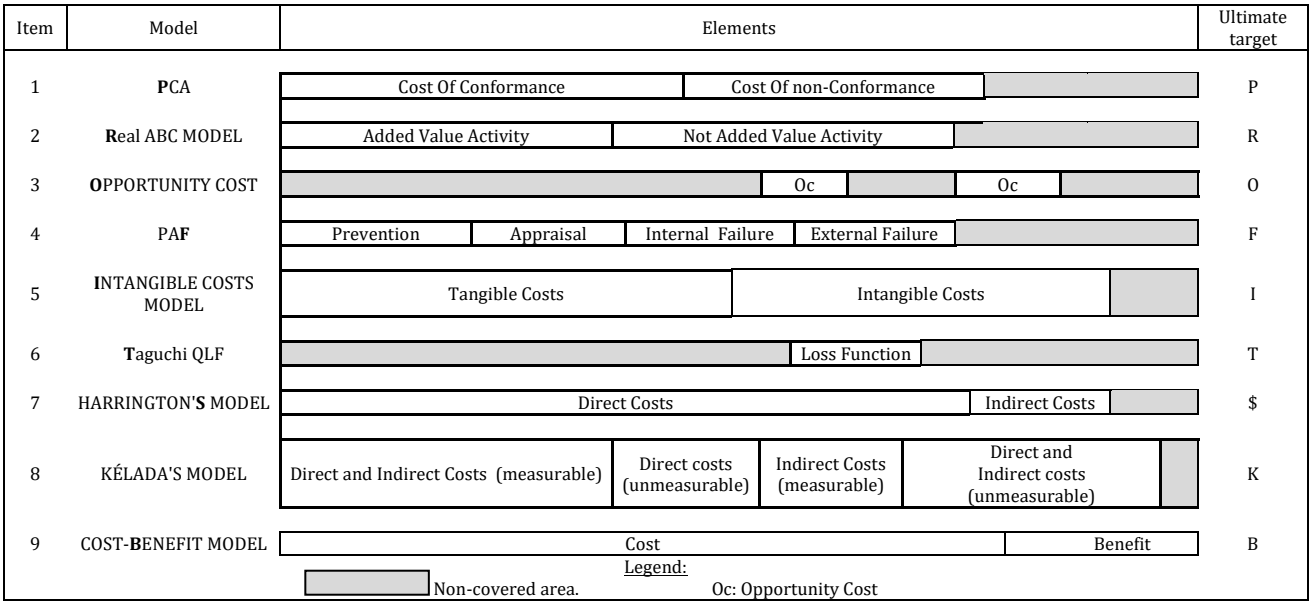

Fig. 2: Correspondence diagram of COQ models

Take as an example a company that manufactures smartphones. The commonly admitted scenario is that this company optimizes its costs of production and at the same time takes care of its brand image in order to attract as many buyers as possible. Moreover, to be able to sell more products, this company employs psychological and programmed obsolescence in different ways: Limited lifespan component, architecture making repair more expensive than replacement, and obsolescence of software preventing correct use. That is a fad effect, pushing the "trained" consumer to change a functional device with a more recent model, etc. We meant by "the trained" consumer, the consumer that is continuously trained to be guided along by its trainer the company. All these practices go in the direction of maximization of the company's profit. That said, what would happen if the angle of view is changed? Supposing that the majority of the consumers haven't been trained to accept the previously described situation, in that case buying a new mobile while the old one is still functioning doesn't represent a loss for the consumer. Is it possible then to say that the consumer's costs are optimized? It's clear in that case that the maximization of the company's profit is obtained at the expense of the consumer's spending. This cost issue doesn't only affect the business and the consumer; it also affects society, the environment, and other stakeholders. Indeed, some products generate losses for the consumer. Let us cite the example of smoking in France whose social costs in 2010 amounted to 122 billion euros, or 6,3% of the GNP of the country, whereas taxes revenues from smoking in the same year didn't exceed 10 billion euros.

Another significant cost is the one linked to the environment which impacts not only the present generations but the future ones as well. The example seen of the digital devices is a perfect illustration of this issue. Thus the manufacturing of a Smartphone weighing 150g requires 183kg of raw materials that to say a MIPS index (Material Input Per Service unit) of about 1200/1 while the manufacturing of just 2g integrated circuit requires around 32kg of chemical substances equivalent to a MIPS of 16000/1. So what about the harmful environmental effects resulting from extracting these resources from nature, and damage caused during the processing without forgetting the effects in the phase of consumption until disposal in the end-of-life stage?

It is obvious based on the above examples and analysis that the existing COQ classifications consider only the costs of the company; the other stakeholder's interests are disregarded. In this case, how should it be proceeded to take into account all the stakeholders 'costs in the COQ system and so fill this gap?

The simplest answer to this question is to integrate these costs (losses incurred to customers, to society, to the environment, etc.) into existing COQ models. But is this the right way to proceed?

It has been already explained that the dominant paradigm states that the only reason for a company's existence is profit; making anything else a constraint. The contemporary business cycle is then schematized in Fig. 3.

In this situation, the interests of parties other than the company could be integrated only into the category of the constraints that the company tries to circumvent. Fiscal optimization is one example. For businesses, paying taxes is a constraint that absolutely should be avoided even if paying taxes is considered in some countries as an act of patriotism.

Being aware these costs are built into the existing COQ models, companies though will try to get around them in the first place. In the current era, this situation seems quite understandable, in a world of

business revolving around profit. In this regard, Friedman (2007) criticized the idea that the company is not only concerned with profit but also with social goals such as employment, elimination of segregation, and avoiding pollution.

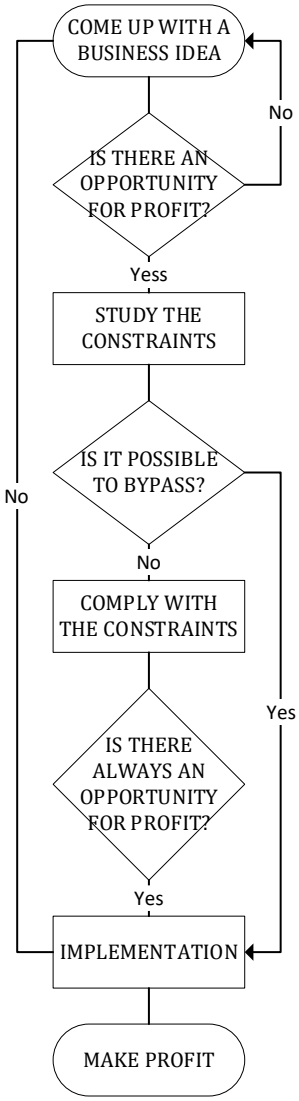

Fig. 3: Business cycle in the dominant paradigm

Friedman (2007) claimed that the unique motivation of the business is money, nothing but money, and all that doesn't bring in money is not welcome no matter how it's benign, noble, and fair it might seem. In this case, every new criticism of the different existing COQ models, which doesn't go beyond the framework of this paradigm, will undoubtedly disregard the consequences of the maximization of the profit on third parties. Therefore, a paradigm shift is key to changing how the company is seen, revising priorities in the business, and then the pursuing profit will be framed by other adequate guidelines provided by the new paradigm. The business cycle consequently becomes Fig. 4.

The question is which new paradigm to choose. In our opinion, in such a transition from the present paradigm to the future one must place the whole business at the service of humans, by identifying and exploring for example sustainable practices over the whole life of a product or service. This represents for us the main track to be explored through extensive research. Suggest a COQ model integrating the costs of all the stakeholders could be also of interesting value for further research.

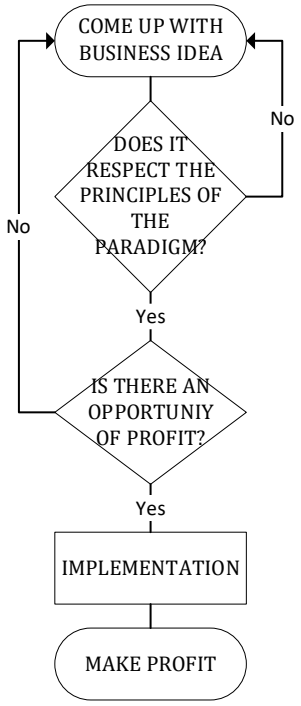

Fig. 4: Business cycle in a paradigm other than a paradigm of profit

5. Conclusion

This article is a literature review of the main quality-related cost models existing in the dominant paradigm. To avoid any confusion, defining the terminologies associated with the quality-related costs was the starting point ahead of listing the main COQ models published in the literature.

Despite the widespread acceptance among the scientific community of quality cost system and its practical use by a number of companies, this system is subject to much criticism such as the difficulty of implementation, the inadaptability to the traditional accounting system, or its limit to cover all the costs related to quality, but we think that the core critique ignored in the different contributions to this field is the finality of the COQ models. These models are designed by the companies for their own benefit, whereas all the stakeholders should be involved to take their specific and general needs into consideration. Customers, employees, and owners as individuals each have specific needs to satisfy despite the possible contradiction among them, while as a group we are confronted collectively with enormous social and environmental challenges to which effective solutions must be provided.

The result of this work is the diagram proposed which is a synthesis of the main existing COQ models seen before, the profit as the main target of all these COQ models is clearly highlighted. A paradigm shift toward sustainable practices is urgently needed,

where the quality-related costs of all the stakeholders are accounted for, not only during production or consumption but through the whole product or service life cycle. In short, the new paradigm should bring answers to the present and future challenges solely for the sake of human welfare. To guide new research, a new COQ model is therefore to be designed within the chosen working paradigm. That model should go beyond the limitations of the existing COQ models, and overcome all their shortcomings while considering the cost generated for all the stakeholders (customers, employees, owners, environment, the entire society in general, and others if they exist).

Afterward, the implementation in an organization of the new model enables checking its feasibility and study of the constraints and the difficulties it will probably be exposed to.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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