Quality costs analysis in the service sector: an empirical study of the Colombian banking system

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ABSTRACT

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Since almost a century ago, quality has been a key factor of any business, and managers are continuously taking decisions to reach the adequate level of quality in order to be competitive. Therefore, measuring Cost of Quality (COQ) is a critical but challenging task. According to both academicians and practitioners, the COQ approach seems to be much more used and explored among manufacturing companies rather than among service organizations. One of the main reasons is the existence of a tangible product in manufacturing, which makes the measurement of defects, rework, and scraps, and the standardization of one single model for different companies relatively easy, while defining similar cost categories is quite challenging in service company settings. Even though the literature suggests a possible applicability of the COQ model to services under the concept of both product and process performance, no practical examples of measuring COQ from the product performance perspective in service companies could be found (with an exception of software companies which present some similarities with manufacturing). Therefore, this thesis explores the possibility of the application of the COQ model under the concept of product performance to a service company, and develops a case study in three Colombian banks. As a result, this research proposes an adapted model of COQ for the banking system that could stand as an operational index offering a practical insight about quality costs to managers. The model integrated the classical PAF (Prevention-Appraisal-Failure) method with significant exogenous and endogenous variables that affect quality in banks. Furthermore, some statistical analyses were performed in order to validate the used data, to correlate operational indices and quality costs, and to identify the factors that have the highest impact on these costs in banks.

Key words

Cost of Quality (COQ), service companies, banking system, operational risks, and opportunity costs.

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To the memory of my father and my grandmother who built the foundation of what I am.

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I. INTRODUCTION

Since businesses nowadays must be efficient in gaining market share and obtaining better margins revenues, managing quality and measuring its cost has become a critical challenge for many companies. One of their main factors of success is to find the best quality level at the minimum price. The Cost of Quality (COQ) is a methodology which can be used for this purpose. Commonly, the quality costs can be calculated either based on product performance or process performance. The product performance perspective is a long term business strategy that analyzes the quality costs of the product life cycle and that involves the whole organization; on the contrary, the process performance view is a short term strategy that analyzes opportunities of savings and involves, generally, just one unit of the business.

In the literature, there are many case studies describing the measurement process of COQ under the business process concept in both service and manufacturing companies; whereas the product concept seems to be much more common in the manufacturing industry than in services. As a matter of fact, both academics and practitioners agree that COQ analysis, which is more practical in manufacturing, is quite challenging in services. The reason is that the existence of a tangible product makes the measurements of defects, reworks and scraps within a manufacturing environment relatively simple tasks, while in services these terms may not even exist. Therefore, when a service company performs a COQ analysis, most of the time it limits its scope to a particular process in one of the company's unit. Service companies do not find the application of this approach in the whole organization practical and cannot thus consider it as a company's quality strategy.

In the reviewed literature, there is just one known COQ-based method specific for services. Carr Lawrence (1982) introduced a COQ-based method applicable to service where the method integrates PAF (Prevention-Appraisal-Failure) with the cost of opportunity. He implemented this method in a unit of a service company in order to find opportunities of quality improvement in some of the key processes.

Likewise, within practitioners, there are not many practical cases, in the recent edition of "The principles of cost of quality"[57] the American Society for Quality mentions just three cases two in education and just one in banking (One Corporation); however, all these cases apply PAF

methodology with the purpose of looking for cost reductions in a particular process in a business unit, rather than applying COQ as a managerial tool that gives a wide insight of quality costs and helps managers in decisions-making. Additionally, these exercises are conceptual, and as the authors identified the collection of quality costs information as their major obstacle, these studies lack the validation of the models against a consistent dataset

Another aspect that makes the application of COQ in services challenging is the fact that within service companies there are significant differences in the production's pattern and the quality dimensions; hence, a COQ model may not apply to more than one company. For instance, the supply chain in a restaurant by far differs from the one in a consulting company, because while a restaurant may work with many vendors and its client is in the last tier of the supply chain, a consultant company could work with a single supplier and its client may participate in the production of the service.

In fact, when comparing the studies of applications of quality costs in services, the suggested models presented differences in the quality costs identification and classification. Moreover, except for the case of software companies, in the case of Banc One Corporation there is no evidence that this model is applicable for other similar organizations. This case merely presents the principal results, but it does not validate if the model could be applicable in other similar companies.

For those reasons, the presented thesis proposes a methodology for measuring COQ under the concept of product performance in banking and tests whether this approach is applicable and could stand as a standard method for similar companies. To achieve this goal, this thesis developed the following outline:

In the first chapter, the literature review presents a general description of the studies and theories of COQ and highlights the principal differences between manufacturing and service companies. The chapter is concluded by the identification of the principal gaps in the application of quality costs analysis in services.

In the second chapter the most important part of the research work is developed. It presents the research methodology and principal results. It contains three main parts:

The first part describes the banking service background. This section includes an analysis of the business nature of a bank, the most common quality approaches in this sector, and the most influential variables in the quality functions of a bank. It also points out why nowadays the collection of quality costs in banks may not be a major obstacle, fact that facilitates a COQ analysis in this sector.

The second part describes the model definition. This section presents the detailed steps in the development of the proposed COQ model for a banking system: First, the main considerations and assumptions are outlined, then the main activities are defined, quality costs identified and, finally, the final model, which is the principal result of this work, is proposed.

The third part describes the case study of the measurement of COQ in three of the major Colombians banks applying the suggested model. This case contains a brief description of the Colombian banking system background, details of the data gathering, results of statistical analysis, and the definition of a COQ benchmark for the Colombian banking sector.

Finally, the thesis points out conclusions, contributions, limitations and future works in this matter.

II. OBJECTIVES

MAIN RESEARCH OBJECTIVE

- Define an adapted COQ method for banking system that can be used as a managerial tool at the director board level, considering the standard banking products or portfolio and the nature of the finance business.

SPECIFIC OBJECTIVES

- Develop a case study performing a practical measurement of quality costs in three of the major banks in Colombia.
- Identify the relationship between the quality costs measurements and some of the principal operational banking indices in the three banks in order to detect general patterns.
- Define a COQ benchmark index for the Colombian banking system.
- Investigate the factors influencing a bank cost of quality function.

1. LITERATURE REVIEW

1.1 Quality definition

As S. Thomas Foster says [1], there are several definitions of quality. However, according to David Garvin [2], most of the definitions could be categorized as:

- **Transcendent:** Quality is something that is intuitively understood but nearly impossible to communicate, such as beauty or love.
- **Product-based:** Quality is found in the components and attributes of a product.
- **User-based:** If the customer is satisfied, the product has good quality.
- **Manufacturing-based:** If the product conforms to design specifications, it has good quality.
- **Value-based:** If the product is perceived as providing good value for the price, it has good quality.

1.2 Product Quality Dimensions

The categories of quality show that quality is not a one dimension definition, since it depends on different aspects. Although, many experts have identified many dimensions of quality (products based) on some concepts as durability, conformance of design's specifications, safety, credibility and access, Garvin [2] identified eight product quality dimensions that are the most widely cited and used Table 1 shows Garvin's product Quality Dimensions.

Garvin's Product Quality Dimensions	
Performance	The efficiency with which a product achieves its intended purpose
Features	Are the attributes of a product that supplement the product's basic performance
Reliability	The propensity for a product to perform consistently over its useful design life
Conformance	Refers to the conformance of the design specifications
Durability	Refers to the degree to which a product tolerates stress or trauma without failing
Serviceability	Refers to the fact that a product can be repaired in a cheaply manner.
Aesthetic	Are the subjective sensory characteristics such as taste, feel, sound, look and smell
Perceived quality	Is base in customer's opinion

Table 1 Garvin's product Quality Dimensions [2]

1.3 Service Quality Dimensions

Although services and products shares some attributes, service quality is difficult to define, because the customer is more involved in the life service's cycle. For instance, considering the conformance dimension, where a product in the phase of production accomplishes, or not, the specifications according to some standard, while a service accomplishes, or not, the specifications according to customer opinion. This is however not unique as it depends on the mood, time, culture, education, etc.

Parasuraman, Zeithamel, and Berry (PZ&B), defined the most widely recognized set of service quality dimensions .Table 2 lists and defines PZ&B Service Quality Dimensions [3].

PZ&B Service Quality Dimensions	
Tangibles	Include the physical appearance of the service facility, the equipment, the personnel, and the communication materials
Service reliability	Differs from product reliability in that it relates to the ability of the service provider to perform the promised service dependably and accurately
Responsiveness	Is the willingness of the service provider to be helpful and prompt in providing service
Assurance	Refers to the knowledge and courtesy of employees and their ability to inspire trust and confidence
Empathy	Refers to the customer's desires of caring and individualized attention from the service firm

Table 2 PZ&B service Quality Dimensions [3]

Similar to the product quality dimension, academics and practitioners have identified other dimensions such as timeliness, availability, professionalism and so on. S. Thomas Foster asserts in his book "Managing Quality" that "service design strives to address these different service dimensions simultaneously. It is not sufficient for a service firm to provide only empathy if responsiveness and service reliability are inadequate."[1].

1.4 The differences in quality between service and industry

1.4.1 Service characteristics

As it is mentioned before, service is different from manufacturing in several aspects. First, several services characteristics are intangible, which means they cannot be inventoried, carried on stock or transferred. The lack of available measurable dimensions may be the principal difference and it makes difficult to measure quality in services. According to Gronroos [64]. There are other differences such as homogeneity, time of production and consumption, inventory and so on. Table 3 shows Gronroos's differences list:

Physical Goods	**Service**
Tangible	Intangible
Homogeneous	Heterogeneous
Production and distribution separated from consumption	Production, distribution, and consumption are simultaneous processes
A thing	An activity or process
Core value produced in factory	Core value produced in buyer-seller interactions
Customer do not (normally) participate in the production process	Customer participate in production
Can be kept in stock	Cannot be kept in stock
Transfer or ownership	No transfer of ownership

Table 3 Differences between services and physical goods. Gronroos, [64]

- The outputs in service are **heterogeneous.** This means that as long as costumers, companies and employees change there are no identical services.

- **Production, distribution and consumption are simultaneous processes**, e.g. in a restaurant or a hotel the customer receives the service at the same time that it is produced. S. Thomas Foster [1] asserts that this fact forces service providers to do it right at the first time. A service cannot be easily repaired or reworked, for example if during a hair dresser service there is an error the likelihood of correcting something is low.

- Services are produced as an **activity or a process** and the core values are created in **buyer-seller interactions**

- The aspect of **customers contact** is more involved in the production of the service, and sometimes the customer participates in the production e.g. in a coffee shop when the client serves his own coffee. This is called **customer coproduction** which leads to a high degree of customization where variables as customer mood and feeling can affect the service quality perception.

- Other authors also mentioned **perishability** as a characteristic of service, meaning that the process output provides customer benefits for a limited duration. [4]

- Other difference is the service **liabilities**, whereas product liabilities refer to the warranties around safety concerns, in service they refer to malpractices related to the professionalism of the service provider and whether reasonable measures were taken to ensure the customer's well-being.

Nevertheless, although service attributes could be similar in many cases, the classification of service companies is very broad. For instance, the service attributes in a hospital by far differs from those in a prison [1].

On the other hand, quality experts assert that because customers are more involved in the creation of service, they create problems for the service provider. It makes the standardization of times, processes and capacity plans difficult.

S. Thomas Foster [1] identified three major concepts that affect the approach to quality by service provider: intangibility, simultaneous production and consumption and customer contact. The last one also implies a high interaction of the employees, and the attitude of employees is therefore a key element in achieving high quality in services.

Other important researcher in the field of service is Dr. Scott Sampson who has identified some aspects that make service different from other sectors; he identified these main differences as a "propositions" [4]:

- *Proposition 1:* The unified service theory: The customer provides significant inputs into the production process and this individual customer consumes the output.

- *Proposition 2:* The unreliable supplier dilemma: With services, the customer suppliers often provide unreliable inputs. This simultaneous relationship as supplier and customer makes it difficult for the service provider to control the supplied inputs.

- *Proposition 3*: Capricious labor: "With services, customer-labor may ignore, avoid, or reject technologies or process improvement, which are intended to increase quality and productivity. As a result, customer buy-in to process change must be carefully addressed"

- *Proposition 4:* Everyone presumes to be an expert: "With services, the customer often provides product specifications (what to make) and process design (how to make it), often without the invitation of the service provider"

Sampson [4] also makes reference to the service paradigms:

- Residual: Services are economic activities not accounted for by other sectors of the economy. "However, even recent industrial classification schemes acknowledge that services cover a "wide variety" of industries, with no clear indication of common managerial issues.

- Non-ownership: Services are transactions wherein the object of the transaction is other than the transfer of ownership of a tangible commodity.

- Act/performance: Services are acts performed by one entity for another entity.

- Rental/access: "Services offer benefits through access or temporary possession, instead of ownership."

Also, in service paradigms related to operations, Sampson mentions the Chase's [4] fundamental argument, which points out that the potential operating efficiency of services is limited by the amount of customer contact with service employees. In fact, Chase goes as far as to propose the famous equation:

$$\text{potential operating efficiency} = f\left(1 - \frac{\text{customer contact time}}{\text{service creation time}}\right)$$

" [4] [5]

These paradigms are the foundation of the most known theory in service, the **"Unified Service Theory"(UST),** defined by Scott E. Sampson and Craig M. Froehle. "The Unified Services Theory states that all managerial issues unique to services stem from the fact that service processes involve customer inputs."[6] Additionally, under this theory, the authors define the principal components of a service (Principal inputs: customer and production process).

From the customers point of view, according to Wemmerlöv [65], the classification of service is made in function of the customer inputs: the customer's self, his belongings or other tangible objects, and information [6]:

- **The customer self-input is common in coproduction service**, where the presence of the customer is necessary to produce the service as it is in a hospital, restaurant or transportation service. If the train or bus should go with empty seats, according to Scott [4] that is not called "production".
- **Tangible belongings** (or property) and physical objects that the customer can provide to produce the service, e.g. a car or clothes repair service.
- **Customer-provided information** is the case of a bank or consultant service where the client provide financial information as process inputs. Without that information the service production process cannot begin.

Related to the production process of a service, in the Unified Services Theory, the unit of analysis is a production process. The authors consider "production" to be modifying inputs in a way that is valued by customers. It means that every unique service offered is a process that leads to sales; however, this theory also mentions that there is a group of a no-service processes, also called "**support processes**", that do not lead to sales, but could affect them. For example, although a client in a restaurant does not pay directly for the cleaning of the place, this cleanliness may affect the service. The important aspect in this idea is that in general, supporting processes are executed without customer inputs [6].

Additionally, the UST identifies the schemes that have at their core a classification of customer inputs. For example, The Service Process Matrix [24] shown in Fig. 1 classifies different kinds of services in order to identify the level of customization and to support decision making in the business. The variables the Service Process Matrix uses to classify services are (a) service customization and customer interaction, and (b) labor intensity.

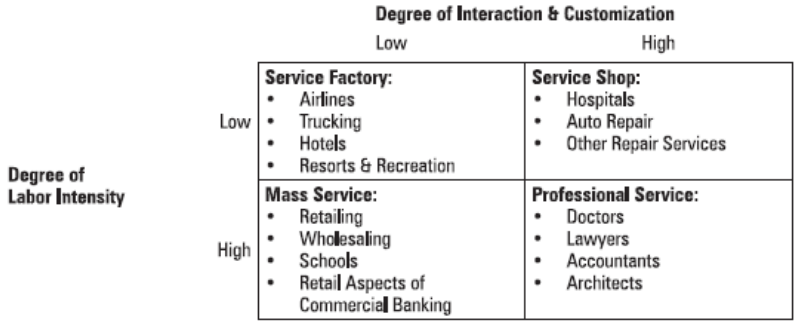


Figure 1 The Service Process Matrix [24]

Based on the past analysis Table 4 summarizes the principal differences between manufacturing and services.

Physical Goods (Manufacturing or industry)	**Services**
Tangible	Intangible
Homogeneous	Heterogeneous ("Heterogeneity- Refers to the potential for high variability in service delivery" [25]
Production and distribution separated from consumption	Production, distribution, and consumption are simultaneous processes (Inseparability [25])
A thing	An activity or process
Core value produced in factory	Core value produced in buyer-seller interactions
Customer do not (normally) participate in the production process	Customer participate in production
Can be kept in stock	Cannot be kept in stock
Transfer or ownership	No transfer of ownership
Perishability and not perishability	Perishability
Liabilities refer to warranties around safety concerns	Liabilities refer to malpractices related to the professionalism
Less or null interaction of the employees with customer	In most of the service cases, strong interaction of the employees with customer
Easy to standardize	Difficult to standardize

Table 4 Sum up of differences between manufacturing and services. Adapted by the author. [1],[4],[64]

To make it simple, one may say that services differ from goods in terms of production, consumption, and evaluation [25].

1.4.2 Types of Service Sector

Within academics, the most important classification is presented by Gronroos [64][25]:

(a) **High-touch / high-tech services**: They are characterized by the need for people and employees during the service process. In contrast, high-tech services, as the term suggests, rely mostly on the use of information technology and automated systems for service production. Such businesses include, for example, internet retailers and telecommunications' companies. It is important to note that, even though these services are largely high-tech, the high-touch or human factor becomes increasingly important when there are complaints, technology failures or when help is needed. In these cases, the service encounter, since service interaction until that time was non-existent and occurs only at a time of need, will be extremely critical. Failure to satisfy customer expectations in these cases may result in negative outcomes with unforeseen possibilities for customer recovery.

(b) **Discretely / continuously rendered services:** When services follow a continuous flow of interactions between customer and service provider then there is an opportunity to develop valuable relationships. Such services include banking, cleaning, security and others. Firms offering discrete services include hair-stylists, restaurants, hotels, repair firms and others. These types of service firm do not have the same opportunity to create valued relationships as the continuous flow services; even though they are profitable as business entities, relationships with customers are more difficult to create and retain. On the other hand, firms offering continuously rendered services rely on repetitive transactions and cannot afford to lose customers since the costs of attracting new customers are relatively higher.

However, Sampson and Froehle [6] point out that there is no single, comprehensive, and consistently used unifying structure that defines what services are and what they are not making difficult finding patterns in terms of the managerial and operational implications. These authors also assert that the concept of service sometimes may be ambiguous, since a company that does not manufacture anything goes under the classification of service seeing those as "residual", hence, this fact shows that services companies differ widely within them.

In analysing service, other important conclusion that Sampson and Froehle [6] make is that if something is a service, its outputs might tend to be intangible and labor intensive, but not the other way around.

Therefore, it has been difficult for researchers to standardize a unique list of types of services. However, some practitioner and academics agree in the classification of service sector as the "soft" parts of the economy such as insurance, tourism, banking, retail and education. Others include [7]:

- Franchising
- Restaurants
- Retailing
- Entertainment, including the record industry, music industry, radio, television and movies
- News media
- Leisure industry
- Transportation
- Consulting and investment advice and services

Public sector could be also considered as a part of the service sector when the company provide services to people.

Other categorization is **voluntary** and **involuntary** services, the voluntary services are those that the customer seeks out actively (e.g. a restaurant, a bank or a cleaning service), whereas in the involuntary service the customer does not seek the particular service even if he/she uses it (e.g. and hospital, prisons, police service and so on) [1].

1.4.3 Supply chain (SC) in services

Some authors on supply chain management claim that the general principles of SC are applicable to services, yet most of the presented examples are from manufacturing supply chains [6].

In a comparative analysis Sengupta *et al*.[16], highlighted similarities and differences between the two sectors demonstrating that effective supply chain strategies in one sector may not be appropriate in the other sector. Traditional Supply Chain Management (SCM) was originally limited to traditional areas like purchasing, distribution and logistics. Over time it has included supply relationship, supply network structure and supply collaboration. These authors also mention some differences such as that in service companies' SC:

- Human labor forms a significant component of the value delivery process.
- It is not that evident how to standardize process and controls and how to verify them as it is in manufacturing.

- Decisions are taken locally and variation and uncertainty are high because of the human involvement.

- Services rely on management capacity because of the flexibility of resources, flow of information, service performance and cash flow.

Traditional supply chains are relatively linear, production flows are typically unidirectional, with items flowing from suppliers to customers. The upstream is information such as orders, feedback, and payment information, and downstream info is material and product. Figure 2 depicts an scheme where customer may contribute with product design, contrary to the manufacturing, where customers are completely downstream of the supply chain [6].

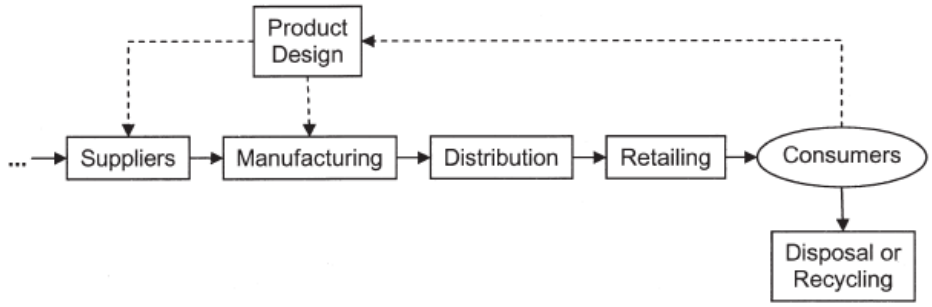


Figure 2 Typical manufacturing supply chain [6]

The Unified Services Theory indicates that service supply chains have an expanded role for customers, namely as suppliers of inputs to service provider processes. This means that service processes are bidirectional, as shown in Figure 3 [6]. The arrows are flows of information, goods or physical human inputs.

As it is mentioned before, one of the major differences between services and manufacturing is the involvement of the customer in the process, hence service supply chain is bidirectional, that means that the customer also provide inputs to the supply chain. The inputs could be information or labor such as in a co-production service e.g. coffee machine in a coffee station.

Figure 3 Bidirectional Service Supply Chain [6].

Besides, service providers may employ other service providers to supply necessary services, this relationship is called "two-level bidirectional service supply chain"[66].

Bidirectional supply chain differs from the typical in many ways [6]:

First, service supply chains tend to be hubs, not chains and service managers are concerned with product flows going in both directions. For two-level bidirectional supply chains, the service provider acts as an agent for the customer when dealing with outside suppliers e.g. a car repair shop may outsource the rebuilding of engines to a machine shop. The car repair shop acts as a hub and represents the customer's needs to the machine shop. Second, bidirectional supply tends to be short [6].

Second, service providers tend to interact directly with consumers of the services without the buffer of distributors and retailers. Advantages of short supply chains include reduced complexity and easier sharing of information [6].

Third, service providers cannot treat suppliers who are customers the same way they would treat suppliers who are not customers." and Forth "service operations need to be robust enough to handle the stochastic nature of customer-supplied inputs "[6]

Considering the concept of garbage in – garbage out in terms of quality in supply chain, the fact of the customer is also a supplier makes difficult for service supplier to meet customer expectations. Therefore service companies may apply good communication methods and verify customer inputs. Some practitioners and academics agree that this fact is the main difference [1] [8].

1.5 Quality methods and techniques applied in service industry

1.5.1 Challenges in managing service quality

Most of the literature in service quality mentions that managing quality is difficult in service processes for many reasons that rely in the fact of the importance of the customer's inputs. According to Sampson [4], these are some of the most important challenge for quality management en service:

- Manage the customer's inputs to deliver promised service. In manufacturing, one key factor of quality is to ensure consistently high-quality process inputs, hence for service it is an art to have the best from the customer.

- Manage customer-executed process, they need training and avoid impact of making mistakes.

- Manage customer-provided property/goods inputs

- Manage customer moods vary

- Manage in process quality corrections

Besides, assessing the outcome of service production often requires measuring the customer's perception of the service experience, which is not precise [6]. The Unified Services Theory suggests that since customer inputs define service processes, we should also attempt to measure the quality of the customer inputs involved in the service. After all, if a customer provides inappropriate or inadequate inputs to service process, that could explain a great deal of his/her dissatisfaction with the service outcome.. Interestingly, one of the most commonly-used service quality instruments, SERVQUAL [67], which does not include any customer inputs in its measurements [7].

Other aspect that may be different from manufacturing is the productivity; in service industries the number of outputs in service production is not necessary directly proportional to the number of revenues or benefits for produced unit or service. For instance, in a consulting company the number of projects is not an indicator of productivity, because many of them could be short and simple projects, while a one complex project may generate more benefits for the company that the rest of the projects. "Customer inputs confound productivity measurement by introducing heterogeneity, implying that outputs cannot be simply counted" [6].

Other important aspect in service is technology, "Automation and technology in services are increasingly important topics [6] and can also be examined through the lens of the UST. Firms often introduce process technologies in order to produce more with more consistent quality at lower cost. These cost savings often come by allowing technology and customer labor to substitute for expensive paid labor.

1.5.2 SERVQUAL

Although criticized, SERVQUAL is the most widely used instrument for measuring service quality, it is a model developed by Parasuraman, Zeithaml and Berry, in 1985, which measures service quality by comparing customers' perceptions (P) and expectations (E) of a service. Based on the difference between the two scores for perceptions (P) and expectations (E), an overall service quality score is calculated [67]. P>E means that perceptions are higher than expectations, hence perceptions of service quality are higher, while P<E means that perceptions are less than expectations; hence perceived service quality is lower. P-E scores are also calculated for each of the dimensions that constitute the service quality construct. The five dimensions of the instrument as described by Parasuraman *et al.,* [67] are reliability, responsiveness, assurance, empathy and tangibles. These are the core of the SERVQUAL measurement instrument. [25]

These dimensions are measured using two sets of statements consisting of 22 items or questions. The gap between the two scores, P-E (Performance-Expectations), helps to measure the service quality for each of the five dimensions and the mean score of all dimensions depicts the overall service quality score for any organization. Positive scores mean that perceived service quality is satisfactory, whereas negative scores indicate unsatisfactory service quality. The two sets or questions mentioned before are used to measure the fifth gap which is the last gap of the SERVQUAL model. The five gaps are:

(a) Gap 1: The Management Perception Gap – Not knowing what customers expect.
(b) Gap 2: The Management Perception – Service Quality Specification Gap. Not selecting the right service design and standards.
(c) Gap 3: Service Quality Specifications-Service Delivery Gap – Not delivering to service standards.
(d) Gap 4: Service Delivery – External Communications Gap. Not matching performance to promises.
(e) Gap 5: Expected Service – Perceived Service Gap (The Customer Gap) SERVQUAL

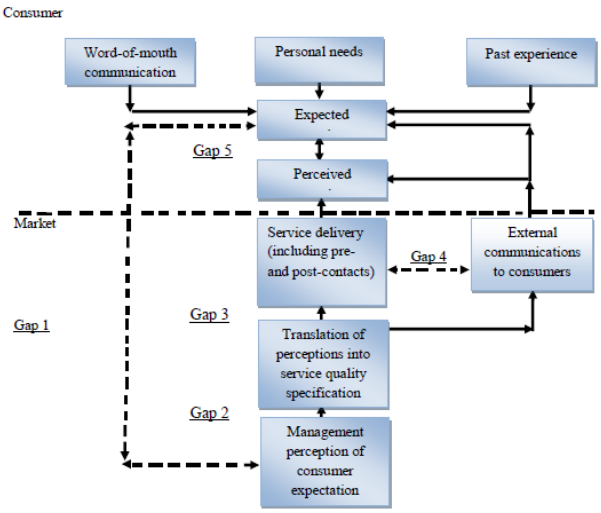


Figure 4 Gap analysis model. Source: [67]

Figure 4 describes the flow of actions in managing customer perceptions and expectations, and collocates where the gaps occur

SERVQUAL offers many advantages such as:

- It is accepted as a standard for assessing different dimensions of services quality
- It has been shown to be valid for a number of service situations.
- It has been demonstrated to be reliable, meaning that different readers interpret the questions similarly.
- Each instrument is easy for customers and employees.

Some researchers have developed modified SERVQUAL models using a more specific scale for particular service such us banking [25].

1.5.3 Service blueprinting

Lynn Shostack, CEO of Joyce International, Inc. is known for the statement, “The process is the service”. Lynn developed the process known as **service blueprinting** [68]. This is an approach of the service flowcharting technique [1].

1.5.4 Moment of truth

According to S. Thomas Foster [1], “The fail points in the service blueprint are often referred to as **moments of truth"**. These are the times at which the customers expect something to happen.”

For instance in banks, the moments of truth happens when there is a direct contact with the customer, these moments can occur face to face, over the Internet, by phone, through a machine such as an ATM, or through the mail, and they may result in either happy customers or lost customers[1].

1.5.5 Poka-yoke

Dr. Richard Chase and Dr. John Grout [69] have promoted the use of poka-yoke (fail-safes) in service The idea behind fail-safe is to ensure that certain errors will never occur. Just as many processes seem to be designed to fail, they also can be designed not to fail. In service, Chase defines different classifications for fail-safe devices. There are:

- Warning methods
- Physical contact methods
- Visual contact methods

Fail-safe methods can also be defined by the "three Ts", Task to be performed, Treatment provided to the customer and Tangibles provides to the customer.

These poka-yoke classifications and Ts occur in many different forms. Some examples: an ATM machines that warns you to remove your card, toilets and sinks that automatically flush and shut off, requirements that bank tellers enter a customer's aye color before beginning a transaction, so that identity is confirmed. [9]

1.5.6 The customer benefits package (CBPs)

This technique consists in grouping the tangible and intangible aspects that make up the services. CPBs helps to define what will and won't be provided by the service provider [54].

The CBP is defined largely by the degree of freedom allowed by the firm in the customization of the services packages. Debora Kellogg and Winter Nie [55] defined a service-process matrix (Figure 5) that helps firms to identify their ability to customize service according to their degree of flexibility as a service provider. Some services may not fit in this matrix; however, many companies find useful insights using the matrix.

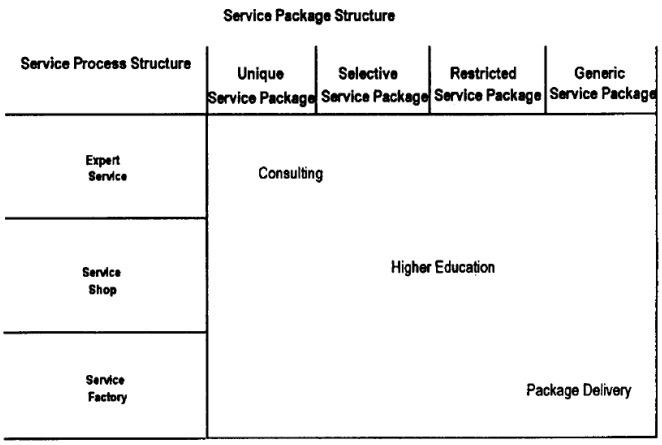


Figure 5 The service process/service package matrix. [55]

The service processes described in the vertical axis of the service process/service package matrix, are summarized in Table 5.

Process name	**Degree of customer influence**	**Examples**
Expert service	High	Accounting Consulting
Service shop	Medium	Education Healthcare clinics
Service factory	Low	Fast food restaurant

Table 5 The service process structure [55]

The horizontal axis of the matrix **"The service process/service package"** (Figure 5) is the service packages, it contains tangible and intangible features. Fitzsimmons and Fitzsimmons [66] offer a definition of the service package that consists of four features: supporting facility, facilitating goods, explicit services and implicit services. Supporting facility consists of the physical resources that must be in place before a service can be offered. Facilitating goods are the goods used or consumed by the customer. Explicit services are the benefits that are readily sensed by the customer and are the essential feature of the service. Implicit services are benefits that are sensed by the customer vaguely and are extrinsic features ancillary to the service [55].

The service package structures are summarized in Table 6.

Package name	Customization	Definition
Unique	Full	Most of the service package is customized. The customer has considerable discretion in defining the how, what and where of the service.
Selective	Considerable	While some parts of the service package are standardized, the customer has considerable discretion in selecting from a wide menu of options.
Restricted	Limited	Most of the service package is standardized. The customer can select from a limited number of choices
Generic	Little or none	Most of the service package is standardized. The customer has little discretion in defining the hoes, what or where of the service.

Table 6 The service package structure [55]

1.5.7 Service Transaction Analysis (STA)

This is a service improvement technique that allows managers to analyze their service processes at a very detailed level; each detailed level is defined as a transaction, as Crosby[1] views service encounters as a series of transactions or moments of truth. STA helps to identify these transactions, and evaluates them against the customer's perspective to determine any gap between service design and what the customer perceive as the service [70].

1.6 Costs of quality COQ

1.6.1 Economics of quality

As it was mentioned before quality has several definitions not only based on the customers' view but also based on functional roles in an organization. It is possible to define quality from different perspectives such as supply chain, engineering, operations, strategic management, marketing, and human resources and financial [1] .We could said at first glance that the costs of quality is a method that defines quality from a financial perspective, since its goal is pursuing quality improvement reducing waste and increasing profitability.

W.E Deming [1] made the first theoretical attempt to link quality improvement to financial results through the "Deming value chain". Figure 6 describes a scheme where Deming linked quality improvement to reduction in defects, improved organizational performance and employment generation.

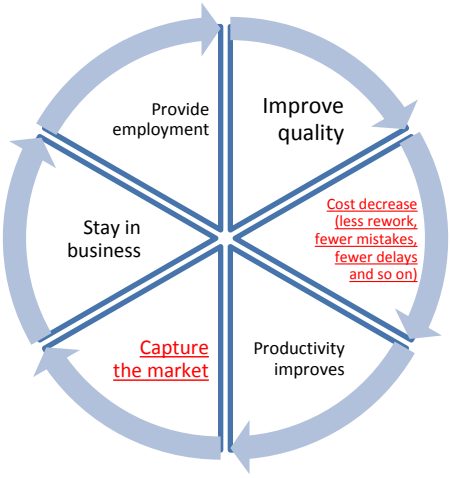


Figure 6 The Deming value chain. Deming, W. Edwards [71]

The first purpose of the finance function is to identify the potential risks of any investments and their potential revenues in order to obtain the maxim return for a given level of risk, hence in order to define quality in terms of a finance language it is necessary to talk in finance primary language which is accounting.

Joseph Juran [1] was the first scholar approached to this communication problem, when he stated that "the language of management is money". Therefore, one way to translate quality in this language is to measure the cost of quality, e.g. the cost of lost sales because of the bad reputation, the cost of defects, the cost of training, the cost of quality projects improvement, etc.

In this view, although projects in quality improvements may be expensive, the results in reductions of defects, waste and other problems have a positive effect on the business revenues and profits. Companies like Motorola, Xerox and GE have proved this fact [1]. However, financial success also depends on the factors such as management style, business strategy and market share, not only in quality improvement [1].

Other concept that influences the financial perception of quality improvement is *"the law of diminishing marginal returns"* also called *"Lundvall-Juran model"* [1] which asserts that there is a point where investment in quality improvement will became uneconomical. Figure 7 represents this law as a quadratic equation that shows that high levels of quality will result in higher costs. This view contradicts the ethic view of quality that asserts that to pursuit quality is a way with not ending .In this sense, some academics assert [11] that unethical conduct may result in customer dissatisfaction.

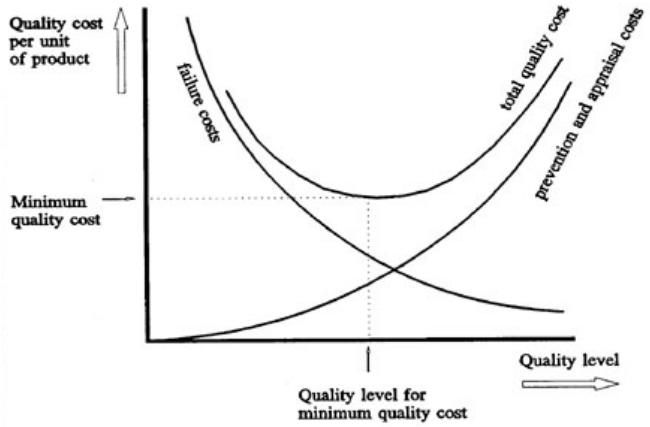


Figure 7 Basic Economic Quality Level Model. [1]

The financial perception of quality is also seen as a perspective of generic strategies, and one of the generic means of competing is cost. They affect operating costs, profitability, and consumer needs. [1].

In practical words, the financial view of quality relies in the fact that, an efficient continuous improvement program meets customer requirements at the minimum costs. Hence, the challenge is reduce the costs needed to achieve quality, identifying and measuring these costs. Therefore, measuring and reporting the cost of quality (COQ) should be considered an important issue for managers [41]. Moreover, such an objective even though not included in ISO 9001:2000 quality principles; it is suggested in the recently published ISO 10014:2006 [43] [44].

1.6.2 Definition of COQ analysis

Although, there is no general agreement on a single broad definition of quality costs [46] COQ is usually understood as the sum of conformance plus non-conformance costs, where cost of conformance is the price paid for prevention of poor quality (for example, inspection and quality appraisal) and cost of non-conformance is the cost of poor quality caused by product and service failure (for example, rework and returns) [12].

Experts also assert that COQ analysis links improvement actions with associated costs and customer expectations, and this is seen as the coupling of reduced costs and increased benefits [12].

1.6.3 COQ Models

Juran was the first researcher in posing a discussion about the cost of quality [45], and after him many others studies have presented other approaches to measuring COQ. Plunkett and Dale [46] conducted a vast research on the COQ models and they concluded that, there is no consistency in the relationship of quality cost categories and they challenged the existence of unique COQ behavior. According to their findings, the COQ models could be divided into three distinct categories. In the first group there are the models which highlight a difference between their quality optimum point and COQ curve slope. The second group includes models which describe quality advancement over time and pointed out to quality milestones. Third group plotted actual quality costs obtained via industries and over time [14].

Later on, many research studies have been performed in different industries, most of them in manufacturing, and also some important literature reviews in the COQ models have been published. As a common finding, they agree that there is not a unique model, because it depends on the business context and characteristics, and the management strategy. However, there have been some different proposals of COQ model classification [48]:

- In 2006 Schiffauerova and Thomson [12] classified COQ models into five groups of generic models: (1) PAF, (2) Crosby's model, (3) opportunity cost models, (4) process cost models, and (5) ABC approach.

- In 2008 Sandoval- Chávez and Beruvides [49] suggested six theories (1) Juran's model, (2) Lesser's classification, (3) PAF model, (4) the economics of quality, (5) business management and the COQ, and (6) Juran's revised model.

- In 2010 Banasik [72] categorized the COQ models into: (1) Juran's model, (2) Lesser's contribution, (3) PAF model, (4) Harrington PQC, (5) Godfrey–Pasewak accounting COQ model, (6) Carr's service model, (7) Juran's revised COQ model, (8) Beruvides and Sandoval-Chávez opportunity cost model, and (9) Beruvides–Chiu capital budgeting model.

- In 2013 Ayati identified 12 different models[14]: (1) Juran's model, (2) Lesser's model, (3) PAF or Crosby model, (4) Harrington PQC, (5) Godfrey–Pasewak accounting COQ, (6) Process cost model, (7) Juran's revised COQ model , (8) Carr's service model, (9)

Opportunity cost model, (10) Activity Based Costing (ABC), (11)Model, Miller and Morris profit based COQ model, (12) , Capital Budgeting model, and (13)Continuous improvement model.

This study aims to perform a measurement of COQ in a service company, which is a sector in involving a great number of very different companies with very different business natures. It is thus important to first provide a brief description of the most widely used COQ classification, so that the identification of the model that will fit best the case study is clearer.

- **Juran's model:** Juran (1951) presented a conceptual - graphical COQ model. As it is mentioned before, this model has been the foundation for the rest of proposed COQ models. In his model he classified COQ into avoidable quality costs and unavoidable quality costs. Avoidable costs are the costs that would totally disappear when there is no defect in the system. He classified COQ into basic manufacturing costs to meet the specification, quality control costs and avoidable costs. Inspection costs were classified in this last. Figure 8 shows how he plotted the economics of quality against quality level. Juran affirmed that the total quality cost is parabolic, and concluded that losses due to the defects will reduce exponentially as the total amount of cost spent on quality control per product increases. In this point is where the quality is most economical.

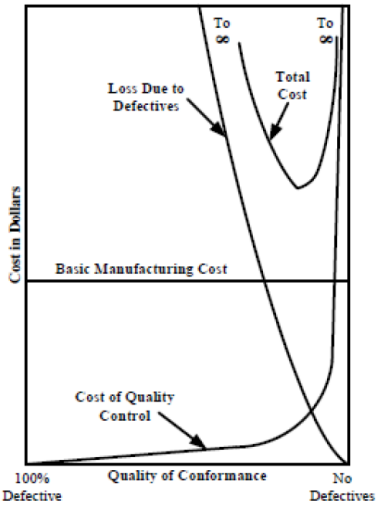


Figure 8 Economics of quality of Conformance Juran (1951)[14]

Based on this model, quality does not search for perfection whose cost would be infinite [45]. Later on, after some discussions around the fact that to do not search for total quality could

be unethical, Juran demonstrated that there is an economic point for quality where a very high quality can be achieved for the minimum quality cost. From this point of view, expected benefit gains from reduction of non-conformance costs would be less than the investment in conformance activities in order to achieve higher quality level. Experts assert that the main objective of the model is to find the level of quality which minimizes the total quality cost per product [41].

- **Lesser's model**, some research mentions that the first scholar who used PAF classification was Lesser [48]. Lesser (1954) proposed a model based on the PAF model. He classified the quality costs in manufacturing environment in order to identify quality costs and hidden quality costs, and suggested quality costs measurement as a tool to justify quality investments. He classified quality costs to identifiable quality costs and hidden quality costs.

- **PAF model**, Feigenbaum [73] presented the PAF model. He divided quality costs to prevention, appraisal and failure costs:
  Prevention Costs: The costs associated with any activities to avoid poor quality
  Appraisal Costs: The cost of measuring, evaluating and auditing product and service to ensure their conformance to predefined specifications.
  Internal Failure: Costs incurred due to the non-conformance of product and service to the specification before product or service is delivered to the customer.
  External Failure: Costs of non-conformance to the specification after the product or service has been delivered to the customer

  Feigenbaum [73] illustrated the PAF model cost components interactions in the following four steps:
  1. Modern quality practice (prevention costs) leads to the decrease of failure costs due to the reduction in number of defected components.
  2. Lower defect rate means less necessity for inspection activity and thus lower appraisal cost.
  3. Better inspection system and inspection equipment (prevention cost) also decrease appraisal costs.

4. The new inspection and audit system will prevent defects, i.e. the reduction in appraisal activity will lead to the reduction in defects.

Porter and Rayner [74] concluded that the main concept of PAF model is that the increment in prevention and appraisal costs would lead to the decrease in failure costs. Other advantage of PAF is that it allows a more precise identification and classification of quality costs [48]. Furthermore, experts asserts that PAF helps businesses to identify the contribution of each quality cost to total COQ at different intervals, to define quality strategies and quality budget [72], to determine the return on their quality investment, and to assess their investment impact on the quality.

- **Crosby Model** [75], according with experts [62] Crosby's classification is similar with the PAF model; however, it categorizes COQ into conformance and non-conformance costs. Conformance costs are defined as costs incurred in order to obtain conformity to design specifications and to meet customer requirements (e.g. prevention costs and appraisal costs). Non-conformance cost is the money wasted if a defective product reaches to the customer

- **Harrington's Poor Quality Cost (PQC) model [76],** Harrington introduced the PQC (Poor Quality cost) model based on the PAF model. The concept of PQC comes from the term "doing the things right at the first time".

  In this model PQC aims at the analysis of white-collar PQC and not the PQC in manufacturing environment. Harrington claimed that PQC would alert managers more than the COQ and will lead managers and employees towards the identification of improvement points. This model replaces the defect term with error and changed the quality target from optimum quality cost to error free point target [48]. Figure 9, describes Harrington's PQC model showing that the increment in the controllable costs will reduce the resultant costs and customer incurred costs. Additionally, instead of defining an optimum quality cost point the model proposes an optimum operation point which leads to search continuous improvement.

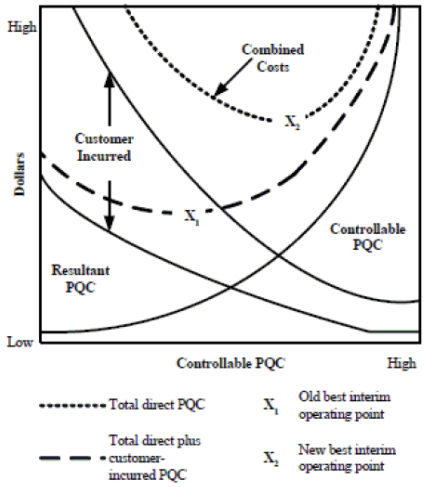


Figure 9 Harrington PQC model (Harrington 1987) [14]

- **Process cost model**, this model highlights the importance of process cost measurement and ownership. The process cost is the total of the conformance and non-conformance costs of a particular process. Ross [42] proposed this model as a computer-aided integrated program to model, and to analyze costs for the manufacturing environment.

  Some researcher assert that [43] process cost model can be developed for any process within an organization, identifying all the activities and parameters within the process to be monitored by flowcharting the process. Then, the flowcharted activities are allocated as conformance and non-conformance costs, and the cost of quality at each stage are calculated or estimated. Finally, key areas for process improvement are identified and improved. Some studies mention that this concept would help to extend the concept of quality costing to all functions of an enterprise and to non-manufacturing organizations. Figure 10 describes the model structure.

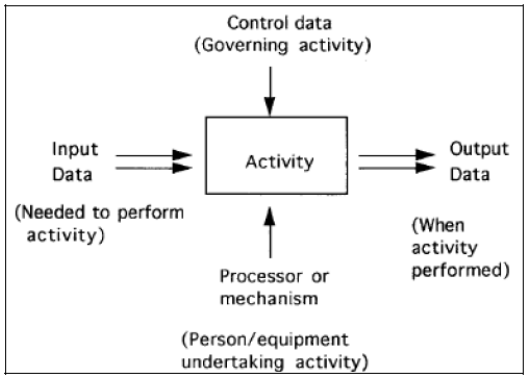


Figure 10 The structure of the process cost model [43]

Within TQM, the use of a process cost model is the most preferred method for quality costing as it recognizes the importance of process cost measurement and ownership, and presents a more integrated approach to quality than a P-A-F model. The process cost model pursues a continuous improvement and can be applied to both service and manufacturing industries.

- **Juran's revised model,** as it is mentioned before Juran model suggests that there is a quality economic point where the total quality cost tends to infinity. However, afterwards Deming [71] claimed that "Cost of selling bad quality product is too high that the best quality cost point is where we have zero defects, thus it is not required to measure quality cost and we have to produce zero defects".

  Juran and Gryna [78] revised the economic trade-off model, and claimed that perfection is achievable in finite conformance costs. They eliminated the exponential behavior of prevention and appraisal costs. Figure 11 compares the classic COQ trade off model versus the revised model; some authors name the classical and modern view [12]. However, they limited the application of this model to the companies with high technological advancement and quality standards. They also stated that the 100% perfection is not reachable in short run and it should be a long term goal of businesses.

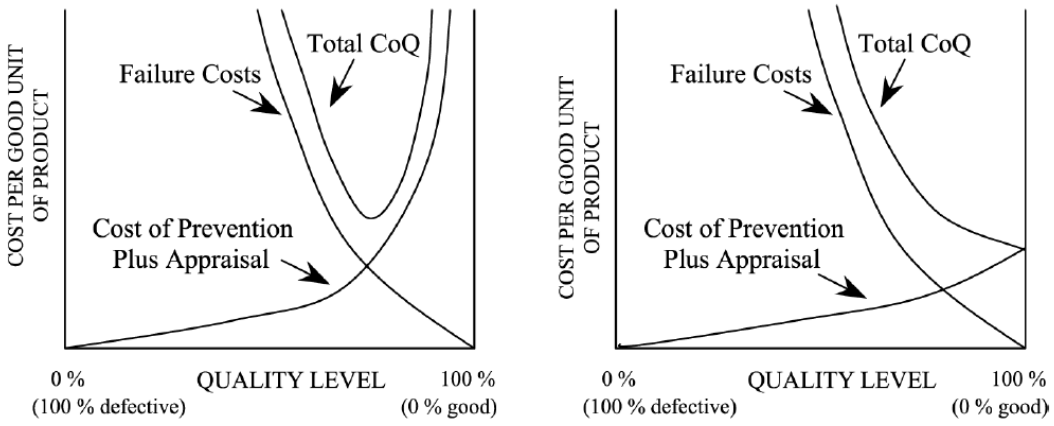


Figure 11 Classic COQ trade off model (right) VS Revised Model (left) [12]

- **Carr's service model** [13]**,** in 1992, Carr introduced the COQ model for the service industry, this is the first model that makes reference to the service companies, emphasising that classification of cost of quality in manufacturing and service is different, and more

challenging in services. Carr implemented COQ measurement in the marketing and sale division of U.S Marketing group (USMG) as a part of its operation management system. The main difference between his model and the PAF model is the classification of opportunity costs as a cost category. In his model, he classified COQ into conformance, non-conformance costs and lost opportunity costs [72].

- **Opportunity or intangibles costs Model**: Opportunity and intangible costs have been considered by many authors [62]. Tatikonda and Tatikonda [79] defined the opportunity costs as the cost of lost customers when the defective product reaches the market. For Schiffauerova and Thomson [62] opportunity costs are the costs of not earning profit as a result of losing customers. Freiesleben [53] presented a list of costs that are classified as opportunity costs such as lost sales, goodwill and warranty to the customer, downtime of process during elimination of error, slowdown of process due to inspection, over-capacity due to certain sale goal, and opportunity costs due to management distraction.

- **COQ - ABC (Activity Based Costing) Model**, Tsai [50] proposed an integrated COQ-ABC model, in which ABC and COQ systems are merged in order to share common information of costs, and non-financial data of management techniques. ABC model is not a model of COQ itself, it is an approach using for accounting in order to book expenses according to the activities that add or not value to the final product or service. ABC systems aims to eliminate non-value added activities in order to reduce defects and wastes.

- **Miller and Morris profit based COQ model:** Miller and Morris [51] integrated the total benefits in the COQ model and asserted that the quality optimum point is where the marginal benefit is equal to the marginal COQ.

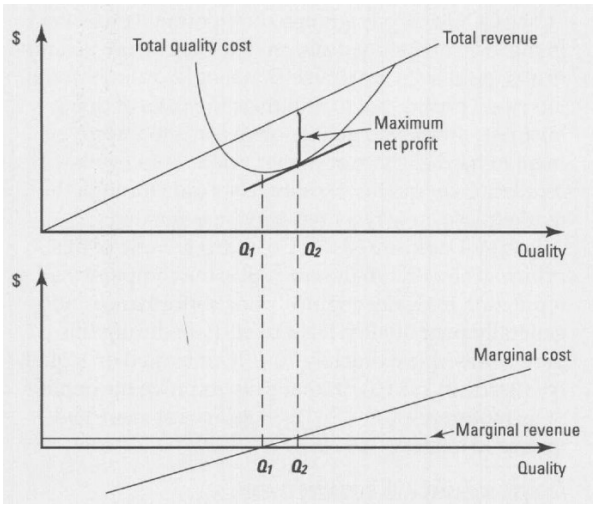


Figure 12 Analysis of quality with increasing revenue [51]

Figure 12 describes how the model compares the level of quality cost against the revenues. Milles and Morris concluded that although the COQ increase the level of revenue does as well for even a larger amount.

- **Capital Budgeting model,** in this model Beruvides and Chiu [80] merged Juran's trade-off model and opportunity cost model. The difference between this model and the cost opportunity model is that this method suggests that the best decision for businesses is not to achieve 100% conformance all the time, which is contrary to the concept behind the Juran's revised model. They used the cost benefit analysis to study the return of investment in prevention and appraisal activities against failure costs for specific period of the time or specific quality program, determining the Economic Inflection Point (EIP), which determines the point of the decision where to cease or continue quality programs or investment. This point varies between different industries and within different level of quality. The model is based on the net present value objective function.

- **Continuous improvement model** , Freiesleben [53] asserted that "with the increasing success of Quality Techniques such as Six Sigma, which show that quality perfection is a desirable objective, the old quality-cost trade-off as propagated by the Cost of Quality Models has to be re-examined". Ittner [52] proposed the first continuous improvement COQ model suggesting that due to the well-established quality programs, companies could achieve the point of reduce non-conformance with minimal or not increase of costs. Figure 13.

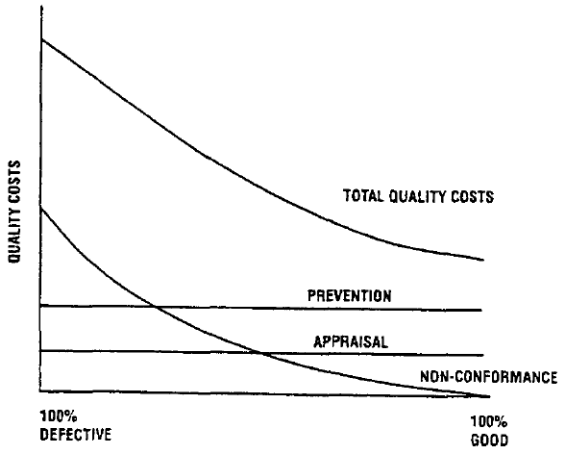


Figure 13 Ittner's Continuous improvement COQ model [52].

Freiesleben asserted that although COQ models alone can only determine a cost-minimal quality level, he tested that in the new COQ model this cost-minimal quality level is equal to quality perfection (Figure 14). He also argued that, statics COQ models cannot determine optimum quality level in practice. Therefore he proposed a continuous improvement model and identified three critical elements in each stage of the quality program; 1. Technical progress 2. Learning from former continuous improvement activities 3. Detection of root cause. Figure 15 depicts the total cost curve of the new COQ model according to Freiesleben [53]

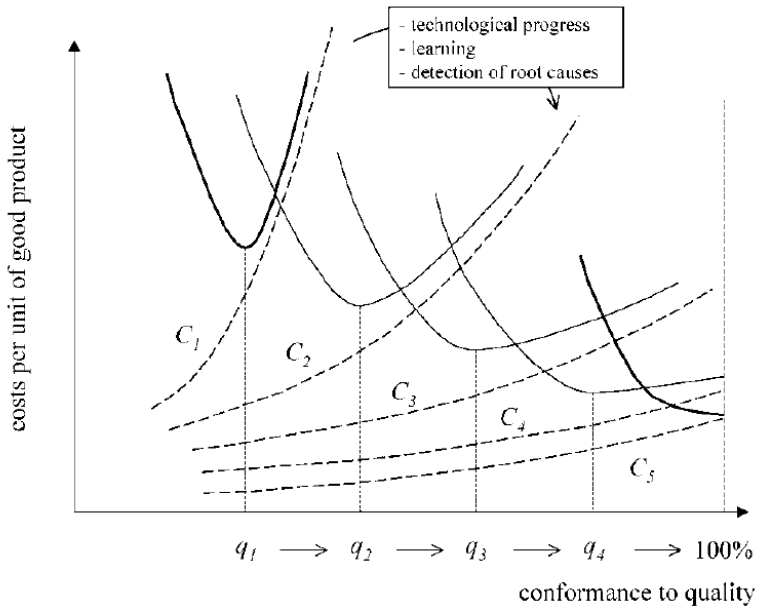


Figure 14 Development of the costs per unit of good product over time [53]

1.6.4 Cost of quality metrics

Detailed metrics make reference to the performance of each element of the total COQ function, for instance, costs of assets and materials, costs of prevention or number of complaint received; whereas, global metrics rely in the global performance of the organization, in order to evaluate the influence of the COQ programs in the total company results. According to academics and practitioners, the most common global metric is the "Return in Quality (ROC)" that divides the increase in profits in the costs of quality improvement programs some other global metrics used in quality studies are the ratio between the total COQ compare to sales, cost and revenues [12]. The following table list these and other global metrics:

Global metrics	
Return in Quality (ROQ)	increase in profit/COQ improvement
Percentage of sale	COQ detailed costs/ total sale
Percentage of costs	COQ detailed costs/ total costs
Percentage of revenue	COQ detailed costs/ total revenue
Process Quality	(available time – rework time)/available time
Quality rate	(input – (quality defects)+start up defects + reworks)/input
First time quality	percentage of product with no rework

Table 7 Global Metrics in COQ studies [12][14]

1.6.5 Cost of quality in service

1.6.5.1 Scholar insight

Although within practitioners it is possible to hear new examples of applying COQ in service industry, within academics the only well-known model is the Carr Model [13]. In 1992 Lawrence Carr introduced the COQ model for the service industry. He implemented COQ measurement in the marketing and sale division of U.S Marketing group (USMG) as a part of its operation management system. In this practical exercise, Carr proved that COQ in service is applicable under the concept of service processes, and offers benefits for the company. Moreover, he introduced a new category of cost called "the cost of lost opportunity". However, this approach was more used as a management tool that as an accounting technique.

This model [13] classifies COQ in three categories:

1. **Cost of conformance** (prevention and appraisal) e.g. training, communications, incoming inspection, pre-installs, auditing.
2. **The cost of non-conformance** (failure to meet customer requirements before and after delivery) e.g. response time in excess of customer requirements.
3. **The cost of lost opportunities**. e.g. cancellation owing to poor service

Some of the key factors of success highlighted in this project were;

1. The program was out of the operating budget process. COQ was used as a tool to help line managers better serve their customers, not as a financial or accounting measure. It was not just cost reduction but improving business practice.
2. Results not used to judge individual performance or eliminated jobs.
3. Measures were based on rough numbers, not exact calculations.
4. The task was to identify areas for improvement and assign project management responsibility. Using Pareto base on: subjective estimates of each problem's cost, potential for correction, external customer impact, degree of difficulty and project size.
5. The emphasis was on process over goals and positive change over measurements.

The main difference between Carr model and the PAF model is the classification of opportunity costs as a cost category [14].

1.6.5.2 Practitioner insight

The American Society for Quality (ASQ) has referred to some business cases of service companies that have successfully applied COQ method; however, they just give a general view, and mention principal results without major details [15].

a. Banking sector

Eleven business units of **Banc One Corporation** participated in a study of quality costs, customer satisfaction and quality deficiencies/defects [15] [57]. They performed a statistical analysis of these

three variables resulting in a finding that measuring these variables over time will lead to an improvement.

As a result of this research, they classified the following costs:

a. Prevention – Prevention cost are proactive activities that are accomplished before or during processing or service delivery. Prevention costs are those costs associated with operations or activities that keep failure from happening and keep appraisal costs to a minimum. Examples of prevention activities are new product review, quality planning, quality improvement team meetings, training programs, written policies and procedures, analysis of quality information, and quality information/improvement projects.

b. Appraisal – Appraisal costs are those costs incurred to project or predict quality levels and to validate the condition of a product or service in order to determine its degree of conformance to quality standards or specifications. Examples include inspection of incoming work, supplies and material, periodic inspection of work in process, checking, balancing, verifying, final inspection, shopper surveys, customer surveys, focus groups, and analysis of customer correspondence/complaints.

c. Internal Failure –Internal costs are the costs due to events of failure that occurs before delivering any service. Examples of internal failure costs are machine downtime, scrap and waste due to improperly processed forms or reports and rework of incorrectly processed work.

d. External failure – External failure costs are the costs due to events of failure that occurs after delivering any service. Examples of external costs are investigation time, payment of interest penalties or customer income lost due to poor quality, reprocessing of an item, scrap due to improperly processed or incorrect forms or reports, time spent with disgruntled customers, and lost or never acquired business due to providing poor service or having a poor quality reputation.

ASQ highlights that in aggregate, these costs range from 10 percent to 30 percent of sales or 25 percent to 40 percent of operating expenses. The latter is the way quality costs are measured in banks, as they do not have sales.

In this case study [15], ASQ underlines some recommendations to follow up when implementing COQ:

- Start with a small scope
- Do not attempt to quality cost every product or service of function within the company.
- Start with activities that you suspect may have failure and appraisal costs.
- Develop flowcharts to assure all activities are captured and then relate all the costs per activity and classify category of cost of quality. They exemplify the case of making a loan and process payment loans.

The last edition of the "Principles of cost of quality" by Wood [57] mentions that this case study also involved the use of other tools of quality control, such as a Pareto Analysis and cause-and-effect analysis.

In the relationship of cost of poor quality to defects and customer satisfaction study, after some statistical analyses, these measures were correlated and some interesting relationship occurred. The authors found that [15]:

- Poor quality as a percent of total COQ can predict opportunities for improvements.
- Defect rates cannot predict improvement's opportunities. They pointed out that customer perceptions must be a better indicator for this purpose; hence they recommend customer survey to identify areas that will benefit from COQ measurement.

In the literature, this is the only case study of COQ analysis in banking

b. Education

In 1992 the University of Western Ontario started a center to drive quality and productivity improvement. Within the projects developed, they performed a COQ measurement in two major processes, in major equipment replacement (personal computers, copiers, facsimile etc.) and in telephone system review [57].

This case study focused on practicing the technique of the COQ technique, launched the project as a management tool, and directed the exercise as a process analysis. In the first project, they calculated

the cost of quality computed as the total service staffs costs times the weighted average of the level of satisfaction (Table 8). In the telephone service's project the formula of cost of quality was calculated based on the time that it would take to correct a problem, after they calculated the costs and multiplied them by the frequency of the problems. Finally, they applied other quality tools to arrive to the root cause of the problems and then they suggested improvements. For the two projects they got a significant savings in a short period of time [57].

In 2007 Trevor Green performed an analysis of cost of quality in an Institute of Higher Education in UK. This study applied Feigenbaum's model to classify costs and based its analysis on Deming's believe [71] that "the unmeasurable cost of loss of future business may be much greater" than the others. Although the author pointed out the difficulty for founding evident savings he noted that the study helped the manager to guide improvement actions.

Similar to the University of Western Ontario's case, to classify costs they started from the problems or cases of failure to find the corresponding appraisal and prevention costs.

The contribution of this analysis is the identification of two types of appraisal costs, which are the desirable and undesirable costs (Table 9). For example, if a student gets a bad grade the institutions must apply some appraisal activities to identify the case of failure, action that they classify as undesirable appraisal cost. A desirable cost would be a previous examination to identify weaknesses. At first glance, it seems that this example could be a failure costs, however this is not a customer satisfaction issue. It is a clear evidence of the participation of the customer in the production of service.

Description	(a) Total Replies	(a) Weighted Average of Satisfaction Level (10=max)	(b) Weighted Average Level of Dissatisfaction	(b) Estimated Productivity Loss	(c) Finance Total Staff	(d) Estimated % of Staff Involved	(e) Weekly Average Hours Used	Weeks Per Year	(f) Average Hourly Salary	Estimated Annual Cost of Quality
Personal computer	17	7.3	2.7	27% ×	45 ×	89% ×	10 ×	46 ×	$28 =	$140,324
Copiers	19	7.1	2.9	29% ×	45 ×	100% ×	2 ×	46 ×	$28 =	34,166
Fax	17	5.4	4.6	46% ×	45 ×	89% ×	1 ×	46 ×	$28 =	23,661
Microfiche	10	5.8	4.2	42% ×	45 ×	53% ×	0.3 ×	46 ×	$28 =	3,644
Microfilm	10	4.0	6.0	60% ×	45 ×	53% ×	0.4 ×	46 ×	$28 =	7,321
									Estimated cost of quality for equipment	$209,316
Computer Training (g)	19	7.5	2.5	25% ×	45 ×	100% ×	10 ×	46 ×	$28 =	144,900
									Estimated cost of quality for equipment and training	$354,216

Notes:

(a) These schedules are based on the survey of 19 members in the department.

(b) A satisfaction level of 10 (100%) indicated full productivity. A satisfaction level of 7 indicated a 70% level of productivity and a corresponding 30% loss in productivity.

(c) Approximate number of non-managerial staff in the department of finance.

(d) Estimated percentage of staff involved is the number of responses divided by the sample size (e.g., 17/19 = 89%)

(e) Average weekly hours that equipment is used was determined by the survey.

(f) Average hourly salary for non-managerial staff is estimated at $28.

(g) When asked, only two people surveyed said they felt they had been adequately trained to perform computer related functions. On a weighted average basis, staff in the survey felt that they were 75% trained to use their computers. Accordingly, lack of training is estimated to reduce personal computer productivity usage by 25%.

Table 8 Finance department cost of quality for equipment and training. [57]

Failure cost	Undesirable appraisal cost	Desirable appraisal cost	Prevention cost
Students with poor attendance submitting substandard coursework for assessment	Work critically assessed. Students receiving one-to-one coaching to identify requirements to bring work up to minimum standard	Check registers for absences. Send out lesson materials to students who do not attend classes.	Research reasons for absence with a view to minimising problem. (We should never lose sight of the aim to attain zero absence.)
Students leave courses before completion	Questionnaire or interview, after the event, to ascertain reasons for lack of retention	Check registers for absence. Immediate contact with students on first occasion of absence to mobilise support	Research issues why students lose the will, commitment, etc. to follow through their chosen courses. Act on identified issues
Incorrect results letters sent out to students because of transcription errors. New letter sent out with apology and new results (the worst effect here is the credibility of the organisation in the eyes of the student)	Course tutor checks all letters before they are sent out	Sometimes there are no real "desirable" appraisal costs because a prevention cost can (and needs to) take care of the problem directly	Design information system such that laptop computer is used directly by examination board secretary (projected on to screen for all board members). Results fed straight into results system. Letters generated from results system
Computer services department delivers inadequate service for academic needs	Log examples of inadequate service provision to use as "ammunition" against computer services department management	Measure service level. Regular contact between academic and computer services staff to "iron out" issues	Training staff from both sides to form a customer/supplier relationship. Staff on both sides to realise that they are both customers and suppliers to each other
Incorrect marking of student work by module lecturer	External examiner re-marking all scripts	Internal moderation identifying problems and discussing issues with module lecturer	Training in application of standards. Regular "standards" meetings, in each subject area, to discuss assessment issues, developments, etc.

Table 9 Examples of types of costs relating to some typical issues[57]

c. Software

Within practitioners, most of the business cases of COQ are in the software companies. ASQ presents a clear classification of these costs (Table 10) considering that although the product is intangible the concept of product life cycle is present (design, production, deliverance and maintenance) [15].

Cost Area		Description	Typical costs
Cost of control or conformance	Prevention cost	Defect avoidance; quality basis definition; project and process-oriented interventions	Efforts to define quality and set quality goals, standards, and thresholds; quality trade-off analysis; definition of release criteria for acceptance testing and related quality standards; training; process metric creation and planning; formal inspection
	Appraisal costs	Defect detection; discovery of product non-conformance; finding the level of non-conformance	Quality control gating processes, contract or proposal reviews, quality audits, go-no go decisions, quality assurance of subcontractors, inspections, static/dynamic analysis, testing, walk-through, desk-checking
Cost of failure of control or non-conformance	Internal failure costs	Pre-release defect or anomaly correction prior to delivery to the customer	Recode, retest, re-review, re-document, requirements rework, design rework
	External failure costs	Post-release defect or anomaly correction and related costs after delivery to the customer	Warranty support, resolution of complaints, reimbursement damage paid to customer, domino effect to reputation or enterprise, added marketing to correct reputation problems, penalties.

Table 10 Typical costs of quality for software. [15]

In 2011, a systematic literature review of software quality cost research [21], based on 87 articles published between 1980 and 2009, concluded that only about a third of the analyzed articles present a case study or more extensive empirical results. This appears to be insufficient for software quality cost research, which strongly relies on quantitative data to generate new findings. However, in 2011 Claude Laporte., et al. [20] who performed a measurement of CQ in Bombardier Transportation, showed the following important findings and assertions:

- Cost of software quality represented 33 percent of the overall project cost. The cost of rework, or the cost of correcting anomalies, was 10 percent, the cost of prevention 2 percent, and the cost of evaluation 21 percent of the total development cost.

- Once a piece of software makes it into the field, the cost of fixing an error can be 100 times as high as it would have been during the development stage

- Many enterprises measure the costs required to perform various functions, such as the cost of developing a product, the cost of maintaining it, the cost of support, and so on. The measure of the cost of quality (COQ) is very useful for improving the performance of processes, as one's objective must be to seek expensive activities and, above all, identify and eliminate waste.

1.7 COQ evolution

In the last version of the book of "Principles of Cost of Quality" that the American Quality Association presented in 2013 [57], it was pointed out that the costs of quality are now better defined that they were before, and also that there is more available data. They referred to a survey that the Chartered Institute of Management Accountants completed in 2009 [57], asking 439 worldwide respondents (in manufacturing and service areas) about management accounting tools. This survey revealed that within a list of 100 suggested tools, COQ were one of the 14 most commonly used costing tools. However, it was used by less than 10% of respondents.

In fact, today in a world where the data started to be worth of gold, companies have developed sophisticated data processing systems that allow them to gather historical information of scraps, rework costs, recalls and so on. In this sense ASQ [57] asserts also that "Service industries are undergoing more in-depth scrutiny by consumer and regulatory groups questioning the validity of price or rate hikes" that means that for some business gathering data is not just an action of "good practice" it is also an obligation.

1.8 Conclusion from the literature review

From the literature review it can be concluded that despite the academics arguing about the flaws of **PAF and Juran's revised models**, they are still the most commonly used within practitioners. Likewise, COQ can be calculated from two different perspectives: one from **the product performance** (product life cycle, as a long-term business strategy) and the other from **the business process performance** (seen more as a short-term business strategy).

There are several case studies of measuring COQ under the business process concept in both service and manufacturing companies. For these cases, the majority of projects are carried out in a particular unit of the company, and the principal goal is finding opportunities of saving. In contrast, the **measurement of COQ from the product perspective is common in manufacturing, but not in services**. Since in manufacturing, the fact of having a tangible product makes the identification of conformances and non-conformances before a product is delivered easy.

Nevertheless, **performing a COQ analysis in a service company is possible**; however, as experts assert, it is more difficult and challenging than it is in manufacturing. The concept of intangibility, simultaneous production and consumption, and high participation of the customer depict a very different scenario. In fact, although the majority of the models which applied the COQ analysis to services are based on the well-known PAF method, **there is no unique model**.

COQ models in services must suit to the business needs of the companies in order to become a "successful systematic tool in a quality management program" [12]. Therefore, before attempting any quality business strategy in services, it is fundamental to understand what type of services is being performed. The vast classification of service companies makes the unification of a single COQ model difficult. For instance, although software companies are classified under the service sector (their products are intangibles), they follow the model of product life cycle (design, production, deliverance and maintenance). Hence, this model may not fit at all in a financial or consulting company where the production of services follows a completely different pattern.

Another important aspect observable in services is that in to identify improvement opportunities **in services it seems to be more helpful to measure customer satisfaction rather than to measure failure costs such as defects or errors.** This is more evident in large companies where low costs of quality could hide opportunities of improvement [15]. Additionally, gathering data of failure costs in services is not evident due to the fact that service performance is just measurable in the consumption's moment and quality is affected by customer's mood, culture, needs, time, and so on. Therefore, when speaking of quality business strategies, service companies prefer to perform analyses that rely on customer perceptions and expectations, rather than on production performance. Evidence of this is that SERVQUAL approach is the one which is most used within service companies to define quality strategies.

1.9 Gaps

Based on the presented literature review two main gaps in the research on the COQ analysis in services were identified. First, within companies that do not follow the pattern of product life cycle there is no practical evidence of the application of COQ analysis under the concept of product performance that stands as a holistic business strategy. Second, within the few cases of COQ analysis of process performance in education and banking there is no evidence that the proposed models may be applied in other similar companies.

As a matter of fact, the studies that performed COQ analysis in banking and education have followed the concept of process performance, and they merely stand as pilot models of saving costs in some of the units of the business. The authors in these studies are in general agreement that the principal obstacles in the COQ analysis are the identification of the type of costs (not evident in services) and the collection of the data [57].

Finally, even if experts assert that applying COQ method in services brings a tremendous opportunity to reduce cost and increase customer satisfaction [15], there is no practical evidence of how this approach can be established as a holistic business strategy that serves as a managerial tool. Therefore, within practitioners there is the misconception that COQ is not practical for service companies.

2. METHODOLOGY

A. Problem definition

Base on the literature review, within the academics there is just one study that proposes a COQ method specific for services. In 1992 Carr Lawrence [13] introduced a COQ method for services that integrates PAF with the cost of opportunity and implemented this method in a unit of a service company. Within practitioners, there are numerous case studies that make references to service companies. Many of them are in software, where, though intangible, there is a product life cycle (design, production, deliverance and maintenance) [15]. These empirical studies mention the PAF classification as a methodology and point out that the principal challenges are in the identification and classification of costs [20, 21].

Apart from software, there are three examples of COQ applied, two in education services [58] and one in banking [57]. However, all these cases apply PAF methodology under the purpose of looking for cost reductions in a particular process in a business unit, rather than applying COQ as a managerial tool that covers the entire system of the service production, and helps the direction board in decisions-making. Moreover, these models are conceptual and do not present validation of their models against real data.

On the other hand, contrary to the manufacturing companies where the supply chain, logistic and customer involvement are similar, within service companies, there are important differences in the model of service production, e.g. the logistic for serving a good meal in a restaurant by far differs from the logistic to offer a legal consultation or internet service accessibility.

This fact is also evident when comparing the studies of applications of quality costs in services. From the literature review we can conclude that the suggested models for software, education and banking companies present some differences, principally in the classification of costs. Moreover, except for the case of software companies, there is no evidence that the presented models for education and banking may apply in all the companies of the same service sector. These studies are merely presented as practical case studies, and they do not suggest that the model could be applicable as a standard generic model for similar companies.

For these reasons, this thesis attempts to perform a COQ analysis in three similar companies under the concept of product performance, in order to explore the possibility to define a model that can be considered as a standard approach for similar companies, and stand as managerial tool at the high level of the organization.

B. Research description

This section describes the type of research and briefly describes the strategy and techniques that the author followed in order to achieve the thesis objectives.

This quantitative applied research is inspired by the necessity of finding more practical evidences of the link between measurement of quality and service companies. Its goal is to define a standard COQ

model for banks that can give managers an improved and more comprehensive insight about the behaviour of quality costs. As such, this study aspires to be a guide for practitioners.

This thesis adapts the PAF mathematical model to calculate COQ under the concept of "product performance" in three companies of the Colombian banking sector. To develop this practical exercise, it was necessary to analyze the categorization of quality costs in a banking service and to identify the most influential endogenous or exogenous variables that affect the banking business nature. Then the adapted COQ model is defined and the measurement of quality costs is performed using real data of the three major Colombian banks.

To achieve the principal goal which was the definition of the adjusted model, first a thorough literature review in COQ methods emphasizing services and a deep analysis of the banking business were performed in order to understand the main factors that affect quality in banking sector. Then the principal variables that define quality in a bank were identified. In order to better understand how the quality costs are interpreted in a bank the author participated in brainstorming with several experts in banking, which allowed the identification and categorization of the quality costs. Finally, the author reorganized the identified quality costs based on the PAF classification and included new variables to build the new COQ function for a banking system.

Once the model was defined, the next step was to perform the measurement of COQ in the selected banks. This part was built as a case study. The suggested model was used to measure the quality costs in the three major Colombian banks that count for approximately 51% of the total assets of the total Colombian market. To obtain the data, the author received the support of the Manager of the statistics department of the Banker's Colombian Association who provided information about the principal sources of banking information.

Based on the analysis of the quality costs identification in banks and on the findings from the available data; it was identified that the financial statements could be the most important source of quality costs. Then we proceeded to consolidate the monthly financial statements of five years, from 2008 to 2012, since in this period by law Colombians banks began to include more detailed accounts that facilitated the identification of expenses in quality for this study. For the costs that were not clearly identified, we calculated some estimates. Later, the database of quality cost was built in order

to calculate the total amount of COQ where the main metric used was COQ/Total operational expenses.

It is important to mention that during the data collection, the information on key operational indices that may enhance the COQ analysis was also gathered.

Later, with the numerical results statistical analyses were performing in order to validate the data, understand the results, find correlation between COQ elements and operational indices, and investigate which factor affects the most the COQ in banking. The applied statistical methods were:

- A trend-line analysis of the selected variables during the chosen period (2008-20012) in order to evaluate whether the data follows classic trade-off or any specific tendency.

- A correlation analysis between the COQ components and some important operational indices, in order to identify what operational variable most influences the quality costs. The chosen variables are:
    i. Number of customer's complaints
    ii. Number of transactions as number of "produced units"
    iii. NPL index (Non-performing loans)

- MATLAB functions of a Principal Component Analysis (PCA) are used in order to check the assumption of normality of the data, and to find the principal components that may most influence the COQ results. PCA is a method that transforms data observations in a new dataset of uncorrelated values that account for decreasing proportions of the total variance of the original variables. Each new observation is a linear combination of the original observations [59]. This multivariate quality control method has the capability of monitoring more than one variable simultaneously where the correlations and covariance between variables are taken into account. PCA finds linear combinations of variables that describe major trends in a data set. It is important to mention that although a PCA analysis is often used for more complex model analysis, the author takes advantage of the benefits that this approach offers in performing multivariate analysis.

- A sensitivity analysis was used in order to identify the factors that influence the total COQ function in a banking system.
- A confidence intervals analysis was performed in order to validate if the results allow defining a range of COQ metric that can stand as a benchmark for the Colombian banking sector.

Finally from these results, the author points out the main conclusions, contributions and limitations, and suggests future works.

2.1 UNDERSTANDING OF BANKING SERVICES

As it mentioned at the beginning of this document, before attempting to perform a COQ measurement in a service company, it is necessary to understand the characteristics and particularities of the particular business.

In simple words, banking can be defined as the business activity of accepting and safeguarding money owned by other individuals and entities, and then lending out this money in order to earn profit. However, nowadays, banking services also include issuance of debit and credit cards, providing safe custody of valuable items, lockers, ATM services and online transfer of funds across the country/world.

Banking business plays a crucial role in the world economy, since banking activity encourages the flow of money towards the productive use and investments. This in turn allows the economy to grow. "In the absence of banking business, savings would sit idle in our homes, the entrepreneurs would not be in a position to raise the money, ordinary people dreaming for a new car or house would not be able to purchase cars or houses"[27].

Banking service could be included within the term of financial services, which are the services provided by the finance industry. This encompasses a broad range of organizations that manage money, including credit unions, banks, credit card companies, insurance companies, accountancy companies, consumer finance companies, stock brokerages, investment funds and some government sponsored enterprises. Some of the principal banking services are operating accounts, making transfers, paying standing orders and selling foreign currency.

2.1.1 Supply chain of banking service

Within academics there is no concise definition of what could be the supply chain (SC) in banking**;** however, some scholars are attempting to identify some characteristics of the baking's SC. To gather these independent comments, it is necessary to understand a basic definition of the SC. As it is widely known, supply chain involves all the activities that transform raw materials into products or services that are delivered to the customers. It means that there are inputs that are transformed for some agents in order to produce an output. As it was mentioned before, the identification of these inputs in services is a difficult task.

Research on operational efficiency identifies the resources of a bank (e.g., personnel, technology, space, etc.) as inputs and some measurable form of the services provided (e.g., number of accounts serviced, or loans and other transactions processed) as output [28].

On the other hand, there have been debates about whether deposits should be treated as an input in the bank's production process or as an output. However, experts [18] assert that deposits are an input, because they provide the necessary funding with which banks can make loans or purchase securities this is called the intermediation approach. However, banks also might provide transactions services for depositors, which might give deposits some characteristics of an output.

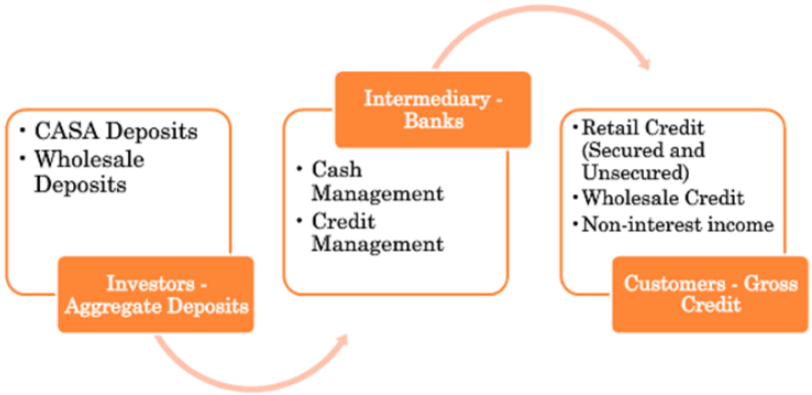


Figure 15 Banking industry SC. Source: Indian consultant [29]

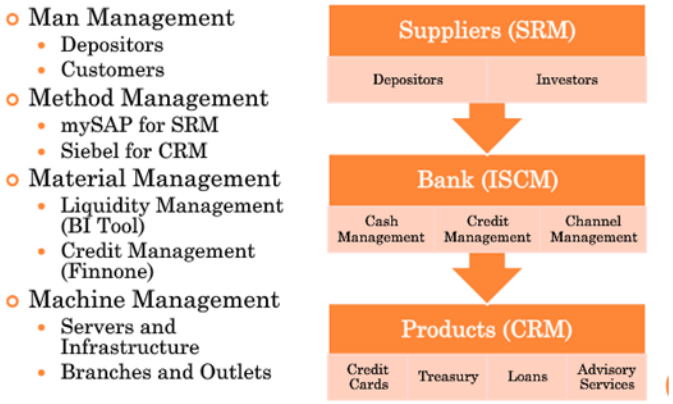


Figure 16 Supply chain Management in banking. Source: Indian consultant [29]

From practitioners' insight, there are some attempts of drawing a scheme of the SC in a financial institution, some examples are shown in Figure 15 and Figure 16: these schemes explain the labor of intermediation of a bank, between depositors and credit customers. Intermediation is operating by the channels management (Branches, ATM or Online systems) and supporting for management information systems. This SC is seen as a unique flow of cash and information without distinguishing neither momentums of transformation from distribution, nor suppliers from customers.

In economics, the intermediation function of a bank is measured as the comparison of the loans credit rates and deposits rates. This approach is known as the intermediation rate

2.1.2 Most common approaches for quality improvement in banking

a. Service profit chain

The service profit chain of Heskett et al. [81] identifies quality and its interrelationships with some of the operational aspects of a service organization. The statement is: (i) profit and growth are stimulated primarily by customer loyalty; (ii) loyalty is a direct result of customer satisfaction; (iii) satisfaction is largely influenced by the value of services provided to customers; (iv) value is created by satisfied, loyal and productive employees; and (v) employee satisfaction results primarily from high-quality support services and policies that enable employees to deliver

results to customers [28]. Figure 17 describes the link between operational (internal) and marketing (perceived) quality

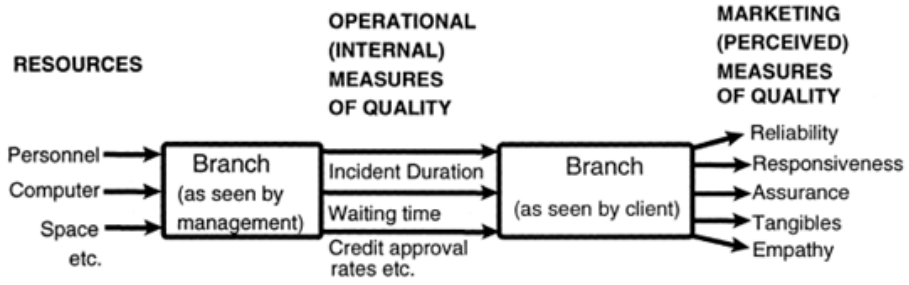


Figure 17 The two-stage model for benchmarking quality using both operational (i.e., Internal) and perceived (i.e., Marketing) measures of quality [28]

Finally Heskett [81] linked operations, quality of services, and profitability in a sequence of the benchmarking models that capture the components of the service-profit chain (Figure 18).

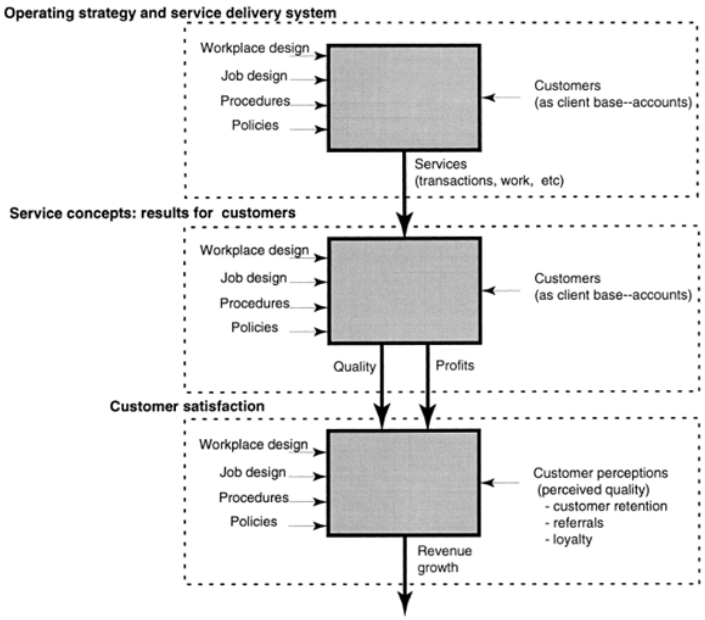


Figure 18 The cascade of models for benchmarking the components of the Service-Profit Chain [28]

The service-profit chain emphasizes the effect of operations on quality. This is the first formal empirical analysis that links not only operational characteristics of the service with service quality, but also the design of the operating system with quality. Empirical results indicated that superior insights can be obtained by analyzing simultaneously operations, service quality, and profitability, than the information obtained from comparing these three dimensions separately.

Similar to this study, in 2012 Faruk Konuk and Filiz Konuk [17] performed an analysis of the relationship between service quality, economic and switching costs in retail banking, and they found that service quality has positive effect on economic and switching costs and these costs have positive effect on both loyalty and word-of-mouth intentions. This implies that, by decreasing customers' economic perceptions, banks can increase customer loyalty and word-of-mouth intentions.

b. SERVQUAL in Banking

In Banking there have been innumerable SERVQUAL analyses around the world. In 2011 Yiannos Rossides made a recompilation of the most important analysis performed in India, Cyprus, UK and so on [25]. Some of these studies applied some different dimensions in order to adapt the model in accordance with the market and business environment. Table 11 shows some descriptions and important findings of these analyses.

Authors/Researchers	Description	Important findings
Blanchard & Galloway (1994)	- Three dimensions, named Process/Outcome, subjective/objective, and soft/hard	- Customers consider the process factors when assessing service quality - Employees are aware of customers' expectations
Avkiran (1994)	- BANKSERV, 17 items loaded in 4 dimensions, namely staff conduct, credibility, communication, access to teller services	- Importance of staff-customer contact and its high value for customers. Banks that embrace high technology solutions to a great extent might lose in terms of perceived service quality in the minds of consumers. - Longer waiting periods for customers may result in negative assessments for perceived service quality.
Johnson et al., (1995)	- Any measure of service quality should consider all dimensions of the service, which are inputs, processes and outputs.	- Output quality was the best forecaster of overall service quality.
Angur et al., (1999)	- Compared the applicability of SERVQUAL and SERVPERF in two banks.	- SERVQUAL provided better diagnostic information than SERVPERF. - The five dimensions of SERVQUAL were not seen to be validated in total. - Process quality outcomes are more relevant to the service encounter and will play a more important role for service quality assessments in the minds of consumers than the technical quality outcomes.
Lassar et al., (2000)	- Compared SERVQUAL and technical/functional quality measures as to their capacity to predict customer satisfaction to a sample of international private banking customers.	- The five dimensional structure of SERVQUAL may not be universal. - The Gronroos model of technical/functional quality measures explains more of the variance in total satisfaction than SERVQUAL. Also, it can predict overall satisfaction better in high-contact service settings. - Service failure and communication may influence the service quality and satisfaction process.

Bahia & Nantel, (2000)	- Banking Service Quality (BSQ) instrument composed of 31 items loaded in six dimensions.	- Specifically developed to measure service quality in banking.
Newman, (2001)	- Nationwide execution of SERVQUAL for a major UK bank between 1993 and 1997.	- Found several disadvantages of the instrument, both for its diagnostic value and its use as a measurement tool, especially if there is lack of top management support. - When factors, which are considered as vital by consumers are low, then soft quality factors, irrespective of the level at which they are assessed by consumers, cannot make up the difference.
Sureshchandar et al., (2002)	- Proposed a construct to measure perceived service quality for banks in India composed of a five-factor structure consisting of core service, human element of service delivery, systematisation of service delivery, tangibles and social responsibility.	- SERVQUAL cannot be considered complete since several factors and the relevant items have not been included, hence, important elements that may define service quality dimensions have been left out. - Aimed to present vital determinants of service quality that were unobserved in previous studies.
Jabnoun & Al-Tamini, (2003)	- Modified version of SERVQUAL (perception side only) to measure service quality in banks in the UAE. The resulting instrument consisted of 22 items loaded on three dimensions namely human skills, tangibles, and empathy.	- The human skill dimension was the most important, which included items from the original dimensions of reliability and assurance of SERVQUAL.
Zhou, (2004)	- Employed SERVPERF to measure customer satisfaction and other consumer intentions for banking services in China. The author suggested a three dimensional construct (empathy/responsiveness, reliability/assurance and tangibility).	- The most important dimension was assurance in contrast to the finding of Parasuraman et al., (1988) that reliability is the most critical dimension. - The researcher suggests that the cultural characteristics of customers may influence the applicability of the model and its constructs in different markets.

Authors/Researchers	Description	Important findings
Bhat, (2005)	- Study measuring service quality of foreign and local banks in India.	- Service quality of foreign banks was much better than that of Indian banks - There were differences across demographic characteristics in variables such as income and age.
Arasli et al, (2005a)	- Used a version of SERVQUAL to measure Greek Cypriot bank customers' expectaionts and perceptions of service quality and to examine the relationship between service quality, customer satisfaction and positive word-of-mouth. Their results showed a three dimensional (reliability, responsiveness/empathy, and tangibles) construct made up of 14 items.	- Expectations were higher than perceptions. - Expectations of bank customers were not met and the largest gap was found in the responsiveness/empathy dimension. - Employees are very important during the service delivery act. - Reliability has the highest effect on customer satisfaction.
Arasli et al., (2005b)	- To compare service quality in the banking sector of Cyprus and to examine the relationship between customer satisfaction and positive word-of-mouth in the Turkish and Greek speaking areas of Cyprus. - Their results supported a four-dimensional construct (reliability, assurance, empathy and tangibles) consisted of 18 items.	- Expectations of customers for both the Greek and Turkish speaking were not met by the service providers. - The largest gap appeared in the empathy dimension. - Customer satisfaction was mainly influenced by the assurance dimension. - The responsiveness dimension was not part of the construct. - The importance of employees for customers in both areas is supported by the findings of this study. - The tangibles dimension was found to be significant in this study in contrast to Parasuraman et al's, (1988) argument that tangibles was the least important dimension.
Lee & Hwan, (2005)	- Studied the relationship among service quality, customer satisfaction and profitability in the Taiwanese banking industry.	- They found that service quality influences customer intentions more than customer satisfaction. - Stresses the importance that should be given to service quality by bank managers.

Table 11 Application of SERVQUAL in banking [25]

Additionally, there are some others analyses performed in particular banking segments such as retail banking [30] and Internet banking [31]. As an example, in the latter, authors identified 17 dimensions of Internet banking service quality (Table 12).

Banking service product quality (1 dimension)	
1. Product variety/diverse features Product range / Product features	
Customer service quality (10 dimensions)	
1. Reliability Correct service, keep service promise, accurate records, keep promise as advertised	**6. Access** Availability for help, ATM access, phone access, e-mail access, account access when abroad
2. Responsiveness Prompt service, quickly solve problems, convenient service	**7. Communications** Clear answer, informing customer of important information, availability of status of transactions
3. Competence Ability to solve problems, knowledge to answer questions	**8. Understanding the customer** Personal attention
4. Courtesy Address complaints friendly, consistently courteous	**9. Collaboration** External and internal collaboration
5. Credibility Confidence in the bank's service, good reputation	**10. Continuous improvement** On online systems, banking products and customer services
Online systems quality (6 dimensions)	
1. Contents Information on products and service online, other information that customer needs	**4.Timelines** Up-to-date information
2. Accuracy Accurate online transactions, errors in interface and contents	**5. Aesthetics** Attractiveness of the web site
3. Ease of use Compatibility, user friendly, easy login, speed of responses, accessibility of the web site, functions that customer's needs, easy navigation	**6. Security** Privacy, information transaction safety

Table 12 Seventeen dimensions of Internet banking service quality [31]

Recently, Choudhury Koushiki performed a SERVQUAL analysis in Indian banking system [32] in order to identify the new dimensions banking service quality considering the regulatory changes in the banking industry that have been numerous and have reduced or eliminated barriers to cross-border expansion, creating a more integrated global banking market. Besides, technological changes

have caused banks to rethink their strategies for services offered to both commercial and individual customers.

This study highlights the fact that banks should enforce their quality strategies, because banking has become more competitive with respect to the pricing of bank products, the number and types of retail banking products offered and the location of points of sale (offices branch). This consequent increase in competition has made service quality a key differentiating factor for banks attempting to improve their market and profit positions.

2.1.3 Endogenous variables that influence quality in banking

2.1.3.1 Risk management

To explain the relevance of risk management in banking, it is important to discuss the importance of banking stability in the world's economy. The banking policies and its management practices have a strong influence in the economy of any country. Along history, we have lived many economic crises that have been boosted by banking collapses.

Aware of this, decades ago the group of the G-10 (Group of industrialized nations) have created a committee to debate and cooperate on international financial matters. The first document agreement is the called Basel Capital Accord, which sets down the agreement among the G-10 central banks to apply common minimum capital standards to their banking industries, to be achieved since 1992.

Nowadays, the Basel committee is the primary worldwide standard for banks regulation [35] The Committee reports to the Group of Governors and Heads of Supervision (GHOS).

This committee has issued three principal agreements [19]:

- **Basel I,** the 1988 Basel Accord, was primarily focused on credit risk and appropriate risk-weighting of assets.

- **Basel II**, published in 2004, uses a "three pillars" concept – (1) **minimum capital requirements** (Addressing risk. Refers to the maintenance of regulatory capital calculated for three major components of risk that a bank faces: credit risk, operational risk, and market

risk.), (2) **supervisory review** (Offers to the regulators better 'tools'. It also provides a framework for dealing with systemic risk, pension risk, concentration risk, strategic risk, reputational risk, liquidity risk and legal risk, which the accord combines under the title of residual risk) and (3) **market discipline**. (Presents supplements regulation as sharing of information facilitates assessment of the bank by others, including investors, analysts, customers, other banks, and rating agencies, which leads to good corporate governance).

- **Basel III**, is the last global (2013), voluntary regulatory standard on bank capital adequacy, stress testing and market liquidity risk. Unlike Basel I and Basel II which are primarily related to the required level of bank loss reserves that must be held by banks for various classes of loans and other investments and assets that they have, Basel III is primarily related to the risks for the banks of a 'run on the bank' by requiring differing levels of reserves for different forms of bank deposits and other borrowings. A bank run (also known as a run on the bank) occurs when a large number of customers withdraw their deposits from a financial institution at the same time because they believe that the financial institution is, or might become, insolvent. This can destabilize the bank to the point where it runs out of cash and thus faces sudden bankruptcy.

Studies find a significant and positive relationship between compliance with information provision and bank soundness. Specifically, countries which require their banks to report regularly and accurately their financial data to regulators and market participants have more highly rated banks, as timely disclosure of high quality information strengthens monitoring by regulators and markets alike [34].

Under these principles banks around the world have implemented a robust risk management system in order to accomplish regulation and prevent financial crisis. However, all the risks are not only related to financial aspects. Among all the different types of risks that can affect financial companies, the operational risk can be the most devastating and the most difficult to anticipate [38].

The work developed under these principles shows that the management of operational risk is a key component of financial and risk management discipline that drives net income results, capital management and customer satisfaction. Banking practices suggest that risks different from credit,

interest rate and market can be substantial [19]. Therefore, experts classify banking risks in six generic types: systematic or market, credit, counterparty, liquidity, operational and legal [82].

For the object of this research, the operational risk becomes an important factor of quality, because it involves taking measures to ensure the quality of the banking transactions and better customer service [38].

Basel II defines operational risk as "the risk of direct or indirect loss resulting from inadequate or failed internal processes, people and systems or from external events". According to Economists [83] the majority of operational losses are due to transaction processing errors as losses result from human error, absence of proper procedures, failure to follow existing procedures, or inadequacies within the procedure when first established [84].

Operational risk has been important for banks to try to prevent fraud, maintain the integrity of internal controls, reduce errors in transaction processing, and so on in order to preserve the best quality services for their customers, but also because errors can lead to huge losses. However, what is relatively new is the view of operational risk management as a comprehensive practice comparable to the management of credit and market risk in principle. In the past, banks relied almost exclusively upon internal control mechanisms within business lines, supplemented by the audit function, to manage the operational risk. While these remain important, recently there has been an emergence of specific structures and processes aimed at managing the operational risk [38].

Understanding that some of the risks to which banks are exposed to exogenous variables like market and government policies, one of the most important management systems in a bank must be the risks of operational system. Therefore, this system counts as an endogenous variable for this research, since it controls and monitors the pulse of the business' health in a bank. This fact points out the link between quality and risk in banking service.

In 1993 Joseph P. Hughes and Loretta J. Mester performed a study that linked the term of quality with risk in banking, under a financial perspective [18]. They suggested that risk premium, which is the minimum amount of money by which the expected return on a risky asset must exceed the known return on a risk-free asset, and financial capital must be included in the function of quality. However,

financial capital is not included since the fact that regulators set a minimum capital-asset ratio for banks may constrain banks from operating at the cost-minimizing financial capital level.

2.1.3.2 Quality assets and quality loans portfolio

Compared with assets in other industries, typical bank assets are primarily made up of business loans and investment securities rather than property, plants, or equipment [85]. Hence, for banks it is vital to monitor and control the quality of their loans portfolio.

The first loan-quality-related financial indicator is the ratio of loan losses reserve to total loans. The loan loss reserve account is also called allowance for loan losses (ALL) account [85]. This ratio is one of the most common industry specific indicators to measure the credit risk for the loan quality. The loan loss reserve account is a contra-asset account to reflect the accumulated money against the future possible uncollectible bad loans. In order to build up the loan loss reserve account, a bank needs to put the money in the provision for loan losses (PLL) as an expense item from the Report of Income (or Income Statement) gradually. Usually, the loan loss reserve equals to 1% of total assets in a typical commercial bank if the common-size-balance-sheet-analysis is used [37]

The ratio of nonperforming commercial loans to total commercial loans is another important measure of loan quality. Non-performing loans (NPL) are the loans that the borrowers have troubles to repay the principle and interest payments on the scheduled time for more than 90 days. The 3-month-or-longer delay beyond the originally predetermined due date forecasts the high default risks [85]. The change in non-performing loans could be a very good indicator to reflect the quality of total outstanding loans very easily [37].

The quality of bank's assets and the probability of banks failure influence costs in many ways. For instance, a large proportion of nonperforming loans may be a signal that the bank neither applies good practices in credit analysis nor performs continual monitoring. Thus lower-quality loans may cause extra costs while the bank tries to recover the bad loans and cover the required capital's level [18].

One of the biggest challenges for a bank is to understand and balance the relationships among loan quality, cost efficiency, and bank capital [39].

2.1.3.3 Quality of customer's historical data

Other aspect that has been analysed, as a factor of quality in banking, is the notion of information reusability. Banks are viewed as information processors, they exist because of their advantage in extracting the surplus associated with the reusability of borrower-specific information [40]. It is shown that a bank's incentive to screen loan applicants, and hence maintain the quality of its assets, depends on the surplus this screening can produce, which in turn depends on information reusability.

Durability of information enhances its value by providing an increased second-period return to the lender [40]. Data quality and data integration are two important topics for today's financial services companies.

2.1.3.4 Market size

Other aspect that has been related to quality in banks is the market size. Quality is positively and significantly associated with market size for all measures, suggesting that banks provide higher quality, on average, in larger markets. [22].

2.1.3.5 Pricing in banking

One of the quality definitions is the perception of the costumer about the relation price-benefits i. e. whether the customer is satisfied with the relation between the price and the service obtained.

Pricing has an impact on customer satisfaction and profitability. Banks' clients have become more demanding and customers' willingness to switch to other providers has risen. In her article, A. Dick [22] suggests that prices for bank products play a central role in the consideration to switch banks. In recent surveys, roughly half of respondents state dissatisfaction with fees and partly also interest rates as a factor which influences their decision to switch. Furthermore, customers identify pricing as an area where they wish to see improvements and regard these as a suitable means of increasing satisfaction with their bank [22].

Nowadays, this aspect is one of the biggest problems of the banking service, because customers, in general, do not see the immediate benefits of paying these fees, which makes banking different from other services such as restaurants or medical service where customers receive the benefits in the moment that they pay for the service.

A Deutsche Bank research [56] mentions that some factors such as proximity and accessibility of the offer are considered in the purchasing decision, i.e. whether there is a local bank and which services it provides via different channels. Additionally, one precondition for the purchase of financial products is a certain degree of trust – precisely because it is often difficult for the customer to make a performance assessment for products. Correspondingly, reputation, (perceived) competence and security also play an important role [56].

Pricing in banking also differs according to products, where the more homogeneous the product, the more intense the price competition usually. For example, macroeconomic conditions have a bigger impact on loan and investment products, whereas the demand for "bread-and-butter financial products", such as bank accounts, is relatively stable [56].

Competitors also influence pricing considerations. A survey about the pricing strategies and tools of European retail banks suggest that almost half of respondents rely on benchmarks as key decision-making tool, and for more than 90% comparing their own offers with competitors is at least one of the pricing techniques they use.

2.2 MODEL DEFINITION

2.2.1 Considerations and assumptions to calculate quality costs in banks

- Measuring COQ in banks should be approached and analysed considering **two points of views, one toward the service with customer perception and other toward the stability of the system and sustainability of the bank in the market.**

- We could say that banks are the most regulated organization of the world, because their direct impact in the economy; hence, they should implement many control and risk systems in order

to be able to run their business in a safe and better manner. The most important goal of these systems is to mitigate the impact of the risks that could affect the business stability, the savings of the customers, and the security of the customer's data. These aspects seem to be similar to the goals of any quality program; hence, one could infer the inclusion of a new variable into the quality formula that counts for the component of the risks system.

- One of the advantages of the requirements imposed for regulators is that banks must disclose information such as financial statements and number of claims. This fact presents an opportunity in the application of COQ model. This may be synchronized with the assertion of the ASQ, when it says that COQ are clearer today in large industrial firms than it was years ago, because they have gathered more statistics, and accounting units are more involved in this activity.

- The principle of "Listen to your customers" in banks is of vital importance. Practitioners are in agreement with this, because "banking is very much a service business, and service businesses are about **people, relationships and trust**" [86]. Moreover, service banking **relationship is built along the time, which makes the measurement of failure costs difficult. When bad quality in encountered in banking service, the outcome of the service experience may come after some period of time has passed** [25]. This explains why banks prefer tools like SERVQUAL; however, there is a tremendous opportunity in the implementation of COQ to have a measurement of the other side of quality that helps as a reference point of the organization performance.

- In banks, quality is positively and significantly associated with market size, risk management and quality assets; therefore, these variables might be considered when analysing the results of COQ, because quality costs in a big and more competitive market may remain more stable, since banks must maintain their efforts to offer a better quality product. Nowadays, perception of banks quality relies on a better customer service, more points of access, technology innovation, security of savings and data, and "good will".

- Quality strategy for banks must be zero defects; they are under the category of high technology.

- The identification of COQ is not straightforward, because there is no general agreement on a single broad definition of quality costs. However, according to Dale and Plunkett [87], it is now widely accepted that quality costs are the costs incurred in the design, implementation, operation and maintenance of a quality management system, the cost of resources committed to continuous improvement, the costs of system, product and service failures, and all other necessary costs and non-value added activities required to achieve a quality product or service [41]. This assertion supports the consideration of endogenous and exogenous variables that affect banking quality systems.

- COQ analysis in banking must focuses on the operational activities rather than financial activities, since investments depend on external risks and factors that go beyond the operational framework.

- Finally, the analysis of COQ in a banking system must consider just the aspects that occur in an operational context instead of a financial scenario. Since the economical results of the investments that a bank makes depend on the exogenous variables that go outside of the operational framework, this analysis is performed considering the three main products of banks that make part of the operational supply chain (saving account, credit cards and credit loans)

2.2.2 Activity identification

As we mentioned before, COQ can be measured in a specific process, as a short term strategy in order to identify cost saving opportunities, or in a product as a long term strategy in order to find improvement opportunities and have an insight of performance in the organization.

This research attempts to perform a measurement of COQ in a whole banking system, under the concept of product performance or organization performance. Therefore, the identified activities include all the activities that a bank must execute in order to offer a continuous service. It covers the whole bank supply chain that is characterized by having two single entities and a bidirectional communication with the customers; because, as an input the customers provide the principal raw

material (money) by bringing their savings to the bank, and as an output the bank offers to the customer credit loans (money), and this relationship is supported by a vast technological infrastructure (Branches, ATM, POS, Mobil bank, and Internet) that provides the communication channels to process transactions and requests from the clients. Figure 19 presents a scheme of bank supply chain.

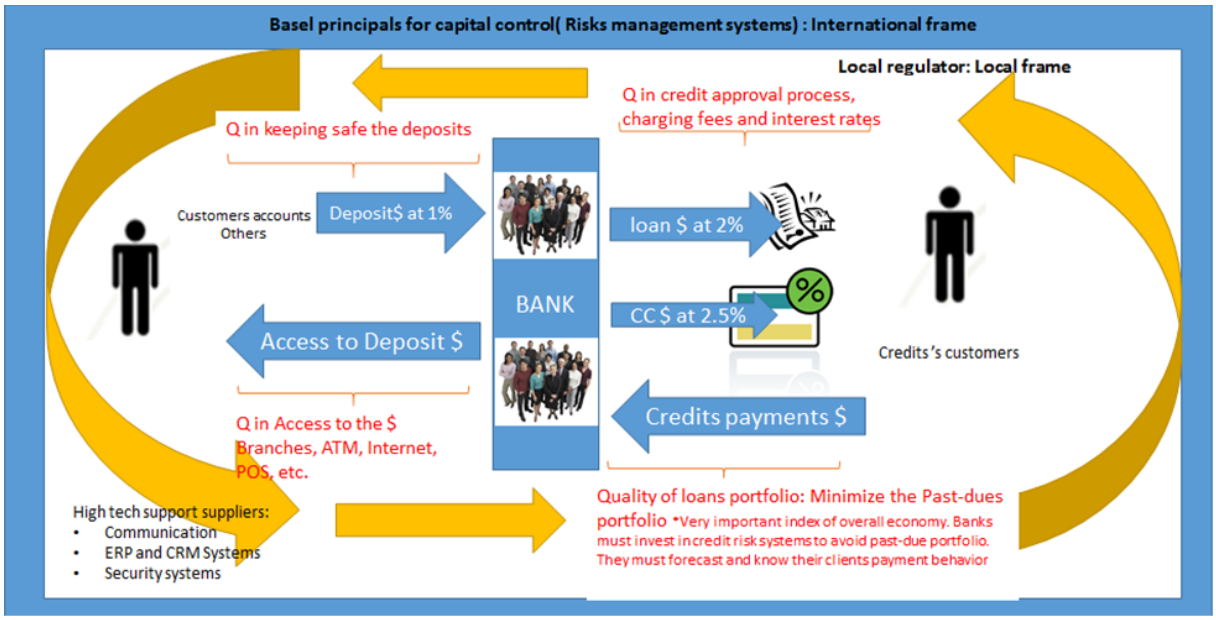


Figure 19 Suggested bank supply chain

One could think that banks capability could be measured in terms of the number of opened accounts or credits. However, this efficiency index may not give any clue about the performance of the banking services as a whole, because banking products are not one- time-service or, in other words, they are not static. For example, once a client opens a banking account in the very beginning, although the first customer service attention may create his/her first perception, this customer cannot evaluate the product performance until he/she uses his/her debit card in an ATM or POS, or until he/she requires a wire transfer, a check, a reference or a credit card, etc. These actions involve many processes that require a vast technical infrastructure and a permanent customer service system.

For these reasons, this scheme is presented as a flow of continuous activities with no stop that guarantees the safe access to savings and credits. In a mature bank supply chain, the set up activities for opening new accounts are very few, and the principal efforts are focusing on maintaining and retaining actual customers by offering better and new services. The principal package of activities can be categorized as:

- Customer service: Personal accounts available 24/7 through different channels. Personal attention in branches.
- Technological infrastructure: Electronic channels (Mobile, Internet, ATM, POS, IVR, etc.)
- Security system
- Risk administration systems
- Reporting systems

2.2.3 Costs identification

Under the concept of the whole banking system we proceed to identify the quality costs using the traditional PAF method. The PAF model was selected because of its flexibility and relative simplicity. In a brainstorming session, with the aid of two experts in banking system we identified the groups of events that may incur costs and affect service quality. They are presented in Table 13.

Cost of ensure quality or conformities	**Prevention**	Innovation projects and quality management & process improvement (Estimated) Training (Estimated) Financial and legal consulting (Available in financial statements) Maintenance and repairs of systems and equipment (Available in financial statements) Maintenance of branches (Available in financial statements)
	Appraisal	Reviews, audit and compliance activities (Available in financial statements)
Cost of poor quality or costs of non-conformities	**Internal failure**	System outage (Operational risk) Crisis management (E.g. run out of cash bill because a market crisis) (Market or liquidity risk)
	External failure	Expenses due to customers claims that were not resolved at the first stage (Operational risk) Expenses for frauds (copy cards cc, phishing, etc.) (Operational risk) Expenses due to systems interruptions or processes errors (Operational risk) Cancellation of product due to negative customer service (Operational risk) Loss due to delays in payments of credit loans (Credit risk)

Table 13 First draft of costs of quality classification

Afterwards, we went through the list in order to analyse the feasibility of measure them, we identified the following possible sources and estimations:

A. Cost of conformities

1. **Preventions Cost**: Most of these costs could be calculated from the financial statements since banks keep a good record of these categories of expenses. Some assumptions must be made to calculate:

- Costs of innovation and quality projects: Although, these costs are not recorded as a one unique amount in the financial statement, for this study we assume that all the projects costs are for improvements.

- Training costs count as a 1% of the total payroll. This estimate is based on the parameter of hours of training per employee which was measured by a study of organizational climate in Colombian banks (Source asked to be confidential). Using this index with the total payroll cost and the number of employees (data available) we obtained this factor. Although it seems to be low, since we are considering the total number of employees, employees that work in customer service must receive more training than others, however this information is not available.

2. **Appraisal Costs**: Available data in the financial statements.

B. Cost of non- conformities

The measure of the non-conformities in a service company is probably the most challenging part when applying COQ methods, because:

- The production and consumption are simultaneous: the identification of internal failure might not be applicable. If ever an error or mistake would occur the customer would be always aware
- Perception of poor quality is subjective: what means a poor quality service for one customer might not be the same for another one.

However, in this thesis we think of the banking system as a whole and consider thus that a bank works as a system of continuous flow of processes that depends on a technological infrastructure and a group of employees, and that is impacted by multiples risks.

Taking into consideration its business nature (as discussed previously), we identify that the failure costs in a bank correspond to the losses caused by the economic impact of some potential risks. In this sense it is important to recall again the types of the identified risks and decide which of them may count as failure costs [63]:

- **Systematic:** Systematic risk is the risk of asset value change associated with systematic factors. It is sometimes referred to as market risk [63]. Interest rate risk and foreign exchange risk are a good examples of the systematic risk. This is a natural risk of any business, not just banks; however, since the consequences are significant it is necessary to control them in a closer manner. Therefore, for this study, we argue that the systematic risk is an endogenous variable that does not count as possible failure costs, since it is not caused by errors in the offering service itself.

- **Counterparty:** Counterparty risk comes from non-performance of a trading partner [63] such as government or another bank partner. Counterparty risk is similar to credit risk; however it is more associated with trading than standard creditor default risk. Since this risk is present in a trading action instead of a custom action during the provision of service, this is not a customer default; and therefore, for this study, counterparty risk is not considered as a failure cost.

- **Liquidity**: Liquidity risk is described as the risk of a funding crisis [63]. In short words it refers to the scarcity of cash associated with an unexpected event, such as loss of confidence or a crisis of national proportion such as a currency crisis. Nevertheless, although a customer that wants to have an access to his/her savings could be affected by this risk, the impact of this risk is more macro in a sense that a funding crisis would affect all the customers of a bank at same time. A particular event where a unique customer has not access to his/her savings because an ATM does not work or a debit card is blocked corresponds to an event of operational risk. The economic impact of liquidity risk is not considered as a cost of quality for this study.

- **Legal**: Legal risks are endemic in financial contracting and are separate from the legal ramifications of credit, counterparty, and operational risks [63]. For example, it can be tax legislation and court opinions. Other type of legal risk arises from the activities of an

institution's management or employees. Similar to the other risks mentioned before, legal risks do not count as a quality costs as long as its causes have not root in the service itself.

- **Credit**: Credit risk is related to the non-performance loans [63]. This risk may arise from either an inability or an unwillingness of the borrower in paying its bank's debts. The credit is one of the principal products in a bank and its risks involve directly the customer as a borrower. Although confusing, it is important to understand that in an event of credit risk the most affected is the bank not the customer, since the bank could make other investments with its "money". Hence, we consider that the economic impact of this risk should count in the total COQ as lost opportunity costs, evoking **Carr's service model** [13]**.**

Although it is not common that banks make reference to the COQ methodologies, banks have implemented very robust tools and systems to identify possible risks in a timely manner, and to calculate or estimate their economic impact which may count as a costs of non-conformance in an event of credit risk.

For example, banks monitoring every day the NPL index (No performing Loans: non-performing loans / to total loans) in order to take decisions that prevent or diminish the economic impact of the non-performing loans. As a result of these monitoring actions, banks could change marketing strategies or switch to other targets. NPL it is also a macro index that governments may use to measure the health of the economy. Indeed, if this index shows a general increase in all the banks in a particular country, it is a serious signal of an economic crisis approaching.

It is usually quite difficult to calculate the cost of lost opportunities in other service companies. Nevertheless, we show here that the financial sector is in fact among the ones which are very familiar with the calculation of the opportunity costs. Since the core of banking business is to make investments the calculation of the lost opportunity costs is much more straightforward.

The full understanding of the complexity behind the measurement and control of the credit risk is beyond of the scope of this research, but what is important in this case, is to identify

the links between this risk and the quality costs. The first link is the relation with the calculation of the lost opportunity costs due to the non-performing loans. We thus argue that:

Lost opportunity costs = Amount of non-performing loans * Minimum rate of return

The second link is between the total COQ and the NPL Index. Once COQ is calculated it is important to analyse the results considering the behaviour of the NPL Index, because an increment in this indicator may cause an increment in the total COQ. However, if the NPL is affected by exogenous variables that a bank cannot control such as an economic crises or a new government policy, this factor should not be included in the COQ.

- **Operational**: Basel II define operation risks as the risk of direct or indirect loss resulting from inadequate or failed internal processes, people and systems or from external events[19]. Some academics assert that the majority of operational losses are due to transaction processing errors [83]. Such losses result from human error, absence of proper procedures, failure to follow existing procedures, or inadequacies within the procedure when first established [84]. According to these definitions, we consider that the economic impact of this risk falls perfectly under the definition of failure costs.

  As an advantage for this research, thanks to regulations, Colombian banks have implemented control systems that help them to calculate or estimate the economic impact of the events of operational risks which must be recorded in the financial statements under the concept of operational risks. As we mentioned before, although in the definitions of risks each bank may consider its own risks, because it depends on target markets, and other particularities of each bank. In short, the events of operational risks are related to the processes of offering products and services.

After the analysis of the first scheme of quality cost classification, the suggested classification of cost of quality for a banking system is shown in Figure 14.

Cost of ensure quality or conformities	**Prevention**	Innovation projects and quality management & process improvement (Estimated) Training (Estimated) Financial and legal consulting (Available in financial statements) Maintenance and repairs of systems and equipment (Available in financial statements) Maintenance of branches (Available in financial statements)
	Appraisal	Reviews, audit and compliance activities (Available in financial statements)
Cost of poor quality or costs of non-conformities	**Lost due to operational risk events**	System outage Expenses due to customers claims that were not resolve at the first stage Expenses due to frauds (copy cards cc, phishing, etc.) Expenses due to systems interruptions or processes errors Cancellation of product due to negative customer service
	Lost opportunity costs	Loss due to delays in payments of credit loans (Credit risk)

Table 14 Suggested costs of quality classification for a banking system

As a part of this research, in order to identify the failure costs we attempted to find the number of formal complaints in a period of time as an estimate from the statistics. However, after the analysis of these estimates we conclude that this information may just give some qualitative information to identify improvement opportunities, rather than a quantitative measure which could be included in the formula of COQ.

For this research we gathered the information on the number of complaints and the number of transactions of three major Colombian banks during a period of time of five years (2008-2012). As a results of this analysis we identified that the proportion of complaints compared to the number of transactions is negligible, i.e. around 0.01 to 0.02%. At first glance it allows to assert that in a mature bank with a robust technological infrastructure more than 99% of the banking transactions are "correct". The analysis shows that the principal reasons of complaints are:

- ATM technical problems
- Calculation of credit rates
- Contract dispute
- Bad customer services
- Reports of credit activity, which refers to the consultation between financial companies about the historical behavior of the customer with other organizations. In many countries there are companies specialized and authorized to gather citizens' credit information in order to be shared with others companies that pay for this services. Financial companies consult these

databases when approving credit loans, because a good or bad passed behavior may indicate how risky could be the future borrower.

- Missing information, e.g. the absence of accounts or credit cards statements
- Fees and commissions
- Fraud (identity theft, fake cheques and bills, etc.)
- Misleading advertising
- Misleading information
- Internet technical problems
- Errors in supporting services (guaranties, cheques processing/deposits/direct payments, etc.)
- Blocked products
- Other technical problems
- Service schedules of payments collection, e.g. a phone call that a bank makes to a customer with a past due balance in a Sunday morning.

We conclude that the number of complaints is not a suitable measure for the quantitative measure of the quality failure.

These results are in agreement with the finding of the business case **of Banc One Corporation** [15] [57] where it is concluded that defect rates cannot predict improvement's opportunities. These studies pointed out that customer perceptions might be a better indicator for this purpose.

2.2.4 Proposed Model: Total COQ Function

Based on the business analysis and the cost identification, the proposed model of the total quality cost function for a banking system is the sum of the prevention costs (P), appraisal costs (A), costs caused for events of operational risks (COR), and opportunity cost of events of credit risks (CO):

$$\mathbf{COQ = P + A + COR + CO}$$

Once identified the COQ model that would fit to a bank, the next step is to apply this approach in a real bank in order to test its feasibility, and to observe and s analyse the obtaining results. Therefore, we developed a case study that will be described in detail in the following sections.

2.3 CASE STUDY

2.3.1 Colombian banking system background

In order to have a general idea about today's Colombian banking system, this sections presents some of its principal characteristics.

Relevant and historically important aspects of banking in Colombia have started to be formed in around 1840s when the first banking institutions flourished. Since then and until today the development of banking has been framed by economic crises, booms and many reforms [60].

According to Asobancaria (Colombian Bankers Association) in the last seven years the Colombian banking industry has been undergoing a process of internationalization, which has resulted in some local financial organizations reaching dominant positions in the markets of the region (South America). This process has been driven by the strong growth of the macroeconomic conditions in the country and the existence of a strengthened regulatory framework [61]. As a consequence of this phenomenon, banks are exposed to a more competitive market that requires them to supply new products and services providing more and better technological innovation, and to ensure access to greater number of citizens.

Actually, there are 23 banking institutions in Colombia: Bogota, Popular S.A., Corpbanca S.A., Bancolombia S.A., Citibank, GNB Sudameris, BBVA Colombia, Helm bank S.A., Occidente, Caja Social, Davivienda S.A., Red Multibanca Colpatria, Agrario de Colombia, Av villas, Procredit Colombia, Bancamia, BancoWWB S.A., Bancoomeva S.A, Finandina S.A, Falabella, Pichincha S.A, Coopcentral.

Figure 20 shows that the intermediation rate has decreased in the last years, which may be a sign of more competence. Although some banks may have more specialization in terms of market targets, in general, all the banks offer the traditional portfolio of products (accounts, credit card and credits loans).

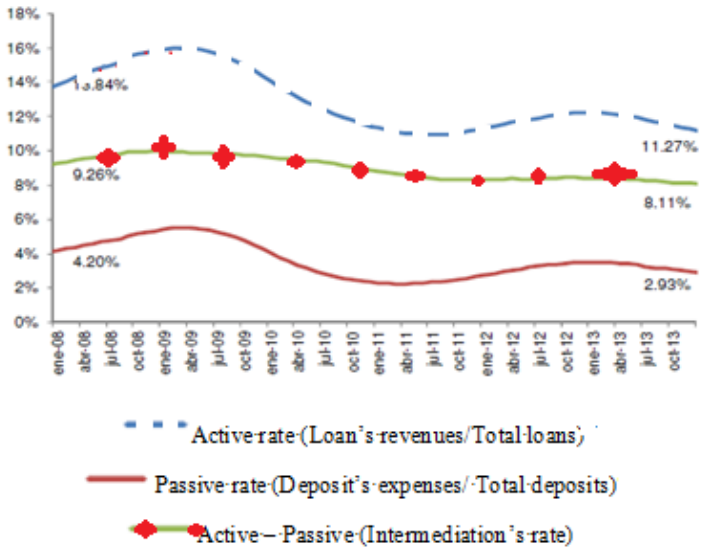


Figure 20 Intermediation margin's evolution. [61].

About banking portfolio, Colombian banks offer a wide option of transactional channels including modern service such as mobile bank. Since 2005 the use of electronic channels has become the most demanded for the customers [61].

Other important characteristic is that the Colombian Banking Regulator has worked under the principles of Basel I, II and III. As a consequence, the banks are obliged by law to disclose their financial statements, and since 2006, they must also record the risk operational expenses, which count for the financial loss caused by faults or shortcomings in processes, people, internal systems, technology, and in the presence of unforeseen external events.

2.3.2 Data gathering

The purpose of this study is to perform a macro analysis of the COQ in a banking system. The principal sources of information are the accounting reports or financial statements where the overall costs and expenses are recorded. To collect this data the principal sources were:

- **www.asobancaria.com : Colombian Banker Association**
- **www.superfinanciera.gov.co : Colombian Government Regulator**

These organizations disclose historical data banking information per period and company. Part of the work involved in this research was to organize, gather, and consolidate the information.

In order to define the selected banks and period, we consulted some officials in these organizations that provided some inputs related to the completeness and quality of the data. Therefore, we selected the data of three of the principal Colombian banks that count for approximately 51% of the total assets of the total market, in a period of five years from 2008 until 2012. The data contains 60 monthly financial statements for each of the banks.

At the request of the data sources, the name of the banking institution will not be disclosed for the present analysis, and they will be named as a bank A, B and C instead. Moreover, it is important to mention that this study does not intend to compare the performance within the selected banks.

2.3.3 Estimation of COQ and statistical analysis of data results

The data analyses were performed in the original currency (in million Colombian pesos), and in constant prices in order to remove the effects of exchange rates and inflation.

2.3.3.1 First estimation of COQ

Once the data was consolidated and the quality costs were identified, using the proposed model the authors proceeded to calculate the COQ for each period per bank, which was in total 180 measures. Afterwards a data validation was performed in order to test if the data samples were normalized and to identify out of control data points.

2.3.3.2 Data validation

With the help of the PCA functions in MATLAB, it was verified whether the data was normalized, and the out of control data points were identified in order to eliminate them and perform the final analyses with fine-tuned data.

In Figure 21 the side-by-side box plots show that data follows a normal distribution for the three selected banks, with a few outliers.

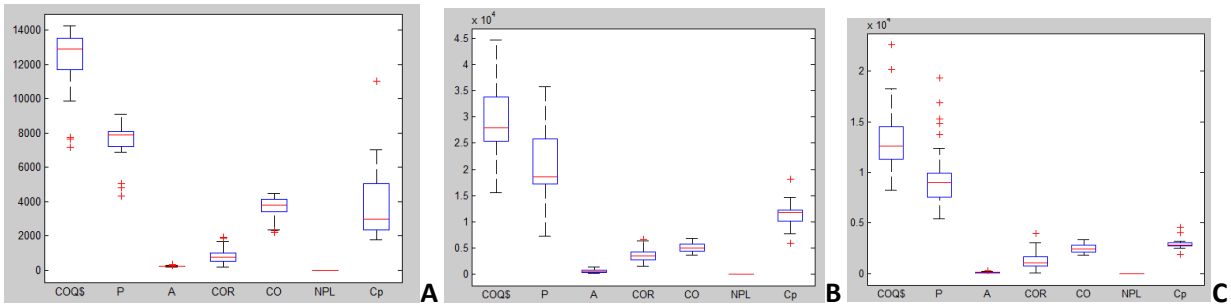


Figure 21 Side-by-side box plots

Out of control data points were identified and eliminated before performing the final analyses. The plots of the Hotelling's T2 control charts, presented in Figure 22, show no point out-of-control.

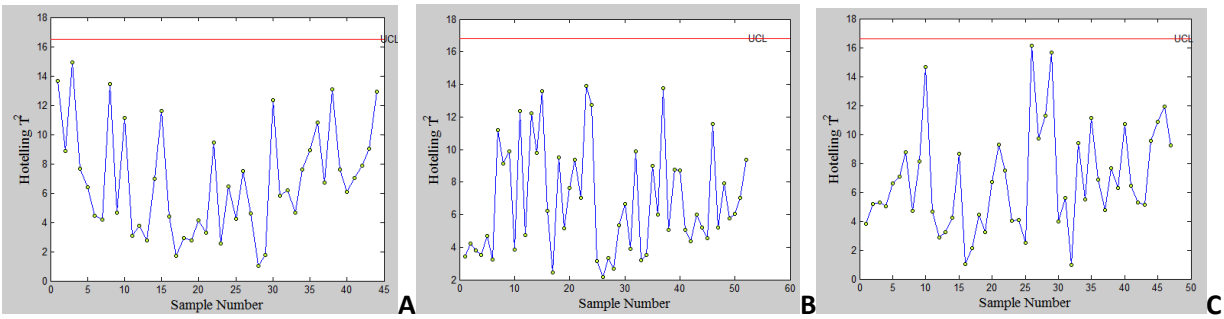


Figure 22 Hotelling's T2 control charts

Bank A had 16 points out of control, bank B 8 points and bank C 12 points. After, we identified the periods with any point out of control. As a result, the data was fine-tuned and reduced to 30 measures per bank. In total 90 measures. All the data is shown in Appendix 1.

2.3.3.3 Trend analysis of the COQ measures and other important operational indices

- COQ measures

The trend analysis was performed for the 30 selected periods in each of the selected banks. Figure 23 displays the COQ measurements.

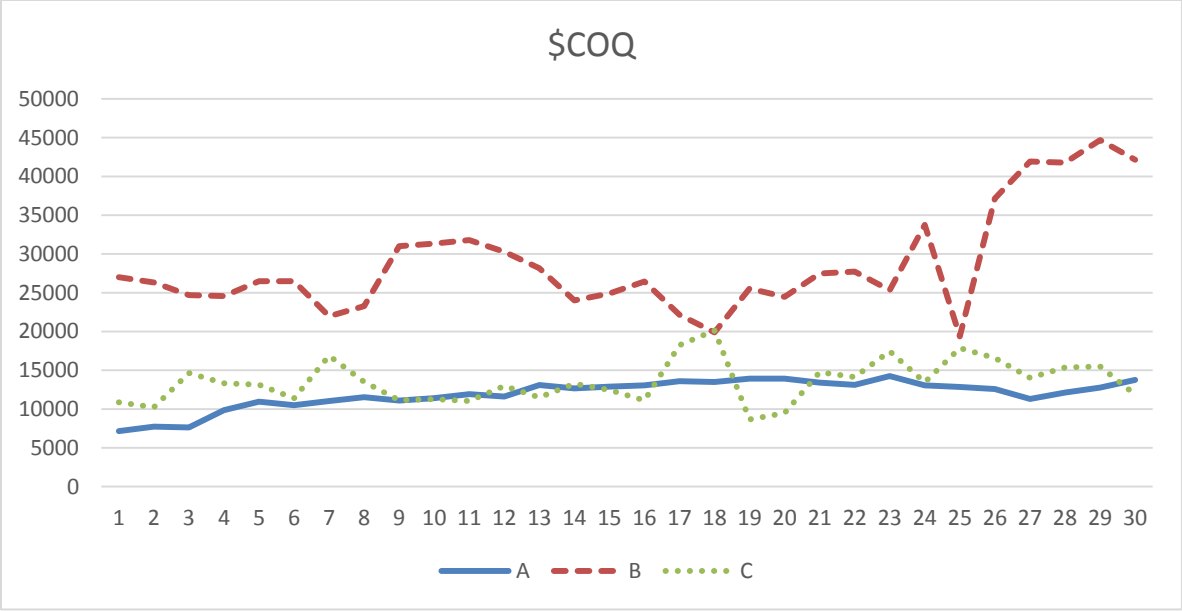


Figure 23 Trend analysis graphs (COQ)

At first glance it is observed that bank B has the highest amount of quality costs. However, it is necessary to conduct an analysis of the COQ results in light of the other operational indicators in order to identify variables that influence the final results, because a simple comparison between banks could lead to erroneous conclusions.

For the analysis of the peaks in the tendency lines in Figure 24, it is necessary to investigate in each bank the particular aspect that may have caused these variations. Unfortunately, for this research we did not have any additional information, but it would be interesting to go into greater detail in future studies.

Likewise, the results of all the component costs of the total COQ function for each bank are depicted in Figure 24, which also shows a rough average of the participation's percentage of COQ's elements.

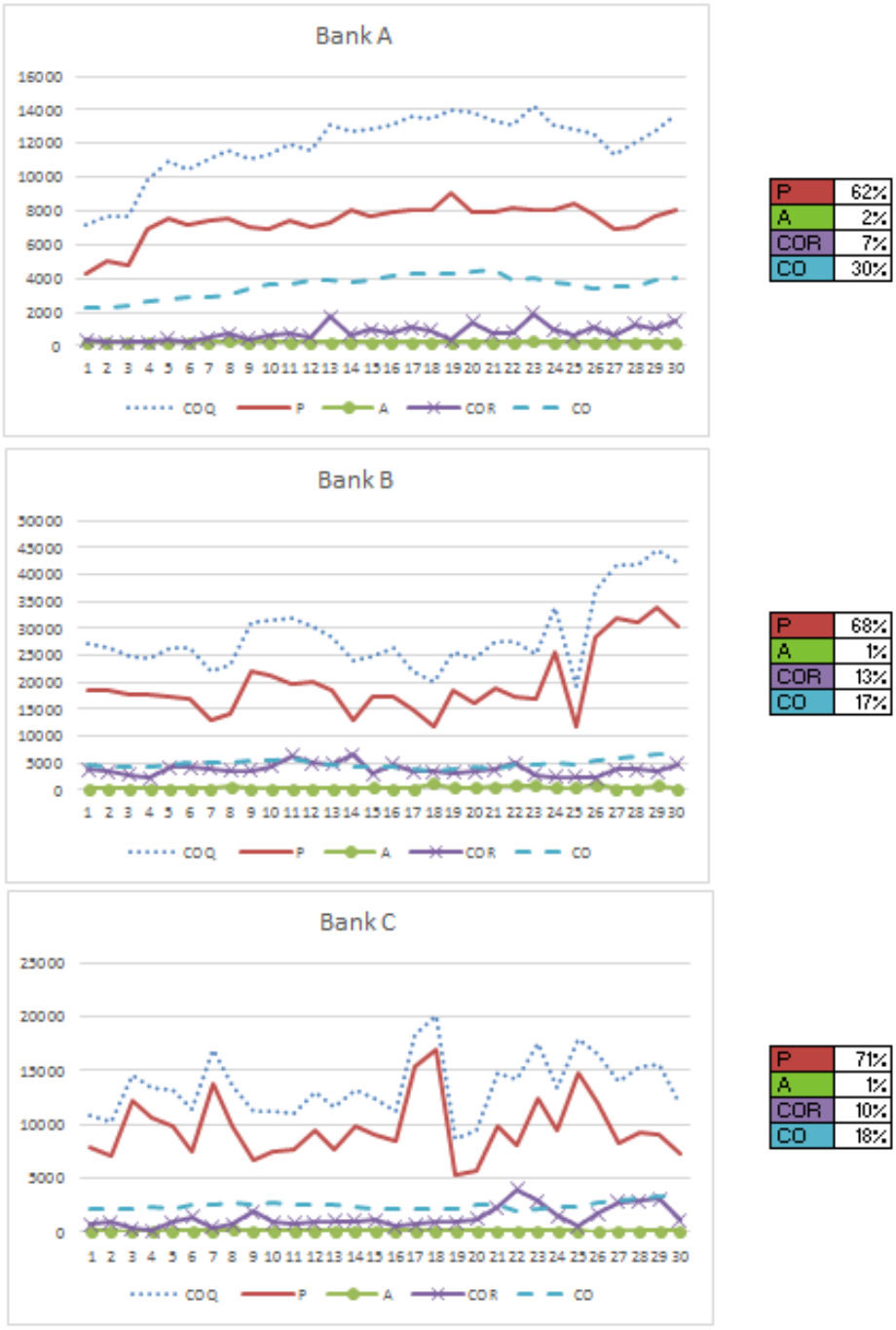


Figure 24 COQ' elements trend analysis graphs

At first glance, we can assume that these graphs show a stable period of a good quality level. In short, the costs of good quality (Prevention and Appraisal) seem to be most influential in the total function of COQ along the analysed period. There is no point of switch between costs of poor and good quality or a mature and immature period of quality. Therefore, considering that the chosen

banks are on the top of the list of the biggest banks, one of the goals of this research is establish a standard range of COQ metric that would stand as a benchmark for the Colombian financial system.

- **Metric definition**

Later, a metric of COQ that better fits the studied case was identified.

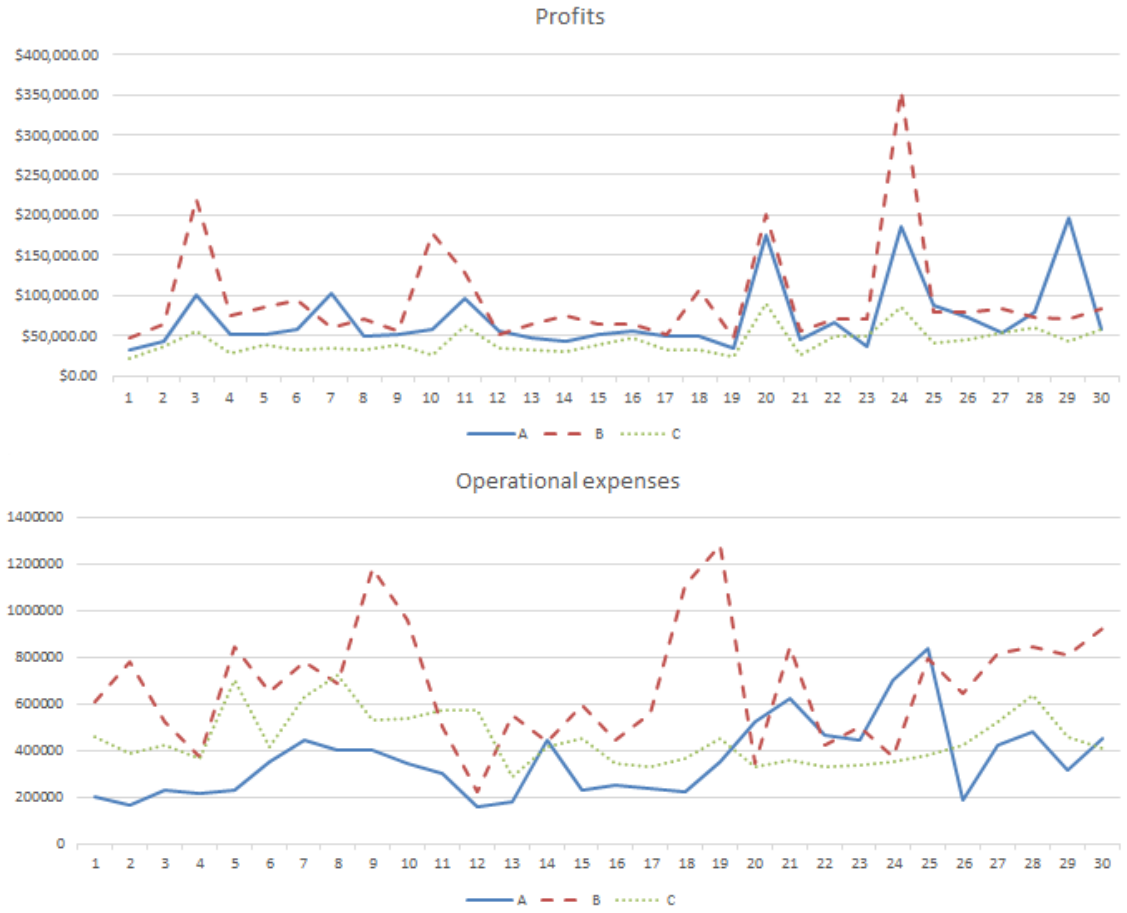


Figure 25 Trend analysis graphs (Profits and operational expenses)

In Figure 25 we observe that although profits, and operational expenses have some peaks, the profits' behavior is more seasonal that the expenses. The three banks present almost the same peaks in profits, but not in the expenses. It seems that profits depend on some exogenous variables (market, inflation, etc.) that dictate the same trends in the profits. Moreover, bank profits depend more on the bank's investments, rather than on its operational activities.

Since the operational expenses give more particular information about each bank they seem to be the best factor for the calculation of the global metric of COQ.

It is important to note that this analysis did not include revenues, since a bank does not have sales revenues, which was already discussed in the chapter that describes the business nature of a bank. The revenues in a bank are the results of investments and they do not have any relation with operational activities such as the number of new saving accounts, credit cards or number of transactions.

- **Other important operational indices**

As it was mentioned before, to understand the measurements of quality cost it is necessary to analyse other indices that may give us some clues about the bank size (volume of transactions Figure 26(a)) and efficiency (complaints and NPL Index Figure 26 (b) (c)).

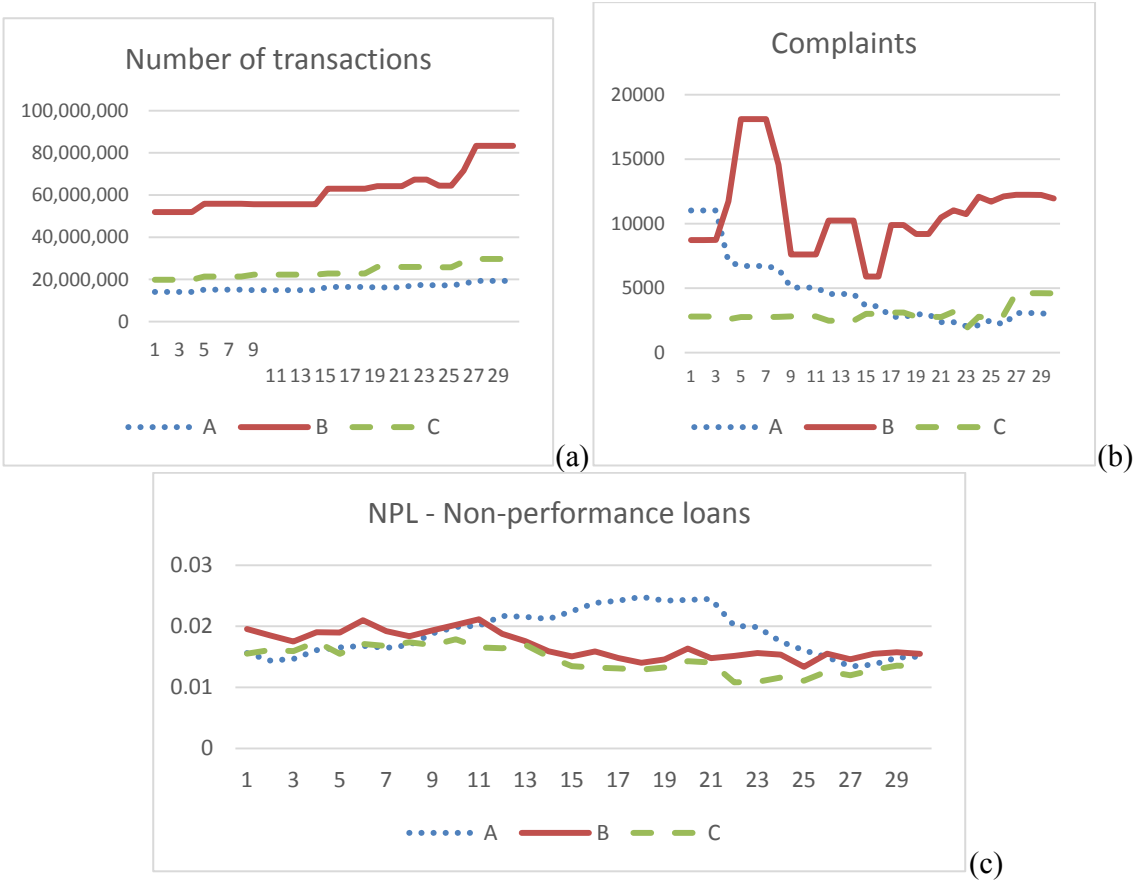


Figure 26 Trend analysis graphs (Number of transactions, complaints and NPL Index)

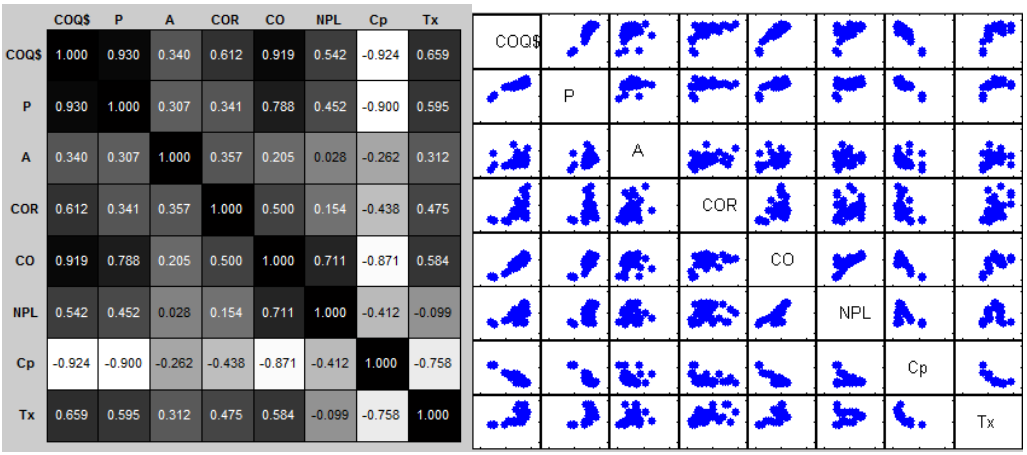
In Figure 26(a) we observe that the number of transactions is the only variable that shows a clear tendency, showing that the chosen banks have improved their performance and that electronic channels have influenced this behaviour. In Figure 26(b) complaints, on the other hand, do not present a clear tendency; however, we can conclude that bank A has presented an improvement in this regard. By the end of the analysed period, the number of complaints shows the same trend as the number of transactions.

According to the analysis of the complaints, by the end of the analysed periods the principal reason of complaints were technical problems, fraud and calculation of interest rate, which are more related to operational issues rather than to the customer service activities.

In Figure 26(c) NPL index presents a different behavior, it smoothly decreases and shows an improvement at the end of the analysed period. The decrease in this index may be due to an improvement in the loans allocation, and in the predictions of the credit risk systems. It is also highly influenced by macroeconomic factors such as employment rate, exchange rates, and other economic issues.

2.3.3.4 Correlation analysis

As the next step, the correlation analyses were performed. Figure 27 shows the correlation factors and the scatter plot matrices to visualize correlations in Bank A.



	COQ$	P	A	COR	CO	NPL	Cp	Tx
COQ$	1.000	0.930	0.340	0.612	0.919	0.542	-0.924	0.659
P	0.930	1.000	0.307	0.341	0.788	0.452	-0.900	0.595
A	0.340	0.307	1.000	0.357	0.205	0.028	-0.262	0.312
COR	0.612	0.341	0.357	1.000	0.500	0.154	-0.438	0.475
CO	0.919	0.788	0.205	0.500	1.000	0.711	-0.871	0.584
NPL	0.542	0.452	0.028	0.154	0.711	1.000	-0.412	-0.099
Cp	-0.924	-0.900	-0.262	-0.438	-0.871	-0.412	1.000	-0.758
Tx	0.659	0.595	0.312	0.475	0.584	-0.099	-0.758	1.000

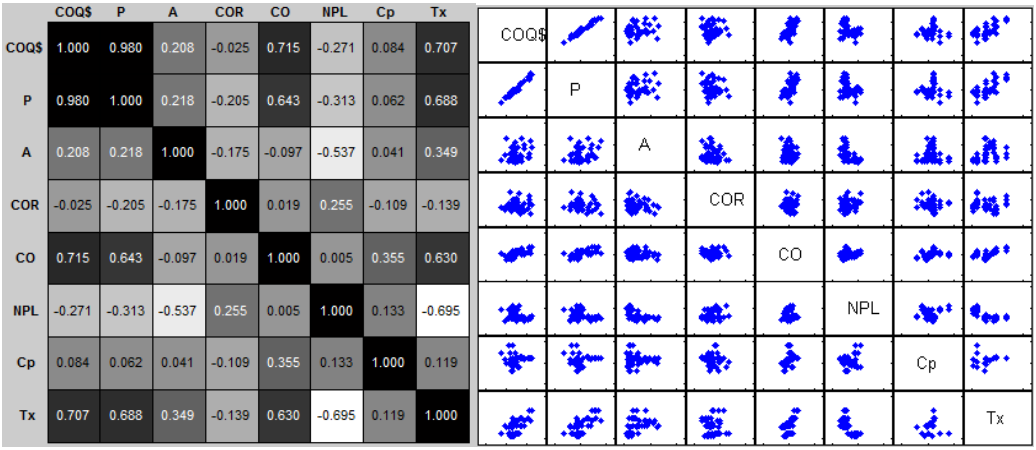
COQ$: Total quality costs, P: Prevention costs, A: Appraisal costs, COR: Risk operational costs, CO: Opportunity costs, NPL: Non-performance loan index, Cp: Complaints, Tx: Transactions.

Figure 27 Correlation and Scatter plot matrices bank A

For bank A the correlations data shows that:

- COQ is positively correlated with prevention cots (P), and opportunity costs (CO).
- COQ is also positively correlated with operational risk costs (COR) or "Failure costs" and appraisal cost (A). However, the correlation with appraisal cost is not significant.
- Considering performance indices, COQ is positively correlated with non-performance loans (NPL) and transactions (Tx). This scenario allows inferring that the bank A could be impacted by the credit risk, because a good NPL index should show a decrease instead of an increase. This may be also the explanation for the increase in the opportunity costs that count as a poor quality costs.
- There is a negative correlation between poor quality costs (COR, CO) and complaints. This is evidence that complaints do not dictate any trend about COQ. Similarly, there is a negative correlation between good quality costs (P, A) and complaints.

	COQ$	P	A	COR	CO	NPL	Cp	Tx
COQ$	1.000	0.980	0.208	-0.025	0.715	-0.271	0.084	0.707
P	0.980	1.000	0.218	-0.205	0.643	-0.313	0.062	0.688
A	0.208	0.218	1.000	-0.175	-0.097	-0.537	0.041	0.349
COR	-0.025	-0.205	-0.175	1.000	0.019	0.255	-0.109	-0.139
CO	0.715	0.643	-0.097	0.019	1.000	0.005	0.355	0.630
NPL	-0.271	-0.313	-0.537	0.255	0.005	1.000	0.133	-0.695
Cp	0.084	0.062	0.041	-0.109	0.355	0.133	1.000	0.119
Tx	0.707	0.688	0.349	-0.139	0.630	-0.695	0.119	1.000



COQ$: Total quality costs, P: Prevention costs, A: Appraisal costs, COR: Risk operational costs, CO: Opportunity costs, NPL: Non-performance loan index, Cp: Complaints, Tx: Transactions.

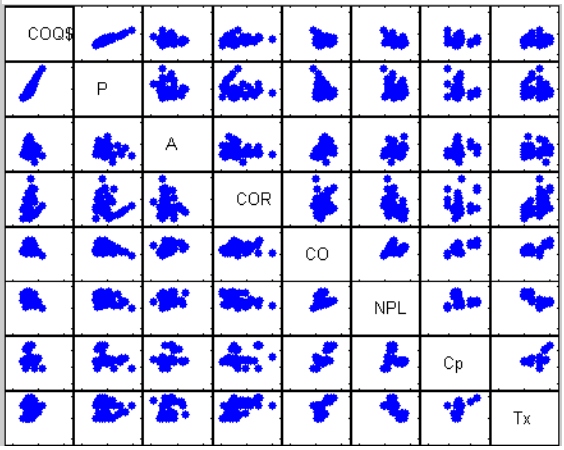
Figure 28 Correlation and Scatter plot matrices bank B

For bank B the correlations data shows in Figure 28 that:

- COQ is strongly positively correlated with prevention cots (P), and opportunity costs (CO).
- COQ is positively correlated with appraisal cost (A). However, the correlation with appraisal costs is not significant.
- COQ is negatively correlated with operational risk costs (COR) or "Failure costs"; however we can assert that there is almost no correlation, since this factor is close to zero.

- Considering performance indices, COQ is positively correlated with transactions (Tx), not correlated with complaints (Cp), and negatively correlated with non-performance loans (NPL). The latter shows that Bank B might be better covered against credit risk.
- There is a negative correlation between poor quality costs (COR) and complaints. This is again evidence that complaints do not determine any trend about COQ. Similarly, there is no major correlation between good quality costs (P, A) and complaints.

	COQ$	P	A	COR	CO	NPL	Cp	Tx
COQ$	1.000	0.941	-0.056	0.208	-0.124	-0.360	-0.055	0.152
P	0.941	1.000	-0.088	-0.108	-0.320	-0.239	-0.222	-0.094
A	-0.056	-0.088	1.000	-0.136	0.424	0.088	0.265	0.140
COR	0.208	-0.108	-0.136	1.000	0.210	-0.449	0.268	0.562
CO	-0.124	-0.320	0.424	0.210	1.000	0.096	0.667	0.614
NPL	-0.360	-0.239	0.088	-0.449	0.096	1.000	-0.084	-0.685
Cp	-0.055	-0.222	0.265	0.268	0.667	-0.084	1.000	0.514
Tx	0.152	-0.094	0.140	0.562	0.614	-0.685	0.514	1.000



COQ$: Total quality costs, P: Prevention costs, A: Appraisal costs, COR: Risk operational costs, CO: Opportunity costs, NPL: Non-performance loan index, Cp: Complaints, Tx: Transactions.

Figure 29 Correlation and Scatter plot matrices bank C

For bank C the correlations data shows in Figure 29 that:

- COQ is strongly positively correlated with prevention cots (P).
- COQ is negatively correlated with appraisal cost (A) and lost opportunity costs (CO). However, the correlations are not significant.
- COQ is positively correlated with operational risk costs (COR) or "Failure costs"; however it is not significant.
- Considering performance indices, COQ is slightly positively correlated with transactions (Tx), and complaints (Cp), and negatively correlated with non-performance loans (NPL). The latter shows that Bank C might be better covered against credit risk.
- There is a low correlation between poor quality costs (COR) and complaints. This again confirms that complaints do not show any trend related to COQ. Similarly, there is no major correlation between good quality costs (P, A) and complaints.

From these results, we can assert that in a mature bank there is a strong correlation between the total COQ and prevention costs (P). This behavior proves that in a banking system where there is a flow of continuous processes the importance of prevention is very high, since the occurrence of an error in the service could affect more than one customer at the same time.

On the contrary, appraisal (A) costs show a very low correlation. In a bank appraisal actions are focused more on administrative and legal issues rather than on operational aspects. Continuous monitoring of flow of service is part of cost prevention, since production and consumption are simultaneous.

Regarding costs of poor quality, we do not find a clear trend in the costs of events of operational costs (COR), however, although in low level, in two of the chosen banks they are positively correlated with COQ. In the case of bank A this correlation is 0.6, which might be considered as a sign of alarm.

Related to the lost opportunity costs (CO) for two of the examined banks, there is a high correlation with total COQ. We can assert that poor quality costs depend on the particular target or performance of each bank. For instance, the banks that are not strong in credit loan allocation are less exposed to the credit risks, hence the lost opportunity cost (CO) is lower than those in the banks that are focused on the credit market.

On the other hand, it is evident that total COQ in a banking system has a positive correlation with the number of transactions. Hence we can conclude that as long as the flow of transactions increases a bank may implement better processes and technical tools to strength their service structure, and likewise more prevention actions (P).

Regarding NPL, when analysing COQ the correlation of these variables should be negative, since quality costs improvements may help to reduce the events of credit risk. However, considering that NPL is influenced for other exogenous factors before making any assessment of quality costs it is necessary to determine which variables are triggering this index.

We can also conclude that the number of complaints (Cp) is not a measure to use when calculating COQ in a banking system, because they are not a good estimator of non-

conformance costs. For instance, if we estimate the costs of attending and fixing customer complaints for an ATM's technical problem, this costs may be lower than the expended costs in fixing the technical problem and the cost of lag times of the ATM, costs that banks estimate as risk operational cost (COR).

Besides, one complaint could hide the real number of customers affected by the same issue, because most of them would try to perform their transactions later or in a different ATM, and probably they will never complain if they have otherwise a good perception of the service of the bank. This explains why banks try hard to create a long good relationship with its clients.

Finally, it is important to note that although number of complaints (Cp) is not a good estimator, it must be taken into consideration when performing qualitative analyses of quality.

2.3.3.5 PCA using MATLAB functions

Although for this research the principal benefit of using PCA was to facilitate the correlation analysis of multiple variables, the complete PCA analysis was carried out as well in order to simplify the data, determine principal dimensions, and identify the principal components that explain the retained variance of the data. In simple words, in PCA the original variables are transformed into linear combinations of uncorrelated variables and such combinations are called the principal components (PCs) Z1, Z2…Zp, where Z1 has the largest variance, while Zp has the smallest. Every Z (principal component contains the sum of the eigenvalues (a) (which account for the variance) times the adjusted data set of variables (x).

$$Z_1 = a_{11}x_1 + a_{12}x_2 + a_{13}x_3...$$

$$Z_2 = a_{21}x_1 + a_{22}x_2 + a_{23}x_3...$$

For this study the outcomes show that for the three banks the first PCs (Z1) retains more than 98% of the explained variance. It can be deduced that the lowest-dimensional space to represent the banks content data is equal to one.

In Figure 30, the biplots help to visualize observations in points and variables in vectors. We can observe that for most of the selected variables, their coefficients of variance in the first component are close to zero, and only the number of transactions (Tx) has a significant coefficient.

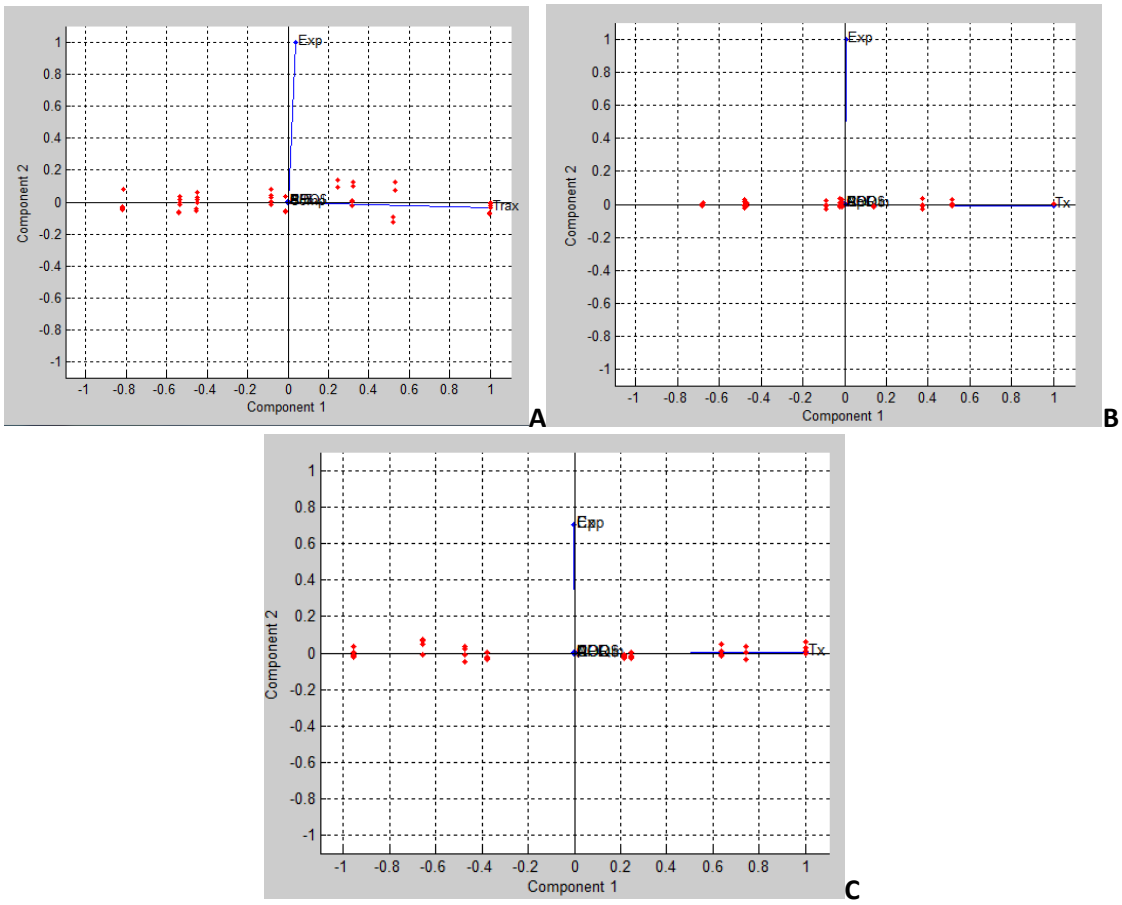


Figure 30 Biplots for the banks data

We can observe that there is a certain pattern, and for the three banks there is not a major contrast in the variances of the variables. As an example, the first component of Bank A is:

$$Z1=0.0008\ COQ + 0.0004P + \ 0.0001COR + 0.0002CO + 0.0549\ Exp + 0.9985Tx$$

In simple words, if we simplify the analysed variables, from these results we could assert that the number of transactions dictates the trends of a variance of the rest of the variables, hence COQ in a bank may be influenced for the volume of the transactions or "produced units".

Appendix 3. Includes the MATLAB code for PCA Analysis.

2.3.3.6 Sensitivity analysis

In order to identify the factors that influence the total COQ function in a banking system a sensitivity analysis is performed using a software of risk and decision analysis called *Palisade*. This software includes an option "Toprank" which is a what-if analysis tool.

To perform this analysis it is necessary to define a calculation model that predicts the result of dependent variable in function of the independent variables. Based on the results of COQ measurement and the statistical analysis, for this practical exercise it was inferred that COQ in banks is highly correlated with the number of transactions; hence, it is assumed that the volume of transactions is a good indicator to predict the COQ.

Therefore, a simple theoretical scenario was created in an Excel spreadsheet to predict the quality costs as a function of the number of transactions. Later, we defined the outputs in order to perform the "what if analysis". From the 50 iterations that this program runs the graphic result is shown in Figures 31.

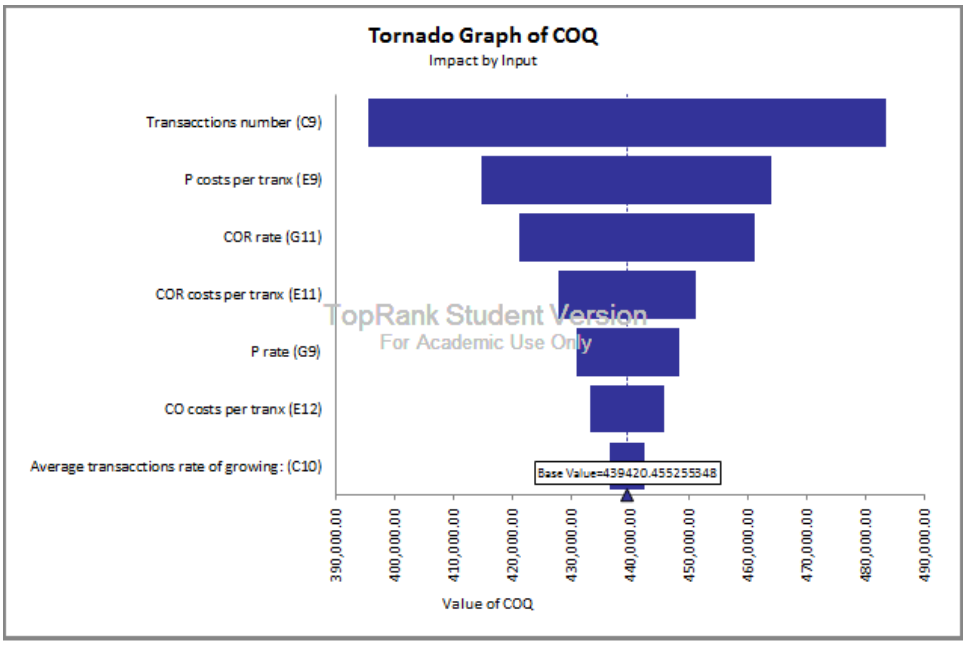


Figure 31 Tornado Graph of COQ

Although these outputs may seem obvious, they confirm that the elements that most influence quality costs in a bank are prevention (P) cost and costs caused by events of operational risks (COR), while opportunity costs caused by credit risk events (CO) have smaller impact on quality costs.

Regarding appraisal (A) costs, those costs have no influence. This finding seems to be synchronized with the operational context of a standard bank. For instance, as long as a bank increases the level of transactions it may also increase the investments in security, innovation, robustness of the technological infrastructure and training, which are identified as prevention costs.

On the other hand, this sensitivity analysis does not give any insight about the effects between the various elements of COQ. However, the determination of these effects and interactions is beyond the scope of this thesis, because we do not have appropriate data of savings.

Nevertheless, it is important to mention that although many COQ studies have demonstrated that the effects of one element of good quality may affect the outcomes of bad quality costs or vice versa, in the suggested model this behaviour may not happen, since it includes, indirectly, risk factors which bring some level of uncertainty. For instance, in an economic crisis the opportunity costs for non-performing loans (CO) would increase despite the operational efforts. However, the events of operational risks are mitigated with the implementation of prevention actions.

Appendix 2. Includes the sensitivity analysis model, tables and additional graphics.

2.3.3.7 The Colombian banking COQ benchmark using confidences intervals analysis

Taking the 90 measures of COQ (corresponding to 30 periods for each of the three banks), a confidence interval analysis using t-distribution function was performed, since the variance is unknown and the sample is small.

From the sample, it is inferred that the average ratio of total COQ over the operational expenses corresponds to 3.98% with a standard deviation of 1.9%. Then, in order to find the 99% confidence interval for the population mean, the author applied a t-distribution function:

$$\mathbf{n} = 90$$
$$\mathbf{X\ bar} = 3.98\%$$
$$\mathbf{s} = 1.86\ \%$$
$$\boldsymbol{\alpha} = 0.01$$

$$\mathbf{P}\left(-t_{\alpha/2,n-1} \leq \frac{Xbar - \mu}{s/\sqrt{n}} \leq t_{\alpha/2,n-1}\right) = \mathbf{1 - \alpha}$$

$$\mathbf{P(}\ \bar{X} - t_{\alpha/2,n-1}\ \frac{s}{\sqrt{n}} \leq \mu \leq \bar{X} + t_{\alpha/2,n-1}\ \frac{s}{\sqrt{n}}\mathbf{)} = \mathbf{1 - \alpha}$$

$$\mathbf{P(}\ 3.98 - t_{0.01/2,90-1}\ \frac{1.98}{\sqrt{90}} \leq \mu \leq 3.98 + t_{0.05/2,90-1}\ \frac{1.98}{\sqrt{90}}\ ) = 1 - 0.01$$

$$\mathbf{P(}\ 3.98 - 2.639 * 0.002) \leq \mu \leq 2.639 + 2.639 * 0.002\ \mathbf{) = 1 - 0.01}$$

$$P(\ 3.46\% \leq \mu \leq 4.50\%\ ) = 0.99$$

These results may conclude with 99% of confidence that the mean of the relation COQ/Operational expenses in a banking system will be between 3.46% and 4.5%.

Additionally, confidence intervals were applied to find with 99% of confidence the fluctuation range of the participation of each COQ's element in the total quality cost function. Table 15 displays the finding results.

COQ Element	Minimum	Maximum
Prevention costs (P)	64.6%	68.5%
Appraisal costs (A)	1.2%	1.7%
Costs of events of operational risks COR	8.4%	11.6%
Opportunities costs caused by events of credit risks CO	20.2%	23.7%

Table 15 Confidence intervals of COQ elements

These results help to infer that in an scenario of relatively good quality the proportion of good quality costs may oscillated between 65 and 70% of the total COQ, while poor quality costs between 35 and 30%

III. CONCLUSIONS

Despite the fact that academics point out the flaws of PAF models, this approach is the most commonly used among practitioners. However, it must be noted that there is no unique model. This is even more valid in case of service companies, since within the vast classification of service companies there are cases where no model may fit.

Although some academics claim that if COQ methods do not predict quality cost for a specific level of quality they may be useless, the benefits of this tool go beyond this only goal. Especially for service companies, where the identification of levels of quality largely depends on customer perception, the application of COQ helps them identify opportunities for improvement, saving opportunities, and a better understanding of how other endogenous and exogenous variables may affect the cost of service quality as a whole.

Each COQ function model must consider the adequate variables that affect the quality costs regarding the situation, the environment, the purpose and the needs of the company. Therefore, before attempting any quality business strategy in a service company, it is fundamental to gain an understanding about the type of service being performed. For instance, in this we conclude that for a bank the COQ function must consider the factor “Risk” since one of the principal characteristics of the business nature of a bank is to deal with many types of risks.

One of the major challenges in measuring COQ in bank under the concept of product performance was the identification of costs. The reason is that the products are intangible and rely on a long relationship between customers and bank. For example, although the basic products that a bank offers are saving accounts, credit cards and credit loans, what a bank really produces every day in the operational framework are transactions; hence, the identification of the internal and external failure costs in a continues flow of banking transactions might be almost impossible. Therefore the non-performance costs of quality in a bank must include the costs of events of operational risks and opportunity costs. As a matter of fact, this study confirmed that the number of complaints is not a good estimator of COQ in banks.

One of the main contributions of this study was the proposal of a COQ model that can be used for any bank which works under the principles of The Basel Committee. The proposal COQ function is

composed of four categories of costs: Prevention costs (P), Appraisal costs (A), costs caused by events of operational risks (COR), and opportunity costs caused by events of credit risks (CO). This approach is the first attempt to model COQ in banking under product concept. Moreover, it is the first time that COR and CO are including in the total quality costing function

From the correlation analysis in the PCA analysis, it can be concluded that COQ in banks depends on the size of the company and the volume of the transactions, since banks must invest continuously in preventions costs in order to guarantee the stability of the banking system. Therefore, within the COQ elements, the prevention (P) costs are the most important ones, whereas appraisal (A) costs are least important. This behaviour is similar to manufacture companies, since the size of a company influence the quality strategy

Another important conclusion of this thesis is that although in the analysed banks the costs caused by events of operational risks (COR) and opportunity costs caused by events of credit risks (CO) seem to have a low contribution to the total amount of COQ, the implementation of robust and efficient systems to control the risks that trigger these costs of non-conformance in banks is undeniably critical. These costs could negatively impact not only the quality costs, but also the banks' revenues. Therefore, base on the obtained results, a low COR and CO costs may infer a good quality cost management.

Finally, with 99% of confidence the results show that the mean of the relation of COQ and operational expenses in the Colombian banking system would be between 3.46% and 4.5%. Considering that this study is based on three of the most important Colombian banks, that the results were in agreement with experts; and also that the selected period showed good results in terms of quality and efficiency, according to we can conclude that this range is a good benchmark for other banks when performing a COQ analysis. In fact, many studies propose such benchmarks for various industries and settings, but none exists for banking; however, this result is consistent with the other ones.

IV. CONTRIBUTIONS

This thesis claims to have several important contributions to the advancement of knowledge in the area:

- This is the first time a banking COQ model was proposed. The model is very generic, it is applicable to any bank that works under the principles of The Basel Committee.

- Although the process perspective is quite commonly used for the COQ applications in services, the product performance approach has not been yet attempted in services (except software companies which present many similarities with manufacturing). In this research, the measurement of COQ in services was performed under the concept of product performance.

- The thesis provided the analysis of the COQ against other important operational indices. Such detailed analysis of the effects and interactions of the COQ cost components has not been performed for services.

- The COQ benchmark has been proposed for the Colombian banking system. This can be used for any COQ study in the banking sector.

- Finally, it is the first time that it is discussed the relation of the costs caused by events of operational risks (COR) and opportunity costs caused by events of credit risks (CO) with quality cost management.

V. LIMITATIONS AND FUTURE WORKS

This thesis has proposed the COQ model that corresponds to the business nature of a banking system. However, as many COQ models it considers only costs, but profits or savings are not taken into account. The suggested research avenue is thus to perform the measurement of quality costs in order to identify savings in a bank. This would be pretty challenging, because in order to infer particular savings for quality improvements an active participation of banking institutions providing an access to great amounts of important data would be required. Besides, considering the complexity of the operational context of banking systems, this approach would be probably a long term project.

As it is pointed out in this study, the measurement of COQ under product concept is applicable to service companies; however due to the great variety of possible service businesses (such as consultant companies, health medical care services, tourism sector, etc.), there is not a single pattern for all of them. It is thus necessary to perform a detailed analysis of the business nature of each service in order to define the adequate model that includes the particular variables that affect the quality costs in that service. There is a great opportunity to propose COQ models and perform COQ analysis in other service sectors in order to investigate similarities and differences and to identify patterns.

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VII. APPENDICES

Appendix 1

Measures of COQ for each of the selected banks in 30 monthly periods

BANK A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
COQ	7151.63	7729.29	7634.847	9866.93	10958.74	10489.99	11040.51	11536.9	11087.4116	11399.28	11931.38	11620.851	13103.312	12668.95	12893.43
P	4334.5	5050.35	4831.365	6880.11	7558.432	7237.542	7404.7	7503.08	7077.556819	6983.333	7381.493	7037.3348	7255.6632	8008.476	7718.554
A	202.982	215.194	241.6676	211.826	224.4052	215.6635	234.5381	265.021	222.1167682	211.3883	212.9034	213.47137	230.52958	213.4825	229.1572
COR	310.51	235.965	232.3464	205.114	420.3852	173.3436	491.061	746.869	381.1651494	617.4801	709.52	526.10413	1699.1194	643.098	995.4334
CO	2303.65	2227.79	2329.468	2569.87	2755.52	2863.444	2910.214	3021.97	3406.572866	3587.076	3627.468	3,843.94	3,918.00	3803.895	3950.281

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Mean	Standar deviation
13066.19	13586.83	13496.55	13926.46	13917.68	13410.11	13115.7	14252.14	13057	12847.4	12587.19	11310.36	12119.7	12765.43	13765.3	11,944.57	1,871.04
7896.119	8017.873	8060.378	9088.949	7929.137	7941.724	8209.303	8081.969	8088.6	8445.68	7840.91	6977.198	7055.09	7647.984	8078.254	7,387.39	1,032.86
231.057	227.3754	234.2182	227.3012	223.1687	238.0489	217.6009	254.5399	223.21	222.486	220.7615	226.8919	231.048	219.9562	235.0226	225.90	12.96
774.7709	1096.241	893.9127	333.3404	1391.255	733.4871	756.2772	1902.653	974.65	560.043	1120.865	638.6812	1283.76	1015.787	1480.571	778.13	449.72
4164.247	4245.339	4308.045	4276.869	4374.117	4496.85	3932.514	4012.979	3770.1	3619.21	3404.655	3467.587	3549.78	3881.703	3971.456	3,553.15	650.88

BANK B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
COQ	26997.1	26326.2	24703.93	24569.8	26490.57	26495.48	21961.54	23262.7	31013.017	31348.45	31788.42	30294.32	28170.465	24007.77	24909.27
P	18553.2	18487.2	17529.19	17757.9	17333.28	16852.59	12823.44	14244.3	21853.78806	21257.42	19514.28	19915.747	18420.939	12764.7	17181.55
A	179.195	191.462	210.2941	208.746	356.8368	257.8044	186.9574	566.612	208.8374315	167.3456	195.897	322.2677	196.06325	231.6323	495.7624
COR	3704.96	3318.87	2836.936	2129.99	4160.51	4220.912	4067.658	3572.33	3571.684862	4360.162	6340.559	4962.9375	4712.4785	6623.269	3099.25
CO	4559.71	4328.69	4127.507	4473.21	4639.946	5164.175	4883.484	4879.5	5378.706638	5563.524	5737.685	5093.3675	4840.9838	4388.169	4132.701

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Mean	Standar deviation
26455.77	22151.26	19891.56	25536.28	24471.37	27485.48	27731.83	25328.59	33756	19380.5	37150.67	41934.11	41784.2	44692.24	42149.19	28,741.28	6,750.02
17280.83	14744.35	11691.24	18290.2	16111.14	18946.65	17356.69	17005.44	25728	11798.7	28355.48	31816.79	31288.2	33814.11	30469.74	19,639.55	6,039.70
192.9164	191.3282	1263.097	369.9508	524.3607	700.9055	926.9862	874.0417	483.21	478.693	992.1239	354.9084	357.632	820.4516	359.9718	428.88	290.01
4808.743	3392.996	3359.496	3174.846	3485.412	3790.148	4950.5	2738.936	2412.8	2455.6	2199.872	3842.268	3776.81	3503.319	4741.693	3,810.53	1,073.79
4173.284	3822.587	3577.729	3701.278	4350.461	4047.777	4497.659	4710.166	5132.9	4647.47	5603.192	5920.139	6361.55	6554.35	6577.782	4,862.32	809.87

BANK C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
COQ	10866.7	10239.9	14642.75	13331.6	13146.55	11394.11	16871.68	13504.7	11143.66188	11290.74	11027.24	12977.951	11512.918	13258.66	12451
P	7953.13	6986.13	12154.73	10635.9	9879.411	7364.671	13761.9	9884.94	6644.880422	7549.384	7576.724	9499.8296	7736.8434	9808.481	9132.422
A	120	140.441	68.5212	180.065	90	90.03243	180.0649	264.032	89.39993738	155.7377	177.918	86.851884	100.25328	132.0534	93.20086
COR	743.5	966.359	299.8324	89.3945	953.3173	1441.751	424.7735	671.516	1854.096209	875.9639	785.23	883.14997	1047.6866	1000.418	1079.724
CO	2050.05	2146.95	2119.667	2426.17	2223.819	2497.652	2504.939	2684.21	2555.285314	2709.654	2487.37	2508.1194	2628.135	2317.706	2145.654

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Mean	Standar deviation
11115.23	18246.36	20130.78	8664.716	9480.275	14758.85	14130.67	17460.66	13439	17869.1	16591.56	14029.86	15360.8	15486.01	11855.8	13,542.67	2,786.23
8405.309	15284.02	16877.7	5379.659	5733.473	9917.079	8078.882	12383.79	9413	14844.2	12037.37	8224.65	9212.42	9008.486	7289.726	9,621.97	2,823.63
92.16156	93.13651	154.0285	92.68695	91.52336	94.31243	91.47343	91.54869	106.48	125.374	21.26721	149.063	168.072	107.9605	152.4488	120.00	46.07
543.6081	707.7024	948.7394	970.1004	1202.803	2296.83	3928.837	2896.835	1555.7	531.668	1743.724	2808.453	2847.79	3029.071	1060.22	1,339.63	936.95
2074.149	2161.502	2150.309	2222.27	2452.476	2450.629	2031.479	2088.486	2364.3	2367.88	2789.198	2847.695	3132.5	3340.495	3353.403	2,461.07	358.57

*Data in million Colombian pesos.

Appendix 2.

Sensitivity analysis's model

Transacctions number	35,376,953.00	P costs per tranx	0.00039	P rate	6%			
Average transacctions rate of growing:	8.88E-03	A costs per tranx	0.00001	A rate	18%			
		COR costs per tranx	0.00005	COR rate	27%			
		CO costs per tranx	0.00013	CO rate	1.24E-02			
Month	**# Transactions**	P cost per Tranx	A cost per Tr	COR cost per	CO cost per T	Total cOQ		
1	35,691,121	0.00039	0.00001	0.00005	0.00013	20,700.85		
2	36,008,079	0.00041	0.00001	0.00006	0.00013	22,319.50		
3	36,327,852	0.00044	0.00001	0.00008	0.00013	24,157.89		
4	36,650,465	0.00046	0.00002	0.00010	0.00013	26,262.07		
5	36,975,943	0.00049	0.00002	0.00013	0.00014	28,689.78		
6	37,304,311	0.00052	0.00002	0.00016	0.00014	31,513.66		
7	37,635,595	0.00055	0.00003	0.00021	0.00014	34,825.32		
8	37,969,821	0.00058	0.00003	0.00026	0.00014	38,740.48		
9	38,307,016	0.00062	0.00004	0.00034	0.00014	43,405.59		
10	38,647,205	0.00065	0.00004	0.00043	0.00015	49,006.31		
11	38,990,415	0.00069	0.00005	0.00054	0.00015	55,778.24		
12	39,336,673	0.00073	0.00006	0.00069	0.00015	64,020.77		
					COQ	RiskOutput("COQ")+SUM(H16:H28)		

What-If Analysis Summary for Output COQ

Top 7 Inputs Ranked By Change in Actual Value

			Minimum			Maximum			
			Output		Input	Output		Input	Input
Rank	**Input Name**	**Cell**	**Value**	**Change (%)**	**Value**	**Value**	**Change (%)**	**Value**	**Base Value**
1	Transacctions number (C9)	C9	395,478.43	-10.00%	31,839,257.70	483,362.52	10.00%	38,914,648.30	35,376,953.00
2	P costs per tranx (E9)	E9	414,746.15	-5.62%	0.000351	464,094.76	5.62%	0.000429	0.00039
3	COR rate (G11)	G11	421,015.77	-4.19%	24%	461,260.18	4.97%	30%	27%
4	COR costs per tranx (E11)	E11	427,724.15	-2.66%	0.000045	451,116.76	2.66%	0.000055	0.00005
5	P rate (G9)	G9	430,949.08	-1.93%	5%	448,234.85	2.01%	6%	6%
6	CO costs per tranx (E12)	E12	433,147.01	-1.43%	0.000117	445,693.90	1.43%	0.000143	0.00013
7	Average transacctions rate of growing: (C10)	C10	436,445.76	-0.68%	7.99E-03	442,416.70	0.68%	9.77E-03	8.88E-03

What-If Analysis Summary for Output COQ

Top 7 Inputs Percent Change vs Output Change in Actual Value

			Input Variation			Output Variation		
Input Name	**Cell**	**Step**	**Value**	**Change**	**Change (%)**	**Value**	**Change**	**Change (%)**
Transacctions number (C9)	C9	1	31839257.7	-3537695.3	-10.00%	395,478.43	- 43,942.02	-10.00%
		2	33608105.35	-1768847.65	-5.00%	417,449.43	- 21,971.02	-5.00%
		3	35376953	0	0.00%	439,420.46	-	0.00%
		4	37145800.65	1768847.65	5.00%	461,391.50	21,971.05	5.00%
		5	38914648.3	3537695.3	10.00%	483,362.52	43,942.06	10.00%
P costs per tranx (E9)	E9	1	0.000351	-0.000039	-10.00%	414,746.15	- 24,674.30	-5.62%
		2	0.0003705	-0.0000195	-5.00%	427,083.30	- 12,337.15	-2.81%
		3	0.00039	0	0.00%	439,420.46	-	0.00%
		4	0.0004095	0.0000195	5.00%	451,757.61	12,337.15	2.81%
		5	0.000429	0.000039	10.00%	464,094.76	24,674.30	5.62%
P rate (G9)	G9	1	0.053142941	-0.00590477	-10.00%	430,949.08	- 8,471.38	-1.93%
		2	0.056095326	-0.00295239	-5.00%	435,142.72	- 4,277.73	-0.97%
		3	0.059047712	0	0.00%	439,420.46	-	0.00%
		4	0.062000098	0.002952386	5.00%	443,783.93	4,363.48	0.99%
		5	0.064952483	0.005904771	10.00%	448,234.85	8,814.40	2.01%
Average transacctions rate of growing: (C10)	C10	1	0.007992535	-0.00088806	-10.00%	436,445.76	- 2,974.69	-0.68%
		2	0.008436565	-0.00044403	-5.00%	437,930.44	- 1,490.02	-0.34%
		3	0.008880594	0	0.00%	439,420.46	-	0.00%
		4	0.009324624	0.00044403	5.00%	440,915.88	1,495.43	0.34%
		5	0.009768654	0.000888059	10.00%	442,416.70	2,996.25	0.68%
COR costs per tranx (E11)	E11	1	0.000045	-0.000005	-10.00%	427,724.15	- 11,696.30	-2.66%
		2	0.0000475	-0.0000025	-5.00%	433,572.30	- 5,848.15	-1.33%
		3	0.00005	0	0.00%	439,420.46	-	0.00%
		4	0.0000525	0.0000025	5.00%	445,268.61	5,848.15	1.33%
		5	0.000055	0.000005	10.00%	451,116.76	11,696.30	2.66%
COR rate (G11)	G11	1	0.241928066	-0.0268809	-10.00%	421,015.77	- 18,404.69	-4.19%
		2	0.255368514	-0.01344045	-5.00%	429,822.65	- 9,597.80	-2.18%
		3	0.268808962	0	0.00%	439,420.46	-	0.00%
		4	0.28224941	0.013440448	5.00%	449,875.75	10,455.29	2.38%
		5	0.295689858	0.026880896	10.00%	461,260.18	21,839.73	4.97%
CO costs per tranx (E12)	E12	1	0.000117	-0.000013	-10.00%	433,147.01	- 6,273.45	-1.43%
		2	0.0001235	-0.0000065	-5.00%	436,283.73	- 3,136.72	-0.71%
		3	0.00013	0	0.00%	439,420.46	-	0.00%
		4	0.0001365	0.0000065	5.00%	442,557.18	3,136.72	0.71%
		5	0.000143	0.000013	10.00%	445,693.90	6,273.45	1.43%

Appendix 3.

PCA MATLAB functions

```
  [n,p]=size(X);
variables = char('COQ$','P','A','COR','CO','NPL','Cp');

figure('Name','scatterplot matrix of the data')
[H,ax,bigax,P]=plotmatrix(X);
axes(bigax);
delete(P);

for i=1:length(variables)
    txtax = axes('Position',get(ax(i,i),'Position'),'units','normalized');
    text(.35,.5,variables(i,:))
    set(txtax,'xtick',[],'ytick',[],'xgrid','off','ygrid','off','box','on')
end

figure('Name','boxplot');
boxplot(X,variables);

X0 = bsxfun(@minus,X,mean(X,1));
S = X0'*X0./(n-1);

xbar = ones(n,1)'*X/n;
H=eye(n)-ones(n,1)*ones(n,1)'/n;
Y = H*X;

xbar = mean(X,1);
[R,sigma] = corrcov(S);

corrmat = corrcoef(X);
figure; imagesc(corrmat);
set(gca,'XTick',1:p); set(gca,'YTick',1:p);
set(gca,'XTickLabel',variables); set(gca,'YTickLabel',variables);
axis([0 p+1 0 p+1]); grid; colorbar;

figure; displaytable(corrmat,variables);


[A,Z,variance,Tsquare]=princomp(X);

figure('Name','PC2 coef vs. PC1 coef');
scatter(A(:,1),A(:,2),15,'ko','MarkerFaceColor',[.49 1 .63],'LineWidth',1);

xlabel('PC1 coefficient','fontsize',14,'fontname','times');
ylabel('PC2 coefficient','fontsize',14,'fontname','times');
text(A(:,1),A(:,2),variables)

expvar=100*variance/sum(variance);
```

```
figure('Name','Explained variance vs number of Principal Components');
plot(expvar,'ko-','MarkerFaceColor',[.49 1 .63],'LineWidth',1);
xlabel('Number of Principal Components','fontsize',14,'fontname','times');
ylabel('Explained Variance %','fontsize',14,'fontname','times');
figure('Name','Pareto of Explained variance vs. Principal Component Number');
pareto(expvar);
xlabel('Number of Principal Components','fontsize',14,'fontname','times');
ylabel('Explained Variance %','fontsize',14,'fontname','times');

figure('Name','Scatter plot of 2nd PC vs. 1st PC');
scatter(Z(:,1),Z(:,2),15,'ko','MarkerFaceColor',[.49 1 .63],'LineWidth',1);

xlabel('PC1 score','fontsize',14,'fontname','times');
ylabel('PC2 score','fontsize',14,'fontname','times');
gname(variables);

alpha=0.05;
USL = ((n-1)^2/n)*icdf('beta',1-alpha/2,p/2,(n-p-1)/2);
USL = p*(n-1)/(n-p)*icdf('f',1-alpha,p,n-p);
figure('Name','Hotelling T-square');
plot(Tsquare,'bo-','MarkerFaceColor',[.49 1 .63],'MarkerSize',2);
xlabel('Sample Number','fontsize',14,'fontname','times');
ylabel('Hotelling T^2','fontsize',14,'fontname','times');
title('Plot of Hotelling T-square');
[Tsquarea, index] = sort(Tsquare);
Tsquaref = flipud(Tsquarea);
indexf = flipud(index);
extreme = indexf(1);
disp(sprintf('The most extreme point in the placesrated data is %d',extreme));
hold on; plot(extreme,Tsquare(extreme),'ro');
USLr = repmat(USL,n,1);
redpts = find(Tsquare >= USLr);
outcontrol(redpts) = Tsquare(redpts);
samples = (1:n)';
dx = .5 * min(diff(samples));
if any(redpts)
  for k = 1:length(redpts)
    text(samples(redpts(k))+dx, outcontrol(redpts(k)),num2str(redpts(k)));
  end
end
text(samples(n)+15*dx,USLr(n),'USL');
hold on; plot(redpts,Tsquare(redpts),'ro');
hline = refline([0 USL]); set(hline,'Color','r')
hold off; gname(variables);

figure('Name','Biploy');
cumsum(variance)/sum(variance);

biplot(A(:,1:2),'Scores',Z(:,1:2),'VarLabels',variables)
axis tight;
```

```
figure('Name','3D Biploy');
biplot(A(:,1:3),'Scores',Z(:,1:3),'VarLabels',variables)
axis tight;


 [Ac,Zc,variancec,Tsquarec]=princomp(zscore(X));
C = Ac*sqrt(diag(variancec));
figure('Name','Component Correlation Matrix');
plottable(C,'%.2f');
set(gca,'LineWidth',1.2);
set(gca,'FontSize',12);
set(gca,'color',[.95 .95 .95],'XColor','white', 'YColor','white');
set(gcf,'color','white');
set(gcf,'InvertHardCopy','off');
set(gcf,'PaperPositionMode','auto');


figure('Name','Scatter plot of 2nd PC vs. 1st PC');
scatter(Zc(:,1),Zc(:,2),15,'ko','MarkerFaceColor',[.49 1 .63],'LineWidth',1);
xlabel('PC1 score','fontsize',14,'fontname','times');
ylabel('PC2 score','fontsize',14,'fontname','times');

figure('Name','Scatter plot of 2nd PC vs. 1st PC');
scatter(Zc(:,2),Zc(:,3),15,'ko','MarkerFaceColor',[.49 1 .63],'LineWidth',1);
xlabel('PC2 score','fontsize',14,'fontname','times');
ylabel('PC3 score','fontsize',14,'fontname','times');

figure('Name','PC3 coef vs. PC2 coef');
scatter(Ac(:,2),Ac(:,3),15,'ko','MarkerFaceColor',[.49 1 .63],'LineWidth',1);
xlabel('PC2 coefficient','fontsize',14,'fontname','times');
ylabel('PC3 coefficient','fontsize',14,'fontname','times');
gname(variables);

figure;
alpha = 0.05;
[outliers, h] = tsquarechart(X,alpha);

figure;
k=1;
[outliers, h] = pcachart(X,k);
ylabel('$Z_1$','fontsize',14,'fontname','times','Interpreter','LaTex');
```