COST OF QUALITY IN DISTRIBUTION LOGISTICS

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Abstract: *The task of logistics in the field of sales and distribution of the products is to achieve the highest quality of service with as lowest cost as possible. These are two conflicting goals that need to be explored and tackled together with the tendency to come up with an optimal solution. The quality of logistics services is directly linked to costs through two key perspectives. The first refers to the good quality costs, which involve investing in preventive solutions, such as implementation of quality standards, planning, management, control and quality assessment. The second perspective refers to the bad quality costs, which are the consequence of nonconformance, internal and external errors. This paper provides a review of different approaches and models for determining the cost of quality, such as: PAF model, opportunity cost model, process cost model, ABC model and Taguchi's loss function. The procedure for determining costs in the area of distribution and delivery of the products from the distribution center to the stores is presented. The methodology in this paper includes: mapping and process analysis, identification, quantification and analysis of the quality costs.*

Keywords*: Cost of Quality, distribution, logistics, PAF model*

1. INTRODUCTION

Distribution process is a process that requires significant resources, and therefore can significantly affect the quality as well as the costs arising from that quality. These costs arise even before the distribution process itself (preventive costs), but also after the distribution process (external errors). In addition, the costs in this process arise in order to provide a flexible, accurate and reliable service. For these reasons, for companies that are monitoring and trying to minimize total costs, quality costs should be one of the key parameters.

The aim of this paper is to present the most frequently used models for determining the cost of quality in the distribution process. The Cost of Quality (CoQ) can be defined as the cost of conformance and non-conformance, ie. the cost that is incurred to match the quality of the service with pre-determined requirements and standards. In addition, the cost of quality in the broader sense means the cost that has been incurred to achieve and

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maintain the appropriate quality, but also the cost resulting from poor quality management, in order to increase customer satisfaction. It can be said that the models which take into account the cost of quality are more complete, since the likelihood of product quality mismatch in real situations is more likely, causing repairs, rework or replacement of the product. For this reason, in this paper, emphasis on such models is given. Based on the literature, it can be concluded that there are models that have a good basis for calculating costs, but they still do not have a formulation, and for this reason they are rarely used in practice but are present in the literature. Those models are opportunity and process cost models.

The paper consists of two parts. The first part gives an overview of the different approaches used to determine the cost of quality. The second part relates to determining the cost of quality in the case of the distribution process.

2. DIFFERENT APPROACHES FOR DETERMINING COST OF QUALITY

Costs of quality in the distribution process can be considered as one of the key performance indicators, through which the efficiency of the process in terms of financial indicators is determined. The aim when implementing models that, when calculating costs, take into account cost of quality is to maximize quality while simultaneously minimizing costs (Andrejić et al., 2018). The cost of quality can be defined differently according to some authors and institutions, and some of them are given below in order to better define the cost of quality. British Standards Institute defined the cost of quality as a sum of cost incurred as a result of prevention and appraisal, as well as the costs of internal and external errors. Mashowski and Dale (1998) defined this cost as a sum of the costs of conformance and non-conformance, where the cost of conformance with the required quality includes: costs of preventing the production of products with poor quality, while the cost of non-conformance includes repair costs or costs of products that did not meet the required quality. A similar definition was given by Srivastava (2008), which defined the cost of quality as a sum of all costs (along the entire supply chain) that arose to prevent the poor quality of the products and meet the required quality. According to Crosby (1984), the total cost of quality is about 20-35% of the sales of production companies, while according to Feigenbaum it is about 10% of the revenue and about 30% of the total production costs (Douri et al., 2016).

Shiffauer and Tomson (2006) classified CoQ models in the following four categories: P-A-F or Crosby models, opportunity cost model, process cost model and ABC approach. Most models that take into account CoQ when calculating costs in the supply chain are based on the P-A-F classification (prevention (P), appraisal (A) and failure (F)). Prevention costs include costs arising from the planning, implementation and maintenance of a quality management system aimed at ensuring compliance with the required quality. In other words, these are costs that arise in order to prevent errors. Appraisal costs are the costs related to checking and defining the level of compliance in order to achieve the required quality. Costs of errors can be divided into internal and external. Internal failure costs arise when there is a mismatch of the service with the pre-defined level of quality, before the service reach customer. External failure costs include costs arising from a service mismatch with the pre-defined level of quality which is detected by the customer. This group of costs is the most dangerous for the company, since it can result with a loss of a customer, as well as additional costs. Also these costs

may have bad impact on the reputation of the company. For this reason, companies should make the greatest efforts to prevent the occurrence of these costs. Given the popularity of this approach to the cost accounting in the literature, a number of models have emerged that represent the modification of the basic P-A-F model. Aniza et al. (2013) applied a hybrid P-A-F model which beside this model also relied on the process cost model. In this approach, the costs are divided according to P-A-F classification, with the difference that each of the categories is further divided into unit costs of certain activities. The sum of all unit costs represents the total cost of quality. In addition to this modification, in the literature another modification was identified, which is based on the basic P-A-F model, but which beside basic cost categories, also takes into account recycling costs. These costs are taken into account considering that recycled products can be used in order to get a new product. In addition to the cost of recycling itself, this model also takes into account the cost of product collection, vehicle costs (fixed and variable), labor costs, container costs, etc. In addition to the aforementioned factors, the type of recyclable material also affects recycling costs. The recycling process can be carried out by the supplier or the factory that is engaged in production. If the recycling process is done in a factory then the costs consist of three types of costs: the cost of purchasing used products, as well as the cost of transport; the cost of recycling, consisting of the costs of sorting, inspection, restoration and disposal of waste; re-production costs (Obied-Allah, 2016). Beside the visible ones, which are the basis for calculating the cost of quality, it is often forgotten at the so-called hidden costs that can be significant and have a negative impact. In addition to hidden costs of quality, hidden costs include costs due to loss of profit, costs associated with user dissatisfaction, which in the worst case can lead to customer loss, as well as socio-economic costs. There are two ways to measure and monitor the cost of quality: temporary measurement and monitoring (when fewer workers are assigned to follow these costs over a specific period of time) and systematic continuous measurement and cost monitoring (where all employees are required to report). The first way is useful when resources and time are limited, but is therefore less detailed, while the other way requires a lot of time and resources, but is more detailed (Abramsson et al., 2006).

Many authors consider opportunity cost as the cost of losing a customer due to poor quality of the provided service. These costs are also considered indirect, i.e. hidden costs. Other authors who studied these costs came to the conclusion that these costs affect more than 83% of total loss in revenue and about 50% of profit loss (Douiri et al., 2016). According to Sandoval-Chavez and Beruvides (1998) opportunity cost is a cost that can be broken down into three groups: insufficient capacity utilization, inadequate product handling and poor quality of delivery (Wang et al., 2010). The cost of quality is defined as lost income and profit that is not realized, i.e. as an opportunity cost. Although this type of cost is often forgotten during calculation, some authors consider that these costs must be taken into account and consider that, in addition to the cost of prevention, appraisal, and errors in the P-A-F model, this cost should also be an integral component of the model. Beside missed sales, some of the authors, as opportunity cost also include permanent loss of customers due to poor quality of the product or service. Freiesleben divided opportunity cost into the following components (Ayati, 2013):

1) lost sale,
2) good will and guarantee to the customer,
3) the delay time due to the correction of the error,

4) slowing down the process due to inspection,

5) overcapacity due to a specific sales target,

6) cost during the management of disruptions during the realization of the service.

Process cost model consists of the cost of conformance and non-conformance of individual processes. The main goal of this model is to calculate the cost of quality of each process in order to reduce or increase the investment cost of prevention for each process (Douiri et al., 2016). In order to calculate the cost of the process, it is necessary to determine the input elements, the activity generating the costs (production, processing, etc.) and the output elements. Although the process cost model helps in determining and analyzing the cost of quality, it's use is not widespread.

In addition to these models, an approach developed by Genichi Taguchi, which was named after him and which refers to the loss function, is also present in the literature. This method combines engineering and statistical methods with the aim to rapidly improve quality and reduce costs. The three ideas behind this approach are: costs can not be reduced without affecting the quality, quality can be improved without increasing costs and reducing variations affect cost savings, which will directly affect performance and quality improvements (Teli et al., 2014). Beside these ideas, Taguchi approach is based on two basic facts, which are: loss due to insufficient quality increases with increasing deviation from the nominal value, for which "zero defect" is achieved and a high level of product quality is provided during the design stage, not in production.

3. DETERMINING THE COST OF QUALITY IN DISTRIBUTION PROCESS

Determining the cost of quality requires the application of a special procedure that includes: analysis and mapping of the processes, identification and evaluation of cost of quality (Kilibarda, 2016).

3.1 Analysis and mapping of the distribution process

The distribution process, figure 1, represents the connection between the demand and the delivery of the items to retail objects. From the perspective of necessary people as well as resources, distribution is one of the most demanding processes. The whole process begins with the demand for an item by stores. After the order is placed and after checking inventory, the order is processed after which a picking order is issued so that picker can start with the process of preparing goods for the stores. After this process the picker performs picking process. Before the distribution, it is necessary to carry out the control of the ordered goods (in order to determine whether a quantitative or qualitative error has occurred), after which, if everything is fine, the goods are packaged and loaded into the vehicle in order to deliver them to the stores. After distribution, the goods are unloaded and handed over together with the documentation to the store manager.

Figure 1. Flow chart of the distribution process

3.2 Identification of the cost of quality

Beside quality costs that are specific to the distribution process, during identification, other costs of quality that enable the realization of this process have been identified as well. All costs are divided according to the P-A-F classification and shown below. In addition to the identification, the source of the costs was determined. The list of the described costs is shown in table 1.

Table 1. Identification of the cost of quality

Cost category	***Cost type***	***Source of the cost***
P	Costs of standard maintenance	Quality sector
P	Training costs associated with the standard	Quality sector
P	Costs of preventive maintenance of assets and equipment	Maintenance sector
P	Costs of establishing and maintaining working procedures	Quality sector Distribution sector
P	Costs of planning the processes in the distribution (sales, ordering, transport, warehouse, delivery)	Distribution sector
P	Costs of quality assurance in the distribution process	Quality sector Distribution sector
A	Costs of monitoring and controlling the distribution process	Distribution sector
A	Customer audit costs	Quality sector
A	Costs of quantitative and qualitative control	Warehouse
A	Costs of internal checks	Quality sector
A	The cost of tracking the shelf life of the product	Warehouse
IF	Costs of errors in processing the order	Order processing sector

Cost category	*Cost type*	*Source of the cost*
IF	Costs of errors in picking order	Order processing sector
IF	Costs of picking errors	Warehouse
IF	Costs of damaged items during picking	Warehouse
IF	Costs of repicking due to damaged products	Warehouse
IF	Costs of filing documents (invoice, bill of lading, etc.)	Shipping department
IF	Costs of invoicing errors	Finance
IF	Costs of errors during the loading of goods	Warehouse
IF	Costs of transportation errors	Transport
IF	Costs of errors during unloading of the goods	Transport
IF	Costs of writing off and destroying goods	Warehouse
EF	Costs of errors during the handover of the goods	Store
EF	Costs of errors in documentation and/or quantity of goods	Store
EF	Costs of complaint processing	CRM sector
EF	Costs of expiration of the product	Store
EF	Costs of product replacement	Distribution sector
EF	Costs of returning the wrong products	Transport
EF	Costs of emergency delivery	Transport
EF	Costs of penalties due to delayed delivery	Distribution sector

3.3 Evaluation of the cost of quality

When it comes to estimating and quantifying the cost of quality, then it is necessary to bear in mind the three groups of costs: direct cost of quality, hidden cost of quality and opportunity cost. Direct costs include costs of: prevention, appraisal, internal and external errors.

The cost evaluation was carried out for two scenarios, which can actually occur in the distribution system (table 2). The first scenario involves a fully implemented quality and prevention system through implemented standards and procedures for process realization, where most of the cost of quality is related to prevention and appraisal activities. Up to 70% of the total direct costs of quality fall to these costs. The remaining 30% of the costs relate to internal and external errors, which is significantly less because there is not too much inefficiency in logistics processes and activities. The second scenario refers to a situation where there is no established quality system in the distribution process, and the costs of prevention and appraisal are relatively small and range up to 15% of the total cost of quality. However, in this scenario, the costs of internal and external errors are extremely high, which is a consequence of the non-conformances that exist in the process of distribution of goods. These costs reach up to 80% of the total cost of quality in distribution process.

Table 2. Share of certain categories in total cost of quality

Cost of Quality category	***Scenario 1***	***Scenario 2***
	Share in total Cost of Quality (%)	***Share in total Cost of Quality (%)***
Prevention costs	45	5
Appraisal costs	25	10
Internal failure costs	10	30
External failure costs	20	55

Bearing in mind the above mentioned cost of quality structure, it is justified to ask what is the level of quality that will ensure minimal cost of quality in the product distribution system. Figure 2 gives a graphical representation of the movement of costs of prevention and costs of errors, as well as total costs. Based on the shown figure, it can easily be concluded that the total costs are minimal at the intersection of the prevention costs and costs of the failures. This can be considered as an optimal level of quality that needs to be maintained in a single distribution system.

Figure 2. Determining the optimal level of quality in the product distribution process

In the process of quality planning, it is necessary to determine the balance between investment in prevention cost and costs arising from internal or external errors. Namely, as can be seen in figure 3 with increased costs caused by preventive measures as well as appraisal, the cost of errors is reduced, which leads to additional profit.

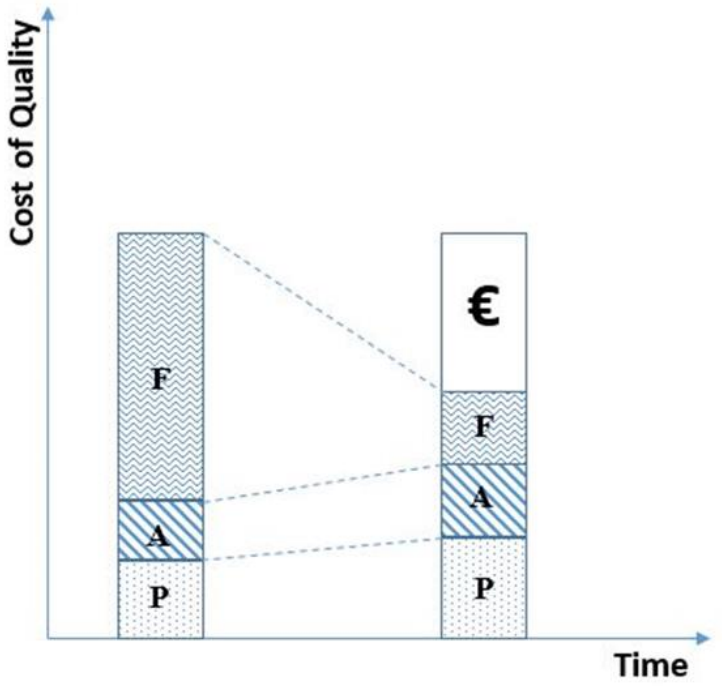

Figure 3. Allocation of the cost of quality

A detailed quantification of direct costs of quality requires precise determination of resources engaged, time needed for performing certain activity and what are the costs of engaging resources for each activity in the prevention and appraisal process. When observing errors, it is necessary to precisely determine the size of the error and engaged resources in order to eliminate that error. It is particularly problematic to quantify the cost of external errors, which can have far reaching consequences on the product distribution system. Unlike direct costs of quality, it is much more difficult to estimate and quantify the so-called hidden and opportunity costs of quality. Hidden costs of quality can also be linked to prevention, appraisal, internal and external errors. As they are not directly visible and linked to the resources involved, a special procedure for assessing and quantifying these costs needs to be developed. Opportunity costs in the distribution system relate to loss of opportunity and sale due to non-conformance and low level of quality of provided service, lack of goods in stock, customer dissatisfaction, etc. These costs may have negative impact on the distribution system and need to be kept under control. However, these costs are very difficult to quantify, measure and track. Opportunity costs are often associated with external errors in the distribution process.

4. CONCLUSION

In the distribution process, the cost-quality ratio is crucial. Costs directly affect the price of service and business efficiency, while the quality affect customer satisfaction and loyalty. Reducing costs and improving quality can be viewed as opposing goals. However, it is necessary to look for solutions that will provide the highest quality of product delivery with as little as possible total cost. This is certainly not an easy task and requires the development and application of a comprehensive methodology and procedure for determining, measuring and tracking cost of quality. In this paper, the authors tried to examine in more detail the problem of cost of quality in the product distribution system and perform rough identification and cost estimation.

The aim is to develop concrete procedures and models for determining, measuring and monitoring cost of quality in future research and papers. It is particularly important to quantify, analyze and monitor the costs that are consequence of internal and external errors in the distribution process. Errors are the result of certain solutions and procedures for the operation of logistics activities, while the causes of errors can be different (spatial, organizational, technical, technological, information and personnel). The cause can be in one process or in multiple processes, while the error is noticed in completely different process. For this reason, it is necessary to determine: the cause of the error in order to eliminate or reduce its negative impact, the cost of the error that represents the measure of the weight and size of the error as well as the negative impacts caused by the error. It is also necessary to bear in mind the impact of the quality of the delivery on the satisfaction of the customer. A lower level of customer satisfaction, which is a consequence of poor quality, results in high costs for the company through lost income because of customer loss, but also through large investments in promotion, marketing and sales efforts.

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