Chapter

Research Methodology for Quality and Risk Management in Logistics

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Abstract

This chapter sees an appropriate approach to build a quality management model by managing the risk of nonconforming logistics activities that result from dynamic environmental changes and contingencies. Logistics management has the misconception that reducing complaints would increase satisfaction to the same extent. Models for positively influencing satisfaction should contain much more than one variable. The customer satisfaction model used in this chapter contains six latent variables: Logistics satisfaction survey; analysis of data from the survey to measure satisfaction with logistics services; chapter to analyze the risk of noncompliant processes in logistics services; survey data analysis to measure the risk of noncompliant processes in logistics services. FMEA analysis was used as a method to investigate the consequences of emerging risks by quantifying the severity, likelihood of occurrence, and detection of nonconforming logistics services that further generated the RPN. The main objective of this chapter is to define the research design and the methods of data collection and analysis.

Keywords: SERVQUA, satisfaction, FMEA method

1. Introduction

The present chapter uses the SERVQUA model to identify the gaps between customer satisfaction and the needs of logistics service users by determining the relationship between customer satisfaction and targeted actions to manage the risk of dissatisfaction by logistics service providers.

The essence of the methodology used is based on the following model assumptions:

- Expectations and perceptions of the logistics services studied must at least match to obtain a positive assessment of quality from users of the service.
- In cases where there is a discrepancy between the target and actual values of the surveyed services, the quality score will be negative.
- Based on strategic discrepancies between target and actual values (system discrepancies) in quality, the reasons for the insufficiency of the measured service quality values are analyzed.

Opportunities to identify discrepancies are related to:

- Customer perceptions: Mismatch between customer expectations and perceptions of the management of the service received in a real environment.
- Senior management perceptions: Mismatch between the perception of the service provider's senior management and customer expectations of the proposed service quality specifications.
- Process execution: Mismatch between service quality specifications and actual performance.
- Communication with customers: Inconsistency between the service and the message addressed to the customer about the service.

1.1 Methodology for measuring satisfaction with logistics services

The survey was first conducted as a pilot online survey to test the feasibility of the questionnaire from 1 December 2020 to 1 January 2021. The pilot survey covered 15 respondents who were mailed the evaluation questionnaire. The results of the pilot survey showed that all the respondents understood all the questions.

The baseline survey was conducted through a questionnaire and included a sample of 115 respondents, who were required to have experience in managing logistics processes. The survey was conducted from 15 February 2021 to 15 April 2021. A total of 105 questionnaires were collected, of which 100 were valid (5 of the questionnaires were not completed correctly and some of the questions had more than one answer), with a response rate of 95%. The survey was conducted directly through a telephone interview or internet communication depending on the suitability of the respondents. The valid questionnaires were collected from 52 logistics service providers and 48 customers.

1.2 Modeling the hypothesis

The model used to conduct the chapter on customer satisfaction with logistics services contains seven latent variables. The antecedents of logistics service satisfaction are customer expectations of logistics service, perceived quality, perceived value, and image. While the two indicators of the consequences of satisfaction are: nonconformities (complaints, returns) and loyalty.

The latent variables were defined using manifest variables appropriate for the purposes of this chapter and were measured in the survey. Associations between manifest and latent variables are described using a set of equations with unknown coefficients.

The following latent variables and hypotheses were investigated and analyzed in this chapter:

- Expectation: Two indicators were studied. Customer expectations related to logistics service culture. The manifestation of expectations depends on how customers perceive and interpret the factors influencing the formation of expectations. Various factors are under the control of the company and depend on the performance of logistics services, while others depend entirely on customer perceptions (psychological, cultural, and social). Therefore, the quality

of feedback and personal contact with employees have the potential to create value and should be a priority. Sales staff need to understand customer perceptions before guiding them to the appropriate choice of product for order preparation. The indicator relates to the provision of a correct logistics service, the speed of response, and the ability of customer-facing staff to make timely decisions on the disposal of a nonconforming product.

The expectation hypothesis: Customers' expectations of the services have a positive impact on the quality of the service provided and an indirect positive impact on overall satisfaction.

- Quality: Five indicators of the expected quality of logistics services were studied. Logistics service quality is the extent to which the set of inherent service characteristics satisfies the requirements of customers and stakeholders[1].

The hypothesis (Quality) that logistics service quality has a priority and positive impact on overall satisfaction was tested during the data analysis.

- Value: Two indicators of perceived value were investigated. The perceived value of logistics services motivates the customer to tradeoff between the quality received versus the price paid to acquire the service. The service that customers receive at the time of purchase influences the perceived value.

The hypothesis (Value) that customer perceived value has a positive impact on overall satisfaction with logistics services was tested during the data analysis.

- Image: The indicator refers to the good reputation and image of the logistics company or the ability of the service provider to inspire trust and confidence. The positive impact of this factor is achieved by measuring satisfaction through various means that provide tangibility to the logistics service and service culture including tangible items relating to the facility, environment, and all types of hardware and equipment required to provide services.

The hypothesis (Image) that customers' perceived image positively impacts expectations, overall satisfaction, and loyalty for logistics services was tested during the data analysis of the chapter.

- Satisfaction: Three satisfaction indicators were studied. The satisfaction indicator is related to the customer's reaction to the comparison between the expected and actual experience of the logistics service. An essential condition for achieving good financial performance lies in finding a way to minimize the differences between the expected and actual experience of the logistics service.

- Complaints: Customer discrepancies (customer complaints) that arise while providing logistics services that are unfulfilled as expected or actual customer requirements. Complaints should be used to improve any process in which a nonconformance is identified.

[1] The definition of quality is adapted from Clause 3. ISO 9001:2015 Terms and definitions.

- Loyalty: Customer loyalty is the customer's positive attitude towards the logistics service provided because of factors that are significant to the customer.

The questionnaire required each survey participant to rate the margin of acceptability of the quality of logistics services on a 5-point scale (0 points – does not meet customer requirements and 5 points – fully meets and exceeds requirements. In cases where respondents' perceptions did not match the two extremes of the rating, they

Rate the statements on a 5-point scale: (1) completely disagree (2) disagree (3) hesitate (4) agree (5) completely agree		
Indicator	**Questions to respondents**	**Evaluation**
Expectation	PLSE1. The knowledge and experience of the nominated contact person are sufficient to understand the problems encountered	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	PLSE2. Problems arising are resolved by the designated contact person	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Quality	PLSQ1. Ordering procedures are easy to use	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	PLSQ2. Shipments rarely contain incorrect quantity	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	PLSQ3. Supplies arrive on the promised delivery date	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	PLSQ4. Shipments rarely contain defective products	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	PLSQ5. The manner in which claims are settled is adequate	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Value	PLSV1. Logistics services meet the requirements (specifications)	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	PLSV1. Logistics services are reliable and on time	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Image	PLSI1. Complaints are rarely due to the method of transportation	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	PLSI2. No difficulties have ever arisen due to lack of availability	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	PLSI3. The time between placing the order and receiving the delivery is short	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	PLSI4. Product return procedures are easy to use	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Rate the statements on a 5-point scale: (1) completely disagree (2) disagree (3) hesitate (4) agree (5) completely agree		
Indicator	**Questions to respondents**	**Evaluation**
	PLSI5. The resulting products are not normally crushed damaged	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Satisfaction	PLSS1. Logistics services to meet your expectations in number and scope	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	PLSS2. Selected logistics services are the right choice	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	PLSS3. I am satisfied with the overall logistics service	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Complaint	PLSC1. The corrective actions taken following complaints are adequate for the problem encountered	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	PLSC2. Corrective actions taken following complaints are timely	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Loyalty	PLSL1 I would recommend the logistics services used	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	PLSL2 I would use logistics services in the long-term	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Table 1.
Survey questionnaire.

could select any number between 1 and 5 to rate how strong their expectations and perceptions were. The accompanying instructions explicitly stated that the purpose of the survey was not to find acceptable or unacceptable responses but only to establish the exact numerical rating that reflected their opinion of the quality of the logistics service and their level of satisfaction as its users.

The survey questionnaire is shown in **Table 1**.

1.3 Model of the empirical study of customer satisfaction with logistics services

Tenenhaus and Michel's [1] study built based on the SERVQUA methodology provides the reference for the possible and expected model of interaction between the variables that would be obtained based on the results of the study (**Figure 1**).

The partial least squares modeling method was used to analyze the data obtained from the survey measuring the identified gaps between satisfaction and needs of the logistics service user customers. Multivariate analyses (partial least squares path-modeling [PLS-PM]) were performed to simultaneously assess the potential relationships between different logistics service quality and satisfaction indicators. An appropriate analysis method was selected after investigating a convenient tool to examine the multiple relationships (latent variables) of variables (factors).

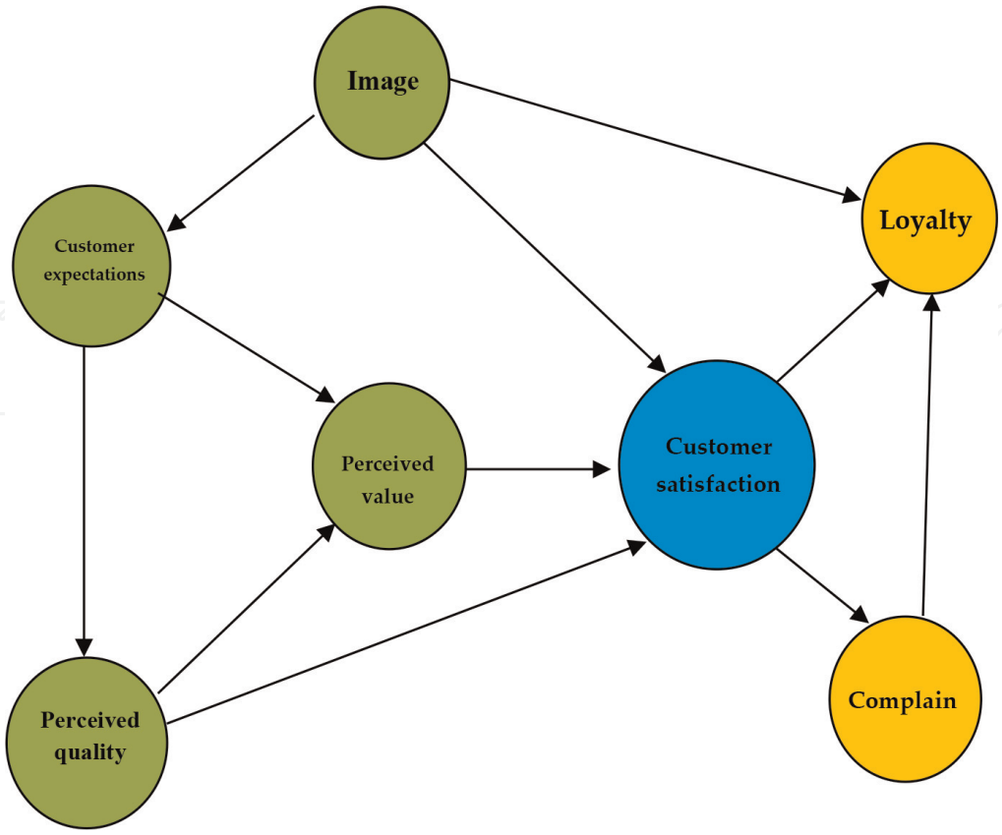

Figure 1.
Key attributes of the causal model describe the causes and consequences of customer satisfaction. Source [1].

1.3.1 Partial least squares path-Modeling (PLS-PM)

The PLS-PM model reflects causal relationships with arrows that start in a latent variable (factor) and point to measured indicator variables. The PLS-PM was chosen as the most convenient tool to examine relationships between observed and unobserved (latent) variables. Matrices in which 15–20% of the data are missing or have experimental errors can be processed by the PLS-PM method.

The possible outcomes of the PLS-PM study are presented in **Table 2.**

Through the assessment method, the relationship between variables acting on a particular outcome through multiple causal pathways is examined. Data processing was done using XLSTAT software [2] for modeling PLS relationships (pathways) implemented in the XLSTAT statistical analysis package of Microsoft Excel. The built-in XLSTAT-PLSPM interface [2] allows to build of a graphical representation of the model and to display results in Excel as tables or graphical images. XLSTAT-PLSPM is fully integrated with the XLSTAT package and allows different survey data analyses to be performed with other XLSTAT applications.

2. Methodology for conducting the risk analysis study of noncompliant processes in logistics services

The main objective of the risk analysis of noncompliant processes in logistics services is to identify, assess, and forecast the significant factors that affect the

Indication of the indicator	Interpretation of the result
	Apparent (observed) variable Observed variables are measured directly and reflect data on the process under study.
	Latent (unobserved) variable The latent variables cannot be measured directly and, accordingly, we make assumptions about the expected influence on the observed variables through modeling.
R^2	The values for this indicator show the amount of variation in the dependent variable resulting from the influence of the independent latent variables. When the values are above 0.5, the dependence is considered to be large.
Path coefficient (β)	Standardized direct and indirect mean effects derived from partial least squares modeling. Path coefficients between latent variables range between −1 and + 1. The closer the indicator value is to 1, the stronger the relationship.
	Relationship directionality (impact) Larger path coefficients are shown as wider arrows and blue and red colors denote positive and negative effects, respectively. In cases where there is no directional impact relationship between the variables, it means that the variables are independent of the other variables in the model.
Weight (w)	The weight is shown in the model next to the corresponding arrow and indicates the relative contribution of the indicator to the corresponding latent variable. The values of this indicator range from 0 to 1 and implies that the closer the value of the indicator is to 1, the larger the contribution.

Table 2.
Outcome interpretation in PLS-PM models (multivariate analysis).

prosperity and development of logistics companies. The fulfillment of this objective is accomplished through the method:

Analysis of types of refusals and their consequences - Failure mode and effects analysis (FMEA). The method is defined and standardized by experts. After the expert team that has the necessary experience and knowledge of the object under study has been assembled, the methodology identifies and ranks the logistics risks under study. Irrespective of the ranking method, it is necessary to identify each logistics risk-specific program and actions to eliminate or minimize the negative impact.

The method applies to various fields of knowledge [3] but it is not known to have been applied to analyze the risks of nonconforming processes related to satisfaction in logistics services. This made it necessary to develop and apply a new methodology to assess nonconforming processes in logistics services, as one of the tasks for this chapter. The chapter investigates the risk in logistics processes that may contribute to the deterioration of satisfaction indicators in logistics services related to FMCG and, specifically, the food sector.

2.1 Assumptions and limitations in the risk analysis of noncompliant processes in logistics services

The methodology is essentially based on the following model assumptions:

- Detecting nonconforming logistics processes at a late-stage leads to higher costs for the company.

- The strategy of detecting and correcting nonconforming logistics processes can be replaced by the strategy to avoid them and eliminate the causes in the planning phase.

- The costs of controlling and tracking nonconforming logistics processes in the stages immediately preceding the physical delivery of goods can be minimized.

- The experience gained from noncompliant logistics processes can be used to address the cause of their reoccurrence in the future.

- The principle of error prevention should be prioritized in managing nonconforming logistics processes.

- Quality control of logistics services should be assigned to highly competent employees who play a role in the actual execution of the processes.

Limitations in the application of the method are related to the control over its management and can be defined in three main directions:

- The control of the risk of noncompliant logistics services is specific to each market segment and may impair its objectivity.

- Despite the measures to control the risks and to neutralize the negative impact of some factors, the developed methodology cannot completely eliminate the impact of all random factors.

- Although the analysis is based on real risks, the achievement of the residual risk values, after the implementation of the control measures, may not be fully consistent with the actual outcome given the influence of unknown factors in the assessment.

- Control measures need to be implemented for fully measurable outcomes of noncompliant logistics processes and those that cannot be measured with complete accuracy.

- The proposed control measures to manage the risks must be adapted to extreme changes in the external and internal environment.

- In establishing the Risk Priority Number (RPN) and its three components of Severity (S), Likelihood (O), and Detection (D), the assessment of the degree of risk assigned by the experts conducting the analysis can be highly subjective.

- The analysis based on expert opinion must also assess whether the three parameters are equally important. In cases where the experts judge that this is not the case, significance coefficients should be assigned to each of the components (S), (O), and (D).

- It should be considered that each factor requires different preventive actions to prevent or minimize the risk of a negative impact of the error or noncompliance occurring even in cases where the analysis results in identical RPN scores for different factors.

2.2 Assigning scores and interpreting results in the risk analysis of noncompliant processes in logistics services

To apply the method, a separate RPN (Risk Priority Number) must be determined for each process.

The numerical value of the RPN denoted the quantification of the risk that caused the nonconformity in the logistics service obtained as the product of the probability of the nonconformity occurring, the probability of the nonconformity being detected before the customers, and the severity of the impact in case it is not detected. The values for each of the RPN components can range from 1 to 10 as indicated in **Table 3**, determination of RPN risk class **Table 4**.

(S) Severity of consequences	(O) Probability of occurrence	(D) Probability of detection
8–10 A small change in the risk factor can make a significant difference in satisfaction with logistics services.	8–10 The risk factor is expected to have a negative impact on satisfaction	7–10 The possibility of detecting noncompliance before it affects satisfaction is negligible
5–7 A small change in the risk factor has the potential to significantly affect satisfaction with logistics services.	5–7 Significant likelihood that the risk factor will negatively impact satisfaction	4–6 There is little possibility of detecting noncompliance before it affects satisfaction
2–4 Changes in the risk factor have only a marginal impact on satisfaction with logistics services.	2–4 Risk factors unlikely to negatively impact satisfaction	2–3 The opportunity to identify noncompliance before it affects satisfaction is significant
1 Changes in the risk factor do not affect satisfaction with logistics services.	1 Negligible likelihood that the risk factor will negatively impact satisfaction	1 The discrepancy can be detected before it affects satisfaction

Table 3.
Determination of RPN components.

Value of RPN	Explanatory notes
RPN over 851 Very high-risk	The potential consequences of noncompliance can cause dissatisfaction, increase the churn of current and potential customers, and significantly degrade the performance metrics of the logistics services that are important to the customer.
RPN 600–850 High risk	The potential consequences of noncompliance can significantly degrade the satisfaction and performance metrics of logistics services that are important to the customer.
RPN 150 to 599 Moderate risk	The potential risk of noncompliance is likely to negatively impact satisfaction and degrade performance metrics for logistics services that are important to the customer to a moderate degree.
RPN up to 149 Low risk	A low-risk class is defined when the potential consequences of noncompliance will result in a temporary reduction in satisfaction.
RPN up to 10 Negligible risk	A negligible class is defined when the potential consequences of the noncompliance occurring will have no impact on the company's operations and customer satisfaction.

Table 4.
Determination of RPN risk class.

2.3 Setting of the empirical study for risk analysis

A pilot study was first brainstormed and conducted to test the feasibility of applying the FMEA method to analyze the risk of noncompliant logistics services related to customer satisfaction from 1 May 2020 to 15 May 2021. The pilot study was conducted with five leading logistics professionals and its results showed that all participants support the application of the FMEA method for analyzing logistics processes. Each participant in the pilot study was required to be an employed logistics manager with at least five years of experience in the field and demonstrated competence through the submission of diplomas and certificates.

The baseline survey was conducted through discussion and brainstorming from 01 June 2021 to 01 September 2021. A total of nine team meetings were held to assess the risk of noncompliant logistics processes using the FMEA method. The analysis team included 10 participants and one moderator. Each participant satisfied the criteria as an employed logistics manager (logistics as part of a manufacturing site or logistics services as an independent company) and had proven competence through the presentation of diplomas and certificates. The moderator took notes on the discussion based on which the main highlights of the participants' opinions were extracted.

2.4 Setting the empirical study to discuss and reach a consensus on risk analysis of noncompliant processes

The consensus was reached in the team meetings by following the steps outlined in **Figure 2**.

2.5 Setting the empirical study for risk analysis of noncompliant processes in logistics services

The method was used, based on the results obtained from the survey on customer satisfaction using the SERVQUA method conducted in the period from 15 February 2021 to 15 April 2021, to analyze possible inconsistencies and errors in the implementation of logistics processes and identify their causes and consequences. Within the framework of quality management in logistics, FMEA has been applied to enhance customer satisfaction and reliability of logistics services to prevent their nonconformance.

Potential system deficiencies are evaluated based on their significance to the customer, the likelihood of their occurrence, and the ability to detect and correct the nonconformity before losses or consequences are incurred. The method can be used to analyze not only planned but also actual processes where the risk of changes and the impact of these changes on the management of logistics activities must be assessed.

The essential advantages of the method are related to uncovering opportunities and adopting a quality management approach through risk management. The method implies performing analyses that enable a collaborative management approach within the logistics organization. In this way, quality management can be oriented towards the risks generated by dynamic changes in the external and internal environment, which are often the root cause of nonconformities in the system. Essential priorities of quality management in logistics should be the realization that quality deficits increase losses and the corporate philosophy must be changed to bring the quality management system back under the control of the logistics organization. The goal is to understand and accept that impeccable service can only be achieved through sustainable

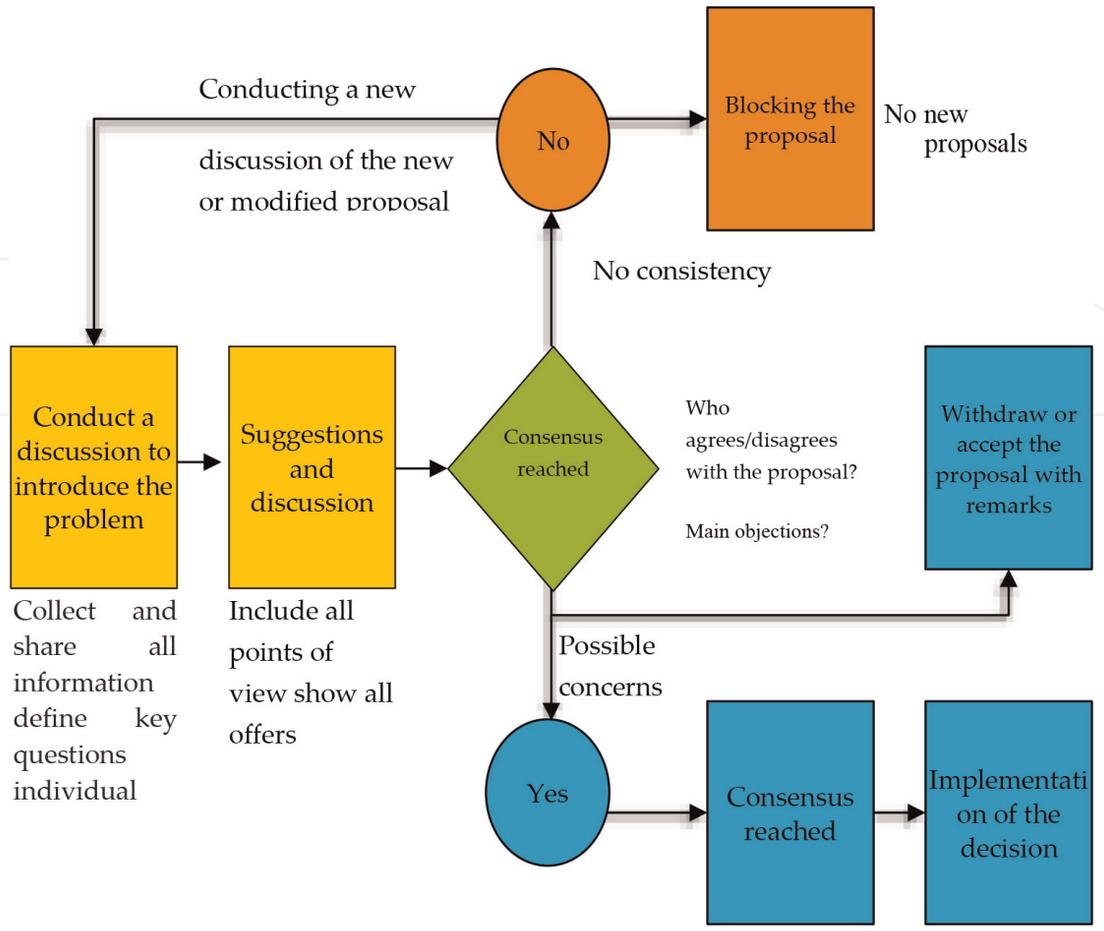

Figure 2.
Consensus model for risk analysis of noncompliant processes in logistics services.

compliance and improvement. The purpose of risk analysis is to identify and promptly address gaps in the service delivery system that negatively impact customer satisfaction.

The FMEA determines the likelihood of these gaps occurring and their potential consequences by assessing, in terms of severity, the measures required to prevent the risk, their effectiveness in specific situations, and the residual risk in the event of system failures. In cases where the method is adopted as a corporate philosophy in decision-making for new service offerings, risks of compromised quality should be identified and mitigated in accordance with the principles for applying the method.

2.6 Methodology for the analysis and summary of the results of the study on the risk of noncompliant processes in logistics services

The methodology to analyze and summarize the results of the study conducted on the risk of nonconforming processes is based on the Pareto analysis. The tool is named in honor of the Italian economist Pareto, who is also its creator [4]. In 1897, after annually analyzing the distribution of wealth in Italy, Pareto found that the incomes in the public were unequally distributed [5, 6]. The Pareto principle, also known as the 80/20 rule, states [7] that, for many events, approximately 20% of the causes contributing to 80% of the effect [8]; therefore, which are unequally distributed. The method can be applied after the significant causes of inconsistencies in the system are identified and analyzed, and losses will be minimized by eliminating them.

The method classifies quality problems in logistics services into two areas – few but essential and numerous but minor problems. This and other methods in quality management must be based on reliable information gathered from specific logistics services applied in practice. The data should reflect real events from economic processes that need to be analyzed and processed further. The analysis appropriately targets problem-solving efforts and identifies the main drivers of nonconformities. Juran interprets this principle by establishing that 20% of the causes of product defects create 80% of product problems.

The Pareto analysis was conducted simultaneously with the risk assessment of noncompliant logistics processes using the FMEA method and the same sample. The obtained data on the ex-ante and residual risk identified by the FMEA method were compared in the Pareto analysis procedure.

The values for upfront and residual risk from noncompliant logistics processes were tabulated in the procedure and the team assigned a percentage to each value such that the total was 100%. The percentages assigned were then used to construct a bar chart.

The Pareto analysis identified the differences in the ranking of causes before and after the implementation of corrective actions to the noncompliant logistics processes. The resulting diagrams have practical implications and can be used by senior management of logistics firms to prioritize actions and minimize risk.

XLSTAT software, which is embedded in Microsoft Excel's XLSTAT statistical analysis package, was used in conducting the Pareto analysis.

The following N number of qualitative or quantitative values were awarded in the Pareto analysis of the sample identified in the FMEA risk assessment of noncompliant logistics processes:

- Number of observations: The number N of values in the selected sample.
- Number of missing values: The number of missing values in the sample that are ignored in subsequent statistical calculations of the values.
- Sum of weights (Sw): The sum of the weights awarded, considering that all weights are equal to 1, Sw = n.
- Mode: The mode of the sample analyzed is the most common category.
- Mode frequency: The frequency of the category to which the mode corresponds.
- Category: The names of the different categories present in the sample.
- Relative frequency by category: The relative frequency of each category.
- Cumulative relative frequency by category: The cumulative relative frequency of each category.

Methods are also applied to analyze, systematize and differentiate various requirements that form satisfaction and help manage the quality of logistics services.

All the principles and methods of building management systems and the comparative analysis between different objects are also applied in the study. In addition to the listed main methods, the principles of quality and risk management required by the international standard ISO 9000:2015 and ISO 31000 have been applied.

The methods used in the chapter have the potential to help achieve its main objective and define the chapter design and the methods of data collection and analysis.

3. Conclusion

Due to the increasing market competition, a necessary condition for increasing customer satisfaction is the provision of qualified services that help organize timely deliveries of the goods requested by the customer. Through process controls, these processes could help to prevent nonconforming services from occurring prior to customer requirements.

The chapter of the study describes the conceptual framework of two groups of methods 1. Methodology for conducting the SERVQUA Satisfaction Analysis Survey (CAP) in Logistics and 2. Methodology for conducting the risk analysis study of noncompliant processes in logistics services. All the principles and methods of building management systems and the comparative analysis between different objects are also applied in the chapter. In addition to the listed main methods, the principles of quality and risk management required by the international standard ISO 9000: 2015 and ISO 31000 have been applied. The methods used in the chapter have the potential to help achieve its main objective and define the study design and the methods of data collection and analysis.

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