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Sustainability Management Model Based on Risk Analysis and Implementation of the Model

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Abstract: In modern business management, the effective management of organizational structures based on goals within the scope of modern management concepts, as well as the continuous improvement of processes for increasing competitiveness, are critical. The purpose of this study is to discuss the matter of risk identification and analysis, practices that are seen in many different fields within the scope of the notion of sustainable management. It aimed to add the dimensions of targets and risk analysis to the scope of process analysis and development, within this study. The stages, starting with the definition of the processes in the process model through the targets based on the risk analysis, are transformed into a quality assurance cycle and completed with the determination, monitoring, and evaluation of the sustainable process development activities. The performance indicators of the business processes in a textile business were determined, and the identification of a model structure with systematic traceability was provided, in practice. The opportunities and threats encountered in achieving the determined goals were identified. The defined factors were examined within the scope of the failure mode and effects analysis and risk analysis methods. The risk evaluations were performed using fuzzy numbers. The results obtained by fuzzy failure mode effects analysis were evaluated through the MATLAB Fuzzy Logic Design Toolbox model. Risks were ranked as a result of the evaluation, and process development activities were chosen.

Keywords: sustainability; process management; risk analysis; management by goals; fuzzy failure mode and effects analysis

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1. Introduction

International trade plays a part in the fundamental goals of national economies' strategies. International trade also increases global business models, accordingly. Supply chains have become globally widespread, and the success of those chains has turned into a strong foundation for economies. The sustainability of the production method of a product, its logistics, and its consumption have become a critical element, and the developments in this field will also leave a mark on the future. Every day, transparent knowledge about how supply chains work, as well as their environmental and social risks and opportunities, has been shared with everyone, primarily, their consumers. This process has played an important role as a part of brand value. The supply chains that can manage their brands according to the goals that they determine through sustainability criteria will be a step ahead. The analysis of the opportunities and risks within the framework of this condition is the focal point of this article. The expansion of big data and fast development of information gathering, monitoring, evaluation, and dissemination contribute to the improvement of sustainability governance forms based on completely novel, measurable success parameters for business life and supply chains on a global scale, together with the developments in information systems [1]. Supply chains are the critical driving forces for competition in business life. Therefore, the measurement and management of sustainability at all rings of the chain is crucial. It is difficult to determine the sustainability performance of supply chains. Suitable tools and methods are necessary for gathering and analyzing data for each supply chain activity and sustainability goal. This study includes a model for measuring the sustainability performance of the business processes in supply chains. Many publications have been published in the literature about sustainable supply chain management and green supply chain management using the content, context, and process frame. The results show that various measurement approaches are used to evaluate sustainability in various industries and supply chain levels. It is seen that the implementation of multicriteria decision-making methods is increasing in this field. The most used approaches are life cycle assessment, the analytical hierarchy process, the fuzzy set approach, balance scorecards, failure mode and effects analysis (FMEA), and data envelopment analysis [2]. Gathering and sharing sustainability data, standardization of the measurements, assessment with quantitative data, common information systems, and cooperation between supply chain members and stakeholders are among the basic challenges that will be required to be solved by measurement approaches in the future. Sustainability and its assessment are of critical importance to industries, governments, and customers. There are sustainability goals and commitments at various levels—such as the company, individual, and government—for each industrial sector. It is inevitable to measure the sustainability success level of all these players within the scope of supply chains, and, therefore, there is a need for tools and sustainability indexes. The assessment of sustainability is an important matter in the world textile industry, as well as in every field. It is quite important to determine the correct sustainability approach that is suitable for the needs of different players in the field of sustainability [3]. Short, middle, and long term activity plans should be formed in line with the goals determined in line with providing sustainability, and a future focused vision should be followed. It is extremely important to define and analyze business processes before ensuring sustainability, which has strategic, tactical and operational dimensions. Integrating sustainability dimensions into business processes will ensure the continuity of the plans and activities to be carried out. If continuity cannot be ensured, it would not be correct to talk about sustainability. It is critical for businesses to provide this sustainability in business processes and development. Businesses benefit from increased flexibility and agility as a result of process management, as well as the ability to quickly reflect on the impact of changes to their practices. The focus of the studies on the long term development of business process performance forms the foundation of the modern management concept. Process performance indicators should be determined by considering the key success parameters influencing the productivity of the process directly or indirectly, and point in the direction of the continuation of the process. Matching the defined goals with the success parameters and their being measurable, provides the sustainability of the process management notion through goals. It is important to develop business processes for mitigating the risks that are likely to be encountered in all business processes at strategical, tactical, and operational levels, primarily in economic, environmental, and social fields within the scope of sustainability, to provide business continuity to realize process goals. This study was performed in practice in a production plant operating in the home textile industry. Process analysis methods, analytic decision-making methods, group decision-making techniques, and risk analysis methods are also used within the scope of the model. The model that is set forth will be a guide for businesses in meeting the requirements of risk analysis practices stated in management systems standards and production management practices. Fuzzy logic methods are utilized for quantifying the qualitative contextual data based on the quality of the data to be obtained during the study.

2. Risk Assessment in Business Processes

There are various definitions of the concept of "process" in the literature. The quality management system standard defines a process as "a set of interrelated or interactive activities that transform inputs into outputs" [4]. In other words, it is a set of activities or actions that add a positive value to inputs and from which an output is obtained from these inputs. The factors of humans, materials, equipment, methods, and environments should be included in a transformation system, to manage the activities transforming operation inputs to operation outputs productively. Processes are expected to be a series of defined, repeatable, measurable, and responsible functions from which limits can be determined and related activities create value in this transformation system. The control activities that enable the progression of the workflow in a manner that is within the operational, functional, or organizational limits that are important to customers, form the processes. Furthermore, a process is a series of activities and actions that move toward a certain goal over time. This leads to a conclusion that is focused on progress and a certain goal, as well as creating an inter-unit value monitoring system and improving the performance of a business [5]. Modern engineering studies are related to designing business processes aiming to continuously improve the systematic structure and productivity of businesses, and maintain their sustainability. Approaches based on modeling techniques, primarily business process modeling, have been developed for determining corporate strategies, meeting the expectations of stakeholders at a suitable quality level, and providing global consistency. At present, as the workplace environment has become more competitive, complex, and unpredictable, risk assessment in corporate governance is gaining more importance every day. These developments led to an approach entitled "risk-sensitive business process management" (R-BPM). This approach aims to combine risk management and business process management, which were previously examined as separate subjects. The management models establishing the BPRIM (business process risk integrated method) framework and supporting the productive practices of the BPRIM framework are the key methods for businesses to guarantee sustainability in the future.

2.1. Business Process Management Concept

Many businesses are endeavoring to define and certify their business processes at present. They define key performance indicators (KPIs) for measuring the performance of their processes, providing their controls, and taking various steps for improvement. They provide adequate techniques for designing, implementing, testing, and analyzing business processes in order to develop and create value in intra- and intercorporate value networks. Process management systems help determine repeated duties, research disputes more comprehensively and make payment policies more consistent [6].

At present, the ability of a company to accommodate itself to a variable working environment is of crucial importance. The driving forces of change may be internal or external, new opportunities may emerge, or customers may change requests. BPM (business process management) provides a platform for changing organizational processes in a faster and more controlled manner. These three aspects should be approached holistically, as the process design should be related to company strategy and should aim at achieving the process goals. BPM enables corporations to consider themselves as high level integrated process communities, instead of a small series of functions or departments [7]. Therefore, it is a comprehensive management approach to bring business processes and corporate strategy together, and analyze, optimize, and apply the top of the range processes. Productivity may also be improved, by eliminating manual data entry, decreasing process cycle time, and decreasing the amount of manual analysis [8]. Process studies lead to the reconstruction of business processes. Reconstruction approaches, comprising practice based process transformations, such as process modeling tools, corporate resource planning practices and codes of conduct, are applied later [9]. Total quality management (TQM), six sigma, and lean are some of the results of such studies. These approaches manage employees for strategical conformity, to achieve corporate goals and target an organizational transformation embracing processes throughout the organization [10]. Business process management practices can be qualified as the fixed life cycle of the relevant BPM activities. Life cycles can be summarized as planning, analysis, design and modeling, implementation, monitoring and control, and continuous improvement.

The traditional business process life cycle defines six key skill areas for managing business processes in a corporate environment [11]. The model was based on the established plan–do–check–act cycle and included developing a strategy, then defining, modeling, implementing, monitoring, checking, optimization, and improving. The new elements that are necessary to be implemented in the traditional life cycle for the life cycle to be ecological are defined in Nowak, Leymann, and Schumm as expanding the traditional or implementing basic changes [12]. According to the philosophy of total quality management, one of the biggest responsibilities of an organization is to find effective methods of developing a business while carrying it out and to suggest an approach for providing for the development of the organization [10]. Process management is a versatile holistic activity that includes process definition, the process supervisor, determining the supplier and customer needs, performance monitoring, and necessary improvements. Implementing a management mentality focused on processes leads to a structural transformation that is suitable for the principles of management by processes. Process management is not temporary work; on the contrary, it is a mode of work for providing sustainability and achieving success. Process management explains how a process works, the process performance is continuously monitored, and the scheme of the process is redesigned to improve the performance. Defining the processes, documenting the processes, determining the process objectives, measuring the process performance, determining the relations between the processes, identifying the internal or external customers, reviewing the outputs, and improving the process play a role in the realization of this type of work [11].

One of the primary goals of company management is to use resources productively. Process management and management by processes are two techniques and management concepts that can help you achieve this goal. Process management is accepted as a preferred technique to increase the effectiveness and efficiency of processes [13]. Process management means a management technique that is applicable within the scope of both traditional and novel management notions. However, management by processes means a management concept. In order for a process to deliver the most efficient and effective performance, it is necessary to identify risks and opportunities with tactical, operational and strategic risk management practices in order to ensure the ability to monitor the operational performance, to perform the necessary planning actions and to improve the operational performance. Three different steps, such as a new process design, the redesigning of a process (re-engineering), and continuous process development, may be mentioned in the transformation from traditional process management to the notion of management by processes [14].

2.2. Risk Definition in Business Process Management

The management of business processes helps corporations achieve their goals of simplification, agility, and operational flexibility. Businesses aim to improve and meet the expectations of stakeholders through the general performance of business processes. Business process management is concerned with establishing the relationship between the value-creating activities and the value itself. This is simply obtained through the steps of design, planning, implementation, and monitoring. Additionally, enterprise risk management (ERM) tries to improve management decisions that are made in an unclear environment, for the sustainability of value. ERM establishes a balance between a series of acceptable alternatives and expectations in decisions and enables the effective distribution of resources. Risk management is a management tool that strengthens the decision mechanisms of management by applying mechanisms that may affect management's achievement its targets and goals, at all management levels and in all functions. Business process management designates, engages, and manages other value creation processes; however, risk management protects and sustains the value created. Risk based business process management (R-BPM) has widespread practice coverage as the integration of risks into the management of business processes in a multidimensional manner. This integration enables the defining, detecting, and effective managing of process related risks. Risk assessment is promoted in all steps of business process management, risks are assessed in order based on their significance levels, and a strong decision support practice is enabled that is categorized based on BPM life cycle steps. The studies included in the literature emphasize the importance of enterprise risk management (ERM) for corporate success. Risks may be caused for various reasons, such as uncertainty in financial markets, threats arising from project failures (design, development, production, and sustainability), legal liabilities, accidents, natural means and disasters, or intentional attacks [15]. The ERM function of a business has critical importance for monitoring and managing the risks and opportunities arising from internal and external factors, primarily social, environmental, legal, political, technological, and economic requirements [16]. Enterprise risk management within an organization directs companies to determine and measure risks to determine long term strategic business goals and stakeholder expectations and establishes a balance between the risk that a company may be exposed to and the opportunities to be found. There are two widespread risk management frameworks used globally. These are the COSO corporate risk management framework and International Standardization Organization (ISO) 31000 risk management standard [16].

Some companies state that none of the standard frameworks have been adopted, but that they have developed their own frameworks, or they have adapted an existing framework to the corporate culture. Companies with an effective risk management system examine strategical, tactical, and operational risks in detail, predetermine the crises that may occur, take precautions to minimize losses, and plan and implement improvement activities. They assess the methods for struggling against risk that will be encountered in decision-making processes for achieving strategical, tactical, and operational goals set and when performing their strategical activities. The businesses that can achieve making risk management a corporate culture have formed the organization, policies, and processes that are necessary for making risk management sustainable. The importance and necessity of considering risks within the framework of sustainability have increased at the enterprise risk management level, and completely new frameworks and integration methods, besides various approaches, have also been presented for integrating sustainability into the current management system structures.

3. Sustainability and Risk Management

Although sustainability is generally mentioned in ecological, social, and economic dimensions, it is important to know the interlocked connections among them. However, when the matter is considered from the perspective of companies, the fundamental goal is to maintain the company within the economic system by creating shareholder value. When the matter is considered from a social perspective, the economic system is only a tool for providing social and ecological sustainability. However, it is not a must for achieving a sustainable situation. The success of a transition to sustainability is directly related to the open orientation of strategy and business processes. In this way, a framework with four steps, being analysis, design, implementation and control, in which the analysis step includes elements up to defining the business scenario, prioritizing processes, determining the project stakeholders, the definition of project goals, the definition of metrics, corporate registry mapping, defining fundamental registry values and sustainability maturity evaluation, and determining the business scenario from "process planning and strategy" [17]. Each sustainability project involves comprehensive changes in an organization, primarily being changes in the company's operations. According to Burnes (2003), however, 40 to 70 percent of these transformation attempts have been unsuccessful. These attempts have been unsuccessful for many different reasons, such as lack of management support, lack of proper communication, and lack of stakeholder participation. However, the reasons behind the failure of the attempts may be challenges in the implementation of such sustainability attempts. Sustainability risk management may be defined as the effect of uncertainty on goals [17]. A sustainability risk is an uncertain social or environmental incident or situation that may have a major negative influence on the company when it emerges [14]. Sustainability risks should be predicted to the greatest extent possible [17]. Although it includes opportunities that may be present for an institution due to changing social or environmental factors, some challenges cause failure in attempts to include the notion of sustainability in the corporate culture. Among the challenges appearing in sustainability attempts, risks, financial and other resource limitations, management and employee attitudes, poor communication, and old practices are classified as internal, while capital costs, competitive pressures, industry regulations, technical know how, green market opportunities, and technical solutions are classified as external [14]. Establishing a connection between creating shareholder value and the contribution or confrontation of a company to strategic sustainability has key importance for sustainability risk management. This requires the integration of sustainability with goal or requirement determination and its cascade throughout the corporate hierarchy at operational, tactical, and strategical levels [17]. Strategic sustainability risk management may provide companies with the ability to predict the direction of a change by understanding long term visions, and it may also avoid relevant threats and actively utilize business opportunities emerging during the transition. Therefore, it is important to state that the matter is not only about the failure to sustain. It is about being a leader by comprehending how a company may contribute to the sustainability of society. The threats and opportunities associated with the ability of primarily ecological and social systems to support meeting human needs in terms of access to freshwater, climate stability, or biodiversity, are referred to as social sustainability risks. Emphasizing both the threat and opportunity dimensions of sustainability risks may ease the application of sustainability risk management. Such an action may be reactive and may focus on avoiding threats rather than being proactive and exploiting opportunities. It is about the risk of social sustainability transition impacting a company's goals; in other words, it means that a sustainability transition is a source of uncertainty [17]. Marhavilas and Koulouriotis stated that, in some studies, the difficulties in implementing sustainability initiatives are defined as the inability to set clear and measurable targets, the struggle to cope with financial incentive pressures, and the inability to accurately determine the reactions of competitors. In another study, the inability to determine the dimensions of the concept of sustainability in the management of an organization's processes in 2012 was defined as the difficulties that will be experienced in the implementation steps [18].

Along with the importance of defining sustainability oriented risks, especially in business processes, a risk analysis method should also be determined correctly. Risk analysis techniques can be reviewed by qualitative and quantitative methods into two main groups: the prediction of the possibility of risks happening and their potential effects [19]. In qualitative methods, risk analysis through verbal logic is preferred instead of risk analysis through mathematical logic. Most of the time, they have no systematic quality as they are based on objective data. The intuition and judgment ability of the assessing expert are important in terms of the reliability of the qualitative risk analysis methods. It is possible to encounter a vast number of risk assessment methods that cannot be known clearly. In addition, quantitative risk analysis methods use mathematical logic by referring to mathematical methods for calculating risk. Quantitative mathematical methods may be exemplified by theories and techniques of probability and reliability, and also by complex techniques such as simulation models. In quantitative risk analysis, numerical values are assigned to parameters such as the possibility of the occurrence of events that may lead to unwanted results or dangerous events, their severity, and their predictability. The assigned values are studied by mathematical and logical methods, and risk values are obtained [20]. Among the most popular risk assessment methods are Fine–Kinney, L type matrix (5 × 5 Matrix), and failure mode and effect analysis (FMEA). The type matrix (5 × 5 Matrix) method is generally used in risk assessment methods in which cause and effect relationships are studied. This method is among the easiest and most widespread methods, but it is not solely sufficient and reliable for businesses, as it includes a number of various workflow diagrams [21]. The L type matrix (5 × 5 Matrix) method is completed by following the steps of defining the danger, assessing the risks, determining the control measures, inspection, and feedback. The Fine–Kinney risk assessment method gives detailed information, in the first emerging document prepared by Fine, about the risk assessment criteria of the risk assessment method and how to implement the mathematical model, and the implementation of the method has been transformed from a mathematical approach to a graphical approach [22]. There are three parameters for mathematically determining the risk priority number (RPN) shown in the Fine–Kinney methods. The value is calculated based on the rating point scale of the parameters [21].

$$\text{Risk Priority Number (RPN)} = \text{Probability} \times \text{Severity} \times \text{Frequency} \quad (1)$$

4. Failure Mode and Effects Analysis in Risk Assessment

Failure model and effect analysis (FMEA) is a mixed risk assessment method, having the quality of both qualitative and quantitative risk assessment. Upon examining the studies included in the literature, it is seen that its implementations are in the field of detecting and repairing process failures rather than in the manufacturing industry or the field of total quality management. Failure model analysis (FMEA) is a method for estimating and evaluating the probability, severity (weight), and detectability (detection) of determined failures, dangers, and threats, as well as documenting the evaluation results [23]. In the FMEA method, FMEA probability ranking values, severity ranking values, and detection ranking values in determining risk priority number (RPN) values are determined based on the decimal ranking scale stated in the literature, in which the definitions of probability, severity, and detection are mentioned. As referenced in [23], risk priority number (RPN) and regulatory preventive activity (RPA) data are obtained by taking the risk priority number values, which are calculated as a result of the FMEA method [23]. Risk priority numbers are ranked based on priority, severity, and detection point scales. The value that is obtained by multiplying the points of the three elements gives the RPN value. The obtained FMEA risk assessment ranking is interpreted with reference to the value ranges shown in Table 1 [23].

Table 1. FMEA Risk Assessment RPN-FRP (Ünlü Tok, 2019).

	FMEA Risk Assessment Rank	
Risk Precaution Rank	**RPN Value**	**Regulatory Preventive Activity**
(1) Negligible	RPN 10	Additional check processes may not be necessary to eliminate risks.
(2) Low	10 < RPN ≤ 40	The current checks should be maintained, and their sustainability must be inspected.
(3) Moderate	40 < RPN ≤ 100	Activities should be commenced without losing time to mitigate risks.
(4) High	100 < RPN < 400	Urgent precautions should be taken for risks, and the continuity of the activities should be decided upon those precautions.
(5) Take Precaution	RPN ≤ 400	Activity should be maintained until the risks are decreased to an acceptable level.

Fuzzy FMEA was preferred in this study as it provides a substructure for presenting relative importance due to using data that mostly includes uncertainty and due to the subjectivity of the results for the relevant parameters. A risk assessment method using fuzzy logic was preferred considering that it provides a substructure for presenting relative importance concerning the relevant parameters to combine the probability (O), severity (S), and detectability (D) parameters occurring for the current situation, with the fuzzy FMEA method and for presenting a more realistic and flexible structure. The O, S and D inputs, which are the relative parameters, were defined fuzzily following a traditional FMEA risk ranking analysis, and it was found that similar results were obtained upon comparing the results of the fuzzy FMEA method with the results of the traditional FMEA method in the current situation analysis. Statistical testing of the compliance in the comparison performed based on RPN and FRPN values was used for the statistical testing of the compliance and to eliminate the relative interpretations.

5. Application of Stated Model

The main stages of the model in this study consist of the following steps:

1. Defining Business Processes

The process card design determined in the definition phase of the business processes presented in this study can be used in both theoretical and practical studies. The information obtained from the literature research on the definition of business processes has been interpreted and developed. The content of process card information could be redesigned depending on the developments in theoretical studies.

2. Analysis of Business Processes

In the analysis of business processes, the information in the process cards determined in the previous step is defined and interpreted. The analysis at this stage is specifically for application and could be used in different business processes.

3. Management by Objectives and the Implementation of Risk Management in Business Processes

In the content of the designed process cards, short, medium and long term goals and strategies could be specified. It is ensured that the risks and opportunities to be encountered in achieving these goals are defined.

4. Development of Business Processes

In this study, development studies can be carried out in business processes with the risk analysis model that is presented in this study.

5.1. Risk Analysis Model

The data obtained and the practices described in the study belong to a textile plant established in 1991 in the Denizli Organized Industry Zone, Turkey, including yarn, fabric, weaving, fabric dyeing, and ready to wear cloth businesses, which manufacture products in the fields of towels, bathrobes, kitchen textiles, beachwear, and baby products. Process identification cards that are stated in the suggested enterprise risk analysis model and implementation steps are shown in Figure 1, which are formed for integrating strategic, tactical, and operational processes with the notion of management by processes and for maintaining the sustainability of the practices as the first step in the implementation phase of the study were filled. The suggested enterprise risk analysis model, whose workflow diagram is shown, and implementation steps were prepared for the business processes, to provide the traceability of the process goals, effectively manage the goals of the processes, and to start corrective and preventive actions by determining the risks that may be encountered in achieving the goals.

5.2. Implementation of the Model by Classical Failure Mode Effects Risk Analysis

Information concerning the code, name, supervisor, and purpose of the process is stated in the process identification cards. The suppliers, inputs, outputs, customers of the process, and other processes interacted with were registered upon completing the documents of the management policies regarding the processes and stating of the relevant standard items. Process goal achievement time and goal code were assigned while defining the process goals. As is shown in Table 2, the performance indicators, which are determined by considering the traceability checkpoints of the goals and the goal codes, were established. The influence of the traced performance indicators on the goal, the tracking frequency, and the tracking period were clearly stated.

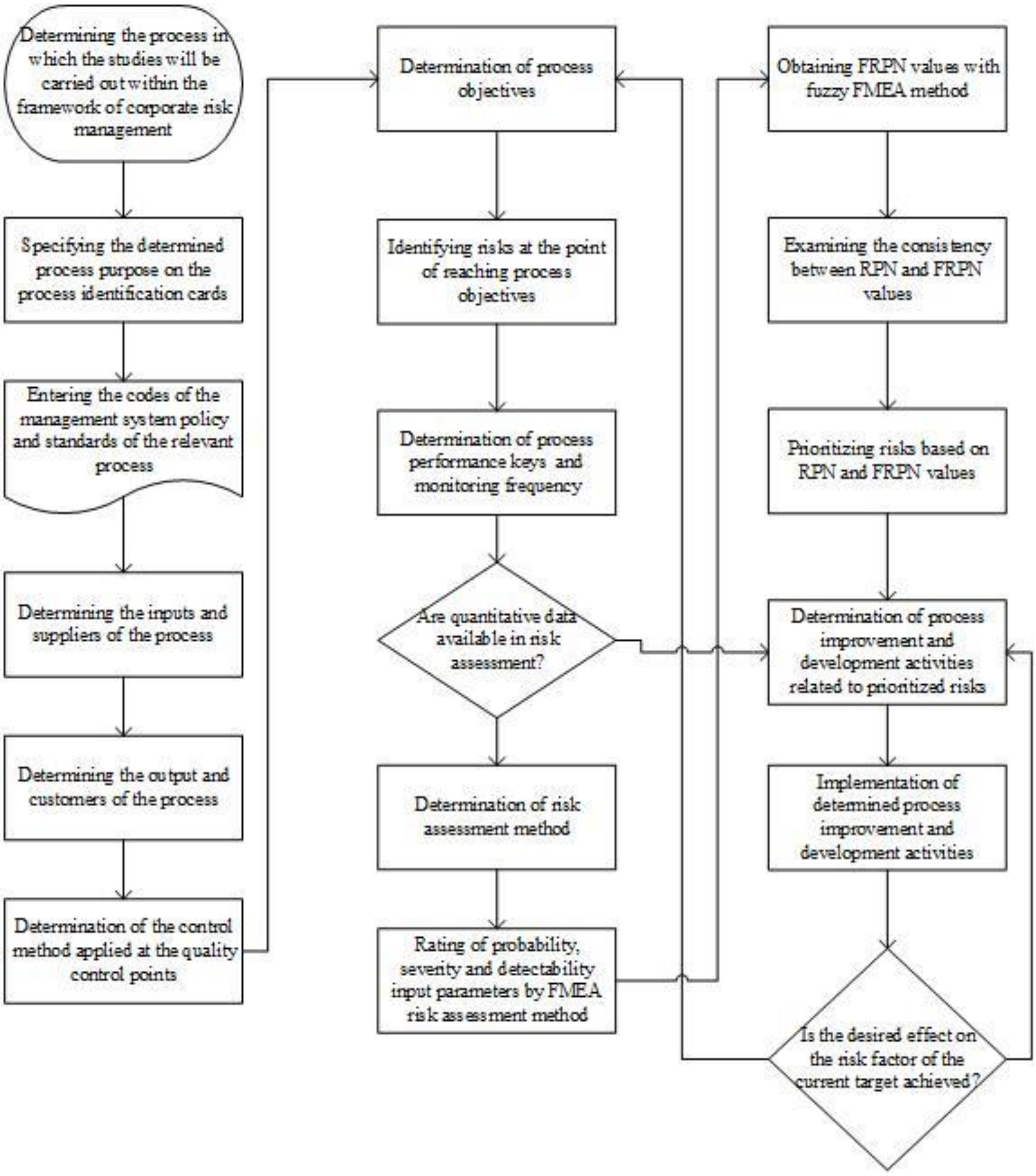

Figure 1. The suggested enterprise risk analysis model implementation steps.

Defining the risks that are possible to be encountered in terms of achieving the determined process goals is among the most important stages. As is shown in Table 3, it is stated whether the risk assessment was a qualitative assessment or a quantitative assessment, and the values of effect, probability, and detectability, which are input parameters, were marked by a group of specialists including five individuals, and the process was following a group decision based on a classical FMEA risk assessment method. The authors of the article took an active part in the implementation process and ensured the coordination of the expert team specified in the article. One of the authors works as a consultant in the company and the other is an active white collar employee and works in the field of integrated management systems. Among the specified expert team, there are four industrial engineers and one textile engineer. The experts work in different functions, as middle level managers and supervisors.

Table 2. Process Identification Card Goal Definitions.

The Process Goal/Goals					**Achievement Time**			**The Relevant Management System Goal/Goal No**	
1. Achieving Uster Quality Standards Values					1 Year			Our Quality Policy L5.2.G001/5	
2. Decreasing The Number of Barré Bobbins to 0					1 Year			Our Product Safety Policy L8.1.K006/2	
3. Providing a Moisture Value Over 7%.					1 Year			Our Product Safety Policy L8.1.K006 / 2	
The Performance Indicators of the Process	Goal No	Influence on the Goal (%)	2020-1	2020-2	2021-1	2021-2	2022-1	2022-2	Tracking Method
1. Uster Quality Values	1	100%	12.5%	11.61%	10.96%				Access
2 The Number of Barré Bobbins	2	100%	11.61%	0.5%	-				Excel
3. Moisture Values	3	100%	6.4%	6.21%	7.73%				Access

Table 3. Process identification card risk assessment.

Risks and Risk Numbers	**Risk Assessment Method**	**Effect**	**Probability**	**Detectability**	**RISK NUMBER**
1. Comparison of Organic Cotton with Other Cotton Types	☑Quantitative Assessment ☐Qualitative Assessment ☐Group Decision ☐Individual Decision	4	6	9	216
2. Forming of Customer Complaints	☐Quantitative Assessment ☑Qualitative Assessment ☐Group Decision ☐Individual Decision	6	4	3	72
3. Weak Yarn and Breaking of Yarn	☑Quantitative Assessment ☐Qualitative Assessment ☐Group Decision ☐Individual Decision	6	4	8	192
PROCESS DEVELOPMENT STRATEGIES/ACTIVITIES					The Relevant Goal/Risk No
1. Measuring the quality values at the beginning of each process and at certain intervals					Goal No/1
2. Maintaining visual inspections during manufacturing by raising the awareness of all operators					Goal No/2 Risk No/ 1
3. Keeping the business environment conditions at an optimum level					Goal No/3 Risk No/ 2.3

Considering the obtained risk priority number order, process improvement studies were carried out and the process was defined under the title of process development strategies/activities specified in the process target card shown in Table 3.

Probability, severity, and detectability input parameter numbers related to the expert group of five individuals and the process supervisors were determined based on the decimal risk assessment scale, which is also included in the literature. The obtained risk priority number value was interpreted considering the ranking table shown in Table 1 and stated in the process identification cards.

The current situation was stated in detail in the failure modes identification card with the RPN obtained as a result of the evaluation, process definitions, goal codes, and failure definitions.

5.3. Implementation of the Model by Fuzzy Failure Mode Effects Risk Analysis

Fuzzy FMEA was preferred as it provides a substructure for presenting relative importance due to using data that mostly includes uncertainty and due to the subjectivity of the results for the relevant parameters. The Fuzzy Logic Design Toolbox model included in the MATLAB program was utilized to calculate RPN values within the scope of the fuzzy logic approach. A model including three inputs and an output variance was established for RPN calculation with fuzzy FMEA. The probability, severity, and detectability risk rankings included in the current situation's failure modes identification card and determined in light of the process identification cards were input as data to the model created. Symmetrical triangular membership functions were used for the probability (O), severity (S), and detectability (D) parameters assigned as inputs in the model. The subzones were stated, respectively, as: very low, low, moderate, high, and very high. As shown in Table 1, the O, S, and D parameters used in fuzzy FMEA were related to lingual variances as very low, low, moderate, high, and very high. The triangular membership functions, which were deemed suitable for input variances, were obtained through the Logic Design Toolbox model. A scale of 1–1000 points, which is the minimum and maximum RPN value range, was divided into five different subzones. The subzones are stated as very low, low, moderate, high, and very high. A rule base was formed for expressing all situations using the Fuzzy Logic Design Toolbox design tool in the established model. The rules were formed by considering all probable situations. The geometric mean values were entered for O, S, and D input parameters over the design model included in MATLAB, and the FRPN value was obtained for each failure mode. The RPN and FRPN risk number values concerning 36 different nonconformities evaluated in practice were filled in in the forms. The ranking and prioritization of the risks, which are the goals of FMEA, were performed based on RPN and FRPN and rearranged. The Spearman correlation factor is the value that makes the correlation relationship of two different variances significant or insignificant, without knowing which one influences the other without considering a cause–effect relationship. Spearman correlation factor (r) values in the literature are interpreted as follows:

If R = [0–0.30], no/weak correlation between variances
If R = [0.30–0.60], moderate correlation between variances
If R = [0.60–0.75], strong correlation between variances
If R = [0.75–1], very strong correlation between variances

The value that is obtained as a result of the analysis performed using SPSS software was determined as 0.885 (p = 0.000), as shown, and was found to be statistically significant. According to the chart, the comparison of fuzzy and non-fuzzy FMEA risk numbers is shown in Figure 2.

5.4. Improved Situation Fuzzy and Non-Fuzzy FMEA Risk Assessment Method

Process improvement and development suggestions are presented and implemented based on the values of FRPN performed for the current situation in this section of the study. The practices were tracked at 6-month intervals to maintain the sustainability of the practices and were registered on goal identification cards. The RPN risk numbers related to 36 different failure modes, which were assessed for the current situation in practice, and were re-assessed for the improved situation as a result of the numbers given by the group decision. The risk numbers that were obtained for the improved situation were recalculated as FRPN by entering the geometrical mean values of O, S, and D input parameters for each failure mode in the Fuzzy Logic Design Toolbox design model included in the MATLAB program. As a result of the process development studies, the values related to the revised risk score were calculated. RPN and FRPN risk number values related to 36 different nonconformities for which improved situations were evaluated are stated. The ranking and prioritization of the risks, which are the purposes of the FMEA method, were rearranged based on RPN and FRPN values upon the activity development suggestions and practices. The risk numbers that were obtained as a result of the improvements were determined to be 0.819 (p = 0.000) as a result of Spearman correlation factor (r) value analysis, which was performed in SPSS software and was found to be statistically related. The chart in which risk numbers were compared was reviewed, and the difference between the RPN and FRPN values of the risk analysis performed following improvement and development activities was compared. It is possible to interpret the obtained data so that there is a very strong and positive correlation relationship between values.

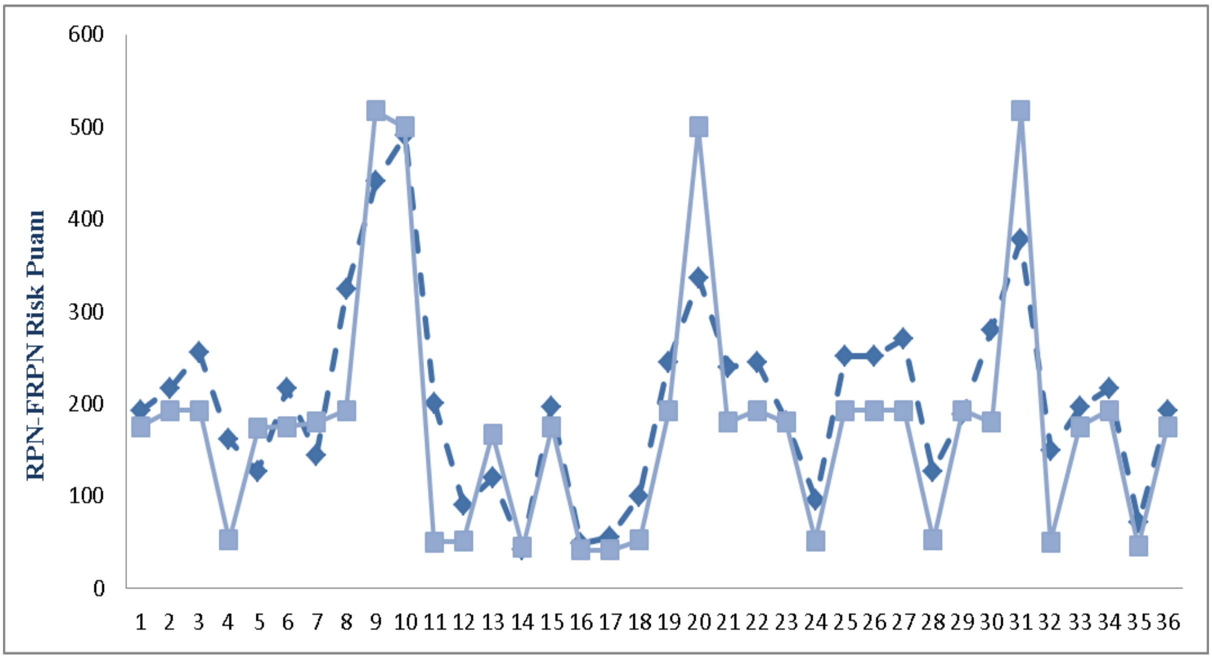

Figure 2. Graphical comparison of fuzzy and non-fuzzy FMEA risk numbers.

6. Results and Suggestions

Businesses have difficulty in forming their strategies and determining their goals while being structured within the framework of sustainability. These challenges arise from economic, social, and environmental changes influencing our business lives and individual lives. Furthermore, a transition is a process in which lean and digital transformation are experienced as a result of such changes. These developments necessitated the use of short, medium, and long term management tools by assessing the risks. The failure modes and effects analysis method is among those tools observed to be frequently included in the risk analyses. In this study, business processes were defined at strategical, tactical, and operational levels based on the notion of process management by goals. A total of 36 different types of failure modes concerning the goals included in the business processes analysis documents defined within the scope of application were detected. Probability (O), severity (S), and detectability (D) input factors were evaluated in groups or as individuals based on quantitative or qualitative values by experts with knowledge and experience on the subject. A common input was obtained as a result of the values assigned to the parameters assessed for the risk group of each goal definition, and the RPN value database was formed, including the goal and risk numbers in FMEA failure identification cards. The results were evaluated again in the MATLAB Fuzzy Logic Design Toolbox program, which is a fuzzy FMEA application, using the same database formed in the continuing process of the study. The RPN (risk priority number) value accepted as the classical analysis output of the 36 failure modes evaluated in practice and the FRPN (fuzzy risk priority number) values accepted in the FMEA analysis were compared both graphically and statistically. In the graphical comparison, it is seen that the risk priority scores are related to each other as a result of classical analysis and fuzzy analysis. Accordingly, O, S, and D inputs, which are the relative parameters related to the failure modes, were defined fuzzily following a traditional risk ranking analysis, and it was found that similar results were obtained upon comparing the results of the fuzzy analysis method and the results of the classical analysis method. Within this scope, the fuzzy FMEA method was evaluated as a method suitable for the analysis of the risks in the notion of process management by goals. The prioritization and ranking of the classical analysis method are performed based on RPN and FRPN values. The Spearman correlation function was calculated for statistical the crosschecking of the conformity and eliminating the relative interpretations, and this value was found to be 0.885 (p = 0.000). It was observed that there was a positive correlation between the risk priority order, which was concluded to be statistically significant. Process improvement and development activities concerning the failure modes that were determined as registered in goal identification cards, were suggested. The failure modes that were determined as being associated with the goal performance indicators included in the goal identification cards for performing the process management system in an integrated manner and for activating its sustainability, were tracked at 6-month intervals. The results of the improvement activities related to the failure modes determined based on the processes were re-assessed by the team of experts and included in the current situation FMEA analysis as a group or as individual results. O, S, D inputs, which are the relative parameters, were defined fuzzily following a classical risk ranking analysis and it is found that similar results were obtained upon comparing the results of the fuzzy method and the results of the classical method in the current situation analysis. The Spearman correlation factor was calculated again to test the conformity statistically and eliminate the relative interpretations in the comparison performed based on the risk priority number and fuzzy risk priority number values, and this value was found to be 0.819 (p = 0.000); therefore, it is seen that there is a very strong positive correlation between them. As a result of the studies on the quality policy of the towel production process, it is aimed to reduce the reference mt/min rate below 16 m per minute. When the threats to be encountered at the access point to the determined target were detected, the RPN score was 144 and the FRPN score was 175. In order to eliminate the risk or reduce the risk level, employees were informed about the improvement in the costs should the mt/min per minute rate drops below 16 mt, and the risk score was recalculated in terms of RPN and FRPN at the point of reaching the target. It was observed that it fell from 22nd to 9th place in the risk prioritization order. Similarly, the improvement and development activities carried out for 36 different risk factors, a sustainable corporate risk management cycle, has been achieved in issues such as cost, time, competition, internal/external customer satisfaction regarding processes that create added value in the enterprise.

Generally, analysis by a fuzzy logic approach is suggested in cases where one or several of the parameters are unclear or very subjective; however, where the classification is possible. It is important to monitor and test the accuracy of the goals that are determined for business processes within the scope of the notion of process management by goals in the studies to be performed in the ongoing process, and the performance indicator concerning the goals. For providing sustainability, the goals of the processes and the failure modes determined concerning goals should be provided, and improvement suggestions should be presented and applied based on risk prioritization. The results of improvement activity applications should be ordered and prioritized by a team of experts through fuzzy FMEA and non-fuzzy FMEA risk analysis techniques by individual and group decisions based on quantitative and qualitative data for following the developments and for testing whether a revision is needed or not. The model will contribute to the literature in terms of the fact that the process management by goals with strategical management elements forms a risk based model and for the model to be systematically tracked for a period. Continuous improvement studies should be maintained as a result of the assessments conducted for the sustainability of the notion of process management by goals. This will guide production management practices and meet the risk analysis practices specified in the management systems standards.

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