POLITECNICO DI TORINO

Department of Management and Production Engineering

Master of Science in Engineering and Management

Master Thesis

Assessment of Post-Crisis Financial Performance and Actions in Italian Companies

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Abstract

The Covid-19 epidemic, which has been effective all over the world since the beginning of 2020, has become an economic crisis with the restrictions imposed by states to stop the spread of this epidemic. While this situation caused serious damage to the production activities of many countries, it brought many companies whose financial situation was not so good anyway to the bankruptcy threshold. Using the financial and non-financial variables of 380 innovative companies, selected among 160 thousand SMEs in Italy that is one of the European countries most affected by Covid-19 economic crisis, the financial impact of the crisis on these companies has been tried to be analyzed by comparing the probability of bankruptcy predicted before and after Covid-19. Prediction was carried out using the machine learning algorithm created by ARISK in order to perform the analysis. The aim of the study is to provide a different perspective to the literature in predicting the bankruptcy status of companies in terms of both the types of companies it evaluates and the algorithm it uses. In this study, the most important point to be reached is the analysis of short, middle, and long-term bankruptcy and default situations by performing predictive financial analysis of especially SMEs companies. This study is expected to be a guiding research for the long-term strategic decisions of companies regarding their financial status.

Keywords: Bankruptcy Prediction, Machine Learning, Risk Management, Covid-19 Crisis

Declaration

This master thesis is carried out at Politecnico di Torino to complete Master of Science in Engineering and Management department. The period of the course was between 2018 and 2021 and the final presentation was made in April 2021. I declare that the thesis was completely performed by Merve ASLAN and it has not in whole or in part been submitted for any other degree or qualification. Thesis was supported by Professor Guido PERBOLI and Adjunct Professor Mariangela ROSANO from Department of Management and Production Engineering (DIGEP).

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1. Introduction

With the globalizing world, borders began to disappear, and markets began to take on a whole. Crisis happening on the other side of the world started to increase the movements in the stock markets and have effects all over the world. With the rapid changes in the markets and the increasing fluctuations in exchange rates, an environment of uncertainty occurred. Along with these, many types of risks have emerged and financial risks, which are seriously affected by all other risks, have created a great uncertainty in the financial conditions of the companies.

Although different risk analysis methods are applied for each risk type, it has become a difficult process to control and manage financial risks due to market uncertainties and different approaches are used in each market and situation. Even if internal controls are increased with enterprise risk management and preventions are taken against possible risks, it is not sufficient in terms of sustainability, scalability, and time management. That's why, machine learning technique has a major role in automating analysis and producing an efficient output in the measurement of financial risks. Thanks to algorithms, big data became manageable and machine learning technique has the capacity to produce output with high accuracy rates in many predictions and decision-making mechanisms. Thus, it has become one of the most common techniques used in predicting many financial risks. However, due to many internal and external economic crises experienced by companies, it is a difficult process to correctly examine and find solutions to the post-crisis outputs of companies such as bankruptcy and high debt ratio.

Most of the studies conducted in the literature on estimating the probability of bankruptcy and default of companies are based on developing with high estimation rates in the short term due to the uncertainty of future risks and require large data.

In this study, the applicability of short and middle term financial risk analysis for small and medium-sized innovative Italian companies is modeled. Furthermore, thanks to the machine learning-based algorithm used in analysis, it has been tried to obtain faster and more accurate data in long-term estimation with many different financial and non-financial parameters or variables. The method of predicting the probability of bankruptcy that may occur in Italian innovative companies after the economic crisis caused by the Covid-19 outbreak has been performed.

2. Research Structure and Research Questions

The aim of study is to predict the bankruptcy status of small and medium-sized Italian innovative companies in the short and middle term using machine learning technique. The economic crisis caused by Covid-19 around the world has seriously affected both governments and private sectors. In measuring the impact of this economic crisis, it was aimed to make predictions by analyzing the financial situation of Italian SMEs. At this point, the literature research was examined step by step from risk management to impact of Covid-19 and handled academic studies in the literature to support the assessment in every aspect.

In Chapter 3, The concept of risk, the characteristics of the risk and typical risk categories is dissected, and depending on these, the risk response strategies are evaluated. An overview of risk management concept (definition, history, aims and benefits) was taken. Under this title, phases of risk management and techniques have been examined and risk assessment has been handled.

In Chapter 4, The concept, history, and terms of corporate risk management are defined. The ERM process and its components were evaluated and compared under the COSO 2004 and 2017 frameworks. The objectives, benefits and limitations provided by ERM to companies are mentioned.

In Chapter 5, Artificial Intelligence, Machine Learning, Artificial Neural Networks, and their usage areas research are realized. Information was given on how machine learning and artificial intelligence techniques are combined with risk management and their usage in the financial sector.

In Chapter 6, An overview of Covid-19 and its financial effects is actualized. Firstly, it was explained how the artificial intelligence technique was used in the Covid-19 crisis, after that the financial effects of Covid-19 in the World, Europe and Italy were evaluated and finally sectoral evaluation was made.

In Chapter 7, The academic studies in the literature are examined, and the financial and non-financial variables used in these studies are investigated. Historical analysis of bankruptcy

forecasting methods used in the literature has been realized. In addition, the general logic of the machine learning technique used in the application is explained in a main frame.

In Chapter 8, Short and middle term predictions are made by evaluating the probability of bankruptcy of Italian innovative companies before and after the Covid-19 crisis according to their regions, activities, and revenues. At the same time, after the financial support policies provided by the Italian government, the companies' middle-term bankruptcy probabilities were evaluated.

Research Questions

Many different studies have been conducted in the literature to develop the prediction methods. Because of the uncertainties in financial situations and the unpredictability of economic crises, the research has mostly focused on short-term (12 months) estimates of large companies other than SME's. In this study, researches have been made and the application has been developed in response to needs such as mid-term forecasting (up to 36 months), being applicable to different markets and being used in financial and non-financial variables. While conducting this study, literature research from many different angles was carried out and answers to the following questions were sought.

The research seeks answers to the following questions;

- What is the risk and what are the types of risk? What are risk analysis techniques and how are they used?
- What is risk management and what are the benefits for companies? What are the phases and techniques of risk management?
- How is a risk assessment done and a risk matrix formed?
- What is enterprise risk management and how is it handled according to both COSO 2004 and 2017 frameworks?
- What is the purpose of enterprise risk management and what are the benefits and limitations for the company?
- What are artificial intelligence, machine learning and artificial neural networks, what is the connection between them and what are their usage areas?
- How are artificial intelligence and machine learning used in risk management and what are their applications in finance?
- How is artificial intelligence and big data methods adapted and used in the Covid-19 crisis?
- What has been the financial impact of the Covid-19 crisis in the World, in Europe and Italy? How have governments and companies been affected by this situation?
- How is evaluated for companies the probability of bankruptcy and default risks that are caused by financial risks?

- What are the bankruptcy prediction methods used in the literature? With which variables were the analyzes performed?
- What is the financial impact of the Covid-19 crisis expected on innovative companies?
- How is the bankruptcy risk expected to be in the short and middle in Italian innovative companies?
- How effect does the financial support provided by the Italian government have on the probability of companies going bankrupt in the middle term?

3. Risk Management

3.1 Risk Identification and Types

Risk has been defined by many people in many different ways. It cannot be said that there is only one common definition. If it is necessary to gather all these definitions under one roof, risk can be stated as the probability of an event occurring or the state of being affected by an event. When we get down to the origin of the word risk and examine its meanings in different languages, they can be the first guide to define risk.

Considering that the origin of the word risk comes from Italian phrase "risicare", its meaning is "to dare". According to another origin, the expression risk is thought to passed from the Latin "rescience", revealed by obstacles such as rocks and cliffs. In addition to these, Chinese added the concept of “opportunity”. In the Chinese language, risk is interpreted as the integration of two symbols, danger and opportunity, as below. This should bring to mind that, the considerations of risk should always be taken into, both in good and bad times. (1)

Figure 1 : Risk Definition in Chinese (2)

By looking at all these different interpretations, it can be said that risk is a versatile concept. Therefore, it can be expressed in different ways depending on diverse disciplines and sciences and is shaped differently according to dissimilar perceptions.

Risk has been defined in various ways over time. Some definitions focus on the probability of an event, while others refer to positive or negative consequences and other uncertainties regarding risks under uncertainty as a subset of uncertainty that can be identified. (3)

Risk is a concept in which future possibilities are evaluated effectively and danger probabilities are explained. Committee of Sponsoring Organizations of Treadway Commission (COSO) expresses the risk as the possibility of occurrence of situations at a level that may prevent the realization of business goals. (4)

If the risk is defined within the framework of the traditional approach, it can be expressed as the probability of not reaching a desired result, loss or damage within a certain time period. In addition, risk can be defined as the probability of occurrence of an undesirable situation and the severity of its impact as a result of its occurrence. Risk points to the problems and dangers that may arise in the future. (5)

To briefly define risk in general terms, it is the probability of a random event occurring. Risk is a combination of the 3 elements which are listed below.

- Cause / Source
- Probability that the event could happen
- Impact, as magnitude of the event

Characteristics of Risks

- Risk is generally unclear or unpredictable. There is uncertainty.
- Broadly speaking, there are two different approaches to risk:
  - In the first approach, risk means uncertainty. In this case, it can contain both positive and negative consequences.
  - In the second approach, risk means threat / danger. In this case it contains only negative consequences.
- Risk changes over time. (Dynamic)
- Risk is a manageable phenomenon.

Risk Types

Risks that an organization may face can be classified in different ways. Risks vary according to the organization's fields of activity, types, purpose, and target criteria. The structural and sectoral characteristics of the organization will significantly affect this classification. Every organization should anticipate and determine its inherent risks. Therefore, it cannot be said that there is a generally accepted risk classification system. At the same time, it will not be possible to separate the types of risks from each other with strict lines. However, we can classify the risks in 2 different frameworks according to their source and functional effect. When we separate the risks according to their source, we can divide them into 2 separate groups as internal and external risks, and into 4 groups according to their functional impact: financial, operational, strategic, and external environmental risks.

Sources of Risk

- ***Internal Risk*** that company can control
  - *Commercial:* Cost management, Inability to control the flow of money
  - *Technical:* Shortcomings in planning production management
  - *Human:* Changes in management, Shortage in human resource management

- ***External Risk*** that company cannot control
  - *Natural: Natural disasters, Environmental effects*
  - *Economic: Economic Uncertainties, Market risks, Inflation*
  - *Political: Unforeseen government intervention, Taxation, Political instability*

Typical Categories of Risks

Financial Risks: These are the risks that may affect the financial structure of the institution as well as the resources it needs to carry out its financial activities. (6) Financial risks are basically; capital structure, credit risk, market risk, country or state risk, liquidity risk and bankruptcy risk. Financial risks arise not only from changes in the market. Any transaction that will delay organizations from making repayments involves financial risk. Financial risks related to the

direct cash flow of the organization refer to the risks that arise as a result of the financial situation and choices of the enterprise. (7)

Figure 2 : Financial Risk Classification

Operational Risks: Operational risks are based on internal processes. In other words, they are caused by operational problems such as inefficient use of the process, system-related deficiencies, human and machine. Unlike strategic and financial risks, there is no positive return in operational risks.

Figure 3 : Operational Risk Classification

Strategic Risks: Risks that can lead to great gains and losses for a company and change depending on the business strategy and culture of the company can be named as strategic risks. Strategic risks can prevent organizations from accessing their short, medium, or long-term objectives. Effective use of strategic risks plays a major role in determining business strategies and achieving their goals. Strategic risks can be considered as risks related to management and organizational structure, economic risks, and partnership issues.

Figure 4 : Strategic Risk Classification

External Environmental Risks: External environmental risks may arise from many different external factors such as economic and political changes, natural disasters, geopolitical risks or terrorist attacks. Since the occurrence of these risks is not dependent on a specific situation, companies should always consider these risks while evaluating the risks. External environmental risks can sometimes affect companies greatly and force different sanctions.

Figure 5 : External Environment Risk Classification

3.1.1 Risk Analysis and Techniques

Risk analysis can be defined as evaluating the risks that may arise during the operations or processes of the enterprises carefully and in detail and taking measures to minimize or eliminate these risks. During the risk analysis, each of the identified hazards are examined separately, and are determined the effects of the risks that may originate from these hazards, how often they may occur, and who may be harmed by these risks, and in what severity. (8) After the risks are analyzed and prioritized according to their importance, severity, and probability of occurrence, it is aimed to eliminate the effects of the risks by taking measures to minimize these risks.

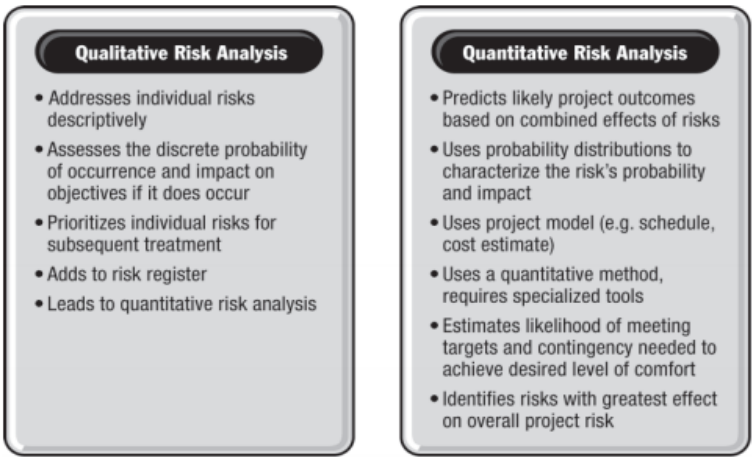

Figure 6 : Comparison of Qualitative and Quantitative Approaches (9)

Risk analysis types are divided into two.

1) **Qualitative:** In qualitative risk analysis method, while the degree of risk is determined, the impact and probability of the risk are determined based on observations and evaluations.

Figure 7 : Qualitative Risk Analysis Workflow (9)

Qualitative Analysis Techniques

- Preliminary Hazard Analysis (PHA)
- Hazard and Operability Studies (HAZOP)
- Failure Mode and Effect Analysis (FMEA)
- Structured What-If Technique (SWIFT)

2) **Quantitative**: In quantitative risk analysis method, while determining the degree of risk, risks can be evaluated statistically since the risk and probability of the event can be quantified.

Quantitative Analysis Techniques

- **Decision trees:** It is a technique used by a business management to examine various decision points of consecutive and probabilistic situations that can help define preferences, risks, gains, goals and can be applied in many important investment areas. The expected value of each result is calculated, and the final decision is made based on this expected value. With the help of the decision tree, each stage of the decision tree process can be seen clearly. A decision tree is used to help manage project risks and choose the best action plan in other situations where uncertainty exists.
- **Probabilistic techniques**
    - **Monte Carlo simulations:** It is a mathematical method that takes risks into account in the decision-making process. It is based on the principle of handling defined risks with different scenarios and simulations and calculating possible outcomes. This simulation method is used to analyze the effects of risks on time and cost predictions. It facilitates decision making due to the uncertainty of time and cost estimates. The quality of the predictions plays a key role in the success of the simulation. Monte Carlo simulation shows the probability of completing jobs. Thus, it helps to evaluate the risks.
- **Sensitivity Analysis**
- **Statistical Approach**

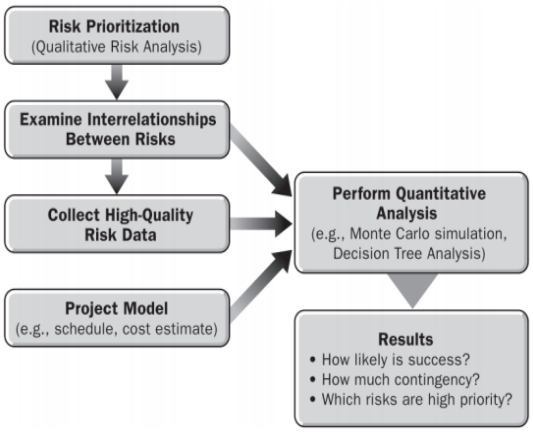

Figure 8 : Quantitative Risk Analysis Workflow (9)

If the quantitative approach is used, the formula of quantitative analysis is stated below.

$$R = I * P$$

the values of p and I are referred to:

R: risk level

I: actual impact in the case the risk event happens

P: probability of occurrence of the risky event

3.1.2 Risk Response Strategies

Identifying and scaling risks is not enough. The main idea is to determine what will be the response to the risks identified and evaluated by the institutions. The aim is to achieve the projected target in the most effective way by reducing the probability and / or impact of the risk. The ability to mitigate risks provides an opportunity manage risk for risk holders. There are 4 different strategy approaches in the management of risks.

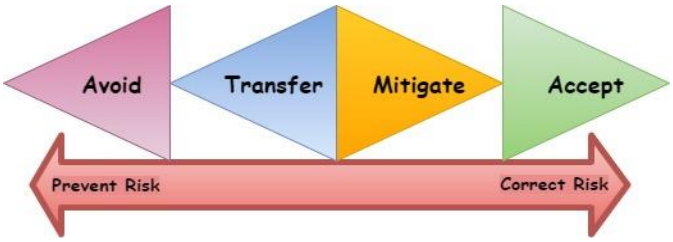

Figure 9 : Risk Response Strategies Types

Avoidance: Risk avoidance involves removing a threat posed by a risk, clearing project objectives from risk impact or modification of the project management plan to save the target in danger. In some cases, the risks can never be ruled out, but certain risks can often be avoided by doing such as narrowing down the scope of high-risk activities, adding time or resources.

Transfer: It is the response to the risk in the form of transferring the activities that are not directly within the main field of duty of the administration or that are not deemed appropriate to be done by the administration in terms of benefit-cost. Risk is transferred to another organization that has expertise and enough resource. Transferring the risk to third parties does not eliminate it, it only transfers management responsibility. In this method, a risk premium is paid to the third party that assumes responsibility for the risk results.

Mitigate: It is the search for a certain threshold by reducing the effect of the probability and / or consequences of the risk. Mitigation cost should be consistent with the likelihood and consequences of the risk. Risk mitigation is to reduce the likelihood of risk by changing conditions such as adding a new action plan or time to reduce the problem. In cases where it is not possible to reduce the probability, it can be tried to reduce the impact of risk by focusing on the links that determine the urgency.

Accept: Accepting risk is a method given to control risky outcomes that are not deemed appropriate due to cost-benefit reasons or that must be accepted for various reasons. This strategy can be carried out actively or passively. In active acceptance, there must be a contingency plan to be implemented when the risk occurs. In passive acceptance, no action is taken except risk registration when the risk occurs.

3.2 Risk and Uncertainty Concepts

Uncertainty is the distribution of possible outcomes that can be obtained. The wider the distribution leads to the greater the uncertainty. On the other hand, risk can be defined as the deviation between the most likely outcome and the actual outcome. In fact, it is not the risk that organizations fear, but it is uncertainty. Although risk and uncertainty are often used to mean the same thing, there is a distinct difference between them.

Uncertainty is closely related to risk, and it can be defined as a skeptical view of the ability to reveal the future. Uncertainty is not an objective concept, since it may vary from person to person, the measurement of risk is not possible in uncertainty. Uncertainty, according to another definition in the business world, is the inability to see the future in terms of business and operating processes. (6) Uncertainty causes delays in projects and strategic planning by blurring decision-making capabilities.

Risk refers to situations in which probability targets can be defined for possible outcomes. Risk can also be expressed as the possibility of not achieving a desired result, loss or damage within a certain time period. At the same time, risk points to problems and dangers that may arise in the future. While the risk has negative consequences such as problem, threat, danger, loss or loss, it also has positive dimensions such as opportunity, benefit, profit and gain.

In other words, risk is a quantifiable expression. Uncertainty can be observed in situations or events where sufficient information is available to define objective probabilities. Uncertainty refers to many conditions and factors that cannot be defined and predicted in terms of their occurrence. Risk can be detected in advance by calculating the probability of the occurrence of a certain hazard and measures can be taken to minimize the damage of the value at risk in return for a certain cost. Uncertainty can only be noticed when shock emerges. Therefore, the feature of being noticed in risk, unpredictability and inability to take action stand out in uncertainty. Risk is expressed as a concept where the probability of an outcome can be determined and so this outcome can be insured. On the other hand, uncertainty, cannot be insured since it indicates a situation whose possibility is unknown. (10)

3.3 Risk Management Definitions and Its History

Risk management is the systematic determination and evaluation of the risks at every level with a specific method in order to achieve the goals of the organization, taking measures to reduce the effects of the risks and monitoring this process in a way that ensures effective operation. In risk management, preventive, guiding, detective and corrective control activities should be implemented. It consists of the processes of determining targets, identifying, measuring and prioritizing risks, and evaluating the response options to be given to the risk. Although the risk management stages may appear to be the same as the risk identification and analysis methods, the risk management process will differ from them in terms of risk assessment. (11)

Even if there are different explanatory of risk management definitions in many places, definitions of risk management may not be enough to truly understand risk management processes. Therefore, characteristics of risk management are listed as follows.

1) Risk management should aim to prepare the best action plan against possible risks.
2) The goal of risk management is to limit the risk appetite by objectively measuring the risks that risk owners are exposed or assumed.
3) Risk appetite in risk management should be determined according to the cost / benefit balance attitude of managers based on their risk-taking strategies.
4) Risk management in businesses is a teamwork and is the common work of employees. Everyone in the organizations is responsible for risk management.
5) Risks should be clearly stated by the institutions to the employees. Companies should elaborate their responsibilities on risk management and provide training support to managers of all levels.
6) Risk management processes should be simple, flexible and applicable, and should be planned and executed in integration with other basic processes (strategic planning, performance management, human resources management, etc.).
7) Systematic monitoring, reporting and evaluation of risk management processes are required.

It is not enough to determine and analyze the risks. The main purpose of risk management is to prioritize the risks after identifying and analyzing them, and to create actions to be taken depending on the severity of the risks. Since the risks will vary depending on many factors such as the management of each organization, the sector to which it is affiliated, the company culture, the requirements of risk management will be different for all.

It is possible to say that risk management studies started after the World War II. In past times, risk management is associated with the insurance industry in order to protect risk owners from accidents and losses. At the end of the 17th century, Edward Lloyd opened a coffee house near the port in England, laid the foundations of today's insurance business with the pool he created to cover the damages to be incurred by the traders in the port, and later founded Lloyds of London. (12) The first academic articles on risk management were published by Mehr and Hedges in 1963 and by Williams and Hems in 1964. Risk management tools started to be used in the USA in the 1970s and spread rapidly in the 1980s. International regulations on risk management started in 1990. In the 1990s, all types of risks are recognized to be managed and controlled. In the early 2000s, various legal regulations started to be implemented all over the world. (13)

3.3.1 Benefits and Aims of Risk Management

The purpose of good risk management is to add maximum sustainable value to all activities of the organization. It tries to understand the potential and downside of all these factors that can affect the organization. It increases the likelihood of success and reduces uncertainty in achieving the overall goals of the organization.

The purpose of risk management can be summarized as follows:

- Reducing the cost of losses
- Sustainable growth
- Effective and quick decision making
- Provides the efficiency of resources and prevents their waste
- It ensures that risks remain at reasonable levels

Risk management should be a consistent and evolving process that continues throughout the organization's strategy and its implementation. The organization must address all the risks surrounding past, present and especially future activities.

In line with the purposes of risk management, the expected benefits of risk management to risk owners are listed.

- Providing to increase the performance of the administrations and to be more effective in reaching the key results they aim.
- To increase efficiency in resource allocation.
- To assist increase the continuity and quality of the services provided.
- To create a more positive image in the public.
- To ensure the strengthening of decision-making mechanisms.
- Increasing the employees' sense of ownership and belonging, it encourages them to be open to innovations.

3.4 Phases of Risk Management

The risk management process is a management tool and represents all the mechanisms that may have an impact on risk owners achieving their goals and objectives. Although it is grouped under different headings, the risk management process basically follows the same steps. There are 4 basic steps to manage risk; identify the risk, analyze the risk, respond to the risk, and monitor and control risk.

1) Identify the Risk

It is the process of determining, grouping, and updating the risks that prevent or make it difficult for the administration to achieve its goals, using predefined methods. After the risks are identified, risk registration is performed manually or in the system, so that risk can be viewed by anyone in the organization with access to the system.

2) Analyze the Risk

The risk analysis process is carried out with 3 successive subtitles.

- *Risk Evaluation:* It is the calculation of the probability and impact of each risk. The probability and effects of the risks are shown in figures and the risk score is calculated. Based on this score, it is aimed to measure the severity of the risk.
- *Prioritization of Risks:* It is the ranking of the risks according to the scores they get as a result of the measurement, starting from the highest score according to the degree of importance. Three risk categories are used to be low, medium and high-risk level.
- *Risk Registration: Each identified risk is enumerated, approved and recorded by authorized persons.*

3) Risk Responses

It is the determination of what will be the response to the risks identified and evaluated by the administrations. The aim is to achieve the projected target in the most effective way by reducing the probability and / or impact of the risk. In this step, administrations should establish risk reduction strategies, preventive plans and emergency plans.

4) Monitor and Control Risk

It is the step where all your steps are reviewed and recorded. Control activities are carried out to keep the risks at an acceptable level. On the other hand, some risks cannot be controlled and must be constantly monitored. Market and environmental risks are examples of these. At this stage, the controls should be followed closely by experts.

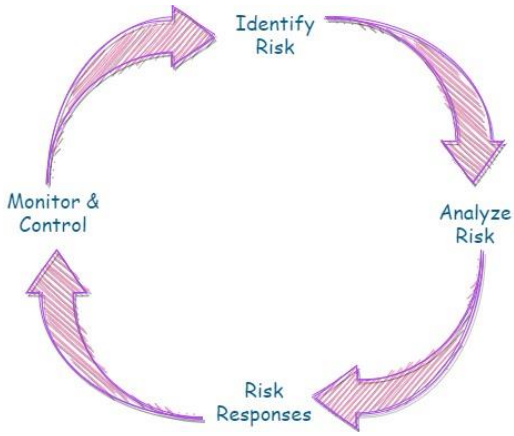

Figure 10 : Phases of Risk Management

3.4.1 Risk Management Techniques

The risk management process is summarized in words starting with the letters 8R and 4T in English. (14)

- Recognition: identification of risk
- Rating: risk rating
- Ranking: evaluation of risk
- Responding: do not respond
    - ✓ Tolerate: do not toss
    - ✓ Treat: Do not intervene
    - ✓ Transfer: transfer
    - ✓ Terminate: termination
- Resourcing: resource allocation
- Reaction: do not react
- Reporting: reporting of risks
- Reviewing: reviewing the risk management framework

The most important processes in risk management stages are defining, analyzing and planning the risk. Key techniques of risk management processes are listed as follows. (15)

Identification of Risk

- **Decision Tree Diagram:** It is a technique used to examine various decision points in situations where there are multiple options that can assist in defining preferences, risks, benefits, goals.
- **Influence Diagram:** It is used to show the effect and connection of a situation, event or condition on another situation based on a cause.
- **SWOT Analysis:** Swot analysis is a concept consisting of the components as named strengths, weaknesses, opportunities and threats. Swot analysis helps to understand all aspects of a risk that may occur. It is a technique that enables to make the right decisions and provides a clear examination of the current situation and future risks.
- **Fishbone Diagram:** It is a tool used to identify and show possible causes of a known problem. It is also known as ISHIKAWA as it was developed by Ishikawa. A cause-effect diagram has been developed to show clearly the causes affecting a process by classifying and relating them.
- **Process Maps:** Process maps are a visual representation of the business process or process flow that defines the sequence of events in a workflow. It also helps identify bottlenecks.

Evaluation of Risk

- **Risk Probability and Impact Matrix:** A risk measurement value is obtained by evaluating two factors, which are the degree of impact of a risk as a result of its realization and its probability of occurrence. This method uses in a quantitative risk assessment method.
- **Pareto Chart:** A Pareto chart named after Italian economist Vilfredo Pareto is a bar chart containing both columns and lines, showing values in descending order with columns and cumulative sum with lines. The purpose of the Pareto chart is to highlight the most important ones among a set of factors.
- **Fault Tree Analysis:** It is a graphical representation of the logical combination of the causes of the identified adverse event or situation. It is failure analysis with top-down and

deductive logic. It is used to identify the best ways to reduce risk or to identify failure at a certain level of the system.

Planning to Avoid Future Risks

- **Futures Wheel Diagram:** The futures wheel is a graphical visual used to determine the direct and indirect consequences of a particular trend, event or decision in the future.
- **Process Decision Program Chart:** This method is the determination of preventive actions by determining the probabilities of risks that may occur in an improved plan. Thus, it helps to observe the risks that may arise and to prepare an emergency plan.
- **Risk-Reward Analysis:** This method is a tool used to reach an optimal design by evaluating the expected risks and rewards of different options.

3.5 Risk Assessment

Risk assessment is the entire process of developing an action plan and strategies to be implemented to minimize hazards and the frequency of exposure to the hazards and to determine the importance level of potential hazards. The risk assessment process consists of the stages of risk determination, risk measurement, determination of the risk appetite that institutions can take, and determination of responses to risks. (16)

Evaluating the risks encountered while trying to reach the corporate mission, vision and goals after the goals and objectives are clearly stated, prepares a suitable environment for these risks to be given the most appropriate response. Risk assessment is the process of identifying and analyzing important risks that may prevent the organization from achieving its goals, as well as determining the most appropriate responses to them. Since the environmental conditions of institutions are constantly changing, risk assessment should be a continuous and repetitive process. (6) At the same time, risk assessment also means making necessary changes in internal control in order to identify and analyze changing conditions, opportunities and risks. (17)

After the risks are defined, a risk assessment is made to decide how best to manage each risk. Risk assessment is the calculation and evaluation of the value of the risks, that is, their possible

effects and the probability of the occurrence of risks. (18) While the impact here expresses the importance of the risk on the organization's ability to achieve its objectives; probability refers to the probability of occurrence of risk within a certain time period. (19)

After the impact of the risk and its probability of occurrence is calculated, the risk capacity that the organization has to deal with is determined. At this step, it is important for top management to lead managers across the organization regarding the types and levels of acceptable and undesirable internal risks. (19)

What is meant by acceptable risk is how much risk the organization will tolerate and how much risk the organization will carry out the necessary activities. Acceptable risk varies according to the activities of the organization, its size and the characteristics of the sector. In other words, the acceptable risk level of each organization should be different. The organization decides how to manage the risks after determining the types and levels of risks according to the possible effects and probability of occurrence. (18)

There are many risk assessment techniques. Different tools and techniques can be effective in different situations and conditions. Risk assessment provides understanding of the causes, probabilities and consequences of risks.

One of these, brainstorming, is the free-flowing speech of a group of experts in order to create solutions to potential dangers and errors and risks. Auditing is another way. It can perform process analysis together with audits. By creating a survey method, the perspectives on risk situations and sources can be evaluated.

In addition to these, SWOT (Strength, Weakness, Opportunity, Threat) or PESTLE (Political, Economic, Sociological, Technological, Legal, Ethical or Environmental) methods can be used. Thanks to SWOT analysis, the opportunities and threats created by risky situations within the company and the sector can be measured objectively. With PESTLE analysis, it is possible to evaluate opportunities and threats related to the external environment.

The most commonly used method is the risk matrix. In this method, probability and impact components are used to show the degree of risk. Generally, the risk probability is shown on the vertical axis and the impact of risk on the horizontal axis of the matrix. According to the risk

score created by these two situations, the risk matrix is colored to understand the importance of the situation that may occur as a result of risk. Generally, the highest risk situations are shown in red, medium risks in orange, and low risk situations in green.

Table 1 : Risk Matrix (20)

The risk matrix range criteria to determine probability index can be classified as shown in the table below.

FREQUENCY		
Verbal	Numeric	Description
'''Highly unlikely'''	1	Unlikely risks, which have a rare level occurrence such as less than 10%.
'''Unlikely'''	2	Seldom risk contains low probability of occurrence however cannot yet excluded entirely.
'''Possible'''	3	Hazard, which have occasional (50/50) likelihood of occurrence harm
'''Likely'''	4	Risks that lies among 60-80% chances of occurrence can be grouped as likely.
'''Very likely'''	5	A definite hazard that has highest frequency (generally more than 80 %) of reveal during certain project stages.

Table 2 : Risk Probability Matrix Example (21)

The risk matrix range criteria for an industrial company example can be classified as shown in the table below.

Operations / Impact	Very low	Low	Medium	High	Very High
Financial	Potential loss less than 100.000 USD	Potential loss between 100.000 USD and 1.000.000 USD	Potential loss between 1.000.000 USD and 3.000.000 USD	Potential loss between 3.000.000 USD and 10.000.000 USD	Potential loss more than 10.000.000 USD
Health and Safety	Minor reversible short term health effect	Moderate reversible midterm health effect	Permenant disabilities, long term hospitalization	1 Fatality	Multiple fatalities
People	Minor impact on employee satisfaction	A few number of employees quiting the job	Major impact on employee satisfaction and a key employee quiting the job	Major impact on employee and the management satisfaction and few number of key employees quiting the job	Major impact on employee, the management and large number of key employees quiting the job
Environment	No environmental damage	Low environmental damage(less than 1 month)	Short-term harmful(a few months). and polluting substances in the environment and societyin the facility	Long-term harmful(1 year). and polluting substances in the environment and society in the surronding vicinity of the facility	Long-term harmful(more than 5 years). and polluting substances in the environment and society in the larger area
Strategic Cooporation /Market	No negative effect on company's strategies . Very minor effect on loss of market, loss of revenue and customer satisfaction.	Low negative effect on company's strategies. Minor effect on loss of market, loss of revenue and customer satisfaction.	Medium negative effect on company's strategies. Major effect on loss of market, loss of revenue and customer satisfaction.	High negative effect on company's strategies. High effect on loss of market, loss of revenue and customer satisfaction.	Critical negative effect on company's strategies. Very high effect on loss of market, loss of revenue and customer satisfaction.

Table 3 : Risk Impact Matrix Example (1)

Identifying opportunities is as important as determining the degree of risks during risk assessment. It should be noted that when some risks are taken, great opportunities can occur. While analyzing the risks, the positive and negative effects of the risks should also be taken into account.

Organizations should have the ability to analyze the risks that are exposed or will be exposed, and they should manage these risks within the risk appetite limits. While conducting these analyzes, organizations should be sure that they have the resources to meet these risks. Every institution has different strategies and risk appetites taken against risks. This depends on the nature of the market that the company is in or the attitude of the company management towards risks.

4. Enterprise Risk Management

4.1 Enterprise Risk Management and Historical Development

Changes due to globalization in today's competitive conditions constantly keep organizations under pressure and force them to run ahead. Low cost and high-quality expectation have become the most important focus for organizations. Due to globalization, geographical boundaries have changed, markets have seriously interacted with each other, the number of uncertainties and the level of competition have increased, and accordingly, ethical values have started to be considered less and investor confidence level has decreased.

Increased efforts to understand and manage the risks faced by organizations have caused inefficiencies. The scope of uncertainties has expanded and as risks increase, an increasing number of functions and responsibilities arise to manage risks, each in a different area. Problems in risk management not only increased the burden on organizations, but also led to an increase in cost and time. The increasingly dynamic nature of risks also imposed difficulties on those who ruled it. Increasing crises and frequent losses prepared the ground for the emergence of this concept.

Both internal and external problems have inevitably shifted the organizations' approach to risk management to a different new paradigm, suggesting that all risks should be addressed in a consistent, detailed and holistic manner rather than managing risks separately in organizations.

ERM refers to a radical change in the way organizations deal with risk. With a holistic approach, ERM is a concept that defines various risk factors and refers to controlling risk management activities across all operating units of an organization, rather than the traditional practice of evaluating specific risks of each business unit individually and deciding how to mitigate it.

Enterprise risk management can be defined as all processes that include defining risks, determining those responsible, creating action plans to reduce their effects, monitoring and reviewing developments, depending on the organization's reputation, mission and strategies. In addition, corporate risk management can also be referred to as the detection and management

of the negative effects that may occur while trying to evaluate the potential opportunities of the organization's process and structure.

According to COSO, enterprise risk management is a process created to manage potential risks at the risk appetite level in order to provide assurance for administrations to achieve their strategic goals. In order to the enterprise risk management process to be more effective, the managers and employees of the enterprise should be involved in the whole process. (22)

Instead of restricting corporate risk management to certain definitions, COSO has specified the following requirements in addition to the definitions.

- An activity ongoing and smooth through institution
- Used in strategy determination
- It is applied at all levels throughout the business and is affected by people at all levels of the business.
- Designed to manage risks within risk appetite level
- Provides reasonable assurance (22)

This definition can be further expanded. It finds clues about how other organizations are managing risk and builds a foundation based on it, in order to provide an application across industries and sectors. (22)

ERM increases internal communication by analyzing the strengths and weaknesses of the strategy when conditions change, by looking at how compatible the strategies of the companies are with their mission and vision goals. Thus, management feel more confident that they examine alternative strategies and that the inputs of their strategies to be implemented in their organization are considered. (4)

4.1.1 Enterprise Risk Management Terms

In order to better understand the concepts related to ERM, the meanings of some concepts related to the subject should be well known. *Some of these terms are explained as follows.*

Risk Appetite: It refers to the level of risk that the institution can accept within the framework of the goal, mission and vision within its strategic plans. In other words, it is the amount of risk that management can meet before deciding on the necessity of a control activity against any risk. (23) Each organization may have a different risk appetite against all kinds of risks that can be borne, and this situation may vary from business to business, from sector to sector. At the same time, the risk appetite for the same risk may change over time depending on the strategic goals of the organization.

Risk Tolerance: Risk tolerance is a criterion that shows how much risk can be tolerated within the framework of risk appetite. (24) It is also defined as the deviation from the risk appetite that is tolerated for a risk and determines the acceptable level of variation within the objectives of the organizations. (25)

Natural Risk: The risk before the organization performs any control activity against the risk is the natural risk. Natural risk occurs when organizations do not take any measures to change the effects of the risks.

Residual Risk: It is the residual risk after control activities are carried out to reduce the impact of risks that will prevent organizations from achieving their goals.

The general formula for residual risk is:

$$\text{residual risk} = (\text{inherent risk}) - (\text{impact of risk controls})$$

Figure 11 : Formulation of Residual Risk (26)

Risk Capacity: Risk capacity refers to the maximum amount of risk an organization can carry to achieve its goals. The risk capacity usually is greater than the highest-level set in the risk appetite framework. (27)

Key Performance Indicators (KPIs): In its simplest form, KPI can be defined as the desired goal. It is a performance indicator used for companies to achieve their long-term financial and non-financial targets.

Key Risk Indicators (KRIs): It is a proactive measure for future and emerging risks, showing the probability of an event, financial or non-financial, that adversely affects business activities, used to help identify and measure potential losses. (25)

COSO: COSO (Committee of Sponsoring Organizations of Treadway Commission) is a voluntary private sector organization that aims to increase the quality of financial reporting with a focus on business ethics, internal control, independent audit and corporate governance. COSO is supported in 1985 by five major financial institutions, the American Accounting Association, the American Institute of Certified Public Accountants, the Financial Executives Institute, the Institute of Internal Auditors and the Institute of Management Accountants. (28)

The development of the COSO enterprise risk management model coincides with the 2000s. In the 2000s, the business scandals that caused great losses in the United States, therefore the stagnation of the economy caused many losses for institutions and the technological changes in the world brought new risks, and the importance of risk management began to be recognized. Until at that time, many risk management techniques have been used, but these have become insufficient in the current situation. A common model that can be used to discuss, define, evaluate and manage risk was needed. The project to reveal such a model was initiated by COSO (Committee of Sponsoring Organizations) in 2001 in the USA. COSO, together with Price Water House Coopers (PWC), has implemented such a study with the aim of developing a ready-made model where managers can analyze and strengthen the corporate risk management of their organizations. An advisory board authorized by COSO also gave its support and led the process. At the end of 2004, the COSO ERM model was published. With the Corporate Risk Management Model of COSO, a globally applicable guide has emerged. (29)

4.2 Enterprise Risk Management Processes and Components

Although risks contain negativities in terms of achieving the goals and objectives of the organization, they are the situations that prevent the organization from seeing the future fully by preventing the best implementation of the determined strategies. The main purpose of ERM can be expressed as achieving corporate objectives by managing risks.

COSO used the term enterprise risk planning for the first time in its report published in 2004 named “Enterprise Risk Management - Integrated Framework” and developed the enterprise risk management system. In this report, enterprise risk management is defined as a process created to provide assurance for organizations to achieve their goals. It aims to identify and analyze the risks that may affect the institution and manage them at the risk appetite level of organizations. Therefore, the detailed handling of internal control activities has been accepted as the basis for the organization to understand the risks that it may face. In the COSO 2004 framework, components and processes are represented as a cube and 8 components are handled and shown below. (30)

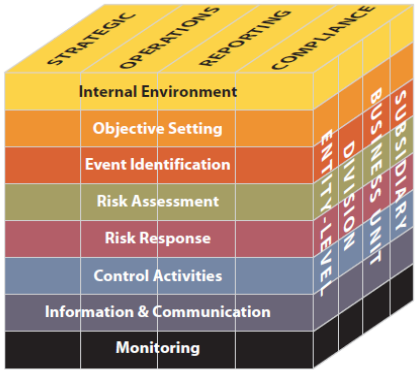

Figure 12 : COSO Cube, 2004 (22)

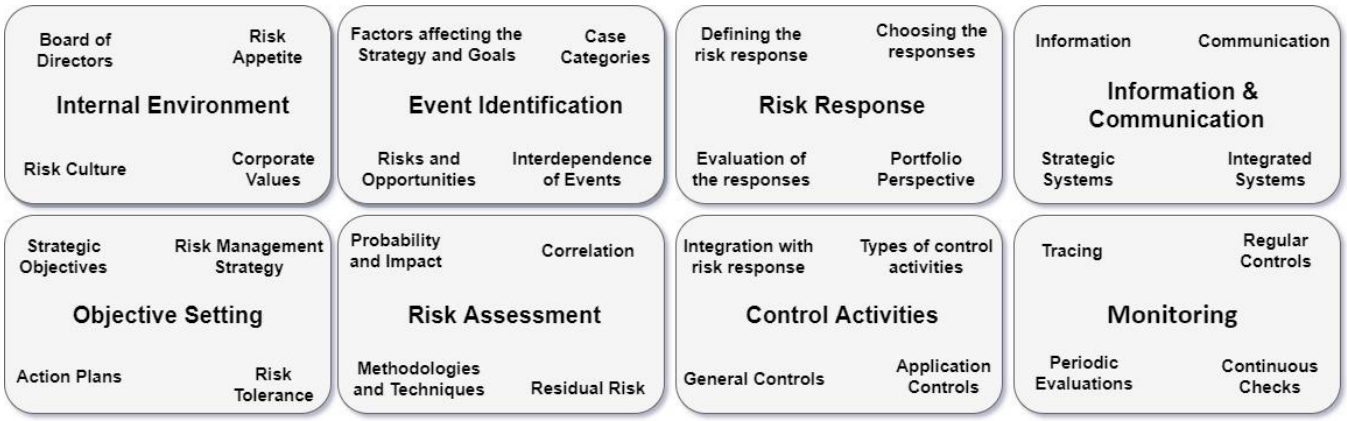

Figure 13 : According to the 2004 COSO framework, Relationship of Objectives and Components

Looking at this framework, the main steps of the ERM process can be expressed as follows;

- Identifying and determining risk
- Measuring of the risks by analyzing
- Risk assessment and prioritization
- Determining and implementing control activities and actions appropriate to the risk
- Information and communication activities
- Continuous monitoring and review of the system

COSO revised its corporate risk framework in 2017 and published a new report titled "Enterprise Risk Management — Aligning Risk with Strategy and Performance". Since the first period of the framework published in 2004, the emergence of new risks, more complexity of risks, increased risk management awareness of stakeholders, expectations for better risk reporting and developments in enterprise risk management have led to the formation of a new framework. (30)

In the updated framework, the importance of integrating enterprise risk management with all processes of the institution was emphasized. Integrating enterprise risk management into all activities and processes of the organization; It has been said that it will improve the decision-making processes regarding the governance, strategy, goal setting and daily operations of the organization and increase performance and it will contribute to the creation, protection and

maintenance of value. Enterprise risk management no longer focuses mainly on preventing depreciation and reducing risk to an acceptable level. Rather, it places emphasis on strategy setting, creating value and attaches importance to sustainability of these values. (31)

Figure 14 : According to the 2017 COSO framework, The Driving Force of An Organization (4)

In the 2017 ERM framework, enterprise risk management is defined as "ERM is the culture, opportunity and practice that the organization can rely on to create, protect and realize value, to manage risk, and which are integrated into the determination and execution of the strategy." In addition, it has been stated that integrating ERM applications by taking the entire organization into account will trigger the acceleration of the growth of the organization and will improve the process from making strategic decisions to company performance. (4)

As it will be noted, in the new definition, it is stated that the main purpose of risk management is to create and protect value, and that it should be integrated into strategy determination and execution. It has been argued that corporate risk management is not a function and department and simply list of risks, additionally it is more than internal control, and so it covers the practices that management uses to actively manage risks. (4)

The framework, updated in 2017, contains many new changes regarding ERM applications and concepts. Some of the main changes are listed as follows.

- Strengthens the link between ERM and decision-making process
- Highlights strategic development and enhanced value
- Improves performance and integration of enterprise risk management

- Emphasizes the importance of company culture
- Uses both component and principle structure rather than just main components structure
- Makes the ERM definition clearer and more understandable (31)

As shown below, instead of the cube used in 2004, a spiral representation is made in the new frame.

Figure 15 : COSO ERM Framework, 2017 (4)

As can be understood from the framework, maximizing company value within the framework of enterprise risk management; It is emphasized that it will be possible by maturing mission, vision and core values, developing strategy, setting business goals and integrating them with performance. (32)

In addition to five interrelated elements in the renewed COSO Corporate Risk Management Framework, 20 principles belonging to them are briefly explained below.

Figure 16 : According to COSO 2017 Framework, Components and Principles (4)

Governance & Culture: Governance and culture form the basis of other components of enterprise risk management. It refers to the distribution of roles, authorities and responsibilities among stakeholders, board of directors and management. Governance determines the style of the organization and establishes oversight responsibilities. Culture is the way to understand attitude, behavior and risk that affect the decisions of management and personnel and reflects the organization's vision, mission and core values. (30)

There are five principles for this component.

1) **Exercises board risk oversight:** The Board of Directors fulfills the oversight of strategy and governance responsibilities in order to support the management in achieving its strategy and business objectives.
2) **Establishes operating structures:** The organization creates the operational structure in order to realize the strategy and business goals.
3) **Defines desired culture:** The organization determines the desired behaviors that characterize the culture of the institution.
4) **Demonstrates commitment to core values:** The organization indicates the organization's commitment to its core values.

5) **Attracts, develops, and retains capable individuals:** The organization gives great importance to building human capital in line with strategy and business goals.

Strategy & Objective-Setting: In the strategy planning process, they act together with enterprise risk management, strategy, and goal setting. Risk appetite is determined in line with the strategy. Business objectives: It forms the basis for determining, evaluating and responding risks. Business objectives ensure the implementation of the strategy and shape the daily operations and priorities of the organization. (32)

There are four principles for this component.

6) **Analyzes business context:** The organization analyzes the potential effects of the business environment it is in on its risk profile.
7) **Defines risk appetite:** The organization describes the risk appetite in the context of value creation, protection, and realization.
8) **Evaluates alternative strategies:** The organization evaluates the effects of alternative strategies on the risk profile.
9) **Formulates business objectives:** The organization takes into account the risks at various levels while setting its business goals in a way that is compatible with and supports the strategy.

Performance: Risks that could affect achieving the strategy and business goals should be identified and evaluated. Risks should be prioritized according to the risk appetite. The organization then chooses its response to the risk and determines the amount of risks it will bear from a portfolio (at every level of the organization) perspective.

There are five principles for this component.

10) **Identifies risk:** The organization determines the risks that affect the fulfillment of strategy and business objectives.
11) **Assesses severity of risk:** The organization evaluates the severity of the risks.

12) **Prioritizes risk:** The risks are prioritized by the organization based on its response strategy to the risks.
13) **Implements risk responses:** The organization determines and chooses its responses to risks.
14) **Develops portfolio view:** The organization improves and assesses a portfolio perspective regarding risks.

Review & Revision: In the light of significant changes, the organization reviews how the performance results in accordance with the targets, whether the enterprise governance practices work well, whether they add value to the organization, whether they continue to add value and whether there are any issues that need to be corrected.

There are three principles for this component.

15) **Assesses substantial change:** The organization determines and evaluates changes that significantly affect the organization's strategy and business goals.
16) **Review risk and performance:** The organization reviews the performance results of the organization and addresses the risks.
17) **Pursues improvement in enterprise risk management:** The organization follows the improvements in corporate risk management.

Information, Communication & Reporting: Communication is the acquisition of information, its sharing throughout the organization, and it is a constantly repetitive process. To support enterprise risk management, management uses appropriate information from both inside and outside. The organization benefits from information systems to hold, process and manage information and data. It reports on the organizational culture, risk and performance by using information on all components.

There are three principles for this component.

18) **Leverages information and technology:** The organization takes advantage of the information system of the organization to support corporate risk management.
19) **Communicates risk information:** The organization benefits from communication channels to assist corporate risk management.
20) **Reports on risk, culture and performance:** The organization reports on risk, culture and performance at various levels within the organization. (4)

4.3 Enterprise Risk Management Objectives and Benefits

The expression ERM differs from the traditional concept of risk management in terms of meaning. ERM means integrating or aggregating all types of risk; also, it is to use integrated tools and techniques in order to reduce risks and communicate in business lines and levels. Integration here means adjusting the capital infrastructure, reaching financial goals and managing the operations of organizations. Value maximization occurs when the balance between growth, development and returns is handled efficiently and effectively in line with the targets. (11)

ERM objectives can be listed as follows:

- Improving the distribution of capital: Obtaining accurate risk information enables management to effectively assess overall capital needs and allocate capital more efficiently.
- Identifying and managing internal and inter-agency risks: Every organization faces many risks. Management aims to effectively respond to and manage interrelated risks.
- Capturing Opportunities: Allows management to identify opportunities and realize them proactively, considering a range of potential events.
- Reducing operational risks and losses: Analyzing risks in advance and identifying events and creating responses helps to reduce costs and losses that may arise from risks.

- Effectiveness of reporting and compliance; It aims to control and manage the risks that are related to the structure of the organization and arise from the external environment.

Enterprise risk management system constitutes the focal point of strategic management in an organization. While the probability of success increases in organizations that are integrated with their processes and targets, settled in all routine operations, and have a dynamic risk management structure in response to changing conditions, the level of uncertainty in the realization of goals and objectives is minimized. Organizations dealing with ERM can better understand the overall risk involved in different business activities. This increases capital efficiency and return on equity by providing them with a more objective basis for resource allocation. Within the scope of the expression, the main benefits of the enterprise risk management system are listed below. (6)

- ✓ It increases the effectiveness of corporate governance and enables managers to perform more effective controls.
- ✓ Corporate risk management is a dynamic process that covers the entire institution with continuity.
- ✓ Makes possible to comply with regulations and respond to risks.
- ✓ Plays an important role in minimizing operational risks.
- ✓ Improves capital and resource allocation.
- ✓ Helps to protect and improve the corporate reputation by reducing the likelihood of risky situations and taking advantage of opportunities.
- ✓ Determines how much of the risk will be tolerated
- ✓ By determining the events that are likely to affect the organization, it ensures that risks are managed at an optimal level rather than simply eliminating them.
- ✓ It is an important tool that provides reasonable assurance in the achievement of strategic goals and objectives.
- ✓ Provides an advantage to future management by strengthening corporate memory.
- ✓ Protects the brand image and reputation.

4.4 Enterprise Risk Management Limitations

Establishment and effective operation of the corporate risk management framework depends on the support of the senior management, the risk management philosophy of the institution, the willingness to take risks, the scope of the ERM system and the existence of the information infrastructure that supports this system. (33) If the top management does not support it or provides limited / insufficient support, the data required for the operation of the system will not be available, risk studies will not be organized and other activities will not be completed properly.

Beyond management support, ERM, although well designed and executed, may not go beyond providing a reasonable level of assurance due to the limitations of the ERM system. The biggest constraint of enterprise risk management is that risks are a result of an uncertainty environment. As it is known, risks arise from the uncertainty of the future and it is not possible to eliminate this uncertainty.

Another constraint in front of the ERM system; risks can change rapidly, and therefore the possibilities and effects previously defined lose their validity. (34) This situation makes it difficult to act with historical data and makes the data that the system already has meaningless.

Another of the limits in front of ERM is the weaknesses that may arise from human nature in the process of making business decisions. Decisions are made with human opinion, in the light of available data and in the pressured process of business life. This situation may weaken the credibility of decisions. (4) In addition, risky areas may not have been identified as a result of misdirection of the system by senior management or other corporate employees. Naturally, it may not be possible for the risk management system to work effectively.

In addition to these, when the benefit-cost balance of the controls to be established during the response to risk is taken into consideration, it causes an increase in costs and decrease in efficiency by performing excessive controls. (35)

The effective functioning of the system depends on the objective determination of the effects of the determined risks on the organization. Today's competitive environment and the vulnerability of businesses to global competition and global economic developments have

caused the lots of diversified risks. For this reason, it has become an important issue to determine the effects of risks objectively.

5. Artificial Intelligence and Machine Learning

5.1 Artificial Intelligence and Usage Areas

In the simplest terms, artificial intelligence (AI) refers to systems or machines that imitate human intelligence to perform tasks and can iteratively heal themselves according to the information they collect. Artificial Intelligence is a created process by using empowered thinking and data analysis methods rather than any specific form or function. Artificial intelligence is designed to significantly improve human abilities and contributions. For this reason, it has become a very important commercial asset today. (36)

In general, AI can be considered as the creation of a mechanism that can perform tasks that require natural (human) intelligence. It requires the machine to exhibit the ability to find reasons. It consists of the process of extracting meaning from events and rules using reasoning, heuristic or other search approaches. The simplest pattern matching, and recognition implemented on symbols over this process is the basis of this work. Artificial intelligence works by combining large amounts of data with fast, iterative processing and intelligent algorithms, allowing the software to automatically learn from patterns or features in the data. This enables machines to learn from experience, adapt to new inputs and perform human-like tasks. (37)

The term of AI first appeared in 1956, but has become more popular today, thanks to increased data volumes and improved algorithms. AI research in the 1950s focused on topics such as problem solving and symbolic methods. In the 1960s, the US Department of Defense began training computers in order to mimic basic human functions, giving place such studies. For example, the Defense Advanced Research Projects Agency (DARPA); It produced smart personal assistants in 2003. This early work paved the way for decision support systems and smart search systems that can be designed to complement and augment the human capabilities that we see in computers today. (38)

With these processes, Artificial Intelligence has now become a term that encompasses all application software, performing complex tasks that require human input, such as communicating with customers online or playing chess. It includes sub-branches such as machine learning and deep learning. Machine learning focuses on creating systems that learn

or improve performance based on the data consumed. It should be kept in mind that all machine learning solutions are artificial intelligence, but not all artificial intelligence solutions are machine learning.

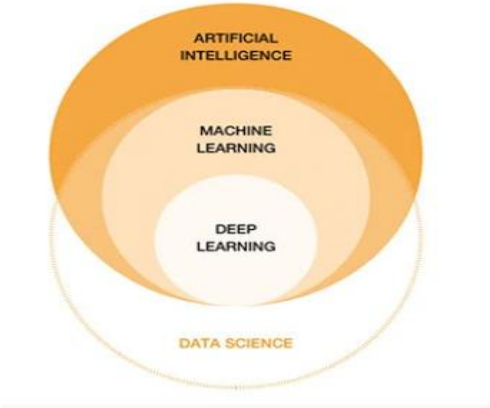

Figure 17 : The Relationship of Artificial Intelligence with Other Techniques (36)

Artificial Intelligence offers value for every line of business, enterprise and sector, thereby providing a competitive advantage to businesses. Artificial Intelligence is a strategic imperative for all businesses looking to achieve greater efficiency, new revenue opportunities and higher levels of customer loyalty. It is quickly becoming a competitive advantage for many organizations. With Artificial Intelligence, organizations are able to process more transactions in a much shorter time, create personalized and engaging customer experiences, and predict business outcomes to support higher profitability.

Summarizing the benefits of artificial intelligence in general;

- It automates repetitive learning and data exploration.
- It adapts through progressive learning algorithms to allow data to do programming.
- It analyzes more and deeper data using neural networks with many hidden layers.
- It makes the best use of data.
- Thanks to artificial intelligence, the risk of making mistakes is almost zero.

AI takes place in many parts of life today. Technology companies have also led to great innovations in many areas by using the artificial intelligence method. As an example to these, Google Assistant is a virtual personal assistant powered by artificial intelligence, available on mobile and smart home devices and developed by Google. It can search the Internet, schedule events and alarms, adjust the hardware settings on the user's device, and display the information in the user's Google account.

Tesla Autopilot, presented by Tesla; It is an advanced driver assistance system feature that allows the car to enter or exit the garage, with capabilities such as lane centering, adaptive cruise control, self-parking, automatically changing lanes without the need for driver steering.

Facebook DeepFace is a biometric Artificial Intelligence-based application technology that can identify or verify people from a digital image or video frame. There are many methods by which face recognition systems work, but generally they work by comparing the features of faces selected from a given image with faces in a database. (38)

5.2 Machine Learning and Usage Areas

With the advancement of technology today, the machine learning (ML) has become one of the most used terms in the technology world. The term "machine learning", coined by the American computer scientist Arthur Samuel in 1959, is defined as "computer learning ability without explicitly programming". (39) Machine Learning is a paradigm that provides inferences from existing data using mathematical and statistical technics and makes predictions about the unknown with these inferences. (40)

Machine learning at its most fundamental; It uses programmed algorithms that take and analyze input data to predict output values within an acceptable range. As new data is sent to these algorithms, they learn and optimize operations to improve performance and develop “intelligence” over time. (41)

ML is considered a subset of artificial intelligence (AI). Machine learning uses algorithms to identify patterns in data. These patterns are also used to create a predictive data model. As the

amount of data and experience increases, the results of machine learning become more accurate. Thanks to its adaptability, machine learning is an effective option in scenarios where data, requests or tasks are constantly changing, or when a solution cannot be effectively coded. (42)

Machine learning as a scientific endeavor has historically emerged from the search for artificial intelligence. Some academic studies in the past have shown that machines have to learn the data after a certain stage, and thus, researchers have developed their studies in order to approach the problems that arise on this subject with various symbolic methods. ML started to evolve as a separate field in the 1990s. The reason for the field change is to use artificial intelligence in addressing the solvable problems in practical life.

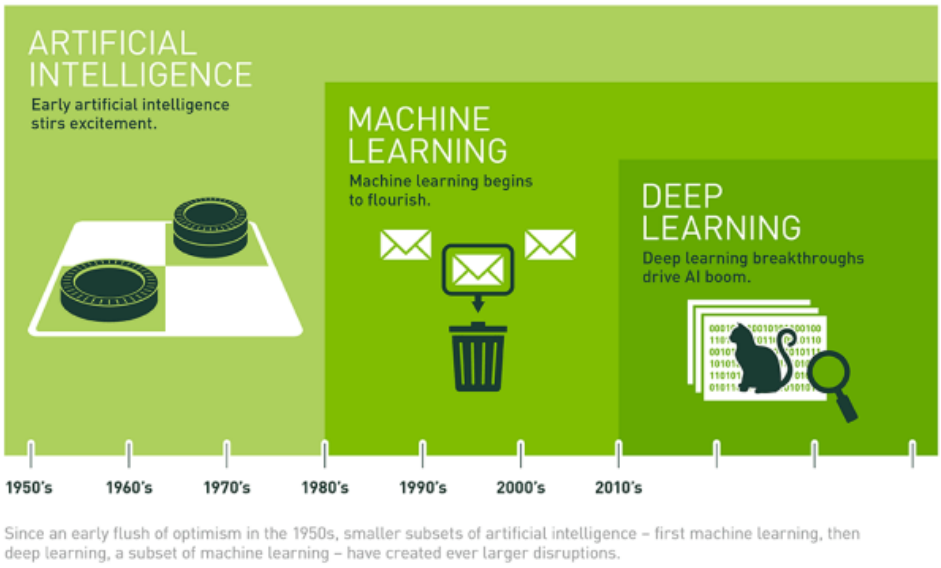

Figure 18 : The Evolution of Artificial Intelligence Over Time (43)

Machine learning focuses on predictions made from learned data based on known properties. In addition, systems developed with machine learning can combine many information such as detailed data analysis and statistical analysis and use this information to solve problems with specific methods. In this way, when the systems using machines are encountered with new problems, they will be able to reveal the solution automatically in the light of the data that they analyze.

Machine learning has many applications and thanks to the advantages it provides, new ones are constantly being added to them. Its advantages can be listed as follows.

- Improving the user experience: Adaptive interfaces, targeted content, chatbots, and voice virtual assistants help improve the customer experience through machine learning.
- Predicting customer behavior: Machine learning allows you to research customer-related data and improve product recommendations to help you identify customer behavior, providing the best customer experience possible.
- Improving data integrity: Machine learning, which is very good at data mining, can take it one step further and improve its features over time.
- Risk reduction: As fraud tactics constantly change, machine learning keeps pace with that. Machine learning tracks and identifies new patterns to catch fraud attempts before they succeed.
- Cost reducing: Machine learning enables critical processes to be automated, creating time and resources, and allowing your team to focus on what matters most.
- Increasing product development: By collecting customer data and associating it with behavior over time, machine learning algorithms can learn relationships and help teams develop products effectively based on customer demand for product development.
- Improves marketing research: It ensures that the correct demand is determined in accordance with customer profiles.

Businesses in all industries benefit from machine learning in different ways. Examples of contributions to important sectors are as follows.

- Manufacturing: It helps manage processes such as predictive maintenance and condition monitoring, material and stock forecasts, purchase trends, demand forecasts, process optimization. Additionally, it gives chance for automating industrial-grade tools for more efficient operations, predicting asset failure and maintenance through ERP (Enterprise Resource Planning) applications, improving quality assurance and improving production line performance.

- Finance and Financial Services: ML, strengthens investment management decisions with risk management and fraud prevention with software that works with machine learning. It provides early warnings about social trends and shock developments, enabling real-time financial decisions and improvement in sales and marketing campaign management.
- Health Services: Examples include diagnostic tools, patient monitoring and predicting outbreaks, more accurately diagnosing diseases, improving personalized care, and assessing health risks, where machine learning helps improve patient care.
- Retail: Machine learning helps retailers analyze purchasing patterns, improve offerings and pricing, and use data to improve predictive inventory planning and overall customer experience.
- Customer services: Answers to questions, measure customer goals, and provide virtual assistant are examples of the support machine learning offers to the customer service industry.

5.3 Machine Learning and Methods

A machine learning method generates an output to make prediction. If this output is categorical, it is called classification and if it is numerical, it is called regression. Clustering, which is an explanatory modeling, is the process of assigning similar observations to the same clusters. Interesting links between observations can be found thanks to Association Rules. Classification and regression methods are described as supervised learning because they require training data, while the other method is called unsupervised learning because it does not require training data.

The disadvantage of supervised learning can be said the generating training data. Thanks to the training data, a function is generated by a machine learning method. With this function, new incoming data tries to be predicted. The most time-consuming part of supervised learning is the preparation of this training data. Errors that may occur at this stage or a poorly prepared training data will also cause mistakes in estimates. Therefore, if more than one expert person prepares these data sets in order to confirm the accuracy, it will reduce the errors in the estimates. On the other hand, there is no training data in unsupervised learning. It tries to learn groups by algorithm. The algorithms in this section try to group the data and assign the new data to the

most appropriate set. It is easy to apply as there is no training data. However, good results may not be achieved in difficult problems.

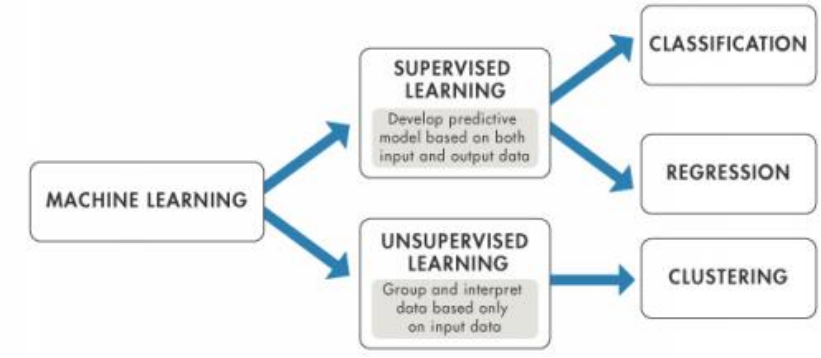

Figure 19 : Machine Learning Classification (44)

5.3.1 Supervised Learning

It is a machine learning technique that generates a function over training data. In other words, in this learning technique, it produces a function that matches the inputs (labelled data) with the desired outputs. Training data consists of both inputs and outputs. The function can be determined by classification or regression algorithms. It was named as "Supervised Learning" because all data are known to which class in the training data set and these data guide the learning process. (45)

In supervised learning, the machine is taught by example. The operator provides the machine learning algorithm with a known data set containing the desired inputs and outputs, and the algorithm finds a method for determining how these inputs and outputs are reached. Although the operator knows the correct answers to the question, the algorithm identifies patterns in the data, learns observations, and makes predictions. These estimates made by the algorithm are corrected by the operator. This process continues until the algorithm achieves a high level of accuracy/performance. (41)

Supervised learning algorithms can be used for the following tasks:

- Binary classification
- Multi-class classification
- Regression modeling

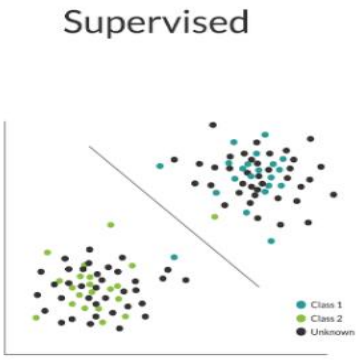

Figure 20 : Supervised Learning Schema (117)

The problems of supervised learning can be of three types:
Classification, Regression and Forecasting.

Classification: In the classification tasks, the machine learning program must draw a conclusion from the observed values and determine which category the new observations belong to. For example, when filtering emails as "spam" or "not spam," the program needs to look at available observational data and filter emails accordingly.

Regression: In regression tasks, the machine learning program must predict and understand the relationships between variables. Regression analysis focuses on one dependent variable and a number of other variables. This is particularly useful for forecasting.

Forecasting: Forecasting is the process of making predictions about the future based on past and present data and is often used to analyze trends.

5.3.2 Unsupervised Learning

Unsupervised machine learning takes advantage of a more independent approach in which the computer learns complex processes and patterns without constant and close guidance by a human. Unsupervised machine learning includes training based on tags or data with no specific, defined output. (46) In an unsupervised learning process, the machine learning algorithm is left to interpret large data sets and handle these data accordingly. (41)

It is a machine learning technique that uses a function to predict an unknown structure over unlabeled data. In this method, it is unclear to which class the input data belongs. The algorithm scans datasets looking for a meaningful link. At this stage, both data algorithms and their predictions are trained, or recommendations are determined in advance.

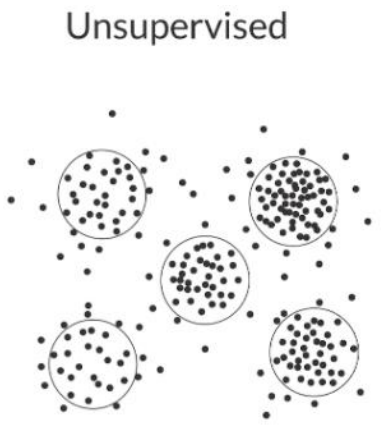

Figure 21 : Unsupervised Schema (117)

Unsupervised learning algorithms can be used for the following tasks:

- Clustering
- Dimension Reduction
- Anomaly detection

The problems of unsupervised learning can be of two types: Clustering and Dimension Reduction.

Clustering: Clustering involves grouping similar data (based on defined criteria). It is useful to analyze each data set to divide the data into several groups and find patterns.

Dimension Reduction: Dimension reduction reduces the number of variables considered to find the exact information required.

5.4 Artificial Neural Networks and Usage Areas

With the development of computer technologies, human beings carry out almost all their operations on these innovative technologies and allow new methods to be found. That is why, in the 1980s, the idea that the machine could think like a human was put forward, and in the 1990s, Artificial Neural Networks technology accelerated, and a great development was seen. (47)

The superior features of the human brain have forced scientists to study it, and a mathematical model has been found by inspiring the neurophysical structure of the brain. Various artificial cell and network models have been developed with the idea that physical components must be modeled correctly in order to model all the behaviors of the brain. Thus, a new science called Artificial Neural Networks has emerged, which is different from the algorithmic calculation method of today's computers.

Artificial Neural Networks is a subtitle formed under the concept of Artificial Intelligence and has become the focus of researchers interested in this subject.

The foundations of the first computational model on which artificial neural networks are based, constructed an article that is published by W.S. McCulloch and W.A. Pitts in the early 1940s. After, a model that reacts to and adapts to warnings within a network was created by B.G. Farley and W.A. Clark in 1954. The first neural computer emerges in 1960. In 1963, the first shortcomings of simple models were noticed, but successful results were delayed until the use of thermodynamics in the development of nonlinear networks of theoretical structures in the 1970s and 1980s. 1985 was the year that artificial neural networks were well known and intensive research has begun. (47)

Artificial neural networks is parallel and distributed information processing structures, which are inspired by the human brain, are connected to each other through weighted connections and consist of processing elements each with its own memory; In other words, they are computer programs that imitate biological neural networks.

According to another definition, ANN is computer software that performs basic operations such as generating new data by imitating the learning path, from the data collected by the human brain for functions such as learning and remembering. (48) Artificial neural networks emerged as a result of the effort to model the learning process mathematically that is inspired by the human brain. (49)

ANN consists of connecting artificial nerve cells with each other in various ways and is usually arranged in layers. It can happen with electronic circuits as hardware or occur with as software on computers. In accordance with the brain's information processing method, ANN is a parallel

distributed processor capable of storing and generalizing information after a learning process. (50)

An artificial nerve cell can be defined as an algorithm or physical tool that reveals a mathematical model inspired by the basic behavior of a biological nerve cell. Based on the definition of biological nerve cell, it can be said that an artificial nerve cell collects the signals it receives from other nerve cells, and when the total signal accumulation exceeds a certain threshold, this artificial nerve cell transmits its own signal to another nerve cell. (51) Artificial nerve cells are also called process elements in engineering science.

Artificial neural networks are data-based systems created by connecting artificial neural cells in layers and aim to use the skills of the human brain, such as learning and making very fast decisions under different conditions, in solving complex problems with the help of simplified models.

In artificial neural networks, artificial neurons are simply clustered. This clustering is done in layers and then these layers are linked to one another. Basically, all artificial neural networks have a similar structure. (50)

Although some successful networks with a single layer or single element can be created, most applications require networks with at least three layers (input layer, hidden layer and output layer). The input layer contains neurons that receive inputs from outside. Also, an important point is that the neurons in the input layer do not apply any action on the input values. They only transmit input values to the next layer and therefore they are not included in the layer count of the networks by some researchers. The output layer contains the neurons that transmit the outputs outside. While the input and output layers consist of a single layer, there may be more than one hidden layer between these two layers. These hidden layers contain a large number of neurons, and these neurons are completely connected with other neurons in the network. In most types of networks, a neuron in a hidden layer only receives signals from all neurons of the previous layer. After performing the neuron process, it sends its output to all the neurons of the next layer. This structure creates a feed forward path for the output of the network. This communication line from one neuron to another is an important part of neural networks. (52)

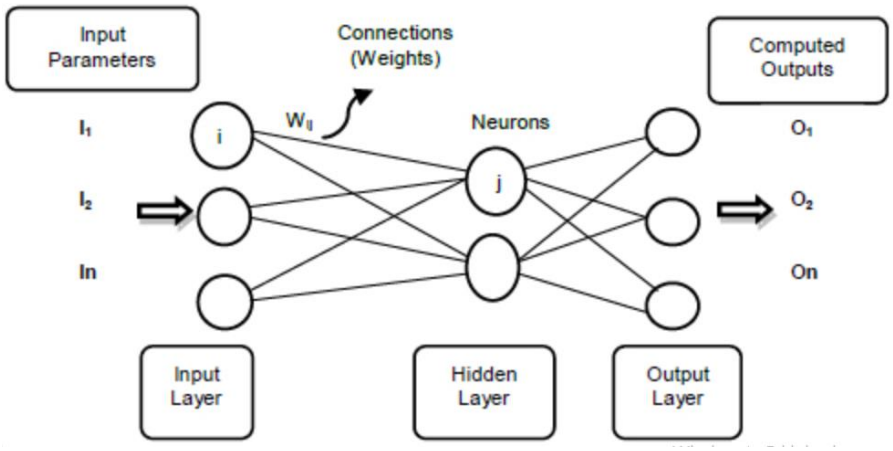

Figure 22 : Basic Layered Artificial Neural Network Structure Configuration (53)

Artificial neural networks have the following basic features:

- Nonlinearity
- Parallel Operation
- Learning
- Generalization
- Fault Tolerance and Flexibility
- Using a large number of variables and parameters

ANN applications are mostly used in prediction, classification, data association, data interpretation and data filtering. (54)

Prediction: Artificial neural networks working on this principle work on estimating output from input value.

Data Filtering: Artificial networks encoded in this direction use the most useful data among the collected data.

Classification: It affects the system to reach a result faster by classifying the input values.

Data Interpretation: It analyzes previously trained network entries and can make new interpretations about an event through these inputs.

Data Association: It associates the information learned with the subjects and completes the missing information as a result.

When the usage areas of ANN are mentioned, it has begun to enter all areas of life with the developing technology. It has started to take an active role in automotive, electronics, energy, space sciences, banking, finance and military fields, especially in the field of health. (55) With humanoid robots, interest in this technology will increase even more. ANN has also many applications such as in traffic control, on data mining in medicine and health services, statistical estimation methods, meteorological precipitation data prediction, solving industrial problems, load flow analysis in power systems. (48)

5.5 Artificial Intelligence and Machine Learning for Risk Management

The adoption of artificial intelligence by organizations requires them to go through a new learning process. Due to the risks related to artificial intelligence that may arise in this process, companies can be timid to this innovation. However, giving confidence that it can be effectively defined and managed within the limits set by the company's risk culture and appetite will eliminate this problem. Thanks to this, effective risk management will play an important role in firms' ability to innovate.

Machine learning techniques, which are the basis of artificial intelligence, completely change the approaches to risk management. Thanks to the growth of artificial intelligence-focused solutions, every problem related to understanding and controlling risk has become resolvable.

Nowadays, AI and machine learning have an increasing interest and popularity in the financial services industry. Because machine learning and artificial intelligence have had a great impact, especially in the financial services industry. Financial institutions increasingly need to AI techniques to manage increasing amounts of unstructured data for risk management purposes or to compete effectively in the marketplace. Because firms realized that they could significantly improve analytical capabilities, streamline and automate financial risk management, credit underwriting, compliance, interactions with customers, and all kinds of business lines.

While the applied use of the term machine learning goes back to the beginning of the 20th century, it can be said that its widespread use was accepted with the beginning of the management of data processes. In the past years, the amount of data collected in financial institutions has increased significantly as the details of reporting requirements have proliferated and the digitization of services creates large amounts of high-frequency and unstructured consumer data. Therefore, financial institutions have begun to use artificial intelligence techniques to deal with large amounts of data of all types resources and formats while maintaining or improving the level of detail of their analysis. Machine learning is seen as a technique that can provide this analytical power in the financial services industry. The greater availability of high-frequency data has made machine learning much easier to implement and it allows to model complex, nonlinear relationships. (56)

In addition, AI provides accurate and real-time information about any risk taken by the company, using machine learning techniques. As data organization moves more towards the use of artificial intelligence, real-time decision making has become a common requirement. The next step of AI after providing real-time information on risks is to report the risks in advance.

The most powerful feature of machine learning is that it can be used for predictive purposes. By identifying relationships or patterns in a data sample and out-of-sample data, it can combine relationships between these data to create a model that can make powerful predictions. Such a model is created by running the variables and identifying the model on subsamples of the data to generate the strongest predictors, and then testing the model on many different data subsamples. The forecast performance will be better proportionally with the more accurate and larger amount of data. Machine learning is closely associated with the "big data revolution" as it relies on large data sets and heavy computing power. (57)

Thanks to forecasting, the firm's market can accurately predict firm risks such as operational or credit risk. The prediction capability of machine learning reveals much more accurately than the data provided by traditional statistical techniques. Going further, it creates a true AI risk management system that will automatically intervene to prevent unnecessary risks, eliminate dangerous risks immediately, and dynamically adjust the firm's risk appetite based on the system's broader risk estimation.

As a result, it can be said that the time consuming and costly nature of risk management has been significantly reduced thanks to artificial intelligence techniques.

5.6 Machine Learning Use Cases in Finance

Machine learning ensures correct results by extracting meanings from big data sets. This information is used in many areas to solve complex and data-rich problems. ML has a critical role in real-time decision making and future predictions in especially the finance and banking industry. ML algorithms progress by learning to create a different insight from the data sets. Thanks to these insights, the results made in the system used over time improve and the efficiency in the area of application increases. Its contributions to the financial sector can be listed as follows.

- Increased revenues through enhanced productivity and better customer satisfaction
- Strengthened security and advanced compliance
- Lower operational costs thanks to process automation (58)

Figure 23 : Machine Learning Use Cases in Finance (59)

Fraud

Fraud is one of the most important issues for the financial security of customers and banks. With identity theft created using new accounts, credit card fraud has become the most important

problem of cybercrime. One area where machine learning has been successfully implemented for more than a decade is credit card fraud detection. (56) Machine learning algorithms are very good at detecting transaction frauds by analyzing millions of data sets that tend to go unnoticed by humans.

In the banking industry, ML systems provide data reliability by comparing transaction behavior with system data or using transaction history to verify a person. ML system examines the copies of transactions and distinguishes fraudulent and non-fraudulent transactions using classification methods. (60) Training of the algorithm is provided from large data sets of credit card transaction data, with verification and retrospective checks. These datasets are trained on historical payment data. Historical transaction datasets compare transactions against predetermined fraud features that distinguish normal card use from fraudulent card use by inferring transactions in the cardholder's transaction history. Generally, the method of automatically sending a real-time verification request to the customer is used to detect unusual purchases. ML-powered technology is also equipped to detect suspicious account behavior and prevent fraud in real time instead of detecting them after a crime has been committed. (58)

Machine learning systems also play an important role in determining money laundering activity by identifying complex patterns in data and the ability to compare and combine transactional movements with data from many other sources to obtain a holistic picture of a customer's activity.

Many fraud scenarios that may occur can be summarized under the following headings.

- Insurance claims analysis for fraud detection
- Anti-fraud solutions for medical claims and healthcare
- Fraud prevention solutions in e-commerce
- Fraud detection in banking and credit card payments
- Preventing loan application fraud
- Machine learning for anti-money laundering

Credit Risk

Artificial Intelligence enables banks to strengthen their system controls and provide loans to their customers with more confidence. To achieve this, the algorithms analyze all available information about a potential borrower, examine the credit history, examine changes in fee levels and essentially determine the credibility of the client and the security of the loan. (61)

Machine learning algorithms are frequently used to predict credit risks, which are common in finance and insurance. ML system algorithms are trained by working on thousands of customer profiles with hundreds of data entries for each customer. Thanks to a well-trained system, algorithms can perform credit scoring tasks in real-life environments. These systems allow employees to work much faster and more efficiently. Banks and insurance companies have a lot of historical consumer data, so they use these data entries to train their machine learning models. Alternatively, they can benefit datasets from other industries such as large telecom or utility companies. (59)

Most ML-based credit scoring solutions use predictive algorithms that tell whether a customer will issue a refund or not. Banks with AI-based credit scoring can even provide loans to people without credit scores, as they have access to larger volumes of customer data. (60)

In addition, these systems are used to determine the scope of insurance to be made in the insurance sector. Analyzes are made to identify trends that may affect future collateral, and fundamental trends are revealed through algorithms. For example, are more and more young people involved in car crashes in a particular state? or are there increasing default rates among a particular group? (62)

Investment and Trading

The finance sector is exposed to various risks, especially when making investment decisions. Artificial intelligence technologies help make the right decision about investments and predict possible risks using data analytics, deep learning and machine learning algorithms.

Every time artificial intelligence processes a new flow of information, it learns by making inferences and systematizes this information. Thus, it provides opportunities to evaluate the situation in the market and create the most profitable investment transactions through big data analysis. Many high-risk investment funds ensured the execution of trading transactions by making the right decisions quickly thanks to their algorithms. As well as being able to study, analyze and systematize data volumes that are too large for a human brain, ML algorithms also have a great impact on the development of investment strategies. The main advantage of using artificial intelligence is that it can make analyzes away from human emotions. Therefore, all ML assumptions are absolutely realistic and rational. (61)

6. COVID-19 and Its Financial Effects

6.1 Covid-19 with AI and Big Data

In recent years, the whole world has been shaken by epidemics such as SARS, H1N1 and MERS, which have had a great impact on human lives. In the face of these epidemics, the scientific world has sought new methods of struggle as well as classical methods. Especially, the innovations brought by the application of artificial intelligence have gained a new perspective in the fight against the COVID-19 outbreak. (63)

In our age, artificial intelligence applications are used to facilitate human life in many different areas. In the current COVID-19 epidemic, which endangers human life in worldwide, artificial intelligence has become one of the important tools in the war against the epidemic with various applications. (64)

The importance of digitalization and technology has become more understandable with COVID-19. Thanks to the utilization of technological innovations in the Covid-19 outbreak, more successful steps were taken in managing the pandemic process. In other words, COVID-19 has not only revealed the importance of technology in terms of epidemic management but has also turned into a process that accelerates the digitalization. (65)

The correct use of data has become the most important indicator affecting the performance and efficiency of private and public institutions. Methods such as artificial intelligence and data analysis that enable data to reveal its value form the basis of the process of extracting meaning from data. In this way, data has an important place in the fight against Covid-19.

With the ease of accessibility to technological devices and services, each activity of each individual leaves a trace of data in the digital world. Many data stacks from social media platforms to videos published on the internet and sent between individuals, mobile phone location information to sensor data of smart wristbands can be considered as a trace. The development of technology and the positive developments in the processing capacity of computers have made it possible to process and analyze large amounts of data. Thus, thanks to the meanings produced from these data sets, it contributed to the effective management of

processes. Processing digital data has allowed the epidemic to be predefined and predictable. (66)

In response to the epidemic, artificial intelligence and big data enabled in terms of managing the epidemic, such as from predicting the progress of the epidemic to detecting infections and accelerating clinical discovery to optimizing resource allocation. Additionally, they provided functionally managing of the process in almost every field such as making simultaneous decisions, creating strategic goals and supporting operational activities. (67)

With the help of artificial intelligence and big data applications, data-driven pandemic responses have taken place in many ways. Thanks to transparent, adequate and correct information, unnecessary information confusion and panic among the public are prevented.

- People have gained access to daily case numbers and other information both in their own countries and around the world in order to learn the course of the pandemic.
- They have simultaneously access to the right information from real sources for learning virus symptoms and prevention of the spread of the virus.
- Thanks to the applications developed in almost every country, people can access information about the health of the people that they come into contact with.
- Countries have become able to predict the spread of the epidemic on a regional and wide scale with the data they collect from their citizens and hospital data.

Thanks to the post-pandemic artificial intelligence and big data development trend, it can be seen two main trends that are likely to affect the post-pandemic period with the faster adoption of artificial intelligence and big data.

First, with the acceleration of the use of technologies such as AI and data analytics, digital transformation has become a necessity in various industries in order to compete and even survive through the digitization of the production of products and services. (67) During the lockdown period, digitization of business activities developed rapidly, especially due to the inability of small and medium-sized businesses to run their business in the traditional way. This will require businesses to adapt their infrastructures to technological developments and make their digital business processes sustainable even after they overcome the crisis. Therefore,

traditional businesses have to adapt themselves to this environment in order to compete in the market, and digitization should become the company's mission in their long-term strategic goals.

The second trend is the greater use of big data, which has extensive meaning for all industries. For the use of this data, it includes a large digital process such as collecting and storing data, extracting meanings using data and managing. However, it will be very difficult to carry out this process effectively. Because dealing with these large data sets and making them available is a time-consuming and costly process. However, whenever businesses manage this process effectively, they will survive in competitive environment in the long run and will be critical key in the growth of the company.

Both trends complement each other, as progress in one area accelerates the progress of others. The development of technology and the involvement of digitalization in business activities will bring radical changes in the way businesses in the coming years.

To give a few examples that manage and contribute to the management of this process by using artificial intelligence-based technologies in the Covid-19 pandemic process, South Korea can be mentioned firstly. In the beginning of the pandemic, South Korea was the second most affected country after China. However, South Korea has managed this process very successfully and one of the underlying factors of this success is its use of big data analysis and artificial intelligence supported warning system. This system makes possible the detection of the social communities and the areas most at risk where the virus may have spread by using artificial intelligence. At the same time, artificial intelligence-based regulation and process management has been applied in the distribution and supply of masks and other protective materials. (68) In addition, the artificial intelligence-based software designed by a company called Infervision, based in China, has been used to detect the coronavirus. This technology accelerates pneumonia diagnosis, abnormal and severe case analysis, coordination of medical resources, treatment evaluations and outbreak monitoring studies. This software is used in many hospitals and epidemic centers in China and has helped diagnose and study thousands of coronavirus patients so far. (69)

Another step in the diagnosis of coronavirus came from the Chinese e-commerce company Alibaba. While a doctor needs a certain time to diagnose the virus and evaluate the findings, the artificial intelligence system developed by the company can detect the virus in 20 seconds with an accuracy of 96 percent. The data used to train the system consists of medical data of 5 thousand coronavirus cases and lung scans. While developing such systems, if the system is trained with more data, the correct detection rate of the disease will increase. (70)

Another benefit expected from big data in combating coronavirus is that it contributes to treatment and vaccine development efforts. Since the outbreak, many countries have started vaccination studies without delay. Artificial intelligence-based technologies, which can shorten the analysis time in complex problems, are expected to help researchers quickly discover thousands of research documents and suggest possible vaccine components in this process. Within the scope of combating the epidemic, Google DeepMind10 uses artificial intelligence algorithms to understand the components of the virus and thus provides important information to researchers. (71) The USA-based Allen Artificial Intelligence Institute has also made available CORD-1911 datasets to enable researchers to access information in a short time to assist coronavirus studies.

6.2 Covid-19 Global Financial Effects

6.2.1 Covid-19 Financial Effects on World

With the Covid-19 outbreak, an 'unprecedented' global shock occurred in an interconnected world economy, involving simultaneous cuts in both supply and demand. The world economy is struggling with the crisis environment created by the Covid-19 epidemic, which it does not expect such a great effect. As of December 2020, nearly 76 million diagnosed cases, nearly 1.7 million deaths, have been recorded in 185 countries. (72) Under the restrictions taken in order to be protected from the epidemic, billions of people locked into homes, uncertainty and heavy economic losses amounting to trillions of dollars have occurred.

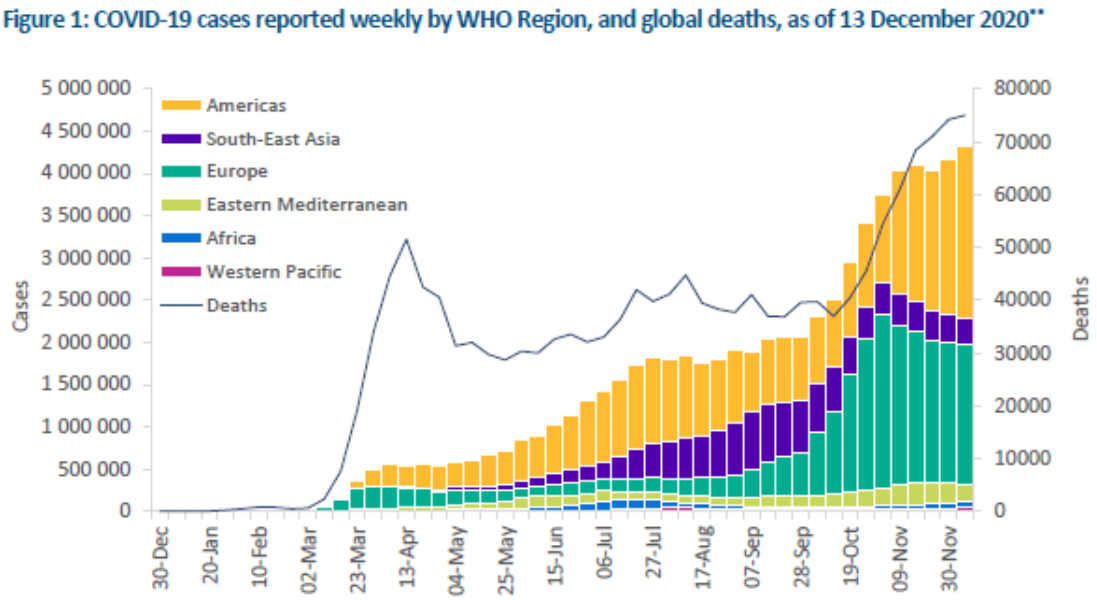

Figure 24 : COVID-19 cases reported weekly by WHO Region, and global deaths, as of 13 December 2020 (72)

It was expected that 2020 would be the first phase of a long-term recovery in the world economy, which made fragile by the tendencies of rupture between the real economy and the financial sector started and spread along the USA-China axis. However, these expectations did not come true as planned. The new type of coronavirus (Covid-19) epidemic, which broke out in March, led to a global lockdown in economic and social spheres, and that's why, all optimistic scenarios came to naught. Although the Covid-19 crisis emerged as a global challenge threatening public health in the first place; It has deeply shaken lifestyles, political and economic orders, socialization and mobility tendencies of societies in advanced and developing countries. (73)

Because of this situation, the world is faced with a demand and supply shock. On the supply side, infections reduce labor supply and productivity, while lockdowns, job closures and social distancing also cause supply cuts. On the demand side, layoffs and loss of income (due to illness, quarantine, and unemployment) and worsening economic expectations have led to reduced household consumption and firms' investment. The extreme uncertainty regarding the course, duration, magnitude and impact of the pandemic has become a cycle that weakens business and consumer confidence and tightens financial conditions and leads to job losses and

cuts in investments. The main challenge in conducting any empirical economic analysis of Covid-19 causes from the uncertainty of how to define this unprecedented shock. (74)

One of the important structural problems in the world economy during the Covid-19 process was that consumers postponed serious consumption decisions due to the global atmosphere of social pessimism and insecurity and shocks caused by a decrease in demand in the markets. The suspension of all expenditure items that were not seen as an urgent need with the exception of food and medical supplies, in the light of the conditions of this period caused the loss of economic growth momentum in many countries. Accordingly, while the USA, Europe and many developing countries are entering into a contraction process; China and Asian economies, which attracted attention with their rapid growth rates, faced the decline in their growth momentum. Moreover, public health costs that have never been accounted for before have emerged, which will deeply affect the recovery of global growth dynamics in the upcoming period, ranging from production processes to the design of consumption and service sectors. (73)

This shock in demand and supply caused serious lockdowns in the Chinese economy, which led to a decrease in production and consumption. In general, the functioning of global supply chains has been disrupted, and all companies in the world have been adversely affected by this situation. Consumer consumption patterns have changed, and sharp declines have been recorded in global financial markets. The volatility in the markets followed a similar course to the 2008 and 2009 financial crisis. As the pandemic intensified with the arrival of autumn, the International Monetary Fund (IMF) changed its estimates and made new estimates of the growth figures for 2020. In its revised estimates, the IMF predicts growth to be 1.0 percent in 2020 in China, where recovery continues after the sharp contraction in the first quarter of 2020, which is partially supported by policy incentives. (75) While China, which steered the world economy, represented 3% of the world economy in 2003, today this rate has exceeded 16%. Thus, any shock to activities in China had a strong impact on markets all over the world, across all different industries. (76)

As the normalization processes progress, consumption habits begin to approach old levels, but it has been revealed how important and difficult it is to manage social psychology and improve the future expectations of social segments in terms of economic performance in such

comprehensive crisis situations. Simultaneous contraction in both supply and demand sides of the world economy in the global epidemic environment paved the way for socio-economic damage in many countries, even in systemic crisis situations such as the 1929 Global Depression. While the social dimensions of this destruction are much more clearly seen in the service sector-dominated economies such as the USA, the new employment opportunities created after the 2008 Global Financial Crisis were not only lost, but a serious social trauma emerged with the unemployment of 35 million people due to the pandemic in the USA. (73)

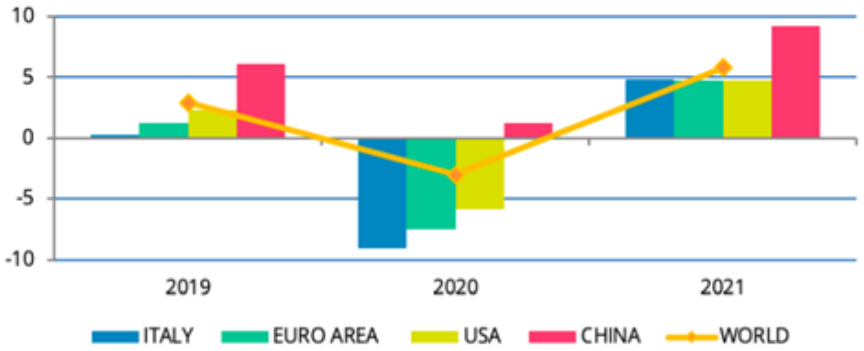

Figure 25 : IMF Real GDP Projections (in %) (77)

While the financial support programs announced by the countries differed according to the size of the budget and the depth of the capital markets, the US and Japanese administrations announced support packages exceeding the level of 2 trillion dollars. (78) However, developing countries that do not have the opportunity to provide the same amount of financial support face serious difficulties in reactivating their locked-up economic structures. In addition, the increase in the risk perception of international investors during the pandemic caused capital flight from emerging markets and made it difficult to finance the financial support programs to be implemented to exit the recession. As a result, the International Monetary Fund (IMF) had to revise global growth rate to -4.9 percent, while predicting the global growth rate of around -3 percent in April for the world economy at the beginning of the epidemic process. (75)

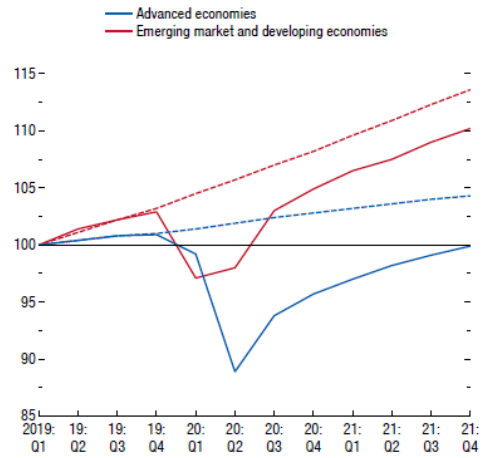

Figure 26 : Quarterly World GDP from WEOR, April (77)

(2019: Q1 = 100; dashed lines indicate estimates from January 2020 World Economic Outlook Update)

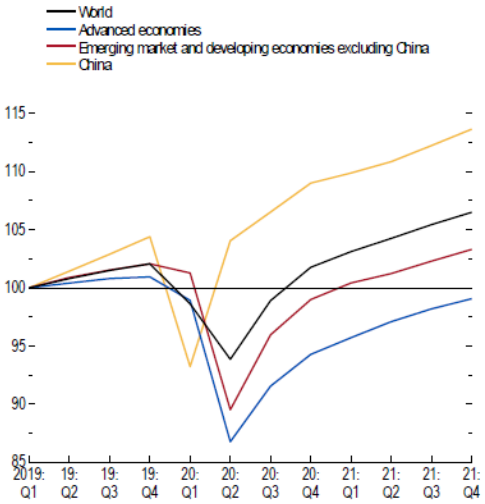

Figure 27 : Quarterly World GDP from WEOR, June (75)

(2019: Q1 = 100)

According to IMF June World Economic Outlook report, a contraction is projected 8% for developed economies, by decreasing 1.9 points compared to April. Given the expected shrinkage rates in developed countries, gradual deep decreases are projected in the United States (-8.0 percent); Japan (-5.8 percent); The United Kingdom (-10.2 percent); Germany (-7.8 percent); France (-12.5 percent); Italy and Spain (-12.8 percent). In 2021, it is predicted that

the growth rate of the developed economy will strengthen to 4.8 percent, leaving the 2021 GDP for countries in this group about 4 percent below the 2019 level. (75)

In addition, the growth in the emerging market and emerging economies group is estimated to be -3.0 percent in 2020, and 2 percentage points lower than the forecasts made in April. Even if there are differences between these countries, Growth among low-income developing countries is estimated to be -1.0 percent in 2020. Based on these predictions, for the first time, negative growth is expected in all regions in 2020. If these predictions are correct, Covid-19 pandemic will have a long-term and cost impact on the world. (75)

6.2.2 Covid-19 Financial Effects on Europe

The Covid-19 outbreak moved very rapidly to Europe, with the outbreak first in China and South Korea and then in Italy. Many European countries have already exceeded China in terms of infected people and deaths. Governments imposed many different restrictions to combat the pandemic. Spain and France followed the Italian model of strict isolation of people and the closure of non-essential jobs. However, Germany implemented lighter restrictions due to the low number of cases and death rates. On the other hand, Sweden's response to Covid-19 proceeded very differently from other European countries; workplaces were not closed, curfew was not imposed, borders were not closed, but some measures such as social distancing and closing universities and colleges were implemented. (79)

As a first response, the European Commission has announced a package worth about 37 billion euros in the fight against COVID-19 to implement the full flexibility of EU financial rules and provide liquidity to small businesses and the healthcare sector. In this context, it was decided to establish a COVID-19 Response Investment Initiative to support hospitals, small and medium-sized enterprises (SMEs) and markets. In addition, the scope of the EU Solidarity Fund, which is worth 800 million euros this year, was expanded and the public health crisis was included in the fund. Thus, the member states most affected by the epidemic will be able to receive assistance from Brussels.

On the other hand, 1 billion euros from the EU budget will be directed to banks in order to provide liquidity to SMEs. European Central Bank also announced the "Pandemic Emergency Purchase Program (PEPP)", which is a bond purchasing program worth 750 billion euros, to provide more liquidity to EU members. (80)

In addition, on April 2nd, the Commission launched a new initiative called "Support to mitigate Unemployment Risks in an Emergency (SURE)". Thus, employees and self-employed people will be protected against the risk of unemployment and loss of income, and families will be supported financially. In addition, different programs supporting short-term work plans and similar measures were prepared in the initiative. It also suggested that all available structural funds be directed to fight against to COVID-19.

All major economic crises pose two extremely important challenges. In the first case, crises consume the liquidity required for the running of firms, while in the second case they deplete equity capital some or all. The restrictions applied after the Covid-19 pandemic, the lockdown situation and the economic crisis environment enforced many companies to increase their costs and decrease their revenues. Therefore, companies found themselves in a liquidity crisis. Eventually, governments and central banks around the world have launched many different initiatives to provide companies liquidity directly or through banks. For example, in March 2020, the European Central Bank (ECB) reduced the interest rate by 25 basis points and eased the requirements for Targeted Longer-Term Refinancing Operations (TLTRO III) by enlarging the list of corporate collateral eligible assets. (81) In addition, most of European countries offered companies many packets through their national banks, such as liquidity assistance, export guarantees and expanding credit limits ranging from 38.6% of GDP in Germany and 29.8% of GDP in Italy, to 14% in France and 9.1% in Spain. (82)

Although governments announce many liquidity support programs, in the long run, all of them can create a disadvantage for companies. Because, when companies access liquidity through loans, in the long run this will increase their leverage, and as the default risk increases, opportunities for companies to develop and invest will gradually decrease.

In the ongoing crisis processes like the pandemic, equity capital will eventually be burnt. The important point here is to understand the amount of equity injection required to balance the

capital structure of companies and to provide the necessary support in order to restore them to their previous state.

The debt overhang problem arises from excessive debt accumulation in the company's balance sheet of the current debt burden, and as a result, the rate at which companies can recover from crises slows down and corporate investment and growth resources are constrained. Therefore, if companies exit the Covid-19 crisis with excessive amounts of debt, the economic stagnation and slow growth rate in European regions for several years will gradually increase. In other words, in the European region, if companies are not injected adequately with equity, they may experience a depressive economic "L-shaped" recession rather than a "V-shaped" economic recovery with a rapid recovery. (81)

With the pandemic, all current macroeconomic situations in the markets and the economic outlook have completely changed. According to the International Monetary Fund (IMF) report, the 2020 GDP of the European Union region is expected to decrease by approximately 7.6%. (83) As can be seen from Figure 28 and 29**,** this contraction is much more than the 2008-2009 financial crisis (-4.2%). Moreover, in the European region, countries most affected by this pandemic crisis, such as Italy, France and Spain, are expected to decline by 10.6%, 9.8% and 12.8% respectively. (83) This situation created an unprecedented financial crisis environment in European countries. While Germany, one of Europe's most powerful countries in financial terms, has many resources to overcome this crisis, countries such as Italy, Spain and France do not have enough resources to overcome this crisis due to their financial deficits. Governments will go to fiscal expansion to cover government budget deficits, which will eventually have a huge impact on Debt-to-GDP rates in the medium and long term. (84)

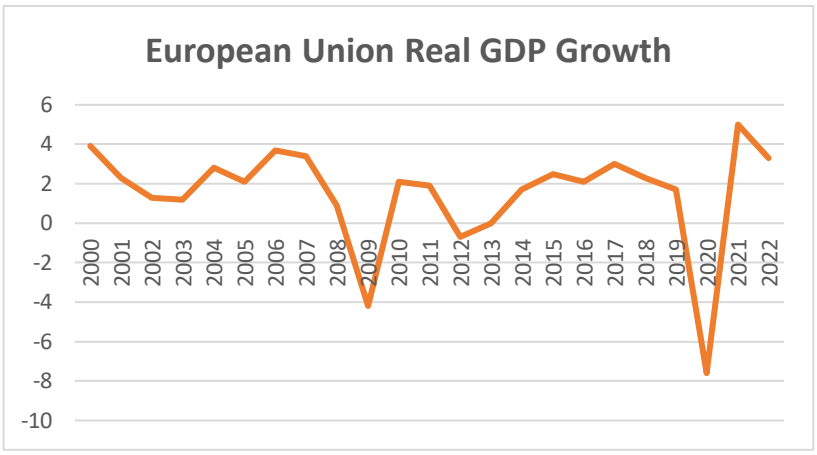

Figure 28 : European Union Real GDP Growth (83)

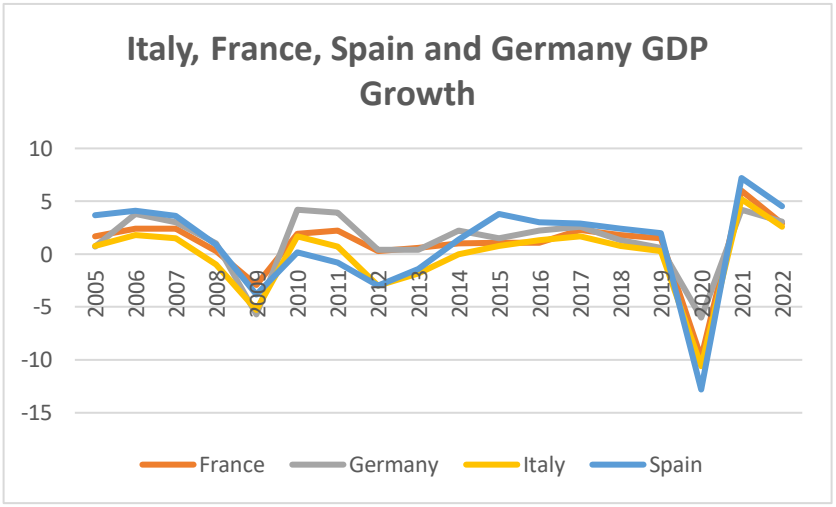

Figure 29 : Italy, France, Spain and Germany GDP Growth (83)

Debt to GDP ratio is the ratio of a country's public debt to its gross domestic product (GDP). If a country cannot reduce its public debt, it will default, and this will cause fiscal deficits in domestic and foreign markets. The higher the Debt to GDP ratio shows that the country can less likely repay its debt. (85)

The financial situation of European countries has started to differ greatly compared to each other in recent years. Figure 30 shows how the financial deficits of Italy, Spain, France and Germany are shaped according to the GDP. All countries responded to economic crises with fiscal expansion, but this further increased budget deficits, and with the 2008 crisis, critical

increases in Debt to GDP ratios occurred between 2008 and 2011. In the following years, although it did not increase with a high slope, this rate continued to increase slowly for Italy, Spain and France. This rate has decreased after 2010 for Germany, which has a budget surplus. However, with the Covid-19 crisis, countries being obliged to financial expansion caused this rate to increase in all countries. Additionally, Italy became the European country showing the worst Debt to GDP ratio among these countries. According to the IMF report, Italy's Debt to GDP rate is expected to be around 161% by the end of 2020. (86)

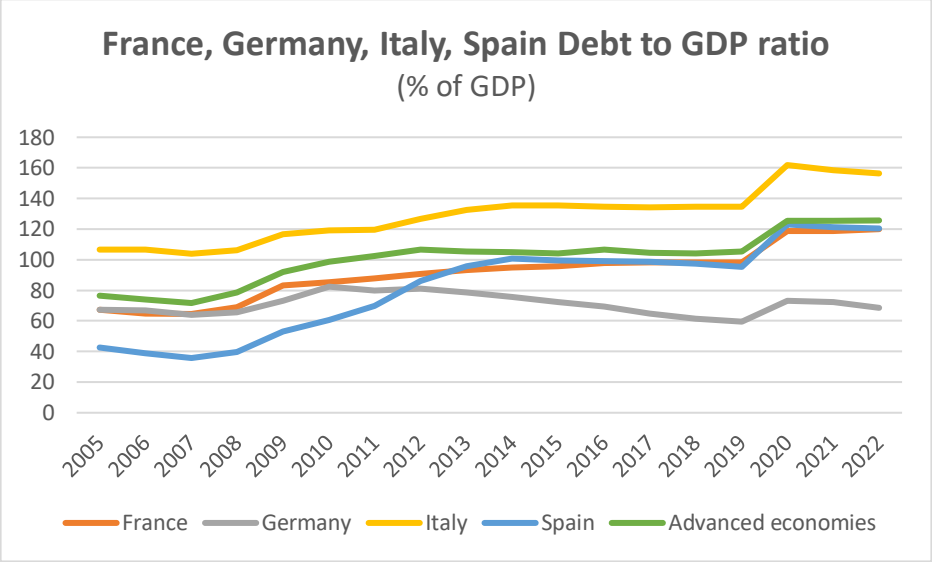

Figure 30 : France, Germany Italy, Spain Debt to GDP Ratio (% of GDP) (86)

While lockdown measures seemed to have successfully contained the virus, the economic consequences were dire. Financial support was provided by many international organizations to able to handle with these economic situations. With this experience, countries and communities such as the European Union have realized the importance of risk sharing. In this process, the supports developed by the European Central Bank (ECB) filled this gap in European institutions. However, it will be important for them to establish new risk sharing methods against future crises. (87)

6.2.3 Covid-19 Financial Effects on Italy

Italy, one of the European countries most severely affected by the virus in the world, has been one of the most important cases in evaluating the effects of the pandemic both with the restrictions it imposed and being affected economically, as it was one of the first in the war with the pandemic. Italy began to face the Covid-19 outbreak 2-3 weeks earlier than other developed economies. With the number of cases increasing dramatically day by day, the Italian government implemented stricter lockdown policies, effectively halting the movement of people not only across the country, but also within cities and towns. In Italy, which has a stagnant economy for the last 10 years, these restrictions have had a great impact on the country's economy.

When the spread of the epidemic in Italy is examined, the spread and density within the country differed greatly according to the regions. The epidemic especially concentrated in Lombardia, Piemonte, Veneto and Emilia Romagna regions, which are the northern regions of Italy. In these regions, Italy's leading companies are located, and the number of employees is very high. These regions account for about 40% of Italian gross domestic product (GDP). (87) For all these reasons, it is thought that the severity of the virus is increasing rapidly in Italy.

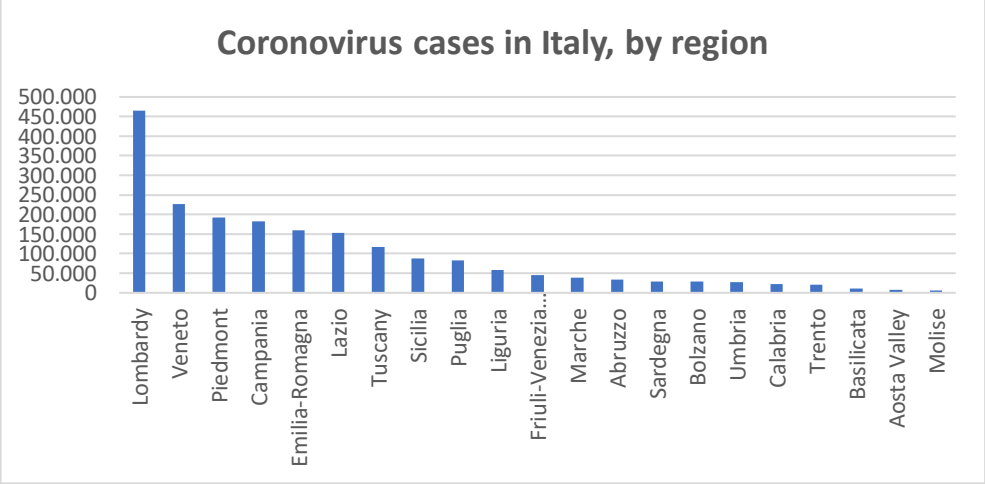

Figure 31 : Coronavirus Cases in Italy, by region (23 December 2020) (88)

The first restriction phase was carried out on March 9 with the closure of all regions, schools and all unnecessary businesses (such as shopping centers, restaurants, hotels). This situation affected approximately 51% of companies and 55% of employees. (87)

The spread of the virus so intensely and rapidly had a negative impact on Italian GDP growth and industrial production. In addition, as China's economy, which has a strong trade relationship with Italy, was affected by this epidemic, and so interest in Italian products began to decline. As a result, the problems in the supply of products used as production inputs such as raw materials or semi-finished products supplied by Italy's companies from China have affected the Italian economy in terms of supply and demand shock. While the textile, tourism, manufacturing industry (such as automotive and technology companies) and luxury sectors were negatively affected by this crisis, it had a positive effect with the increase in demand in the pharmaceutical sector.

With the number of cases increasing worldwide at the beginning of April 2020, the world faced the risk of a global recession. This recession led to a decrease in Italy's export and import capacity and therefore the Italian economy further weakened. These effects on exports and industrial production cause to a severe decline in GDP and an increase in debt payment costs. The deterioration in the economic dynamics that occurred after the spread of the pandemic had a negative impact on the economic performance, financial structure and payment performance in all sectors. In large-scale companies with high operational costs, a liquidity problem arose as costs increased and revenue started to decrease, and it was observed that debt rates started to increase due to that situation.

Restrictions imposed by the Italian government have been effective in containing the spread of the pandemic, but the economic consequences have been just as intense. According to the IMF report, Italy's GDP is expected to decrease by 10.6% in 2020. (83) The reason for this decrease is predicted to be due to the expected decreases in consumption (-11.8%), investment (-15.4%) and industrial production (-14.5%). (87) However, in order to eliminate the negative effects of the pandemic, there has been a high increase in public debt with the increase of government supports such as unemployment assistance, credit support to companies and health investments. However, according to analysis, a rapid increase of approximately 5.2% is expected in 2021. (83)

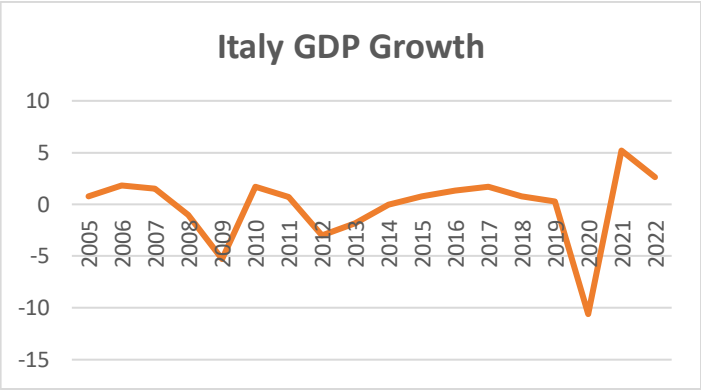

Figure 32 : Italy GDP Growth (83)

On the other hand, when analyzing data from manufacturing firms, there is a high contraction in the industry due to the lockdown. The Purchasing Manager Index (PMI) is an indicator that examines the buying tendencies of companies' purchasing managers to purchase goods and services. This indicator is basically a survey to explain the growth forecasts. It is one of the indices that can explain the growth forecasts of countries in the best way. While this value above 50 indicates the expansion in the sector, being below indicates the contraction.[38] The Italian PMI fell from 40.3 in March to 31.1 in April, due to the Covid-19 crisis, and the index reached its lowest level. (89)

Figure 33 : Italy - Purchasing Manager Index (PMI), manufacturing (89)

With a slow growth in Real GDP Growth since 2013, Italy had gained momentum in terms of Government Balance. Budget balance is the case where public revenues and expenditures are equal. Except for the expenses required to produce services, the interests paid for government debts are among the budget expenses. When the calculation is made excluding interest expenses, the primary balance is found. If the primary balance is negative, it means that the government revenues cannot cover the expenditures for producing services and investments, while positive means that the government revenues can finance services and investments. As can be seen in Figure 34, it can be said that the Italian Government Primary Balance was stable during 2011 and 2019 and is in a much better position compared to other developed economies. However, this situation has experienced a serious decrease due to the increases in public spending with the Covid-19 pandemic crisis.

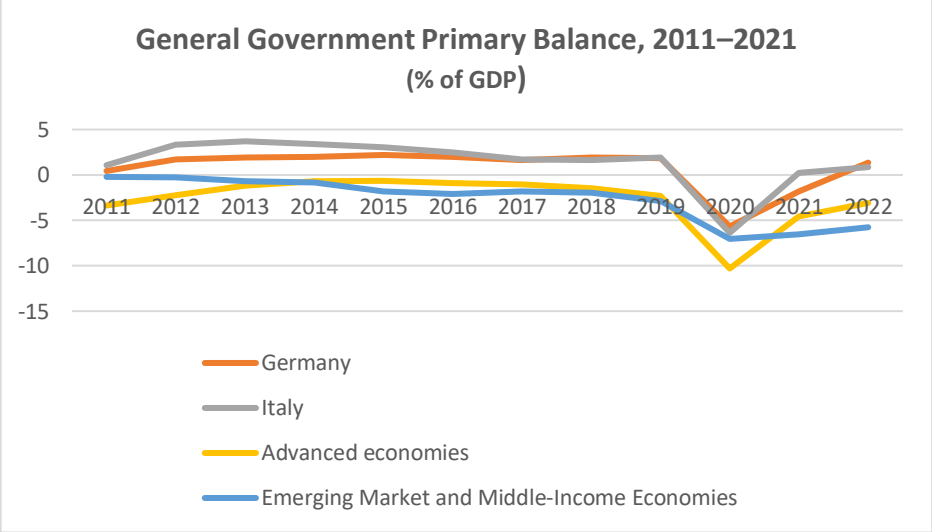

Figure 34 : General Government Primary Balance, Between 2011-2021 (90)

If it is necessary to summarize the measures taken by the Italian government in response to the economic crisis caused by the pandemic in the Covid-19 outbreak, it can be stated as follows.

- Reducing the speed of virus spread thanks to lockdown measures
- Increase in health expenditures to protect public health
- Providing credit and liquidity support to companies economically affected by the epidemic through banks or government incentives

- Facilitating access to bank loans and lowering interest rates
- Provide incentives to reduce financial costs for companies affected by the pandemic
- Assisting employees to maintain employment
- Providing financial support to people who are unemployed during this period (79)

In this context, concrete examples can be listed as follows.

- Regulations were made to allow the recruitment of 20 thousand healthcare professionals. The National Emergency Fund, which was 3.5 billion, was increased by 1.65 billion, with 150 million allocated to healthcare workers for overtime and 340 million for the increase of ICU beds.
- Contributions were suspended for small, medium and large-scale companies and professionals in the sectors affected by the pandemic, thus providing the opportunity to make a lump sum payment or in installments up to four equal months, without any sanctions or interest.
- SCT advance payments for natural gas and electricity were reduced and postponed.
- A tax regime has been implemented for investments in innovative start-up companies and SMEs. For persons investing in innovative startups or SMEs, a tax reduction equal to 50% of the invested amount has been supported.
- In order to revitalize the tourism sector, a bonus holiday support was provided to the households at a fee determined according to the size of the household. (91)

6.3 Sectoral Evaluation of The Financial Impacts of Covid-19

The Covid-19 epidemic, which took the whole world under its influence and brought social and economic life to a standstill, seriously changed the lifestyle, ways of doing business, consumption habits, business markets, value chains and habits. This change has led to many different economic situations. While it brought positive interaction to some sectors, it created a negative effect for some sectors.

As a result of the lockdowns realized in the prevention of the spread of the virus, many businesses were damaged and become incapable of doing business. While companies engaged in international trade were significantly affected in the first stage, all sectors were damaged in the following times. It caused a significant decrease in the country's GDP and an increase in debt ratios, especially due to its serious impact on sectors such as export and industrial production with high operational costs.

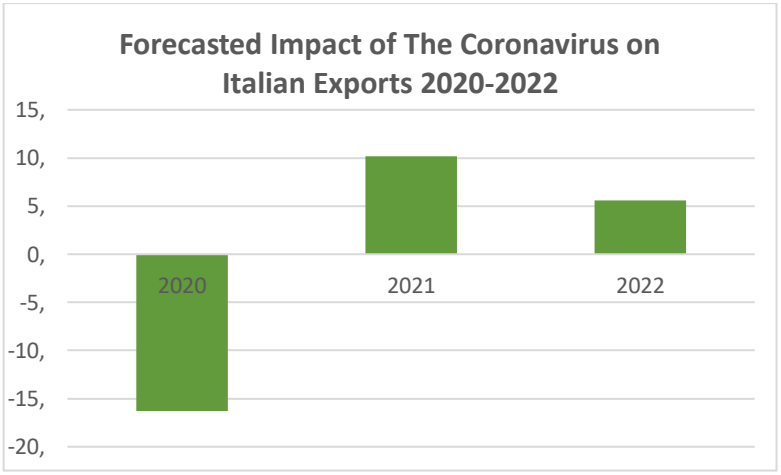

Figure 35 : Forecasted Impact of The Coronavirus on Italian Exports 2020-2022 (92)

On the other hand, thanks to digital technologies (such as internet, social media, mobile phone applications), it was tried to prevent the economy from slowing down completely. Thanks to these technologies, people turned to online meetings, online food ordering and online shopping during their stay at home. Even though the consumption rate decreased significantly in this process, digitalization prevented its activities in many sectors such as retail, education and health to stop completely economically. Firms that have adapted to e-commerce early were less affected by Covid-19 crisis.

Indeed, online sales increased by 80% compared to last year and a 40-percentage point increase for the pre-pandemic period, according to a Nielsen survey of consumer goods online sales conducted in the last week of February and the first week of March. The main products consumed in online shopping have been household goods, internet, sportswear, home fitness equipment, media and toys. (93) In this period when healthy nutrition and keeping immunity

strong were even more important, as a result of consumers turning to vitamin, honey and herbal products, the healthy products category was also among the rising categories. In the field of consumer electronics, sales of accessories such as webcams, monitors, headsets and microphones have increased in connection with the diffusion of e-learning and remote work. In line with the trend of cooking at home, it was observed that the demand for durable consumer goods shifted to small household appliances (water heater, mixer, mini oven, etc.). However, there was a significant decrease in e-commerce sales in the clothing, furniture, footwear and tourism sector. (79)

E-commerce enabled industries to do business, but online consumption caused price reductions due to open competition, and therefore profit margins of businesses decreased. This led to the expansion of the product range due to competition to sell products with less profit.

Although the economy is tried to be kept alive with online trade, trade has entered a serious depression period due to the simultaneous shock of demand and supply that emerged with the Covid-19 outbreak. Manufacturing industries in developed countries severely affected by the pandemic have blurred their supply chains due to difficulties in trading transactions with other countries. Due to the high dependence of international supply chains on the Chinese industry, the percentages of exports and imports fell sharply. Moreover, the recovery of the service sector, which accounts for a quarter of the global trade in goods and services, can be said that this crisis will continue even longer, especially in service types that cannot be traded online. (79)

According to the analysis, with the spread of the pandemic, a particularly negative impact has been observed on tourism, fashion and luxury, travel and automobile manufacturers around the world. Serious interruptions occurred due to the dependence of many automobile factories in Europe on many raw materials and semi-finished products supplied from China. For these reasons, FCA and Japanese automaker Toyota have warned that some factories in Europe may halt production due to serious parts supply, while delaying the reopening of the auto factory in China due to severe uncertainty about the evolution of the virus.

On the other side, approximately 8 million flights were canceled due to the closing of the borders of many countries around the world with the pandemic. The aviation industry expects

a total revenue loss of 419 billion dollars. (94) Shopping centers and the retail sector have also been damaged, as people do not want to be in crowded places and social distance rules have come. However, due to the development of e-commerce and the increase in the amount of transactions people make online, this effect has been positive in sectors such as telecommunications and internet services.

When the effects of the Covid-19 epidemic on the sectors in Italy are examined, the biggest fear is the worsening of the economic stagnation experienced by Italy in recent years and the negative effects of the sectors such as tourism, luxury and automotive, which have serious contributions to the Italian economy. According to the latest data of the World Tourism Organization (UNWTO), Italy, where 62.1 million tourists came in 2018, faced numerous booking cancellations and flight restrictions due to the coronavirus epidemic crisis. (95) According to the study announced by the Italian Chamber of Commerce and the Chamber of Tourism, it was announced that 31 million 625 thousand tourists lost and 7.4 billion euros in losses are expected in the three-month spring period covering March 1 - May 31. (96) In the Italian fashion and luxury sector, Chinese customers represented almost 30% of the total purchases of Italian luxury goods in the first ten months of 2019. However, with the pandemic and the decrease in the speed of international trade and the decrease in the demand for luxury goods, significant reduction occurred in this sector. (97)

The economic crisis caused by the Covid-19 epidemic had different effects on the Italian economy, varying from sector to sector. According to a study published by Mediobanca, one of the leading Italian commercial banks, the sectors most affected during the lockdown period were airline manufacturing (-22,1%), energy (-15,9%), fashion (-14,1%) and automotive (-9,1%). (98) The tourism sector, which represents 13% of Italy's GDP, was also badly affected by this crisis. According to the latest analysis of the Italian national tourism agency (ENIT), from February 2020 to September, foreign tourists decreased by 58%, domestic tourists by 31%, and the estimated economic loss was € 24,6 billion. (99)

In addition, the catering sector has been hit hard during the lockdown period. According to the analysis by Italian National Institute of Statistics (ISTAT), the catering industry lost about 13 billion Euros in the second quarter of 2020, and a decrease of over 22 billion Euros is expected in the whole of 2020. (100)

However, in addition to all these, the Covid-19 outbreak had a positive effect on some industries. Analysis by Mediobanca shows that companies operating on the web and software services are the most beneficial (+ 17,4% compared to the first quarter of 2019), followed by the main distribution groups (+ 9,1%), pharmaceuticals (+ 6,1%), online payment system providers (+ 4,7%), electronics (+ 4,5%), and food (+ 3,4%). (98)

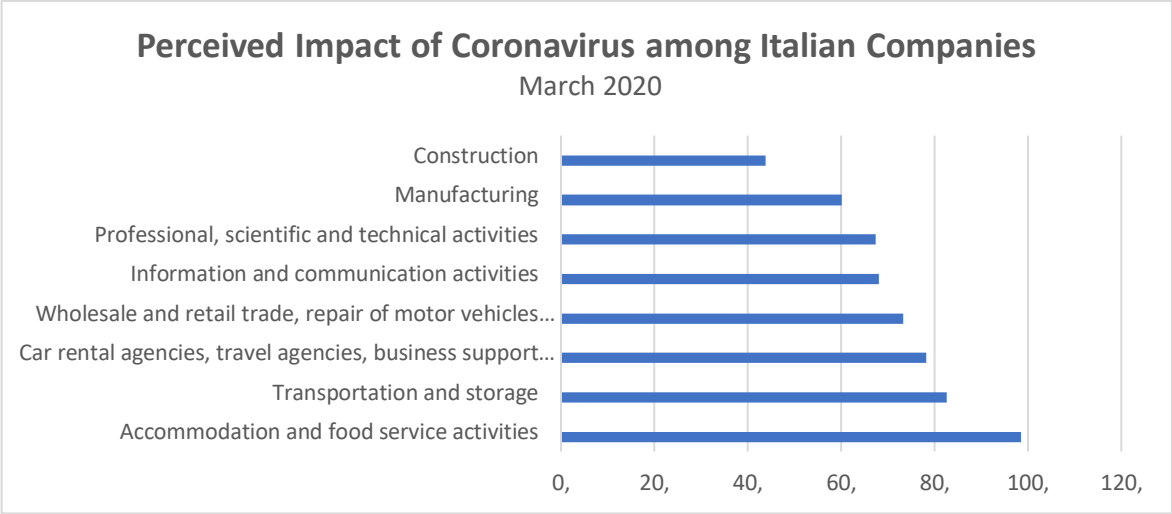

Figure 36 : Perceived Impact of Coronavirus among Italian Companies in March (101)

The effect of Covid-19 on some important industries is explained as follows.

Manufacturing: The biggest impact of the Covid-19 pandemic on the manufacturing sector is the disruption in the supply chain and a serious decrease in demand. This is an extremely severe crisis that leads to disruptions in business processes and supply chains, even plant closures. On the other hand, companies producing industrial products and chemical products faced some consequences such as delaying demands, disruption of supply and closing of facilities, which significantly fluctuates retail sales and purchase prices.

Automotive Industry: has a serious sensitivity to China, which is both the world's largest automotive market and the largest production center. Because, as the consumption and production market, China represents 30% of the total market. Within the scope of the precautions taken to prevent the epidemic, serious drops occurred in sales. Wuhan, the starting point of the Covid-19 outbreak, was the center of hundreds of automotive parts suppliers that

provided parts to local operators and export them to the rest of the world, as well as representing 10% of vehicle production in China. (102) That's why, an important part of China's automotive industry exports are these parts manufacturers. The long-term disruption of the production in these factories has increased the risks of global parts shortages and supply chain's bottleneck.

Transportation Industry: The global quarantine imprisoning a third of the world's population in their homes has seriously damaged transportation companies. In particular, airlines were severely affected by this crisis. Due to its high dependency on China and its close relationship with international trade, transportation has been one of the sectors most affected by the Covid-19 outbreak. Since the first shock in China, the transportation industry has faced serious problems due to shrinking demand in all its sub-sectors such as air, sea, road and rail. Major airlines expect a decrease of at least $ 100 billion in revenue for 2020. (102)

Construction: The construction industry is characterized by high financial debt, high fixed and sunk cost. The sector experienced a liquidity problem due to the high contraction in sales. Many construction firms fight with the risk of default for this reason.

Tourism sector and service activities: The tourism sector, which plays an important role in the development of countries, keeps social, political and economic relations alive on international scale. However, the tourism sector is quickly affected by the events in the world. The impacts of COVID-19 were most rigid in the hospitality and tourism sectors, with activities and reservations being almost completely stopped in many countries. With the spread of the pandemic, the cancellation of hotel and tour reservations increased, and the companies of this sector, which already earned money on a seasonal basis, experienced major revenue contractions.

Technology, Media and Entertainment, Telecommunications: Under the constraints imposed by the pandemic, people's time at home has increased and people's demands for this sector have been stagnating. Not only has there been a huge increase in the use of existing services, but also new technologies have been adopted by customers and customer behavior has begun to change. Internet usage rates and television watching rates raised significantly during the isolation process. As a result of the new order, the network density has rose depending on the usage rates of the customers. Managing these high levels of demands poses certain

challenges to the technology and telecommunications industries. In addition to the increasing demand for network capacity, pressure on significant areas such as data protection, privacy and employee health in the supply chain and customer service continues. On the other hand, the decline in advertising costs for major sectors such as travel, consumer products and sports affect the liquidity of many media companies that survive with advertising revenues. (103)

Pharmaceutics industries: The troubles in the supply chain in terms of raw materials and semi-finished products trade with China and the people's orientation to this industry to feed healthy in virus period caused the shock of supply and demand together in the pharmaceutical industry with high R&D costs. However, the increased demand for medicines and the possibility of developing effective vaccines can bring high returns to these companies over time.

7. Financial risks and assessing the probability of company bankruptcy and default

7.1 Literature Review

Finance function has an important place within the business. Finance is a fundamental function that keeps businesses alive in order for businesses to develop and grow in a balanced way, to survive under adverse economic conditions and to ensure that businesses grow in line with their goals. In order to maximize the value of the firm by maintaining the optimum balance between risk and profitability, finance must be managed correctly. As finance is a major component of a business, financial stability is essential for the survival of a business, and companies' performance will either improve or stagnate based on this stability. The methods that can be used in determining the stability and ensuring sustainability have become the most important issues for businesses.

Today, businesses have to make more effort than in the past to ensure their continuity. With the effect of globalization, the disappearance of commercial borders caused businesses to compete with both national and international rivals. In order for businesses to be successful, they must both determine their global competitive strategies well and benefit from new competition concepts such as speed and standardization brought by the ever-evolving technology. The performance of the enterprises in the domestic and foreign markets and the added value that they create show the competitive power of that enterprise. Foreseeing the destructive effects of competition and determining possible insolvency situations in advance has a key role for companies. For financial institutions, it is also very important to predict business failures or establish decision support mechanisms, as wrong decisions can have direct financial consequences. (104)

The financial crises experienced once again demonstrated the importance of forecasting models for financial distress and bankruptcies. The trouble of even a single firm has a serious and negative impact on a wide range of stakeholders such as shareholders, creditors, partnerships, investors. With the increasing number of companies going bankrupt, it creates a devastating effect on industries and economies. Bankruptcy forecasting has made one of the most important

problems faced by decision makers in finance, has led to the development of numerous bankruptcy prediction models and has attracted the attention of both academics and business world. (ABC1) While the first models focused on measuring the explanatory power of a single financial ratio, today new models are being developed to the extent of the complexity of the concept. (105)

Globally, company bankruptcies continued to increase with an annual rate of 9% in 2019. The situation that led to this situation actually played a role in the ongoing increase in bankruptcies in China (+ 20%) and, to a lesser extent, the reversal of the trend in Western Europe (+ 2%) and North America (+ 3%). In addition, the increase in the number of bankruptcies in large-scale companies (with a turnover of 50 million Euros and above) continues. In the first three quarters of 2019, 249 such insolvencies were recorded, with a turnover exceeding 145 billion euros in total. In 2020, 6% increase in bankruptcies is expected globally. The reason for this can be summarized as the declining growth momentum in the industrial sector and the longer-than-expected recession, political uncertainties, and social problems. The financial problems in the Asian continent in 2020 are expected to be the main determinant of the increase in global bankruptcies, with an annual bankruptcy increase of 8%. This value is seen as in China +10% and in India +11%. In addition, with the slowdown of growth in Western Europe, where bankruptcies are stable, an increase in bankruptcies is expected in following European countries; Germany (+ 3%), Italy (+ 4%), Spain (+ 5%) and United Kingdom (+ 3%). (106)

	Agriculture	Manufacturing, Mining & Utilities	Construction	Retail/ Trade	Transportation/Logistics/Storage	Services	Other
Belgium	66%	12%	10%	4%	4%	13%	-
Denmark	-6%	18%	-3%	4%	32%	11%	-29%
France	-8%	-6%	-5%	-4%	5%	-3%	-32%
Germany	13%	9%	-8%	-2%	2%	-3%	-3%
Italy	-	5%	-10%	2%	-	-1%	-8%
Netherlands	-18%	3%	12%	4%	-1%	2%	19%
Norway	-13%	-8%	4%	1%	-1%	0%	2%
Spain	-29%	13%	-19%	9%	0%	-2%	5%
Sweden	14%	6%	1%	7%	-2%	8%	-15%
UK	8%	10%	4%	1%	-1%	4%	16%

Figure 37 : Changes in Business Insolvency by Sector for Selected European Countries (106)

(2019 vs 2018, ytd figures available as of Mid-December 2018, in%)

Assessing and predicting bankruptcy risk is important for managers in making decisions to improve a firm's financial performance, but it also plays a critical role in equity or bonds, creditors and investors who take this into account before making an investment decision in the company itself. (107) The forecast of bankruptcy has long been an important and widely studied subject, as the prediction of corporate insolvencies can have a significant impact on bank lending decisions and profitability. It can be said that the main effect of such research is bank credit. Banks need to be aware of the counterparty's financial situation and estimate the risk of default before granting a loan or providing an expansion. Thanks to the prediction systems, companies can make more accurate decisions and thus avoid many financial losses. Companies' outstanding debt volume reaches trillion dollars in many countries. Even a small percentage change in this system will provide high profits. In addition, it can help identify a potential problem borrower as well as determine the loan interest rate according to the person's profile and accurately assess the credit risk. (108)

Bankruptcy has a serious impact on the global economy. In case of bankruptcy, all stakeholders are adversely affected by this situation, and in general, it creates consequences that affect the society such as unemployment and economic stagnation. Therefore, it is very important to establish bankruptcy forecasting methods to determine the financial stability of the institution.

Bankruptcy forecasting methods are divided into 2 classes as quantitative and qualitative methods. Quantitative bankruptcy prediction methods make bankruptcy forecasting using financial rates, while qualitative bankruptcy methods make bankruptcy predictions by considering the internal and external environmental factors of the business world. (109). When developing a bankruptcy estimation method, using both quantitative and qualitative variables to meet the needs of an industry or to present the right outputs to the decision-making user will increase the effectiveness of the developed model. (110) Bankruptcy is estimated using financial variables or ratios and non-financial variables. The prediction accuracy of the developed model depends on these variables.

Financial variables: Financial ratios reflect the characteristics of an organization's stability, profitability, growth, activity, and cash flow. (111) The most commonly used financial variables for bankruptcy estimation are shown in the table. (110)

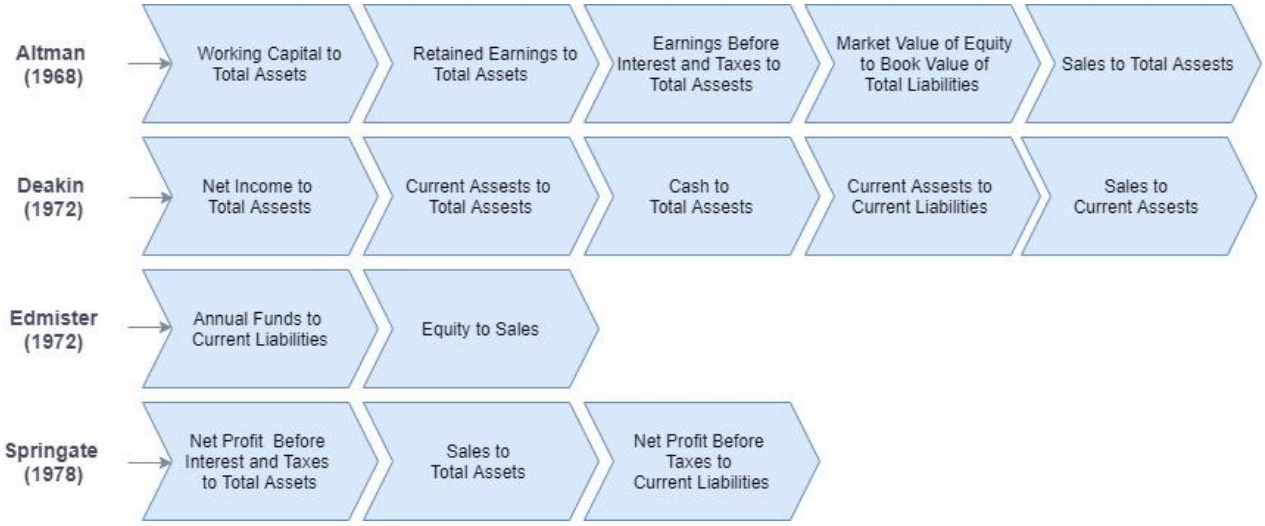

Figure 38 : List of Financial Ratios Used for Bankruptcy Prediction Analysis (110)

Non-financial variables: Non-financial variables are parameters that firms are affected by internal and external factors. Figure 39 shows several qualitative bankruptcy forecast variables used in business to analyze the bankruptcy forecast.

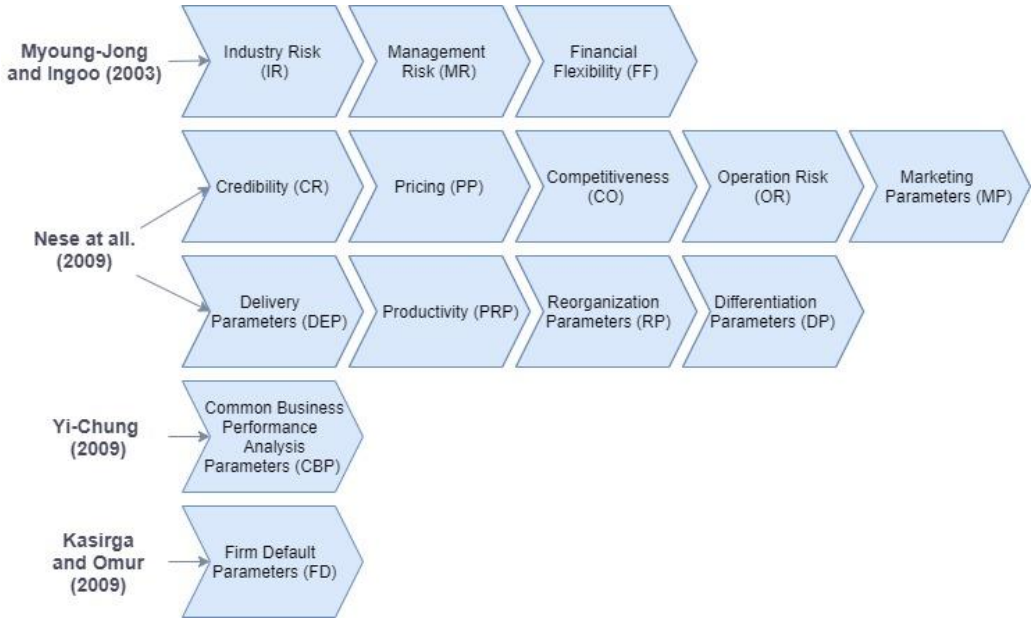

Figure 39 : List of Non-Financial Bankruptcy Prediction Parameters (110)

Bankruptcy estimation methods used in the literature: There are many different studies in the literature ranging from simple techniques to complicated techniques to create bankruptcy forecasting models. The first studies to predict bankruptcy were carried out with univariate analysis by Beaver (1966) and predicting whether a business will go bankrupt using multivariate discriminant analysis was performed by Altman (1968). Other researchers such as Altman, who used multiple discriminant analysis to predict bankruptcy are Blum (1974), Deakin (1977), Beynon and Peel (2001) and Neophytou et al. (2001). In addition, following methods are also used and brought to literature by these researchers; regression analysis (Meyer and Pifer 1970), logistic regression approach (Ohlson 1980), probit analysis (Zmijewski 1984), factor analysis technique (West 1985) and recursive partitioning (Frydman et al. 1985). Since the 1990s, machine learning techniques such as neural networks and decision trees have been widely used in the development of bankruptcy estimation and credit scoring models. For example, genetic algorithm (Ning et al., 2011), genetic programming (Hussein, 2009; Pedro et al., 2010), case-based reasoning (CBR) (Sungbin et al., 2010) neural networks (Chulwoo et al., 2012), fuzzy classification (Fengyi et al., 2011) and decision trees (David et al., 2012) are other methods used for bankruptcy estimation. (110)

The bankruptcy prediction models use different explanatory variables and statistical techniques and can provide valuable information about companies' financial performance and risks. However, the predictive power of the bankruptcy prediction models varies depending on factors such as countries, sectors of activity, periods, age of firms or size of firms. The main problem encountered in bankruptcy prediction models developed in the literature is that the models cannot be generalized because they are developed using a specific sample from a specific sector, a specific time period and a specific region or country. (107)

In the studies about bankruptcy prediction in the literature, models created by Beaver (1966), Altman (1968), Ohlson (1980) based on accounting variables come across as the most quoted models. In these models, the researchers used different variables, financial ratios, and statistical techniques.

In a seminal article written by Altman (1968), he developed a model in which financial ratios were combined, unlike Beaver's (1966) model known by his name (Beaver Model), which developed a model using financial rates alone. He used multivariate statistical techniques and

multivariate discriminant analysis (MDA) to classify solvent and insolvent companies using financial statement data. (112) Thus, Altman tried to predict whether the businesses would go bankrupt in the future, using some financial ratios.

In his first study, Altman used a sample set of 66 industrial companies, 33 bankruptcies, and 33 other non-bankrupt companies for a 20-year (1946–1965) analysis period. From these data sets, he found a total of 22 potential financial variables based on the data provided in the annual reports of companies, and together with the use of statistical techniques and MDA analysis, he obtained the five variables with the highest significance. The five variables used are as follows. (107)

1. working capital/total assets
2. retained earnings/total assets
3. earnings before interest and taxes/total assets
4. market capitalization/total debt
5. sales/total assets (108)

With this study, Altman is the first scientist in finance literature to develop a multivariate model that can predict bankruptcy. Working on a model to find prominent financial ratios in predicting bankruptcy, Altman found 5 distinctive financial ratios and coefficients determining their weights in the model in which the dependent variable consists of insolvent and non-bankrupt enterprises. By multiplying each financial ratio by the coefficients, he obtained a value of Z from their sum. This model, which later became a standard, started to be used in the analysis that predicted whether the businesses entering into financial crisis will go bankrupt. It is still widely used as input in neural networks and even for other nonlinear models. (113)

In the recent past, Z value has been used in predicting bankruptcy risk, such as strategic planning (Calandro, 2007), investment decisions (Sudarsanam & Lai, 2001; Lawson, 2008), pricing of assets (Griffin & Lemmon, 2002; Ferguson & Shockley, 2003), capital structure decisions (Allayannis et al., 2003; Molina, 2005), credit risk pricing (Kao, 2000; Jayadev, 2006), problem securities (Altman, 2002; Marchesini et al., 2004) and tests for Z value (Citron & Taffler, 2004; Taffler et al., 2004). (113)

7.2 The Framework of Adapted Machine Learning Method

In this study, all processes from the development of the ML System to its implementation have been adapted according to the article "A Machine Learning-based DSS for Mid and Long-Term Company Crisis Prediction" written by Guido Perboli and Ehsan Arabnezhad in July 2020. (114)

Decision Support System (DSS) developed by ARISK was used for financial risk prediction. ARISK is an innovative start-up company founded in 2017 based in Milan and Turin and it is a fin-tech spin-off of Politecnico di Torino providing business interruption prediction services to SMEs. The DSS system is split into two different sections: a training and tuning module and a prediction server.

The main feature of this DSS system is that it can make accurate prediction that can be applied in different markets in the short (1-2 years), medium (3 years) and long (up to 5 years) terms by using financial and non-financial variables. In addition, this machine-learning based DSS is not only limited to financial data but can also evaluate and combine different types of risks. The main structure of DSS sections is shown below.

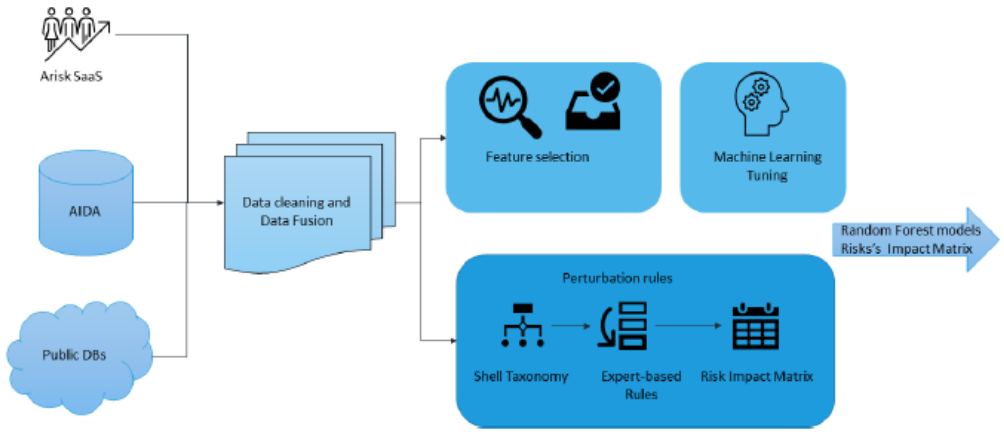

Figure 40 : Decision Support System - System Training and Tuning Module (114)

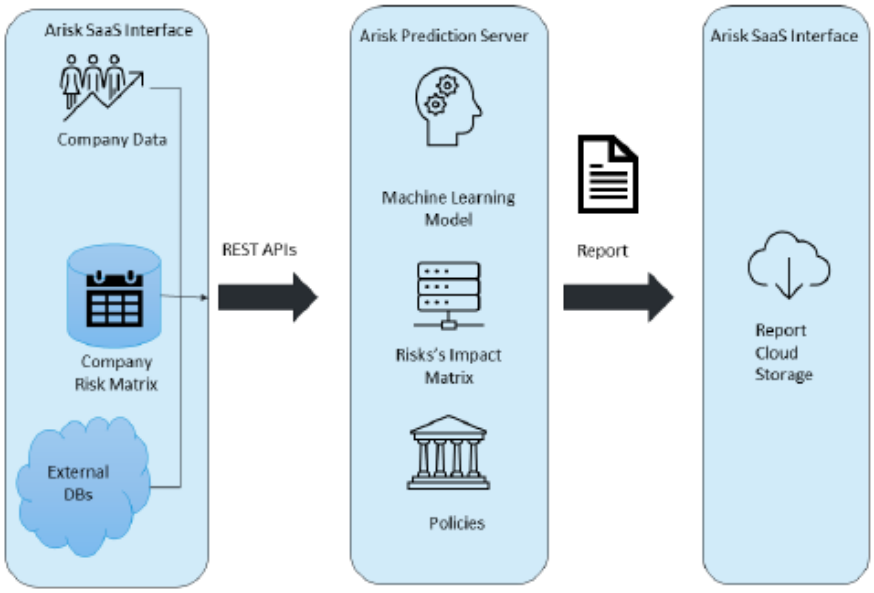

Figure 41 : Decision Support System - Machine Learning Prediction Module (114)

The training and tuning module data were collected from the Italian Camera di Commercio that provide the public database, in public financial data, while financial data provided by AIDA Bureau van Dick was used for financial index and ratios. At the same time, ARISK's proprietary interface was used to collect additional data. After the collected data, data cleaning and data fusion process is applied. In this way, the data is clustered as core and non-core data. While core data is used directly in the machine learning module, non-core data cannot be used directly in the machine learning module. Non-core data can be thought of as more qualitative data. Core data progresses through the machine learning process. First, Feature Selection procedure is performed to realize feature reduction, and then the appropriate machine learning algorithm is applied. This DSS handles many machine learning systems such as Random Forest, XGBoost, Logistic regression and Neural Networks. When initially creating the data set, 150 different financial variables were found according to the data collected in the companies. However, if a financial feature does not affect on the classification by more than 1% in each step it is removed order to use these financial features effectively and to obtain an efficient output, and finally 15 most important financial features were found by using the iterative feature removal process. As many other articles have implemented, these financial features are not directly disclosed under the Non-Disclosure Agreement, however, some feature information of data types is shown in Figure 42.

Feature	Feature Value	Feature Type
ATT10	Absolute Value	Revenue/Profit
ATT11	Index/Percentage (%)	Revenue/Profit
ATT12	Absolute Value	Revenue/Profit
ATT13	Absolute Value	Revenue/Profit
ATT14	Index/Percentage (%)	Revenue/Profit
ATT15	Index/Percentage (%)	Cost/Debt
ATT16	Absolute Value	Cost/Debt
ATT17	Index/Percentage (%)	Cost/Debt
ATT18	Absolute Value	Cost/Debt
ATT19	Index/Percentage (%)	Cost/Debt
ATT20	Absolute Value	Production
ATT21	Absolute Value	Production
ATT22	Index/Percentage (%)	Revenue/Profit
ATT23	Absolute Value	Production
ATT24	Index/Percentage (%)	Cost/Debt

Figure 42 : Data Sets Features (114)

The outputs of this system are then passed to the prediction module. On the other hand, non-core data is considered secondary data and is used as perturbations of the Machine Learning features, since it cannot be combined directly with Machine Learning predictor. “The non-core data are first classified by a tree-based taxonomy, based on the SHELL-based taxonomy by Cantamessa et al.” (115) It is an aviation accident analysis method that was first proposed by Edwards in 1972 and later developed by Hawkins in 1975. SHELL Model is a simple and understandable diagram where we can illustrate the different parts of human factors. It is one of the models that best explains the human interaction with other system elements. The word SHELL consists of software, hardware, environment, liveware people and liveware environment. This model takes into account all obvious and hidden, invisible errors. For these reasons, it was decided to use the SHELL for Startups model when evaluating non-core data with its basic understanding. Then, the outputs of the SHELL model are combined with expert-based rules that map the effect of different components on core features and create a risk impact matrix that will be used to perturb the Machine Learning module in the prediction module.

Figure 41 indicates the main framework of how the prediction module works on DSS. After the risk matrix is created according to the company's data, a request is sent to the prediction server by REST APIs. After the prediction server checks the data, the core data is transferred to the machine learning model, while the non-core data is processed by the risk impact matrix. The

predictive effect generated by the non-core data prediction is transferred to Machine learning along with the corresponding oscillations of the core data. For each core and non-core data sets, 5 separate predictions are developed as 12, 24, 36, 48 and 60 months. Additionally, international and national regulations are examined, performance indexes are created and included in the report.

8. Assessment of pre/post COVID-19 performance in Italian innovative firms

In this part, how the machine learning technique affects the financial situation of the innovative companies in the bankruptcy prediction is analyzed and how it is affected according to the characteristics of the samples is shown. In order to ensure compatibility with the DSS system mentioned above, (114) among the companies in 160k samples that used in the article were classified according to their industry, 380 innovative companies found were examined and analyzed by adapting to the system. Prediction was made using the data of the companies between 2014 and 2019 and the highest revenue value of companies between these years was observed to be approximately 40M €. The companies are still active until the end of 2019 and according to official records, they have not gone bankrupt, have not realized a merger or acquisition. The legal form of all companies is either limited or joint-stock companies. The classification of the companies according to the activity they are in was determined according to their ATECO code and they were examined in 4 classes to be industry, commerce, public and service. ATECO code is a coding tool used to classify companies according to their economic activities and is a classification method created by the Italian Ministry of Economy. (116) In addition, the locations of the companies in Italy are also classified and are considered as 4 separate regions: north east, north west, center and south. In Table 4, the sample distribution is shown by classifying companies according to the regions, activities, and revenues. The majority (55%) of the companies were settled in Northern Italy. In addition, these innovation companies predominantly display industry and service activities, while the number of innovation companies in the “Service” category stands out compared to other activities.

Classification	Categories	N° of Companies
Region	North West	134
	North East	75
	Center	90
	South	81
Activity	Industry	131
	Commerce	24
	Public	1
	Service	224
Revenues	<5 M	226
	5 <= X <10 M	85
	10 <= X <15 M	29
	>= 15 M	40

Table 4 : Information of Italian Innovative Companies in Different Segmentation

Table 5 demonstrates the bankruptcy probability of innovative companies, grouped according to the activities determined by the ATECO code. The analysis calculates the probability of a firm's bankruptcy in the short (12 months) and medium (36 months) term as low if less than 30%, medium if between 30% and 50%, and severe if greater than 50%. For example, in the short term, 66% of firms operating in the service sector have a low probability of going bankrupt, while 22% of them have a medium probability of going bankrupt and remaining 12% of firms have a high probability of going bankrupt. The companies in the "Commerce" industry have the highest probability of bankruptcy in both the short term and the medium term compared to other industries. In the medium term, the number of companies with low risk level decreases and concentrates towards medium risk level.

Risk of Bankruptcy	Activity	N° of Companies	Prob. <= 30%	30% < Prob. < 50%	50 % <= Prob.
Short Term	Industry	131	56%	31%	14%
	Commerce	24	46%	33%	21%
	Public	1	100%	0%	0%
	Service	224	66%	22%	12%
Medium Term	Industry	131	53%	41%	6%
	Commerce	24	42%	46%	13%
	Public	1	100%	0%	0%
	Service	224	64%	27%	9%

Table 5 : Italian Innovative Companies Bankruptcy Risk, According to Their Activities

In Table 6, the data are classified according to 4 different Italian regions using the same sample. According to the number of companies in each region, bankruptcy probabilities are specified, from low to high bankruptcy risk. In the short and medium term, companies in the North West and South regions appear to have a higher risk of bankruptcy than other regions. It can be said that companies in the North East region have a lower probability of going bankrupt than other regions.

Risk of Bankruptcy	Location	N° of Companies	Prob. <= 30%	30% < Prob. < 50%	50% <= Prob.
Short Term	North East	75	64%	24%	12%
	North West	134	63%	22%	15%
	Center	90	58%	31%	11%
	South	81	59%	27%	14%
Medium Term	North East	75	60%	37%	3%
	North West	134	60%	31%	10%
	Center	90	57%	34%	9%
	South	81	58%	32%	10%

Table 6 : : Italian Innovative Companies Bankruptcy Risk, According to Their Location

In Table 7, companies are evaluated by dividing them into 4 different classes according to their yearly revenues (companies with revenue less than 5M €, companies between 5M € and 10M €, 10M € and 15M € and with revenue greater than 15M €.). As can be seen from the table, companies with high probability of going bankrupt in the short and middle term are predicted

as companies with a revenue higher than 15M €. In the medium term, the probability of companies' bankruptcy is seen to shift from a low risk to a medium risk level.

Risk of Bankruptcy	Revenue	N° of Companies	Prob. <= 30%	30% < Prob. < 50%	50% <= Prob.
Short Term	<5 M	226	63%	24%	12%
	5 <= X < 10 M	85	54%	29%	16%
	10 <= X <15 M	29	59%	41%	0%
	>= 15 M	40	65%	15%	20%
Medium Term	<5 M	226	62%	30%	8%
	5 <= X < 10 M	85	51%	41%	8%
	10 <= X <15 M	29	55%	45%	0%
	>= 15 M	40	58%	25%	17%

Table 7 : Italian Innovative Companies Bankruptcy Risk, According to Their Revenues

Considering the financial impact of the Covid-19 crisis and evaluating the financial support offered by the Italian government to businesses, the financial impact on the sample was measured using Machine Learning technique (Decision Support System).

Mean values of revenues, EBITDA, number of employees and number of shareholders of 380 innovative companies are shown in Table 8.

N° Companies	380
Revenues	6.8 M€
EBITDA	892 K€
N° Employees	41
N° Shareholders	7

Table 8 : Italian Innovative Companies – Sample's Main Characteristics

To monitor the situation of post COVID-19, the simulation was applied by reducing the revenue of each firm in the sample by 30%. (rate determined by CONFINDUSTRIA, the main Company Association in Italy). In the study, the financial loan policies can be provided by the Italian government are modelled according to 10%, 20% and 30% of the previous year revenues of the companies. The bankruptcy risk probabilities are computed in the middle term (three years).

Table 9 indicates the simulation results for each situation by doing a classification of risk that shows lower than 50% is low-medium risk, between 50% and 70% is high risk and more than 70% is very high risk. While 92% of companies were less than 50% likely to go bankrupt before the Covid-19 crisis, this rate dropped to 32% after the Covid-19 crisis. The financial impact of the Covid-19 economic crisis on the revenues of companies is clearly visible. After the Covid-19 crisis, 32% of firms in the sample had a low and medium risk probability (less than 50%), while this rate increased to 33%, 34% and 34% respectively, with government-provided financial policies. The number of companies in the very high-risk group has increased significantly after Covid-19 from 0% to 21%. Thanks to the financial support of 30%, the number of companies with more than 70% probability of bankruptcy decreased to 6%. Thus, as can be seen from the table, the financial supports provided by the government assisted to reduce the number of companies in very high-risk group. Due to both the decrease in mean risk and the decline in the number of firms with more than 50% probability of going bankrupt, it may be advisable for companies in the sample to benefit from the revenue support of 30% provided by the government. However, to decide these policies, companies should make a choice by considering repayment terms and interest rates in order not to create debt accumulation and liquidity problems in the medium and long term.

Risk of Bankruptcy	Prob. < 50%	50% =< Prob. <= 70%	70% < Prob.	Mean Risk
Pre-Covid-19	92%	8%	0%	35%
Post-Covid-19	32%	47%	21%	60%
Loan %10 Revenues	33%	51%	16%	59%
Loan %20 Revenues	34%	56%	10%	56%
Loan %30 Revenues	34%	60%	6%	55%

Table 9 : Bankruptcy Probabilities of Pre-Post Covid-19 Situation and After Financial Policies in Italian Innovative Firms

9. Conclusions

The estimation of the insolvency of companies has been the focus of researchers for a long time in the literature. By using machine learning supported artificial intelligence, risks and problems in many areas have become predictable with a proactive approach. With the development of machine learning algorithms, the literature has gained a different perspective and the probability of bankruptcy has become predictable with high accuracy rates for long term.

The economic crisis caused by the Covid-19 epidemic has seriously affected many economies around the world, putting SME businesses under financial stress, especially due to lockdowns. The purpose of this research is to analyze and compare the predicted financial situations of small and medium-sized innovation companies in Italy before and after the Covid-19 outbreak, and to simulate the situation with the financial policies provided by the government.

As it can be understood from the output of the analysis, it is predicted that this economic crisis leads to an extremely financial stress on companies and the depression will continue for a long time. DSS, which is used in the application, is an important guide in the financial risk planning of companies. It enables the creation of realistic and more robust risk maps by using many financial and non-financial parameters together and combining them with machine learning technique.

By developing more projects on these systems and combining more data with more beneficial information, higher accuracy can be achieved. In this way, companies and governments will have a golden guide in evaluating the risks of their financial situations.

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