KADİR HAS UNIVERSITY
GRADUATE SCHOOL OF SCIENCE AND ENGINEERING
PROGRAM OF INDUSTRIAL ENGINEERING

DESIGNING OF AN ENTERPRISE PRODUCT INNOVATION SYSTEM FOR COMPANIES

MEHMET ÖZHAN DEMİRHAN

MASTER THESIS

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MASTER THESIS

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This work entitled **DESIGNING OF AN ENTERPRISE PRODUCT INNOVATION SYSTEM FOR COMPANIES** prepared by **MEHMET ÖZHAN DEMİRHAN** has been judged to be successful at the defense exam held on **06/06/2018** and accepted by our jury as **MASTER OF SCIENCE THESIS.**

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ONAY TARİHİ: (6 / 6 /2018)

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ABSTRACT

Today, innovation is the most decisive factor for companies to grow and gain competitive edge in the market. In particular, firms support a product innovation policy in order to be permanent in the market. Product innovation refers to the emergence of new products and the development of existing products. By means of companies' product innovation reduces expenditure; new customers win and make high profits.

AHP Method with a numerical example to evaluate the projects in this system. Organizational, technical, strategic and financial criteria have been examined. In the selection of the projects, companies have given much importance to the financial and organizational criteria. This research is expected to be very useful for evaluating and selecting projects for companies.

Keywords: Innovation; Product Innovation; New Products; Product Innovation System; Fuzzy AHP Method;

ŞİRKETLER İÇİN BİR İŞLETME ÜRÜN İNOVASYONU SİSTEMİ TASARLANMASI

ÖZET

Günümüzde firmaların büyümesi ve pazarda rekabet üstünlüğünü elde etmelerinde en belirleyici unsur inovasyondur. Özellikle firmalar piyasada kalıcı olabilmek için ürün inovasyon politikasını desteklerler. Ürün inovasyonu yeni ürünün ortaya çıkmasına ve mevcut ürünlerin geliştirilmesini ifade etmektedir. Şirketlerin ürün inovasyonu sayesinde giderleri azalır, yeni müşteriler kazanır ve yüksek kar yaparlar.

Bu çalışmada, şirketler için bir ürün inovasyon sistemi tasarlanmıştır. Bu sistemde projeleri değerlendirmede sayısal bir örnek ile Bulanık AHP Yöntemini kullandık. Organizasyon, teknik, stratejik ve finansal kriterler incelenmiştir. Proje seçiminde şirketler finansal ve organizasyon kriterlerine çok önem verilmiştir. Bu araştırma şirketler için proje değerlendirmesinde ve seçiminde çok yararlı olacağı düşünülmektedir.

Anahtar Sözcükler: Yenilik; Ürün Yeniliği; Yeni Ürünler; Ürün İnovasyon Sistemi; Bulanık AHP Method

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LIST OF ABBREVIATIONS

AHP	: Analytic Hierarchy Process
ANP	: Analytic Network Process
ASME	: American Society of Mechanical Engineers
B2B	: Business to business
ELECTRE	: Elimination and Choice Translating Reality
M&A	: Mergers and Acquisitions
OECD	: Organization for Economic Co-operation and Development
PROMETHEE	: Preference Ranking Organization Method for Enrichment Evaluation
R&D	: Research and Development
SCSR	: Strategic Corporate Social Responsibility
SMEs	: Small and medium-sized enterprises
TOPSIS	: Techniques for Order Preference by Ideal Solution
TRIZ	: Theory of Incentive Problem Solving
UK	: United Kingdom

CHAPTER 1
INTRODUCTION

In today's competitive environment, companies are struggling to get one step ahead of their competitors. It is observed that in our country, especially in recent years, enterprises are in the effort of developing innovation. Innovation is defined in different forms in different areas. Innovation is the development, adoption and implementation of new ideas, processes, products or services.

By creating new products, businesses contribute to market success and sustainable economic development is achieved. For this, companies should have a system or design related to product innovation. In this study, a product innovation system based on innovation for companies is being designed. Product innovation can be defined as the development of new products that focus on meeting the current and unmet needs of consumers and which can create in new markets in this way, offering value to consumers by utilizing new technologies.

Ideas are very important for the product innovation system. Companies get ideas from a wide variety of sources. These ideas are evaluated within the enterprise. The ideas that pass through the evaluation go into product development. During the product development phase, the products pass a number of tests and procedures. The products that pass these tests successfully start to be produced in the production department.

The product has in other situations that support innovation in the innovation system. Establishment of a strong strategic infrastructure in firms, creation of innovation culture and university-industry cooperation studies for new projects are required.

In order to design a new product innovation system for companies, the second chapter describes the definition and types of innovation.

In the third part of the study, the design of the product innovation system for companies is explained.

In the fourth part of the work, a mathematical method was used to evaluate new innovation projects for companies. Organization, technical, strategic and financial criteria are discussed. We used the Fuzzy AHP method to evaluate the projects. Method results are mentioned, respectively.

Finally, conclusions of the study results are expressed in Chapter 5.

CHAPTER 2
INNOVATION RELATED AND RESEARCH

2.1 Definition of Innovation

Innovation comes from the Latin word "innovatus". This word implies the use of new methods in social, cultural and administrative environment. The reason for the use of the innovation word is to indicate the importance of commercialization.

Innovation means both a process (innovation / renewal) and a result (innovation) as a concept. One of the internationally accepted sources for the definition of innovation comes from the Oslo Manual published jointly by the OECD and Eurostat. In 2005, which is still in force, the innovation is defined as follows:

An innovation is practice of a new or importantly developed product, or process, a new marketing method, or new organizational method inbusiness practices, office organization or external relations [1].

Innovation is the process of renewing science and technology to provide economic and social benefit. That is, combining commerciality with creativity. Innovation is about creating the future and ensuring sustainable profitable growth.

Innovation is the output transformation process that creates value for new ideas (such as product, method or service). This process consists of two steps. The first is the emergence of new and creative ideas. The second is the commercialization of new and creative ideas that are revealed.

Competitiveness is very important in the business world. For this, it is necessary to increase the product quality, to gain additional features the product, to increase productivity in production and to reach high automation levels. In fact, these talents emphasize to competence in innovation [2].

Innovation deals with individual and social needs (health, rest, work, transportation, etc.) at a better level. Innovation is the essence in the spirit of entrepreneurship: Every new venture comes at the end of a process to bring about a certain innovation. Moreover, all initiatives need to be constantly renewed to be able to sustain their competitiveness. It is very important to be able to grow economically, maintain competitiveness and employment opportunities. For this, countries have to turn new ideas into technical and commercial success quickly [3].

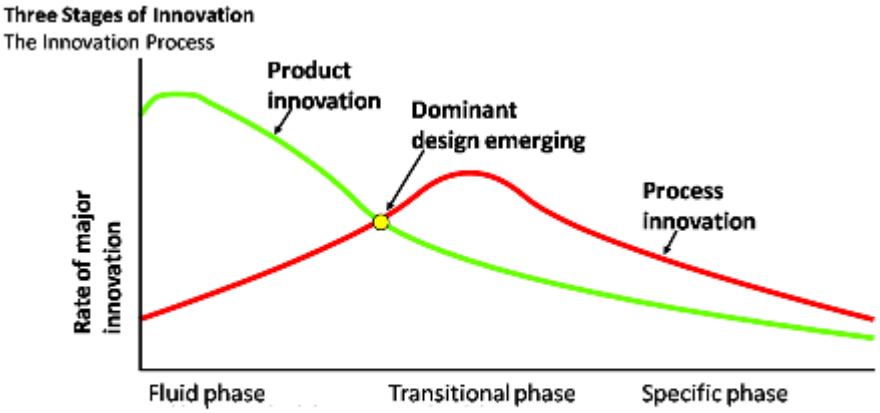

Figure 1. Dynamics of innovation [4]

Innovation was first introduced by economist and policy scientist Joseph Schumpeter as the driving force of development. The concept of innovation is to give a new product to a product or an existing product that the customer does not already know. The concept of innovation is a new production process, creating a new market, finding new sources of raw materials or semi-finished products [5].

Today, businesses are a source of innovation and economic growth. In this new approach, the organization of production within the enterprise, technological learning and renewal are mentioned.

The history of business is full of businesses that are overpowered by more innovative competitors because they cannot innovate and keep their product portfolio up-to-date and competitive [6].

The most important feature when it comes to the market-leading businesses is commercialization. For this, it is necessary to develop new products or production methods [7]. For example, when countries develop new software or new drugs, economic growth becomes a contributory factor. Discounts on prices for products such as phones and automobiles contribute more to economic growth.

2.2 Innovation Types

Innovation can be done products, services, production, distribution, business, design and marketing methods in a company's [8].
The Oslo Guide innovation is grouped into the following [1]:

- Product innovation
- Process Innovation
- Marketing Innovation
- Organizational Innovation

2.2.1 Product Innovation

It is an effort to improve the existing product to a higher level. To market a significantly improved product or service that contains new or specified user-specific features. The technical specifications include significant improvements in materials, software, ease of use, or other functional features [9]. For example, new products such as internet-enabled mobile phones or color televisions have emerged. Product innovation begins with a new product idea. Then the evaluation of ideas passes through the stages of commercial analysis, product development, market testing.

2.2.2 Process Innovation

Process innovation is implemented of the new or significantly developed production or distribution method. This management also includes significant changes in equipment or software. Process innovation is a change in the structure of a product or in the management of service delivery. If process innovation is made at the quality of the

product or at the cost, it can be recognized by consumers. Changes made outside of quality and cost may not be realized by the consumer. Innovation has changed the conditions of competition in production process and many industries. It is aimed to reduce production unit costs in the byproducts and processes [10]. Examples of such innovations are real-time sensors that can generate transactions, automation equipment, automatic packaging, laser cutting tools, computers, mobile scanners for recording goods and inventory.

2.2.3 Marketing Innovation

The development of new marketing methods that involve significant changes in product design, positioning, promotional activities, packaging, pricing and distribution channels is called marketing innovation. Marketing innovation involves new sales techniques, new financial methods [11]. An innovation brought to the market in the form of a beverage bottle is an example of this type of innovation.

2.2.4 Organizational Innovation

It is the application of a new organizational method in a company's business practices, workplace organization or external affairs. This innovation is a new internal communication system, a new costing system and so on. Business organization is also the implementation of a new and effective organizational management. The redefinition of sectoral relations, taking advantage of structural changes in the market, is an innovation effort that is radically changed in zero profit situations, radically changing the business model [12]. For example, the ISO 9001 quality management system is a necessary tool to ensure customer satisfaction and profitability, with a customer-focused and continuous development philosophy. Quality management systems can be applied to any kind of organization such as industry, service, public, private sector.

CHAPTER 3
DESIGNING AN ENTERPRISE A PRODUCT INNOVATION SYSTEM FOR COMPANIES

This design consists of 5 sections. It constitutes finding of ideas, evaluation of projects, product development, manufacturing and other supportive functions. In Figure 2 shows the design of a product innovation system for companies.

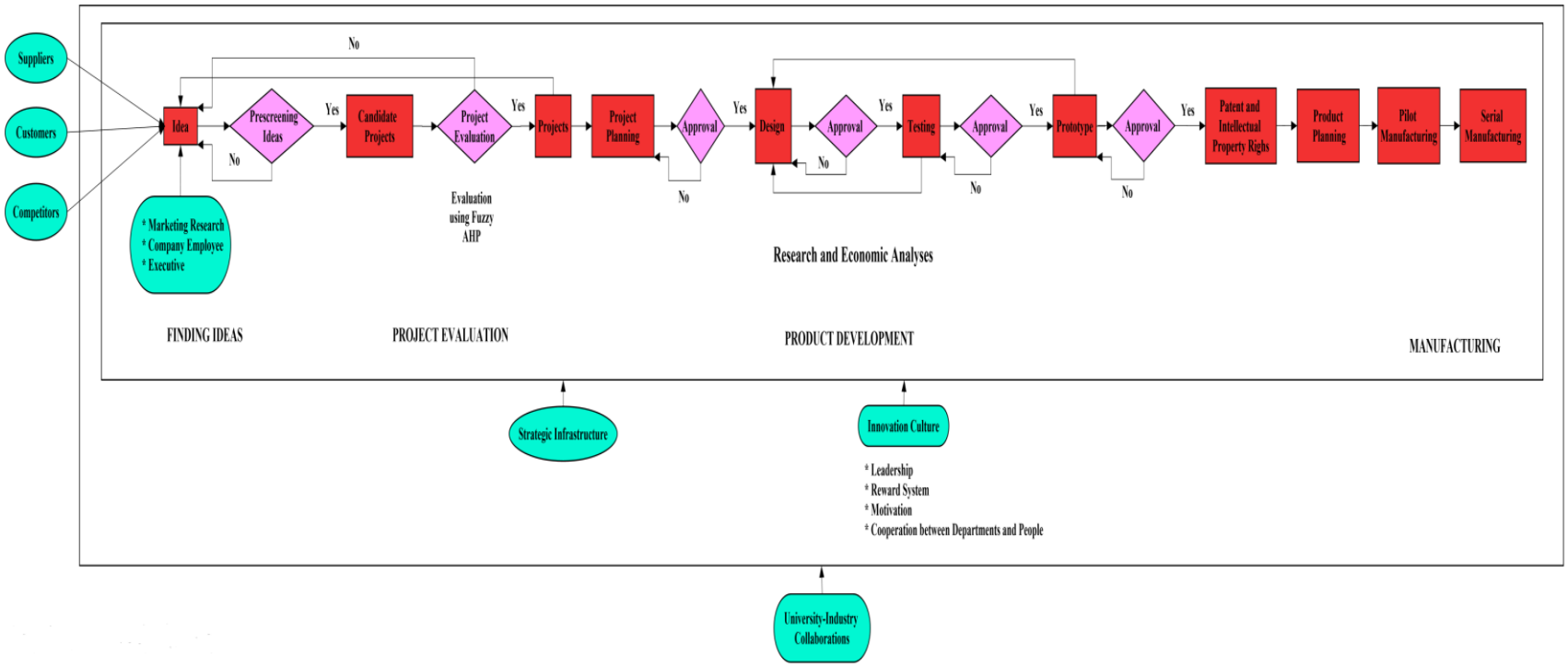

Figure 2. Designing an Enterprise a Product Innovation System for Companies

3.1 Finding Ideas

3.1.1 Idea

Ideas can come from within the enterprise for an innovative product. However, ideas can be taken by consumers to ensure that the products of the companies are well presented. Customers' expectations from products are that the product is quality and reliable [13].

The main sources of ideas for an innovative product are:

- Suppliers
- Customers
- Competitors
- Marketing Research
- Company Employee
- Executive

3.1.1.1 Suppliers

Cooperation with suppliers is a challenge as one of the key elements of successful innovation. Companies that have started implementing total quality management programs have laid the foundation for developing collaborations with suppliers that have emerged as a valuable source of ideas for innovation. Supply chain management is the integrated management of the material, information and money flow that enables the customer to achieve the right product, right time, right place, and right price for the entire supply chain at the lowest possible cost. One of the most important aspects of supply chain management is to define contracts that provide coordination of joint innovation projects. Suppliers create work and resources in a long-term partnership working collaboratively on innovation projects according to technology projects. Supply chain management members can then trust contracts that are often used for commercial purposes to coordinate joint innovation projects. Strategic alliances enable you to overcome competitive advantage and prevent new market initiatives. For example, in

the Netherlands, work has been done with five factories working with different manufacturing sectors. In this study, agreements were signed to control innovation projects between high-tech suppliers and factories. As a result of this study, the Firms use commercial materials to coordinate an innovation project on an SC based on the innovation process stage. Firms accept contracts to coordinate an innovation project of suppliers according to level of addiction with suppliers, consumer's desires, and level of outsourcing [14].

Innovation is crucial to the success of firms. Firms look for ways to deal with suppliers themselves to solve problems. The supplier's products are very good and can solve the problems of the companies. For example, the relationship between product innovation and suppliers was investigated based on Spanish manufacturing companies. As a result of this work, companies that collaborate technologically with suppliers have a positive aspect of product innovation and radical product innovation [15].

One of the important elements of innovation is the development of new products. Suppliers have a crucial role in improving the innovation performance of firms. It increases the competitive advantage for companies. Both the buyer and the supplier must be eager to attend in the new product development projects and must have the necessary abilities and experiencing to do so. As buyers' demands increase, firms are allocating more resources to suppliers. The goal of the purchasing departments of the companies is to reduce the cost. In a study of 498 companies worldwide, the effects of supplier collaboration on firm innovation performance and the characteristics of the purchasing function were investigated. As a result, the fact that companies attach great importance to the innovation strategy affects supplier cooperation efforts positively. Companies' high level of purchasing knowledge influences supplier cooperation efforts good. The fact that the companies have made great efforts to cooperate with the suppliers is affecting the innovation performance positively [16]

3.1.1.2 Customers

When companies are innovating, the most important source of ideas is the customers. Customers are an important factor in creating value for the firm. There is a residual role

for customers in service production and delivery. The ability to develop and use customer engagement makes it possible for companies to improve their performance. For example, a study has been conducted on service companies operating in the UK and Ghana. This study investigates the relationship between innovation and customer participation capability and firm performance. The result of this study is a positive relationship between service-firm customer participation capability and firm performance. Product and process innovation has helped the relationship between customer participation and service provider performance in both Ghana and the UK [17].

The spread of new digital technologies into the manufacturing industry conceives new occasions for digital innovation. Compound digital technologies such as sensors, radio frequency identification and cloud computing with non-digital products can offer new products and services to the firm. To develop digital innovations, companies must be experts in digital technologies and help their customers' needs. Good management of various customer and user information by companies is very important for innovation. To give an example, research has been conducted on customer and user information in the digital innovation processes of three global B2B manufacturing companies. B2B, or "Business to Business," is the abbreviation for cross-company marketing or sales practices. The spread of digital technologies brings new ideas. Expand of digital technologies meets one needs of customers in the short term. Firms must embark on new methods to acquire, distribute and use user information in the long run [18].

Innovation is essential to meet existing customer and market requirements. Manufacturing and service industries are investing in innovation. Service innovations are needed to accelerate economic growth. For example, the effects of customer orientation on production and service companies' innovation performance were investigated by taking samples of 1646 manufacturers 'firms and 686 service companies. Customer orientation, supplier collaboration and technology talent have positively impacted innovations in both service and manufacturing companies. The impact of customer orientation and supplier co-operation has been very strong in service

companies. The effect of innovation on technology ability has been very powerful in manufacturing companies [19].

3.1.1.3 Competitors

Creating new products for companies is very important. The inter-accounts competition level increases. To produce new products, it can be applied jointly in competition policy. It is also necessary to pay attention to cost policy. When companies cooperate jointly, they give importance to the internal organizational design policy. For example, the relationship between information and competitor cooperation and firm's product innovation performance is examined based on the 627 Flemish manufacturing companies. As a result of this research, when the mechanisms of internal information sharing and official information protection are available, rival co-operation impacts the product innovation performance of firms positively [20].

Firms should generally follow elements that cause competition. They should take these factors into account when innovating themselves. Factors such as factors of action (potential impact, visibility, volume of action) of competitors, geographic distance between competitors and focal firms, and competitive success of competitors can determine the competitive behavior of focal firms. The publication of a competitor's financial statements clearly shows the strategic intent of the competitor firm and the ongoing competitive power. For this reason, recognizing companies' financial statements has a critical prescription for competitive dynamics. To give an example, a study has been conducted on a competitive dynamic viewpoint about the innovation of competitors and the firm's product strategy. This study was conducted between 1987 and 2010 with a sample of 235 firm-competitor pairs in computer software sector. Competitor firm's R & D efforts will lead to a focus company's future competitive threats and more product action. The size of the focused company versus the competition affects innovation performance [21].

Mergers and acquisitions (M & A) are a very important growth strategy. These transactions exceeded GDP 2.2 trillion US $ in countries such as Canada and Italy in 2012. The power of the companies increases in the market. But the merger of firms can

sometimes lose their market value. Therefore, competitors can benefit from this situation. M & A is becoming increasingly popular in technology-based industries. This partnership has consolidated companies into innovation strategies. For example, European company's competitors and merger strategy has been explored the impact of innovation in the pharmaceutical industry. The technological development of the company is more likely to be bought by competitors [22].

3.1.1.4 Marketing Research

Businesses closely monitor emerging technologies and competitive activities that affect the market. In order for the companies to remain long in the market, it is necessary to constantly and strategically gather information. Market research and strategic planning are very useful for the firm. In addition, research increases on competition. For example, research has been done to recognize innovations between 2008 and 2011 years in Brazil's textile industry. Innovations have been made in line with market demands and fashion trends in the textile sector [23].

3.1.1.5 Company Employee

Employees are excellent resources for new product ideas. But management being prejudiced against employees, not finding them creative enough, they could also cause an idea that could be used to disappear. Companies should encourage employees to say their new ideas. New ideas should be assessed by management. An employee who does not get an answer to the idea loses his desire to innovate over time. When people are given the opportunity to have a share in determining the future of the business they are working on, their motivation will increase. For example, if an employee owns a few stocks in the company, his innovate desire grow [24].

3.1.1.6 Executive

Senior management is a key resource for new product ideas with years of knowledge. Hundreds of companies realized the power of innovation and innovation around the world. Managing innovations of the managers is very important for the company.

Today, competition is increasing in difficult business life. Most companies are great importance to their own innovation capabilities, high firm technology, sustainable R & D. Firms need to maintain their corporate sustainability for the search for advanced technology and innovation. These companies must also be harmonious with the environment at the same time. For example, the relationship between strategic corporate social responsibility (SCSR) and innovation and corporate sustainability has been explored. According to the results, SCSR helps external and internal development of information sharing and provides the effectiveness of corporate sustainability. Firms support R&D technology with institutional academic cooperation. Developing corporate social responsibility is very important for managers and companies [25].

3.1.1.7 Methods used in the determination of the new product idea

Find a new idea is very important to a firm or entrepreneur. Many ideas must be collected for resolve needs and problems. There are a number of ideas gathering techniques to encourage employees, experts and customers to find new ideas. These techniques are used in sectors such as manufacturing, service, banking, construction. These techniques are applied to departments such as strategic planning, product development, finance, human resources, marketing [26]. Some of them are listed as follows:

3.1.1.7.1 Brainstorming

Opinion collection is also a very common method. The brain storm method is used in engineering design processes, strategic problems. This method is frequently used in group work. The presence of the leader is very important in the group. Leaders are very helpful in bringing out ideas. All ideas are evaluated. Having a lot of ideas is a good thing [27].

3.1.1.7.2 TRIZ (Theory of Incentive Problem Solving)

It is a creative method used for innovative problem solving. This method solves the problems of innovation and complex problems [28].

3.1.1.7.3 SCAMPER Method

The Scamper method is a method used to transform a single idea into several different transformations. With this method, innovation is usually made to the product size [29].

3.1.2 Prescreening Ideas

In Organizations are generally more concerned with the opinions of managers. However all sources of ideas should be considered equally in innovation. Considering that the ideas are equal, it makes all employees in the company very happy. Thus, companies lead innovation. All ideas gathered should be conveyed to the documents. Each idea must be stored as a document with the thought that one day may be absolutely useful.

Nowadays companies have designed an idea suggestion form to present their ideas as documents. Internal and external sources of ideas are expressed through this form. For example, the Dell Company has started the "Intellectual Storm" project at different points in the world, constituting a virtual community where users are invited to develop product ideas and present new product ideas online. As a result, all ideas must be documented in innovation [30].

The ideas collected are sent to the management board for evaluation. Administrators help increase the opportunities at all levels of the organization. They help to present the selected projects on the market. Projects should work without errors in related with strategy, business and technological environments. The ideas should be finished in a timely properly. If a project is suitable for the strategic and commercial suitability of the company, that project is accepted by the board of directors [31].

There are several factors that affect decisions during the elimination of new product ideas:

- The managers' opinions are given more importance.
- The idea is complicated.
- The idea is not suitable to the sector.
- Some managers may be closed to innovation.

To sum up, After the Board evaluates the ideas; the innovation manager explains the ideas accepted in writing and verbally [32]. In this study, many ideas were rejected by the board of directors and only 10 project proposals were accepted in the project preliminary idea round.

3.2 Project Evaluation

3.2.1 Candidate Projects

Nowadays technology and increasing cost are progressing rapidly. Companies support projects that are candidates for innovation to meet requests. Candidate projects target communication networks and problem solving issues. 10 candidate projects should routinely develop applications for coordination and cooperation with external sources such as suppliers, customers and internal functions within the company. At the same time, the creation of new products also increases competition within the firm [33].

3.2.2 Project Evaluation

This phase is the most important part of the innovation process. The decisions that are given by the Board of Directors are vital. Innovation manager explains the decisions made by the board of directors [34]. We used the fuzzy AHP method to find useful ideas for companies in this study. Five projects were selected by passing through decision-making mechanisms of 10 project ideas declared as written form.

Organizational, technical, strategic and financial studies have been carried out for these projects. In addition, selected projects are numbered by the company. We told a detailed study to use of the fuzzy AHP method to select innovation projects in the companies in chapter 4.

3.2.3 Selected Projects

After the idea is constituted, a clear vision is determined about of the product. The Board of Directors works on topics such as project team, definition, analysis, plan and feasibility. These issues are critical issues that can affect the project positively or negatively. Projects that are negatively made a decision cannot be approved on by the management [35]. We have been living up to 5 new projects in this project as a project.

3.3 Product Development

3.3.1 Project Planning

After the projects are selected, the project team is determined by the board of directors at the firm. The project team is composed of the managers who are involved in different departments. One person among the managers is assigned as the leader of the project. It is important to lay a scheme while revealing a new product. Project plan consists of budget, resource and time criteria's [36].

It is the phase in which ideas are subjected to a commercial appraisal by making cost and sales analysis. These analyzes are done with various scientific methods and techniques and based on these, it is decided that the product can be developed or not developed. Budget plan is one of the most important stages of the new product development process for companies. If the cost of production is considered to be excessive as a result of the financial evaluation, analysis of risk and profit should be made very careful and detailed. Company may be made decision subcontractor production with another company [37].

R & D expenditures should be made according to the financial strength of the company. Emergence of a new product by competitors affects the sales of the other firm. After a marketing strategy is developed, the profitability of the product must be determined. Profit of the product is found by calculating the sales and costs of each product. If the project achieves the target of the profit level of firm, the project will proceed to the next stage. But if the company cannot profit enough, the idea is eliminated in the product development process. So the company gets rid of the big expenditure [38].

Resources of the company are important when planning the project. Large-scale firms are more likely to access outsourced financing than small-scale firms. Employees at a large firm can specialize by making a division of labor among them in certain issues. Small firms are less likely to introduce new products due to resource shortage than large firms. If the innovations are financed by external sources, there may be some risks. For example, lenders will want to see the innovation project to be satisfied with the payment of debts. In such a case, information about innovation will have the possibility of reaching market, opponents. For this reason, the financing of innovations from equity will prevent infiltration of information about innovation [39].

Lack of market orientation and inadequate market assessment are a reason for the failure of new products. The development of a new, quality, low-cost product by a firm can gain a significant share of the market for this firm. Economically, the most profitable business will undoubtedly be the first to offer innovation to the market. It has great advantages to enter the market first. Now companies are allocating resources to R & D for innovative projects [40].

As the main sources of finance that SMEs can benefit from; funds from the financial system (loans from banks and private financial institutions, finance through leasing and factoring, funds from consumer financing companies, funds from capital markets etc.), commercial debts (with and without bonds) equity. Capital markets can be considered as an important resource alternative for external financing required by SMEs [41].

It is absolutely necessary to take time to develop a new idea. Completing the new product development process with new technologies will give companies an advantage in terms of price, time and market. For example, SMEs can capture demand gaps and evaluate opportunities in a timely manner, establish closer relationships with customers and staff, and adapt to developments in technology more easily [42].

The most classic example of process innovation is the just-in-time production system. Thanks to this system, only the needed products are produced at the required time and quantity. The system increases productivity while minimizing the amount of stock and responds quickly to variability [43]

At the commercialization of the new product, the timing of the market penetration is very important. If a new product is substituted by a previous product of the company, the business will delay access to market until the old product stock is exhausted. But if the product is seasonal, new product presentation may be delayed until the current season [44].

Innovation should be done on time and quickly, as the life of the products is shortened. Company has an important place in the market. However, there are also negative sides to being fast. Reducing product development time can lead to adverse conditions in products. Most importantly, more quality products are emerging from time. Care should be taken that there is no reduction in quality due to the speed of product development, as the goal is to quickly identify successful products, rather than a series of failed products. Goal is not to quickly produce improved failed products. Successful and high qualities of products are revealed [45].

The biggest problem faced by companies in the new product development process is the uncertainty and risk. When especially technological developments are rapid so today, these uncertainties and risks have increased even more. Firms are struggling to get rid of this situation, which causes cost increase and waste of time. The companies are trying very hard to get rid of this situation. This condition cause cost increase and time loss. In addition, the uncertainty and risk situation is another situation that increases the time of

new product development is very long. In addition, that the time to develop a new product is too long increases uncertainty and risk [46].

3.3.2 Design

Design is a very important criterion for product development. Firms attach importance to the design of the product to meet the needs of the customers. In particular, design helps to customer in shaping the product image during marketing. If the product appearance is reliable and good quality, consumer always prefers that product. Design is tool differentiation acquisition and one of the factors that increase the success of innovation. By reason of design emphasizes functionality and appearance. It increases the value of product and competition. Nowadays, computer aided technology is used when designing the product. Generally, such as two and three dimensional drawing and blueprint drawing programs are used [47]. For example, Toyota makes design work on new concept cars. Powered by Fuel Cell technology, it produces a new concept car. It has high design and quality standards. In all Toyota engines, great emphasis is placed on low emissions and fuel economy, and high performance and driving qualities are aimed.

3.3.3 Testing

The testing phase is the stage at which product quality, product functions are tested and your reactions are taken. Appropriateness of the ideas being tested is assessed for the transition to other application phases [48]. This process results in prototypes and other work that the top management can evaluate intellectual and innovation. Possible ideas are defined. Ideas that cannot pass the test phase return to the design phase and are evaluated.

While strong organizations support test stage; poor organizations lack the experience-supporting structures and rewards systems and place importance on error risk. Employees are encouraged to write articles, participate in conferences and trade fairs to present their ideas in powerful organizations. In addition, employees are encouraged to work with academic partners and test their ideas. External partners can also be found.

For instance, a business can collaborate to tests with a business partner, client, or academic institution. These organizations define testing as a learning activity rather than as a mistake. For this reason, the trial process is valuable. Also, these organizations share data with innovators so that mistakes are not repeated. Data sharing is especially important for pharmaceuticals, biotechnology, and financial markets. Besides, large firms use technology creatively in the testing process [49]. For example, while Goodyear used to run the testing processes of tires with slow, expensive, anti-environmental road tests, now is experimenting with cheap, fast and environmentally friendly computer software. For exemplify, while Goodyear used to run the testing processes of tires with slow, expensive, anti-environmental road tests, now is experimenting with cheap, fast and environmentally friendly computer software. Thus leads to the development of new products. By this means, costs and time required are reduced for the development of new products. In particular, participation of employees in education and learning programs is ensured.

3.3.4 Prototype

During the prototype test phase, individuals evaluate the prototype of the new product. At this stage, the product is compared to other brands in the market, how the product is developed and how consumers change their post-use preferences. Prototypes provide information about configuration, behavior, and the function of a product when combined with virtual simulations created through extensive software in conjunction with the engineering model. As a result, the prototype test allows the company to find potential product problems and solve them. There are three types of prototype testing. These are alpha, beta and gamma tests. Product is tested in a laboratory environment that shows the planned performance in the alpha test. Employees use the product in their own environment for a certain period of time and report their experience in the beta test. Individuals use the product without a time limit and report problems with the product in the gamma test [50]. Experts and newly recruited individuals can evaluate the prototype. Projects that do not pass the prototype evaluation process are returned to the design stage. For example, Apple's first touch screen device produced prototype tablets 0.35 code-named in 2002. Apple has preferred to smaller devices in those years because of

the high cost of touch screens. This device, which was designed as a tablet sixteen years ago, was presented to consumers as an Iphone in 2007. Ipad was presented to consumers in 2010. Iphone and Ipad are intelligent and have high technology.

3.3.5 Patent and Intellectual Property Rights

Product innovations are often protected legal safeguards by patents. The patent prevents the inventor from producing, using or selling by someone else without permission of the owner of the invention for a certain period of time. Patent provides special commercial advantages to the innovator. Innovation efforts of companies increase. Innovation is direct proportional to patent numbers. Patents are often used as a demonstration of technological development. It is used by many businesses to protect intellectual property rights, such as technological inventions. However, every patent may not be come a commercial product. It is also important to remember that many innovations can enter the market without patents. [51]

3.3.6 Product Planning

Product planning is a part where manufacturing information is produced. When companies plan their product, they apply to the product tree system. Product tree is a list of materials needed for the production of a product. These materials involve raw material, semi finished product, and components that are not directly in the product but are required for production. Component at each level in the product tree can also consist of components at a lower level. In general, product tree is defined for the product and any assembly / subassembly. Product tree specifies the subcomponents of the product in question and how much is used per unit.

Accuracy of the product tree should be at least 98%. That is, there should not be any component or amount of error at least 98% of the product tree. However, achieving this level of 98% is not enough. Product tree should be checked continuously and necessary precautions should be taken and the target should be 100 %.

In a company must actually be a single product tree for a product. When each department is preparing a different product tree in accordance with their needs, it is not possible to control all of these trees in good quality. Companies with such scattered and broken product trees are generally informal, old-fashioned businesses where departments are disconnected. When the problems related to the product trees arise, it becomes more difficult to pick up the right part at the right time and the right amount, and the accuracy of the calculated costs decreases [52]

There are some principles that a company must follow when it abide to creating product tree databases. Let us briefly summarize these principles:

- Information on the part number and the product tree records must meet the needs of the engineering, production, planning, procurement, finance, etc. departments of each customer in the company.
- Part numbers must be unique for each piece. A new number should be given to the new shape in the revision result.
- The numbers in the product trees are part numbers.
- Every piece of product that needs to be scheduled in time must be placed in the product tree.
- Levels of the product tree should be as low as possible.
- When changes are made to the product tree, all relevant departments in the company must approve.

Another important issue in product planning is the production of assembled products. In order to produce assembled products, assembly chart model is applied in the factories. Assembly chart model defines how parts will unify together, the mounting sequence and the general structure of the product. It lists all major materials and components, subassembly operations, inspections and assembly operations. Firms start with the components purchased at the lowest level. Companies list all of the potentially inventoried intermediate steps (raw, semi-finished to finished components, sub-assemblies, packing materials, etc.). Product structure has certain a level. Parts used to

make items at a level are represented at a lower level. Higher level is represented by a lower number. Last item is represented at zero level [53].

While the products plan, they go through a certain term of process. To control this process period, companies use the process chart method. Various process schedules are designed to meet the needs of a specific level or analysis phase. Different transaction table types share a common set of core symbols. Some process charts have additional symbols for special process steps. Generally firms use ASME symbols. These symbols are occurred operational, inspection, transport, storage and delay topics.

Operation is the main step in which parts, materials or products are usually replaced. This symbol is used for is used for the activities of grasp, position, use, etc. of a material. Inspection symbol checks quality, quantity or identity of product. For example, counting the number of products produced. Transport symbol refers to the movement of an object or equipment from one place to another. For instance, the material can move by a trolley. Storage is the part of an object that is hidden and protected against adverse situations. For exemplify storage of product in the storage room. Delay occurs when an object is waiting for the next activity. For example, when slow down the system in a manufacturing plant may delay the production of other products [54].

It is very important to do cost analysis while developing a product. In order to accurately calculate the product cost, it is necessary to determine the fixed and variable costs well. Total fixed costs do not change in a given company volume, but it decreases or increases with the changes in the business volume. If there is growth in the business volume, it will gradually increase in cost, and if the business volume shrinks, it is necessary to check these costs. There are fixed costs that can be managed. These fixed expenses consist of facilities, basic organizational structure of the enterprise, investments made in spare parts, building taxes, insurance, depreciation, salaries of managers and production personnel. Examples of fixed costs that can be managed are research and development, advertising and training expenses. Variable expenses

determine raw material, energy, packaging, labor costs. If the variable expenses are managed well in a company, the company is economically profitable [55].

Businesses must meet the needs and desires of consumers in order to exist. Demands and needs must be available at the desired location, at the desired quantity and price. Otherwise, consumer satisfaction will not be achieved. Marketing function includes activities to provide consumer satisfaction by serve as a bridge between the producer and the consumer in the enterprises. For this reason, intense competitive environment marketing activities have a vital proposition in today's.

Marketing activities start with marketing planning. There are two basic steps in marketing planning. The first one is to set the target market and the other is the marketing mixing. Company must determine which market segment it will address and conduct production and marketing activities tailored to the consumer's desire and need in this market segment. When creating a marketing mix, the product, price, distribution and promotion issues must be decided [56].

- The product is the element that will meet the needs and demands of the consumers. Packaging, product image, new product development, brand is included in the concept of the product.
- Price is the price determined for a product. When marketing a product, it is necessary to give the right price decision. If the price is high, the consumer will not buy the product, and in case of low price the profitability of the firm will decrease.
- Distribution is a decision that must be made about where to send the products that consumers want. In this case, physical distribution and distribution channels activities should be planned.
- Promotion is the act of influencing, persuading and informing consumers to buy products. Personal sales, advertising, promotion and sales development activities are being done [57].

Supplier chain management has a important role while product planning is done. It is a logistic system where raw materials are converted into products and delivered to customers. There is a close relationship between the customer and the supplier. This close relationship adds financial and spiritual value to the company's product. Provides coordination and synchronization to balance demand and supply [58].

3.4 Manufacturing

After a product development phase in a firm is over, it is passed to the manufacture department. Manufacture function is a crucial function in terms of ensuring the competitive advantage of the company. Because the company supply with meets the needs and desires of consumers with its production function. Ability of the companies to achieve their objectives and to work effectively depends on the efficient functioning of the production function [59]. Manufacture department consists of two parts. These are plot manufacturing and serial manufacturing.

3.4.1 Pilot Manufacturing

It is an experimental production for the purpose of predicting the quality, cost and possible problems of a goods or service to be transferred to a new market in a production field. Small quantities are produced. It evaluates the product performance in this manufacturing. If there is no negative situation in the evaluation of plot manufacturing, the product is passed serial manufacturing [60].

3.4.2 Serial Manufacturing

Machines and facilities are systems in which only certain goods are allocated and operations on a certain goods are performed one after the other. Since the product is standardized, it is always the case that the same operations are performed in order. Demand level for the produced goods is high, so the production quantities in serial manufacturing are very high. The serial manufacturing systems can be divided into two sub-assemblies as assembly and flow type. Assembly production is carried out in large

quantities and for a long time. For example: Refrigerators, washing machines, dishwashers etc. Flow manufacturing, machinery and facilities are designed and built to produce only one kind of product. For instance: Sugar, cement and textiles etc [61].

3.5 Supporting Functions

3.5.1 Strategic Infrastructure

It is very important that the corporate infrastructure is appropriate for managing the innovation of the companies. Companies should determine long-term mission, vision and strategies [62].

The vision of innovation is to create a sustainable innovation culture that creates value for all stakeholders by making a difference with innovative practices and preparing for the future [63].

Innovation mission is to support innovative ideas in existing and new fields, product, service, process, business model according to customer needs by working together with all stakeholders, to systematically experience and to develop the company [64].
Firms plan strategic targets to innovate. It is important to increase competition power and company profit with innovation activities. Innovation projects should be beneficial to society and the environment. Employees should say innovative ideas and a systematic innovation infrastructure should be established. The qualifying conditions must be provided for encouraging creativity and participation and turning innovation into corporate culture. In-Company entrepreneurs must be active and entrepreneurship must be a way of life. [62].

3.5.2 Innovation Culture

Innovation culture is the whole of the activities that value companies and give positive feedback to the business [65]. In the culture of innovation, top management must have an understanding of innovation. A feeling of trust and honesty should be constituted in

the company. Instead of punishing and blame, support and tolerance must emerge. Innovative ideas should be listened and valued by managers. Creative co-operation between individuals and groups should be established and developed in the culture of innovation [66]. Innovation culture has four important criteria's. These are leadership, reward system, motivation and cooperation between departments and people.

3.5.2.1 Leadership

The creation of innovation culture is the responsibility of the firm manager or leader. Cultural change is about changing behavior, beliefs and values of people. Leader should motivate employees on innovation. Leader must explain the company innovation goals to employees very well [67].

3.5.2.1 Reward System

The main purpose of your entrepreneurship is to create new strategic paths and create new markets. Managers always want to increase the efficiency of the company. Innovation performance should be kept high in corporate entrepreneurship. Companies must appoint prize system to encourage employees to innovate. In this case, competition within the company increases. In-house increases production of ideas. Thus the reward system will strengthen the institution's innovation culture [68].

3.5.2.3 Motivation

The skills and motivation of people working are important on innovation projects. Leaders of innovation projects should motivate employees both inside and outside the company. They need specific skills in managing communications. Employees also experience frustration and lack of motivation when the innovation process takes longer than expected. Therefore, employees start to make routines unwilling [69].

3.5.2.4 Cooperation between Departments and People

One of the most important elements of innovation culture is the cooperation between departments and people. Managers and employees must embark on operating within

themselves. There must be clear communication between management and employees. Managers should be very helpful in this regard. Listening to employees' complaints and ensuring that they are knowledgeable about their business development time's increases confidence and commitment [70].

3.5.3 Innovation Role of University-Industry Cooperation

The innovation performance of an economy depends on the individual performance of firms such as firms, research institutes, universities, as well as their interaction with the social institutions such as values, legal regulations, as elements of a collective system that creates and uses information. For this reason, successful people and interactions are very important for innovation in university-industry cooperation [71].

Today, all aspects of production are more knowledge-based. The research infrastructure, high-quality workforce and innovation culture have become more important than natural resources. This situation requires the creation of a supportive environment for innovative firms. In order to be attractive for companies, the regions go to structures that support innovation strategies. In this context, it is observed that the regions are becoming more and more natural economic areas. When the regions formulate appropriate structures to support especially innovative firms, they can represent meaningful economic interest communities, identify real flows of economic activity, and take advantage of the real bond and synergy advantages among economic actors. [72]

University-industry cooperation can be developed in three stages on innovation:

- Parties should learn about each other's resources.
- The parties should set out the goals of interaction. Ties between organizations can be classified as technological ties, business ties coordination, information ties, social ties, economic ties and legal ties.
- Coordination results of activities ensure efficient use resources and appear activities.

One of the issues that should be realized for the dissemination and development of the innovation role of University-Industry cooperation is the establishment of University-Industry Innovation Network. Networks are systems where resources and activities are gathered together. Advantages of networks help reduce commercial transaction costs. It provides technology and other supporting factors appropriate to the strategic interests of the parties [73].

Relations with the university help firms develop their competitiveness by allowing them to monitor technological changes and strengthen their innovation capabilities. Universities can regulate information transfers by accessing new resources, technical knowledge, and industrial application opportunities [74].

CHAPTER 4
PROJECT EVALUATION USING FUZZY AHP

4.1 Multiple-Criteria Decision Making and AHP

Decisions about the problems people encounter in their daily lives have often and more than one contradictory goals / criteria. Multi-Criteria Decision Making is expressed as the process of assigning values to alternatives by evaluating several criteria together. This method allows you to choose the best one among the criteria's applied more than one and at the same time [75].

Many methods have been developed for Multi-Criteria Decision Making. These methods have some advantages over each other. One of the problems that the decision maker may encounter when starting the solution is to determine which method is the proper method. When determining the most appropriate method, the decision maker should look at the qualification of the problem and its process characteristics [76].

All problems have more than one criterion in very criterion. Relevant criteria are determined in each problem set. Although there are hundreds of factors to consider for the decision, the decision maker can accept the most important criteria. Decision maker will determine the alternatives that are most suitable for him in three stages, assessing the available alternatives under the existence of the determined comparison criteria. Determination of the first stage criteria and ranking of significance levels according to each other. Second step is to determine how well the alternatives represent these criteria and reach the final assessment of each alternative over all criteria. Last step is to choose the alternative with the highest score [77].

Multi-criteria decision making; in terms of the theoretical development as well as practical applications, has shown a rapid development in the field of decision analysis. It has a strong logic structure and a wide range of applications, which has been recognized by its success in decision making. In the first stage of multi-criteria decision

making methods, many methods are used in determining the importance levels of the criteria mentioned. These are Multi Objective Decision Making and Multi Attribute Decision Making methods [78].

Multi Attribute Decision Making method is used to solve problems that arise from multiple criteria. The most preferred methods are Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Techniques for Order Preference by Ideal Solution (TOPSIS), PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation) and ELECTRE (Elimination and Choice Translating Reality) [76].

AHP method was invented by Saaty in the 1970s. AHP is a mathematical method that evaluates qualitative and quantitative variables in decision making, taking into account the priorities of the group or individual. In this method, the decision maker's aim is to determine the factors and the sub-factors belonging to the factors. In the AHP, the aim is first determined and the factors that affect the aim in this direction are tried to be determined. At this stage, the questionnaire study or the opinions of experts in this field can be consulted in order to determine all factors affecting the decision process. Graphical display of the problem target, criterion and decision options should be developed with the determination of factor and sub-factors. Creating a hierarchy for the problem is useful for better understanding the negative situation [79]. An exemplary hierarchy is given in Figure 3.

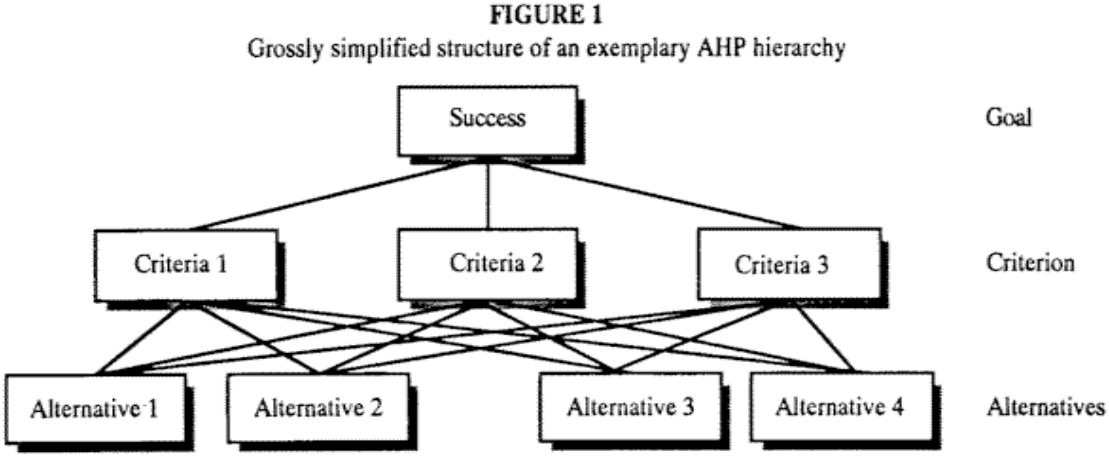

Figure 3. Sample a hierarchy [80].

Binary comparison decision matrices are established to determine the significance levels of factor and sub-factors among themselves. 1-9 importance scale is used recommended by Saaty in constructing these matrices [81]

Intensity of relative importance	Definition	Explanation
1	Equal importance	The two alternatives contribute equally to the objective
3	Moderate importance of one over the other	Experience and judgment slightly favor one over the other
5	Essential or strong importance	Experience and judgment strongly favor one over the other
7	Demonstrated importance	One is judged much more important than the other
9	Extreme importance	The evidence favoring one over the other is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values	When some compromise is needed

Figure 4. Significance Scale Values and Definitions [81]

AHP has a process that simplifies complex decision problems. It examines the definition and elements of decision making decision problem.

The AHP has a process that simplifies complex decision problems. It examines the definition and elements of decision making decision problem. This method allows both objective and subjective considerations of the decision problem to be included in the decision process. AHP is a very suitable method for use in taking group decisions. Contents, elements and requirements of the AHP methodology are generally described above. The steps of implementation of the method are listed to estipulate below [82].

Step 1: Define the problem and determine the target in this problem.

Step 2: Starting from the objectives, criteria in the medium-level and the alternatives in the lowest level should be placed in the hierarchical structure.

Step 3: To determine which alternative or criterion is dominant, using the scale given in Table 1, binary comparisons between alternatives (lowest level) and criteria (intermediate level) should be made and the size of binary comparison matrices (n x n).

Step 4: For each column in the binary comparison matrix, the matrix should be normalized by taking column sums and dividing by the sum of the columns of the elements in the matrix.

Step 5: Row created for each alternative or criterion must be summed to the normalized matrix. (The values calculated in this phase are the priority values for the criteria or options, and the matrix formed by these values is the priority vector matrix.)

Step 6: Priority values obtained for each criterion or option in the priority matrix created by the priority vector must be multiplied by all the elements in the column of the criterion or option in the binary comparison matrix. (Matrix weighted total matrix created with the values calculated in this phase.)

Step 7: Total value of the weighted total matrix should be divided by the priority matrix row values obtained in step 5. The resulting (n x 1) size final the matrix of the values must be arithmetic average. Then the λ_{max} (the greatest eigenvalue of the matrix) must be computed.

Step 8: The priority values obtained for each criterion or option in the priority matrix created by the priority vector must be multiplied by all the elements in the column of the criterion or option in the binary comparison matrix. (Matrix weighted total matrix created with the values calculated in this phase.)

Step 9: The total value of the weighted total matrix should be divided by the priority matrix row values obtained in step 5. The resulting (n x 1) size final the matrix of the values must be arithmetic average. Then the λ_{max} (the greatest eigenvalue of the matrix) must be computed.

Step 10: Calculation of the consistency rate can be summarized as follows.

α_{ij}: The binary comparison matrix (i, j). Value,

w_j: Relative importance vector j. element

λ_{max}: The greatest eigenvalue of the matrix,

n: The size of the matrix,

CI: Consistency Indicator,

CR: Consistency Rate,

RI: Random Indicator.

λ_{max} is calculated as follows.

$$\lambda_{max} = \frac{1}{n} \cdot \sum_{i=1}^{n} [(\sum_{j=1}^{n} a_{ij} \, . w_j)/w_i] \quad (1)$$

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (2)$$

In Figure 5, random values are seen according to the matrix size (n). As size grows, there is also an increase in random values [83].

Random Index (R.I.)

n	1	2	3	4	5	6	7	8	9	10
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Figure 5. Random Index [83].

Consistency rate is calculated as follows.

$$CR = \frac{CI}{RI} \quad (3)$$

The consistency rate in the Analytic Hierarchy Process should be less than 0.10. If the consistency ratio found is greater than 0.10, the binary comparison matrix should be reviewed and the consistency rate calculated by repeating the steps after the correction.

Step 10: Binary comparison results between each other of the criteria are obtained with the alternative priorities calculated based on the criteria. By multiplying the obtained criterion priorities by each alternative, the final priority value to be achieved is calculated.

4.2 Numerical Example with Fuzzy AHP

In this study, we evaluated new innovation projects for companies with the Fuzzy Analytical Hierarchy Method. It is more appropriate to use fuzzy decision making methods in real life problems involving uncertain situations [84].

Criteria and new project alternatives that are important for the firms were identified in the study. Then, general information is given about the general framework of the Fuzzy AHP method. Finally, binary comparison matrices were evaluated to using criteria's, alternatives linguistic variables and fuzzy numbers. New projects determined by the companies are evaluated under the criteria they specify. Most the suitable project has been tried to be determined by way of Fuzzy AHP method for the company.

As companies evaluate new innovation projects, they take into consideration various criteria and try to make choices among many alternatives. With this feature, the problem that has become a multi-purpose decision-making problem can include the criteria with the importance changing according to the decision-maker. These criteria may vary by decision makers [85].

We have identified 4 main criteria for evaluating new innovation projects of companies and 12 specific sub-criteria related to these main criteria. These four main criteria are organizational, technical, strategic, and financial.

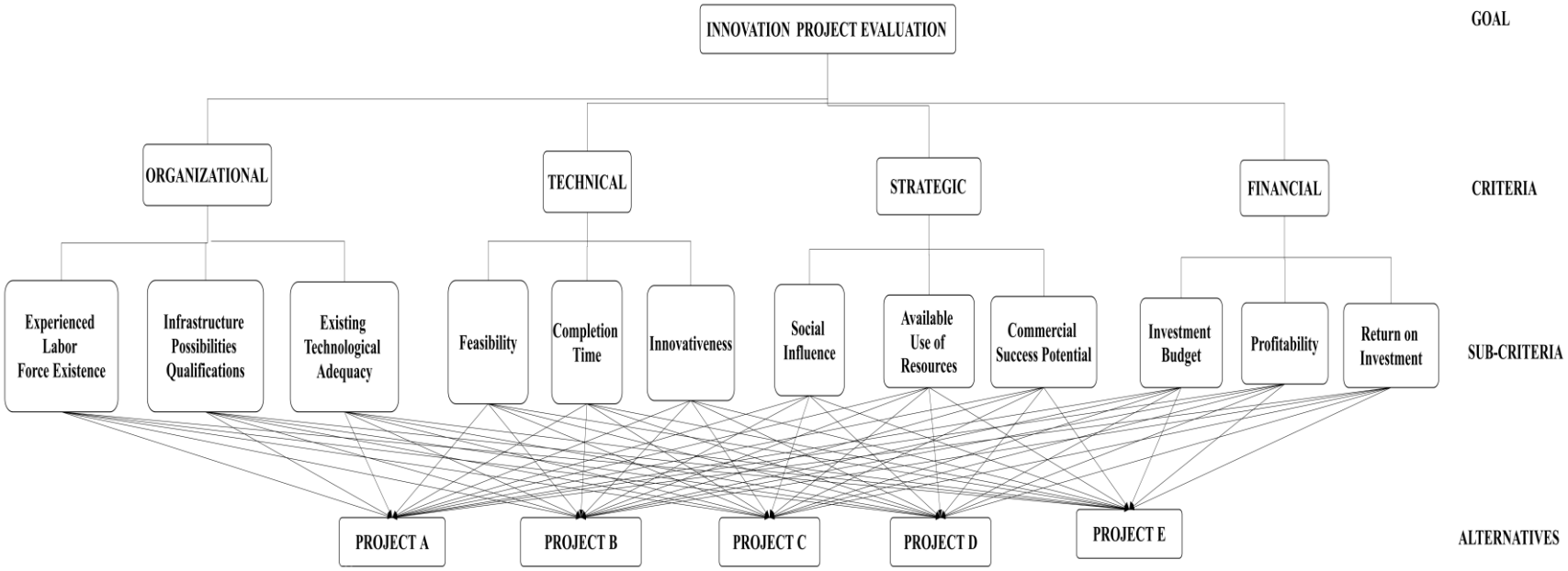

Figure 6. Innovation Project Evaluation AHP Diagram

Organizational structure of a project; it should contribute to the production of productive results that should be formed in accordance with the mission, vision and strategies of the company, include organizational control function, be dynamic, be compatible with one another, be able to be done on time and properly. The organization's main criteria are three sub-criteria. These are experienced labor force existence, infrastructure possibilities qualifications and existing technological adequacy.

Experienced labor force existence: It is necessary to evaluate the existing human resource in the direction of business objectives and determine the future source.

Infrastructure possibilities qualifications: Firms should especially build and develop research infrastructures. It should be encouraged to develop information and technology by benefiting from their infrastructures. Thus, new projects with strong and visionary occur.

Qualifications and existing technological adequacy: Today, technologies are developed very quickly. In order for firms to adapt to the market, new technological developments must be dominated. It is a situation profitable for the company with new technology infrastructure of projects.

Second criterion is technical. When evaluating projects, it is significant to plan for the technical direction. The technical main criterion has three sub-criteria. These are feasibility, completion time and edibility.

Feasibility: Various commercial, economic and social analyzes and environmental impact analyzes are carried out for the projects. When project has passed the analysis successfully, the project will be implemented to the company.

Completion time: Projects are planned for a specific time period to achieve certain goals. The scheduling of the timing factor has a vital importance to the success of the project. Many works to be done in the whole of the project must be carried out in a harmonious manner in a certain time period.

Edibility: Innovation is indispensable for companies today. Projects should always be open to new ideas.

The third man criterion is strategic. Firms should be managed projects in a strategic way. Strategic method is planned in details the development of the project from start to finish. The strategic main criterion has three sub-criteria. These are the social impact, available use of resources and the commercial success potential.

Social Impact: At the same time, an idea has social dimension. The product must be useful to the public, good quality and reliable.

Available use of resources: When developing the project, the resources should be used in place and effectively.

Commercial success potential: While evaluating the projects, the commercial analysis of the product should be estimated.
The fourth main criterion is finance. Financial analysis is absolutely done while companies develop products. Financial main criterion has three sub-criteria. These are the investment budget, profitability and return on investment.

Investment budget: A financial budget should be constituted to develop the project. Companies must not exceed this budget in order to avoid financial loss.

Profitability: It is absolutely necessary for the companies to evaluate the project income and expenditure. For this reason, it turns out that the product is profitable or harmful.

Return on investment: It shows the income of the investment made and whether or not this investment should be continued.

In this study, the extended fuzzy AHP method proposed by Chang was used to calculate the weights of the matrices. [86, 87]

The following section describes the theoretical structure of the Fuzzy AHP method in general.

$X = \{x_1, x_2 \dots, x_n\}$ is an objects sets. $U = \{u_1, u_2 \dots, u_n\}$ is an aims sets.

$$M_{gi}^1, M_{gi}^2, \dots, M_{gi}^m \quad i = 1,2, \dots, n \tag{4}$$

All $M_{gi}^j (j = 1,2, \dots, m)$ values are triangular fuzzy numbers.

The process followed in the method is summarized below [87, 88].
First of all i. the elemental fuzzy synthetic value is defined as follows:

$$S_i = \sum_{j=1}^{m} M_{gi}^j \otimes [\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j]^{-1} \tag{5}$$

The comparison of the synthetic values obtained and the weight values from these comparison values are obtained. The comparison of the two fuzzy numbers and the calculation of the degree of likelihood are done as follows:
While M2 and M1 are two triangular fuzzy numbers, $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$'s probability degree

$$V(M_2 \geq M_1) = \sup_{y \geq x} [\min (\mu_{M1}(x), u_{M2}(y))]$$
$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M2}(d) \tag{6}$$

$$\begin{cases} 1, if\ m_2 \geq m_1 \\ 0, if\ l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, \ other\ conditions \end{cases} \tag{7}$$

The peak intersection point is d point equally between $V(M_2 \geq M_1), d, \mu_{M1}$ and μ_{M2}. It can be expressed as shown in Figure 7.

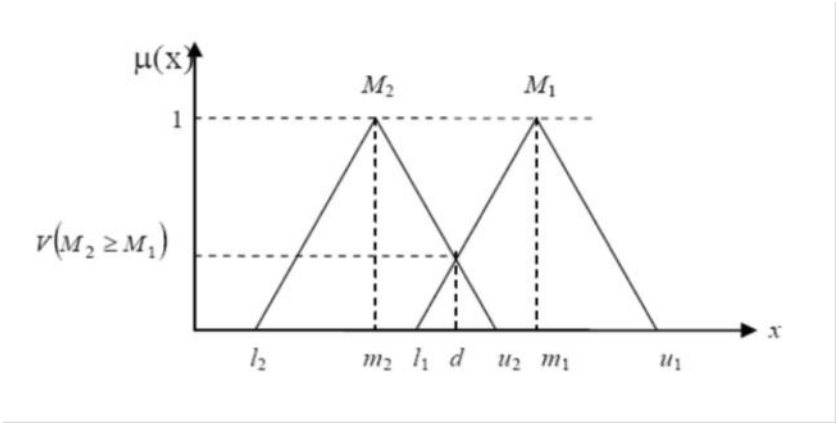

Figure 7. The intersection is between $\boldsymbol{M_1}$ and $\boldsymbol{M_2}$ [89].

The likelihood level of a convex fuzzy number greater than k convex fuzzy numbers (i = 1,2, ..., k) is defined in the following equation 8.

$$V(M \geq M_1, M_2, \dots, M_k) = V[(M \geq M_1), (M \geq M_2) \dots (M \geq M_k) \quad (8)$$

$$= \min V\ (M \geq M_i),\ i = 1,2,3, \dots, k \quad (8.1)$$

Assuming this is $d'(A_i) = min\, V\ (S_i \geq S_k)$,
The weight vector for $k = 1,2, \dots, n;\ \ k \neq i$ is expressed as:

$$W' = (d'(A_1), d'(A_2), \dots, d'\ (A_n))^T \quad (9)$$

$A_i\ (i = 1,2, \dots, n)$

Finally, the weight vectors obtained by normalization are obtained as follows. W represents the weight vector composed of non-blurred numbers.

$$W = (d(A_1), d(A_2), \dots, d(A_n))^T \quad (10)$$

4.3 Implementation

In the implementation phase of the fuzzy analytical hierarchy process method, fuzzy decision matrices were created by first comparing all the measures in a binary way using the scale shown in Table 1 [89]. The comparisons are scored for companies.

Table 1. Scale Used in Fuzzy AHP According to Chang Method for main and sub-criteria [88].

Verbal Importance	**Fuzzy Scale**	**Response Scale**
Equally Important	(1, 1, 1)	(1/1, 1/1, 1/1)
Moderately Important	(2/3, 1, 3/2)	(2/3, 1, 3/2)
Strongly Important	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
Very strongly Important	(5/2, 3, 7/2)	(2/7, 1/3, 2/5)
Absolutely Important	(7/2, 4, 9/2)	(2/9, 1/4, 2/7)

The main criteria and the sub-criteria are compared in the form of two decision matrices in this scale direction and the importance levels of the criteria are calculated. The weight of all the criteria according to the method was first calculated by using two-way comparisons among themselves. When binary comparisons have been assessed in terms of alternatives criteria, and then passed on to finding the best solution to have all the alternatives together.

Table 2. The paired comparison matrix of main criteria

Main Criteria	Organizational	Technical	Strategic	Financial
Organizational	(1, 1, 1)	(3/2, 2, 5/2)	(5/2, 3, 7/2)	(2/3, 1, 3/2)
Technical	(2/5, 1/2, 2/3)	(1, 1, 1)	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
Strategic	(2/7, 1/3, 2/5)	(2/5, 1/2, 2/3)	(1, 1, 1)	(2/7, 1/3, 2/5)
Financial	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(5/2, 3, 7/2)	1, 1, 1

Synthetic values obtained from the values in Table 2:

$S_{Organizational} = (0.233, 0.351, 0.523)$

$S_{Technical} = (0.129, 0.189, 0.282)$

$S_{Strategic} = (0.079, 0.109, 0.157)$

$S_{Financial} = (0.233, 0.351, 0.523)$

$W = (0.350, 0.190, 0.110, 0.350)^T$

Organizational Weight Vector= 0.350

Technical Weight Vector = 0.190

Strategic Weight Vector = 0.110

Financial Weight Vector = 0.350

After the main criteria are evaluated, similar calculations are made for all of the sub-criteria. The evaluation of the sub-criteria for organizational criteria is shown in Table 3.

Table 3. Evaluation of Sub-Criteria Related to Organizational Criteria

Main Organizational Criteria of Each Sub Criterion	Experienced Labor Force Existence	Infrastructure Possibilities Qualifications	Existing Technological Adequacy
Experienced Labor Force Existence	(1, 1, 1)	(2/3, 1, 3/2)	(5/2, 3, 7/2)
Infrastructure Possibilities Qualifications	(2/3, 1, 3/2)	(1, 1, 1)	(3/2, 2, 5/2)
Existing Technological Adequacy	(2/7, 1/3, 2/5)	(2/5, 1/2, 2/3)	(1, 1, 1)

$S_{Experienced\ Labor\ Force\ Existence} = (0.301, 0.443, 0.651)$

$S_{Infrastructure\ Possibilities\ Qualifications} = (0.254, 0.387, 0.582)$

$S_{Existing\ Technological\ Adequacy} = (0.123, 0.169, 0.241)$

$W = (0.442, 0.387, 0.170)^T$

Experienced Labor Force Existence Weight Vector = 0.442

Infrastructure Possibilities Qualifications Weight Vector = 0.387

Existing Technological Adequacy Weight Vector = 0.170

The assessment of the sub-criteria for technical criteria is shown in Table 4.

Table 4. Assessment of Sub-Criteria Related to Technical Criteria

Main Technical Criteria of Each Sub Criterion	Feasibility	Completion Time	Innovativeness
Feasibility	(1, 1, 1)	(7/2, 4, 9/2)	(2/3, 1, 3/2)
Completion Time	(2/9, 1/4, 2/7)	(1, 1, 1)	(2/7, 1/3, 2/5)
Innovativeness	(2/3, 1, 3/2)	(5/2, 3, 7/2)	(1, 1, 1)

$S_{\text{Feasibility}} = (0.322, 0.458, 0.649)$

$S_{\text{Completion Time}} = (0.097, 0.126, 0.167)$

$S_{\text{Innovativeness}} = (0.288, 0.416, 0.597)$

$W = (0.458, 0.126, 0.416)^{T}$

Feasibility Weight Vector = 0,458

Completion Time Weight Vector = 0.126

Innovativeness Weight Vector = 0,416

The evaluation of the sub-criteria for strategic criteria is shown in Table 5.

Table 5. Evaluation of Sub-Criteria Related to Strategic Criteria

Main Strategic Criteria of Each Sub Criterion	Social Influence	Available Use of Resources	Commercial Success of Resources
Social Influence	(1, 1, 1)	(2/3, 1, 3/2)	(2/5, 1/2, 2/3)
Available Use of Resources	(2/3, 1, 3/2)	(1, 1, 1)	(2/7, 1/3, 2/5)
Commercial Success Potential	(3/2, 2, 5/2)	(5/2, 3, 7/2)	(1, 1, 1)

$S_{\text{Social Influence}} = (0.165, 0.240, 0.361)$

$S_{\text{Available Use of Resources}} = (0.147, 0.210, 0.304)$

$S_{\text{Commercial Success Potential}} = (0.398, 0.550, 0.743)$

$W = (0.244, 0.213, 0.543)^{T}$

Social Influence Weight Vector = 0.244

Available Use of Resources Weight Vector = 0.213

Commercial Success Potential Weight Vector = 0.543

The consideration of the sub-criteria for financial criteria is shown in Table 6.

Table 6. Consideration of Sub-Criteria Related to Financial Criteria

Main Financial Criteria of Each Sub Criterion	Investment Budget	Profitability	Return on Investment
Investment Budget	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)
Profitability	(3/2, 2, 5/2)	(1, 1, 1)	(1, 1, 1)
Return on Investment	(3/2, 2, 5/2)	(1, 1, 1)	(1, 1, 1)

$S_{\text{Investment Budget}} = (0.174, 0.228, 0.313)$

$S_{\text{Profitability}} = (0{,}242, 0{,}316, 0{,}410)$

$S_{\text{Return on Investment}} = (0{,}367, 0{,}456, 0{,}556)$

$W = (0.228, 0.327, 0.446)^{T}$

Investment Budget Weight Vector = 0.228

Profitability Weight Vector = 0.327

Return on Investment Weight Vector = 0.446

After the criteria are evaluated within themselves, project alternatives are evaluated on the basis of sub-criteria.

Binary comparisons of the candidate projects with each other according to the 12 sub criteria specified are shown in Table 7 to Table 18. After comparison with each criterion calculated weight vectors are also shown under the tables.

Evaluation of projects according to experienced labor force existence sub-criteria is shown in Table 7.

Table 7. Evaluation of projects according to experienced labor force existence sub-criteria

	Project A	Project B	Project C	Project D	Project E
Project A	(1,1,1)	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(1,1,1)
Project B	(2/3, 1, 3/2)	(1,1,1)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(1,1,1)
Project C	(2/5, 1/2, 2/3)	(3/2, 2, 5/2)	(1,1,1)	(1,1,1)	(3/2, 2, 5/2)
Project D	(2/5, 1/2, 2/3)	(3/2, 2, 5/2)	(1,1,1)	(1,1,1)	(3/2, 2, 5/2)
Project E	(1,1,1)	(1,1,1)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(1,1,1)

$$W_{\text{Experienced Labor Force Existence}} = (0.321, 0.074, 0.288, 0.288, 0.030)^{T}$$

Consideration of projects according to infrastructure possibilities qualifications sub-criteria is shown in Table 8.

Table 8. Consideration of projects according to infrastructure possibilities qualifications sub-criteria

	Project A	Project B	Project C	Project D	Project E
Project A	(1,1,1)	(3/2, 2, 5/2)	(1,1,1)	(1,1,1)	(3/2, 2, 5/2)
Project B	(2/5, 1/2, 2/3)	(1,1,1)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(1,1,1)
Project C	(1,1,1)	(3/2, 2, 5/2)	(1,1,1)	(1,1,1)	(3/2, 2, 5/2)
Project D	(1,1,1)	(3/2, 2, 5/2)	(1,1,1)	(1,1,1)	(3/2, 2, 5/2)
Project E	(2/5, 1/2, 2/3)	(1,1,1)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(1,1,1)

$$W_{\text{Infrastructure Possibilities Qualifications}} = (0.333, 0, 0.333, 0.333, 0)^{T}$$

Assessment of projects according to Existing Technological Adequacy sub-criteria is shown in Table 9.

Table 9. Assessment of projects according to Existing Technological Adequacy sub-criteria

	Project A	Project B	Project C	Project D	Project E
Project A	(1,1,1)	(2/5, 1/2, 2/3)	(1,1,1)	(1,1,1)	(2/5, 1/2, 2/3)
Project B	(3/2, 2, 5/2)	(1,1,1)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(1,1,1)
Project C	(1,1,1)	(2/5, 1/2, 2/3)	(1,1,1)	(1,1,1)	(2/5, 1/2, 2/3)
Project D	(1,1,1)	(2/5, 1/2, 2/3)	(1,1,1)	(1,1,1)	(2/5, 1/2, 2/3)
Project E	(3/2, 2, 5/2)	(1,1,1)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(1,1,1)

$$W_{\text{Existing Technological Adequacy}} = (0, 0.5, 0, 0, 0.5)^{T}$$

Evaluation of projects according to feasibility sub-criteria is shown in Table 10.

Table 10. Evaluation of projects according to feasibility sub-criteria

	Project A	Project B	Project C	Project D	Project E
Project A	(1,1,1)	(5/2, 3, 7/2)	(1,1,1)	(1,1,1)	(5/2, 3, 7/2)
Project B	(2/7, 1/3, 2/5)	(1,1,1)	(2/7, 1/3, 2/5)	(2/7, 1/3, 2/5)	(1,1,1)
Project C	(1,1,1)	(5/2, 3, 7/2)	(1,1,1)	(1,1,1)	(5/2, 3, 7/2)
Project D	(1,1,1)	(5/2, 3, 7/2)	(1,1,1)	(1,1,1)	(5/2, 3, 7/2)
Project E	(2/7, 1/3, 2/5)	(1,1,1)	(2/7, 1/3, 2/5)	(2/7, 1/3, 2/5)	(1,1,1)

$$W_{\text{Feasibility}} = (0.333, 0, 0.333, 0.333, 0)^{T}$$

Consideration of projects according to completion time sub-criteria is shown in Table 11.

Table 11. Consideration of projects according to completion time sub-criteria

	Project A	Project B	Project C	Project D	Project E
Project A	(1,1,1)	(5/2, 3, 7/2)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(3/2, 2, 5/2)
Project B	(2/7, 1/3, 2/5)	(1,1,1)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(1,1,1)
Project C	(2/5, 1/2, 2/3)	(3/2, 2, 5/2)	(1,1,1)	(1,1,1)	(3/2, 2, 5/2)
Project D	(2/5, 1/2, 2/3)	(3/2, 2, 5/2)	(1,1,1)	(1,1,1)	(3/2, 2, 5/2)
Project E	(2/5, 1/2, 2/3)	(1,1,1)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(1,1,1)

$$W_{\text{Completion Time}} = (0.557, 0, 0.222, 0.222, 0)^{T}$$

Assessment of projects according to innovativeness sub-criteria is shown in Table 12.

Table 12. Assessment of projects according to innovativeness sub-criteria

	Project A	Project B	Project C	Project D	Project E
Project A	(1,1,1)	(3/2, 2, 5/2)	(1,1,1)	(1,1,1)	(3/2, 2, 5/2)
Project B	(2/5, 1/2, 2/3)	(1,1,1)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	1,1,1
Project C	(1,1,1)	(3/2, 2, 5/2)	(1,1,1)	(1,1,1)	(3/2, 2, 5/2)
Project D	(1,1,1)	(3/2, 2, 5/2)	(1,1,1)	(1,1,1)	(3/2, 2, 5/2)
Project E	(2/5, 1/2, 2/3)	(1,1,1)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(1,1,1)

$$W_{\text{innovativeness}} = (0.333, 0, 0.333, 0.333, 0)^{T}$$

Evaluation of projects according to social influence sub-criteria is shown in Table 13.

Table 13. Evaluation of projects according to social influence sub-criteria

	Project A	Project B	Project C	Project D	Project E
Project A	(1,1,1)	(2/5, 1/2, 2/3)	(3/2, 2, 5/2)	(1,1,1)	(2/7, 1/3, 2/5)
Project B	(3/2, 2, 5/2)	(1,1,1)	(5/2, 3, 7/2)	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
Project C	(2/5, 1/2, 2/3)	(2/7, 1/3, 2/5)	(1,1,1)	(2/5, 1/2, 2/3)	(2/7, 1/3, 2/5)
Project D	(1,1,1)	(2/5, 1/2, 2/3)	(3/2, 2, 5/2)	(1,1,1)	(2/5, 1/2, 2/3)
Project E	(5/2, 3, 7/2)	(3/2, 2, 5/2)	(5/2, 3, 7/2)	(3/2, 2, 5/2)	(1,1,1)

$W_{\text{Social Influence}} = (0, 0.392, 0, 0, 0.608)^T$

Consideration of projects according to available use of resources sub-criteria is shown in Table 14.

Table 14. Consideration of projects according to available use of resources sub-criteria

	Project A	Project B	Project C	Project D	Project E
Project A	(1,1,1)	(5/2, 3, 7/2)	(2/5, 1/2, 2/3)	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
Project B	(2/7, 1/3, 2/5)	(1,1,1)	(1,1,1)	(2/3, 1, 3/2)	(2/7, 1/3, 2/5)
Project C	(3/2, 2, 5/2)	(1,1,1)	(1,1,1)	(5/2, 3, 7/2)	(2/3, 1, 3/2)
Project D	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(2/7, 1/3, 2/5)	(1,1,1)	(3/2, 2, 5/2)
Project E	(3/2, 2, 5/2)	(5/2, 3, 7/2)	(2/3, 1, 3/2)	(2/5, 1/2, 2/3)	(1,1,1)

$W_{\text{Avaiable Use of Resources}} = (0.264, 0, 0.322, 0.117, 0.296)^T$

Assessment of projects according to commercial success potential sub-criteria is shown in Table 15.

Table 15. Assessment of projects according to commercial success potential

	Project A	Project B	Project C	Project D	Project E
Project A	(1,1,1)	(1,1,1)	(2/7, 1/3, 2/5)	(3/2, 2, 5/2)	(5/2, 3, 7/2)
Project B	(1,1,1)	(1,1,1)	(3/2, 2, 5/2)	(2/3, 1, 3/2)	(2/5, 1/2, 2/3)
Project C	(5/2, 3, 7/2)	(2/5, 1/2, 2/3)	(1,1,1)	(2/5, 1/2, 2/3)	(2/7, 1/3, 2/5)
Project D	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(1,1,1)	(2/3, 1, 3/2)
Project E	(2/7, 1/3, 2/5)	(3/2, 2, 5/2)	(5/2, 3, 7/2)	(2/3, 1, 3/2)	(1,1,1)

$$W_{\text{Commercial Success Potential}} = (0.263, 0.160, 0.142, 0.172, 0.263)^{T}$$

Evaluation of projects according to investment budget sub-criteria is shown in Table 16.

Table 16. Evaluation of projects according to investment budget sub-criteria

	Project A	Project B	Project C	Project D	Project E
Project A	(1,1,1)	(2/3, 1, 3/2)	(2/3, 1, 3/2)	(2/3, 1, 3/2)	(3/2, 2, 5/2)
Project B	(2/3, 1, 3/2)	(1,1,1)	(2/5, 1/2, 2/3)	(5/2, 3, 7/2)	(2/3, 1, 3/2)
Project C	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(1,1,1)	(5/2, 3, 7/2)	(5/2, 3, 7/2)
Project D	(2/3, 1, 3/2)	(2/7, 1/3, 2/5)	(2/7, 1/3, 2/5)	(1,1,1)	(1,1,1)
Project E	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(2/7, 1/3, 2/5)	(1,1,1)	(1,1,1)

$$W_{\text{Investment Budget}} = (0.229, 0.254, 0.517, 0, 0)^{T}$$

Consideration of projects according to profitability sub-criteria is shown in Table 17.

Table 17. Consideration of projects according to profitability sub-criteria

	Project A	Project B	Project C	Project D	Project E
Project A	(1,1,1)	(2/3, 1, 3/2)	(1,1,1)	(5/2, 3, 7/2)	(3/2, 2, 5/2)
Project B	(2/3, 1, 3/2)	(1,1,1)	(2/5, 1/2, 2/3)	(3/2, 2, 5/2)	(2/3, 1, 3/2)
Project C	(1,1,1)	(3/2, 2, 5/2)	(1,1,1)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)
Project D	(2/7, 1/3, 2/5)	(2/5, 1/2, 2/3)	(3/2, 2, 5/2)	(1,1,1)	(5/2, 3, 7/2)
Project E	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(2/7, 1/3, 2/5)	(1,1,1)

$$W_{\text{Profitability}} = (0.325, 0.183, 0.114, 0.256, 0.122)^{T}$$

Assessment of projects according to return on investment sub-criteria is shown in Table 18.

Table 18. Assessment of projects according to return on investment sub-criteria

	Project A	Project B	Project C	Project D	Project E
Project A	(1,1,1)	(2/7, 1/3, 2/5)	(3/2, 2, 5/2)	(1,1,1)	(2/3, 1, 3/2)
Project B	(5/2, 3, 7/2)	(1,1,1)	(5/2, 3, 7/2)	(2/5, 1/2, 2/3)	(3/2, 2, 5/2)
Project C	(2/5, 1/2, 2/3)	(2/7, 1/3, 2/5)	(1,1,1)	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
Project D	(1,1,1)	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)	(1,1,1)	(2/7, 1/3, 2/5)
Project E	(2/3, 1, 3/2)	(2/5, 1/2, 2/3)	(3/2, 2, 5/2)	(5/2, 3, 7/2)	(1,1,1)

$$W_{\text{Return on Investment}} = (0.105, 0.528, 0, 0.007, 0.359)^{T}$$

After each criterion and the weights of the candidates for these criteria are calculated, the display of all priority weights is shown in Table 19.

Table 19. The Final Results of the Projects Evaluations

Main Criteria Weight Vector		Sub-Criteria Weight Vector		Project A	Project B	Project C	Project D	Project E
Organizational	0.350	Experienced Labor Force Existence	0.442	0.321	0.074	0.288	0.288	0.030
		Infrastructure Possibilities Qualifications	0.387	0.333	0	0.333	0.333	0
		Existing Technological Adequacy	0.170	0	0.5	0	0	0.5
Technical	0.190	Feasibilty	0.458	0.333	0	0.333	0.333	0
		Completion Time	0.126	0.557	0	0.222	0.222	0
		Innovativeness	0.416	0.333	0	0.333	0.333	0
Strategic	0.110	Social Influence	0.244	0	0.392	0	0	0.608
		Available Use of Resources	0.213	0.264	0	0.322	0.117	0.296
		Commercial Success Potential	0.543	0.263	0.160	0.142	0.172	0.263
Financial	0.350	Investment Budget	0.228	0.229	0.254	0.517	0	0
		Profitability	0.327	0.325	0.183	0.114	0.256	0.122
		Return on Investment	0.446	0.105	0.528	0	0.007	0.359
Total weight vectors				0.255	0.174	0.217	0.172	0.182
Rank				1	4	2	5	3

When an evaluation is made by looking at alternative priority weights, it is seen that there is a ranking among the projects. We have reviewed the main criteria of organization, technical, strategic and financial to uncover new product innovation projects for companies. Financial (35%) and organizational (35%) topics seem to be more important.

We reviewed the sub-criteria of the organization's main criteria. In terms of decision makers, the capacity of experienced labor force has the highest importance of 44%. The importance level of infrastructure possibilities qualifications is second rank with 38%.
When we review the technical main criterion, feasibility has the highest precaution with 46 percent. The innovativeness sub-criterion is second at the importance level with 42 percent.

We have analyzed the sub-criteria of the strategic main criteria. In terms of decision maker, the commercial success potential is the highest with 54 percent. Social influence is second in importance with 24 percent.

When we reviewed the financial main criteria, return on investment has a 45 percent significance level. The significance level of profitability is second rank with 33%.
When all criteria and alternatives determined by the decision maker are evaluated taking into consideration; the most suitable project for companies is project A (26%). The second eligible project is project C (22%). The third favorable project is project E (18%).

All weights were calculated using Microsoft Excel.

CHAPTER 5
CONCLUSIONS

Businesses have to change and adapt to the process they have in order to sustain their economic lives. They should also take into account the fact that their competitors may come up with a product that will change the competition rules at any time. Having the power to change and adapt is crucial for companies to survive.

We have designed a new product innovation system so that the companies market is also permanent. This system is idea the most important key point. For example, many ideas come from customers, competitors, suppliers etc. Ideas are predestinated on the board. The ideas that can be realized are taken to the candidate project status. These candidate projects are reevaluated with extensive testing. Five projects are selected on the evaluation result. These five projects have been included in the product development process. These processes include project plan, design, test, prototype, patent and property rights and product planning functions. Projects that pass these processes successfully transmit to the production section. Product is tested in pilot production. The product that receives positive results from the test is passed through series production.

As we evaluate candidate projects, we used fuzzy AHP method with a numerical example. In this method we have identified 4 main criteria. These are organization, technical, strategic and finance. Firms attach more importance to the financial and organizational situation. Technical and strategic issues are less important than other criteria. In the financial situation, profitability and return on investment should be analyzed well. A strong infrastructure must be established for the realization of the projects in the organization. Companies must have experienced labor force existence. Projects should be innovative and feasible in the technical department. In the strategic part of the projects, they should give significance to commercial potential and social influence.

As a result, companies must innovate if the market wants to be permanent. A systematic, planned and analytical way must be followed to create a new product. A company with an innovation system is always one step ahead of other companies.

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