

## PAPER DETAILS

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## Investigation of the Criteria Affecting the Decision of Use of Drone Technology in the Logistics Sector by DEMATEL Method

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### Abstract

Logistics is a dynamic sector that has been affected by technology since its early times. Drone vehicles rose up to the idea that technology can be integrated into logistics due to the ability to move objects from one point to another. The main idea of this study is to integrate drone technology into the logistics industry and purpose is; It is the theoretical investigation of the effects of drone technology on the logistics industry today and in the future also the determination of the degree of impact. In this research process, a literature study was conducted under the name of innovation, new technology and logistics terms also. A table was created with the subject headings obtained as a result of the literature analysis and new criteria were determined. These criteria are presented to expert opinion. These tables were analyzed with the DEMATEL decision-making method and the effectiveness levels of the criteria were determined. While the most determined criterion was the increase in the market share of the firm also the criterion with the least impact was determined as security problems. Interviews and analyzes have proven that drone technology will have an important place in the logistics industry in the future.

**Keywords:** Drone (UAV), Innovation, Logistics, New Technology, DEMATEL

### 1. Introduction

Logistics is originally a military term. However, the real importance of this term on the stage of history was first grasped during World War II and then logistics began to be viewed and applied from a scientific perspective. After the 2<sup>nd</sup> World War, many US businesses accepted the importance of

logistics and started to benefit from logistics services that have been continuing since 1960 [1]. The short definition of logistics; is the supply of a product from one point to another within the framework of five lines (the right product, the right price, the right time, the right place and the right

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amount of product). Logistics has many parts within itself, storage and stocking, production logistics, distribution logistics and reverse logistics, etc. One of the sectors most affected by technological developments over time is exactly the logistics sector. E.g; Use of QR codes, integration of GPS systems into transport vehicles, placement of AS/RS systems in warehouse and stocking processes, etc [2].

Drones (Unmanned Aerial Vehicles - UAV) can be controlled by fly or go on the ground thanks to commands given by remote control or computer systems. Recently, we have seen that drone technology has been used in many areas and workloads also costs have decreased in these areas. In many and our country, drone technology has not yet been fully used in logistics and other fields but when we look at the developments in the world, only seen that companies such as Amazon<sup>TM</sup>, American Express<sup>TM</sup>, AliExpress<sup>TM</sup> and FedEx<sup>TM</sup> are experimenting with drone transportation.

Since the first day of its use, drone technology has been integrated into many sectors such as security, journalism, military, agriculture and construction etc. It has given rise to the idea that drone vehicles can be integrated into logistics with the ability to transfer (transport) physical objects from a certain point to another desired point. From this point of view, the main idea of the study is to integrate drone technology into the logistics sector in our country and others also to investigate the current and future importance and effects theoretically then analyzing the specified factors within which it can be beneficial for users.

In the research process, a literature study was conducted under the name of innovation, new technology and logistics terms. In order to analyze the subject more powerfully, in-depth interview questions were asked to logistics experts. A table was created with the subject headings obtained as a result of the literature analysis and new criteria were determined. These criteria were presented to expert opinions. These all tables were analyzed with the DEMATEL method and the importance levels of the criteria were determined. In addition, it is thought that some new criteria that have not been created on the relationship between drone and logistics earlier which will be created in this study and will help with the criteria for future studies.

## 2. Literature Review

Gökmen, Özdemir (2016), analyzed the relationship between R&D, innovation, export and economic growth in Turkey. In this research, two different methods were used as Zivot-Andrews test and Engle-Granger cointegration analysis [3]. The study was carried out as two separate models and the direct positive from the patent to the growth, the negative directly from the growth to the patent and the negative components from the research-development to the growth were obtained and the unilateral connection result was obtained.

Yavuz (2010), investigated the effect and/or contribution of innovation activities carried out in enterprises to organizational performance in his study [4]. The scope of this research is set out in the "Oslo Manual Manual (2005)", as Marketing and organizational, products and processes innovation types also these terms are taken into account [5]. The results have identified that organizational innovation has an integrated effect by affecting other types of innovation and positively affects financial performance.

Wagner (2008), develops a conceptual framework for innovation management in logistics service providers that taking both macro-sectoral and micro-firm level perspectives. Empirical data on the German transport industry are applied to explain the current situation [6]. The results show that despite the importance of innovation for the competitiveness of logistics service providers, the innovation activities of companies in this sector and the share of innovators are at a lower level than other sectors. Only 30 percent of LHSs are innovative. LHS innovation is less based on structured innovation, new product development and commercialization processes but instead often becomes visible in the form of investments in technologically advanced infrastructure and equipment.

Budak (2019), investigated the progress of drone journalism in Turkey and its meaning for reporters in the journalism industry and its functionality in news gathering in his research [7]. Drone usage actions of Anadolu Agency, Demirören News Agency, Ihlas News Agency in journalism were investigated. As a method, descriptive analysis method was used although the results provide

positive contributions to the journalism sector, ethical and safety issues that we can list as negative besides these positive aspects are emphasized.

Yılmaz (2019), made predictions and researches for some specific situations in these recent periods when drone usage areas have expanded in his study [8]. For example, this research has been prepared on the areas of use of unmanned aerial vehicles in humanitarian logistics activities. The necessary information for this purpose was collected by the literature review method. The humanitarian aid logistics management applications of unmanned aerial vehicles were defined and the study subjects related to the unmanned aerial vehicles supported humanitarian aid logistics were mentioned also it proved that unmanned aerial vehicles are a technology with future potential for the activities applied in the field of humanitarian aid.

Burmaoğlu (2010), aimed to determine the relationship between national innovation indicators, national logistics performance and to investigate the effect of innovation indicators on the logistics performance of countries, in his article [9]. For this purpose, the relationship between logistics performance and innovation indicators was examined and as a result of these analyzes, the positive and statistically significant effect of human resources and intellectual assets variables on logistics performance was presented as an innovation policy proposal.

Erdal (2018), aimed to determine the importance levels of the main logistics innovation skills in order to support which innovation skills LHSs will focus on and to make the best use of the resources they have opened in this direction [10]. Within the scope of this purpose, in-depth interviews were conducted with the managers of three logistics companies that had at least one activity on logistics and innovation in the last five years and five different experts including two academicians from the International Logistics Management department who were acquainted with the MCDM method. As a result of these interviews, the importance levels of the main logistics innovation capabilities were revealed by using the judgments of the experts and the analytical hierarchy process method.

Çakıcı (2016), aims to evaluate the relationship between innovation and sustainable competitive advantage in the context of food and beverage

businesses [11]. Within the scope of this study, the data obtained through the survey of 153 food and beverage businesses which have the tourism business and investment certificate given by the Ministry of Culture and Tourism and maintain their effectiveness in Istanbul at the same time that were analyzed with the convenience sampling method. Descriptive statistics, factor analysis, simple and stepwise regression analyzes were used to analyze the data. It has been identified that innovation activities and investments directly affect sustainable competitive advantage within the scope of food and beverage businesses.

Bastürk (2018), was investigated by using a mathematical approach on traffic control with drones in Istanbul, in the study [12]. It is aimed to collect instant data by making controls with a minimum number of drones in the busiest traffic areas. The regions where the application is made are the E-5 and 3-80 highways. At the end of the study, the current traffic control system and the use of drones will be compared in terms of various factors. Lower maintenance cost, large scanning area capacity, instant data collection capability and earthquake, flood, etc. It is thought that its features such as being able to operate effectively in natural disasters will provide an advantage to the use of drones in traffic control.

Erdal and Korucuk (2018), investigated the importance of the objectives of new technologies, in their research [10]. There are criteria determined by the Turkish Statistical Institute (TUIK) about the importance levels of the aims of new technologies. These are: increase in sales revenue, increase in the market share of the company, decrease in logistics costs and expenses and increase in profit volume. It was made with a solution between the aforementioned factors and the companies that provide services in the field of logistics. Considering these issues, the priorities of innovation objectives were determined with the fuzzy DEMATEL method by conducting face-to-face interviews with the managers of 12 different companies working in the field of logistics that have carried out any innovation activity in the city of Erzurum in the last five years. The results of the Innovative Research conducted by TURKSTAT in 2010-2012 were compared with the results of the aforementioned article. "Increasing the company's

market share", "increasing the profit volume" and "decreasing the logistics costs and expenses" were determined as the most important criteria for innovation purpose.

Şimşit (2014), evaluated Turkey's Logistics Performance in the Framework of Global Competition and Innovation. World Bank Logistics Performance Index data was used [13]. Turkey's logistics performance has been tried to be determined by using different focal points descriptive statistical techniques method. Logistics performance; Over time, due to reasons such as globalization, structural changes in trade and rapidly developing technology so it has become a key tool in countries' trade volumes, export diversification, their capacity to attract foreign investors and thus economic growth and competitive advantage. In this sense, Turkey is in a very important geostrategic and geopolitical position and a rapid growth has been observed in the logistics sector since the beginning of the 2000s.

Yıldırım (2016), aimed to investigate the effect of drone technology on logistics and to determine its advantages and disadvantages, in his article [14]. Within the scope of this study, current applications and projects in the world of logistics have been researched and the advantages and disadvantages have been tried to be determined. At the same time, today's usage areas were also used. The main focus of this study is the logistics perspective on drone technology. When we analyze drone usage, it can be said that there is a great expectation in commercial matters, government regulations and industry benefits. The use of drones is expected to create significant advantages for both. If necessary legal arrangements are made, it is possible for end users and sectoral enterprises to use it commercially.

Murray and Chu (2015), answered questions such as whether the drone can be used in different sectors what advantages it will provide if it is used and how solutions will be provided to the problems that it will create [15]. The areas where drone technology is used are no longer limited to the military. In this new parcel delivery paradigm, two mathematical programming models are presented that aim to steer and program drones and delivery trucks in the most efficient way. A scenario where drones collaborate with other delivery vehicles is presented. Two simple but effective and intuitive solution

approaches are presented for solving practical size problems which along with mixed integer linear programming formulations for the drone delivery problem of two sizes.

Kambir (2019), a review of the drone supply system was made in their research and focused on the advantages of drone use [16]. E-Commerce has become very widespread today also food orders and grocery shopping have increased in the form of delivery from the seller to the door. Speed and reliability have become an important criterion in such forms of shopping. Recently, there have been technological developments in the field of drones. In this study, Naza M-Lite control system, ESC (Electronic Stability Program) and GPS systems were used. The results achieved and predicted by the GPS system utilized within the scope of this project increase accurate delivery. Shortening delivery times and giving a precise performance are some of the advantages it provides. We can control the drone's behavior and also adjust its direction and speed with the ESC system.

Işık and Kılınç (2011), researched the importance of R&D and innovation in regional development and analyzed them by comparing [17]. Innovation and knowledge have now become an important element in the development of countries. Many countries are in search of a model focused on innovation and knowledge. Now, instead of traditional production factors such as labor and capital, the importance of knowledge has increased and the focus has been on the production of innovative products and goods that provide added value. In this project, the ratio of R&D expenditures in GDP, the number of researchers and entrepreneurs, the number of patent registrations and applications, the number of trademark and utility model registrations were determined as innovation indicators. These indicators have been compared for the World, OECD, EU-27, Japan, USA, Turkey, Greece, China and Brazil. As a result of this research, it has been concluded that countries with a higher share of R&D and innovation expenditures in GDP have a competitive advantage. In the light of these data, it would not be wrong to say that innovation and R&D expenditures have a positive effect on development. Companic (2018), aimed to integrate various theoretical perspectives on technology diffusion and adoption to inform supply chain decision makers

when to invest in new robotic systems and to propose a framework [18]. In these periods when the technology-life cycle is decreasing, the rise of e-commerce and the difficulties in finding qualified personnel in warehouse activities have increased the competition. In these cases, companies have started to turn to technology and robotic systems. In this study process, robotic systems and technological breakthroughs made and tried in this field were examined and certain criteria came to the fore. The use of drones in the warehouse has offered significant efficiency for stock handling and stock transparency. Drone system used in Amazon<sup>TM</sup> warehouses that reducing the costs in the collection process which is the biggest warehouse cost can be counted as a development that will lead to the adoption of the drone system. On the other hand, these developments are the developments that can shed light and set an example for this field in our country.

McCunney and Cauwenberghe (2019), can drones be blended with other transportation methods, not just on their own and to achieve shorter times and lower costs in the procurement process? answers to the questions were sought [19]. They are very rare in Turkish sources while such studies are more common in foreign sources in the literature.

Also this study examines when drones can be used to supply trucks with products to reduce delivery time and costs. The project started with the idea of establishing transfer bases at certain points that supplying drones from the warehouse to this base also loading products onto trucks. The study used SIMIO simulation as a method and applied a subset of the city of Boston and Pittsfield, Transfer points and same-day deliveries in the rural area around MA are simulated on the relationship between drone and truck. As a result of these simulations, the project in the Pittsfield region was found to be 36% faster than the traditional transportation method. Time and costs are the main components of logistics. This process also reduced the distance trucks traveled per 8-hour working day by 24%. In the Boston study, package deliveries were 66% faster and trucks traveled 10% less per day. This study has shown how important drone deliveries are and how they reduce costs and delivery times.

Yoo (2018), looked at drone transport from a different perspective. Because this study is not

viewed by LHSs but in terms of customers' adoption of this method [20]. This research conducted an online survey among 296 U.S. consumers to investigate their opinions to determine attitudes towards the delivery service of drones. Although the results have negative consequences such as complexity, performance risk and privacy risk, they play an important role in shortening delivery times and being environmentally friendly by minimizing carbon emissions.

Iino (2018), describes Hitachi's drone and business project in collaboration with industry, academia and government in their research [21]. The aging of the population and the decrease in birth rates cause inadequacies in the working population today and in the future. For this reason, there is a tendency to operate with unmanned aerial vehicles to support human operations. The cultivated use of drones is expected in applications such as infrastructure inspections, measurement, crop growth analysis and disaster response especially in urban areas. Hitachi Group has started the project called "Drone Business Project" jointly with different departments and produces a wide variety of solutions.

Edwards (2018), investigates the factors that trigger the adoption of drone as distribution mechanics in Chinese logistics companies [22]. Using the "Technology Acceptance" model which is presented as security, perceived usefulness, and perceived ease of use as factors affecting the purpose of use and a model of potential barriers to its adoption has been developed. A survey was conducted and confirmed by using empirical data in order to examine these factors. It appears that resolving key security issues during product delivery and ingestion is a crucial consideration for e-commerce suppliers.

Şekkeli and Minister (2016), investigated the connection between logistics coordination skills, logistics innovation skills, customer relations skills (CRM) and competitive advantages and logistics performance of companies working in the logistics sector, in their study [23]. Data were collected from logistics companies in 9 cities of Turkey which are members of UND by means of questionnaires within the scope of this study. The data were analyzed with the SPSS method. As a result of this research, it was concluded that there are significant connections between logistics coordination skills,

logistics innovation skills and CRM and competitive advantage and logistics performance. The common points of these studies are that they are written on the effects of innovation, logistics and new technological tools on logistics or their integration into the logistics sector. They are studies that can help the most up-to-date technology studies such as drone technology since these studies were written in 2010 and after and keep up to date.

### 3. Innovation and Drone Technology

In the “Oslo Manual”, the concept of innovation is defined as “the application of a new or significantly improved product or process, innovative marketing method or new organizational method in internal business execution, company organization or external contacts” [24].

The term innovation has been classified in many ways in the literature. It has been examined separately in terms of innovation degrees, applied areas and features. Technical and managerial distinctions have been made in the literature for the term innovation. Technical innovations are the principle related to the priority business movements of the enterprise and managerial innovation is the innovations that occur in the social order of the enterprise [25].

Innovation in logistics has been defined as “any logistics-related service is that from the basic to the complex up to a specific focus group that is seen as new and helpful. The audience can be internal where innovations increase operational efficiency or external where innovations serve customers better”.

A drone is within the ability to take off and land vertically also fly linearly and carry loads. It is equipped with different cutting-edge technology such as infrared cameras, GPS and laser (consumer, commercial and military UAV). Drone vehicles controlled by remote ground control systems (GSC) are also specially designed to be small and fully functional and equipped with technologies called payload [26].

Drone usage areas in logistics that can make inventory in a warehouse, transport goods by air or perform security duties. In the United States, some companies use drones to deliver products to the end customer. Many companies including Stock

Logistics are already valuing the real options of using this type of technology for their warehousing services. E.g; A series of transmission tests were carried out on medical supplies in remote areas of Rwanda and the program was later expanded to Ghana [27].

Telematics refers to a set of technologies used to remotely monitor and control devices. E.g; shipment tracking, vehicle diagnosis and driver hours monitoring etc(Figure 1). Radio Frequency Identification technology can be used to track goods and products throughout the supply chain. While few companies have applied this technology to their supply chains and a recent study found that one-third of companies are actively considering this technology for supply chain applications and 12% will implement it within the next two years [28].

Some of the advantages of using this technology are:

1. Distribution costs are saved,
2. Faster deliveries are made,
3. They provide the opportunity to reach hard-to-reach areas,
4. They reduce urban traffic and CO<sub>2</sub> emissions,
5. They help control stocks and movements inside the warehouse,
6. No shifts are required because drones can operate 24 hours a day, 365 days a year.

Shipping companies like FedEx<sup>TM</sup> and UPS<sup>TM</sup> use drones to monitor traffic and optimize drivers' routes based on real-time data. Logistics companies such as DHL<sup>TM</sup>, Amazon and related organizations such as Google<sup>TM</sup> are developing and testing unmanned aerial vehicles, especially for transporting light consumer goods. For example, Boeing has recently developed a drone to carry payloads of up to 225 Kilograms [29].

Additionally, farmers are using drones to monitor livestock over large areas. Firefighters use drones to monitor and map fires. Private companies use drones to monitor pipelines, buildings, and similar infrastructures. Using drones to inspect power lines, towers, tall structures such as chimneys and roofs will save businesses huge amounts of money and prevent human harm and risks [30].

With the help of specific electromagnetic sensors, drones can be used to gather geological

information to help geophysicists identify and better predict the location and presence of minerals, oil and natural gas. Surrounding sensors that can be packed into a drone can be used to help find and save life in the midst of natural disasters. Drones can be used to collect and deliver medical samples, supplies and medicines to remote or otherwise inaccessible areas in a disaster area. Drones can also use infrared sensors to detect humans with heat signatures which is helpful in search and rescue scenarios. The police delegate traffic controls, vehicle monitoring and tracking to drones [31].

#### 4. Methodology

Multi-Criteria Decision Making (MCDM) is a discipline that deals with decisions that are subject to several criteria or qualities that may be concrete or uncertain involving the selection of the best alternative from several potential candidates in a single decision. Typically, a decision problem is a situation in which an individual has to choose one of them without prior knowledge of alternative courses of action available and which is the best. A decision process can be organized in three stages: defining the purpose of the decision, recognizing the problem to be solved, diagnosing cause-effect relationships for the decision situation and determining the decision. The second phase is model development and use which includes the development of formal models to systematically and transparently compare decision makers' preferences, values, trade-offs, alternatives or actions with each other. The third stage is the development of action plans such as analysis does not resolve the decision. The purpose of a decision process is to effectively generate information about the decision problem from available data.

Since parametric statistical techniques such as Regression, ANOVA and FACTOR Analysis etc. cannot be used because of assumptions that can not be provided for a limited population for Scala and the Questionnaire. DEMATEL was preferred among the operational techniques suitable for the structure of the problem and at the same time, it was aimed to determine the importance levels of the criteria determined in the study. As it is known,

DEMATEL is a technique that can be applied when decision makers are limited or few.

#### 5. DEMATEL Method

In this section, multi-criteria decision making methods and the DEMATEL method which is chosen for this study will be discussed. In this study, various criteria regarding the relationship between Turkey logistics and drone were prepared by blending the criteria that LSPs (Logistics Service Provider) look at before using innovative products and the criteria in the research on the use of drone technology in the field of logistics. A proposal will be made to LSPs by determining the weighting levels of these criteria. The DEMATEL technique can transform the relationships between factors into an understandable structural model of the system and divide them into a cause group as well as an effected group [32].

DEMATEL was developed to solve the complex problems. This method can increase the understanding of the particular problematic group of interacting factors and criteria and provide a viable solution by creating a hierarchical related network system. This technique is widely used in solving complex problems. The DEMATEL method is a powerful method that allows group information collection and is a powerful method in terms of both creating a structural form and visualizing the cause relations of sub-systems on a figure [33].

Steps to be followed in DEMATEL solution as follows;

##### *Step 1: Defining the problem*

The identified problem should be clearly stated.

##### *Step 2: Determination of criteria*

The correct determination of the criteria is necessary to examine the relations as accurately as possible.

##### *Step 3: Measuring the relationship between criteria*



0	No Effect
1	Low Impact
2	Moderate Impact
3	High Impact
4	Very High Impact

Step 4: Creating a direct relationship matrix

$$X = \begin{bmatrix} 0 & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & 0 \end{bmatrix}$$

Step 5: Normalization of the direct relationship matrix

$$s = \max(\max \sum_{j=1}^n X_{ij}, \sum_{i=1}^n X_{ij})$$

$$C = \frac{X}{s}$$

Step 6: Creation of the aggregate relationship matrix

$$\lim_{H \rightarrow \infty} C + C^1 + C^2 + \cdots + C^H$$

$$F = C + C^1 + C^2 + \cdots + C^H = C(I - C)^{-1}$$

$$F = \begin{bmatrix} f_{11} & \cdots & f_{1n} \\ \vdots & \ddots & \vdots \\ f_{i1} & \cdots & f_{in} \\ \vdots & \ddots & \vdots \\ f_{n1} & \cdots & f_{nn} \end{bmatrix}$$

Step 7: Determining the relationship between the criteria

$$D_i = [\sum_{j=1}^n f_{ij}]_{n \times 1}$$

$$R_j = [\sum_{i=1}^n f_{ij}]_{n \times 1}$$

Step 8: Creating the network diagram

Step 9: Determination of criterion weights

$$W_{ia} = \sqrt{(D_i + R_j)^2 + (D_i - R_j)^2}$$

$$W_i = \frac{W_{ia}}{\sum_{i=1}^n W_{ia}}$$

## 6. Defining the Problem

Theoretically investigate how much the related sector can be affected by the negative effects of drone technology on the logistics sector today and in the future and to present guiding findings to the sector about the measures that can be taken for a solution by determining the degree of sub-effects.

### 6.1. Determination of Criteria

At this stage, the articles were examined during the literature review, various evaluation, performance and decision criteria were combined, summarized and presented in a holistic table with additional criteria that will be the subject of the study. The most used ones from these criteria were selected and determined as the "effects of drone technology on logistics" to be used in this study. In addition to these criteria, the "Financial Performance" criterion used in all four articles and the "Logistics Performance" criterion used in three articles were determined.

The criterion of "Increasing Market Share", which is among the criteria of TUIK (Turkish Statistical Institute), which is the main target of many companies and research in order to determine the degree of importance of the objectives of new technologies and the criterion of "Costs" used in three studies has been determined as "Increase in Logistics Costs" in order to be more specific. Finally, "Security Problems", which were found in two studies and were reached as a result in three studies but unlike these studies were taken as the criterion. Since institutions will use the criteria determined in making decisions about the use of drone technology and in having new decisions after they decide and start using it that they are briefly named as "criteria affecting the use decision".

**Table 1.** The criteria for the impact of innovation and drone technology on logistics

Article	Criteria analysed from Articles	Identified New Criteria
Yavuz, 2010	1) Production Performance 2) Marketing Performance 3) Financial Performance	
Erdal, 2018	1) Strong, New Value Motivation to Create 2) Close and Reliable External Relations 3) Ability to Identify Customer Needs 4) Versatile Innovative Service 5) Supply Chain Performance	
Erdal, Korucuk, 2018	1) Increasing Turnover 2) Increase in Market Share 3) Decrease in Costs 4) Increase in Profit Margin	1) <i>Logistics Performance,</i> 2) <i>Increased Market Share,</i> 3) <i>Financial Performance,</i>
Şimşir, Akan, Firat, 2014	1) Level of wages and costs 2) Quality of infrastructure 3) Adequacy and quality of services 4) Efficiency of processes 5) Reasons for significant delays 6) Changes in logistics performance	4) <i>Logistics Costs,</i> 5) <i>Security Problems.</i>
Murray, Chu, 2015	1) Financial Performance 2) Velocity 3) Cost	
Yoo, Yu, Jung, 2018	1) Transport Performance 2) Security and Privacy Problems	
Edwards, others 2018	1) Financial Performance 2) Security Problems 3) Ease of Use 4) Usability	

K1: Logistics Performance  
K2: Increased Market Share  
K3: Financial Performance  
K4: Logistics Costs  
K5: Security Problems

The criteria listed above are defined criteria for the effects of drone use on logistics activities. These determined criteria may change in line with the development of technology and the desired requirements of the time. In order to facilitate the solution process of the problem, the codes written above will be used instead of the criteria names. Questions were asked to the relevant logistics companies within the criteria given with the letter "K".

*Logistics Performance(K1):* This criterion means that the supply chain is used more effectively as a result of shortening the delivery times, reducing the warehouse and stock needs and reducing the number of vehicles used.

*Increased Market Share(K2):* The fact that it is a rising value with the development of R&D investments and technological infrastructure can bring the company to a more valuable position in the sector in which it is located. It is an important criterion about how it will affect the value of the firm accordingly.

*Financial Performance(K3):* In the long run, technological equipment has the ability to reduce the workload and replace most costly tools which is harmful to the company in the short run and can

bring financial gain in the long run. It is a defined criterion in terms of evaluating financially.

*Logistics Costs(K4):* In addition to the convenience that technology can bring in logistics services, there are some costs incurred by investments in technology and training qualified personnel. It is a selected criterion for the evaluation of logistics costs.

*Security Problems(K5):* The use of technological tools can cause some technical errors or prevent most predicted errors by taking the workload away from people. It is an important criterion for the evaluation to be made on security.

## 6.2. Measuring the Relationship Between Criteria

In this study, it is desired to list the importance of the effects of drone technology on the logistics industry. The new five criteria we determined were turned into a matrix table and in order to get the opinions of experts on the this subject by asking to 14 large capacity companies (total market share estimated 36%) and 31 low capacity companies (total market share estimated 19%) are using and considering using drones in the sector in later times (transporting in warehouse and on distribution network mostly inner city). 9 large capacity and also 16 low capacity companies of these (Total 25) are responded these interview questions by sending back.

**Table 2.** Measuring Criteria

<b>0</b>	No Effect
<b>1</b>	Low Impact
<b>2</b>	Moderate Impact
<b>3</b>	High Impact

## 6.3. Creating the Decision Matrix

The “Decision Matrix” in Table 3 was formed by taking the arithmetic average of the scores given by the experts to the criteria.

**Table 3.** Decision Matrix

CRITERIA	K1	K2	K3	K4	K5
K1	0	2,4	1,68	2	2,24
K2	2,24	0	2,04	2,4	2,36
K3	2	2,08	0	2,24	2,24
K4	2,56	2,52	1,96	0	2,52
K5	2,28	2,48	1,92	2,52	0

## 6.4. Determination of Normalized Direct-Relationship Matrix

As a result, the normalized direct-relationship matrix given in Table 4 was found. The S value was calculated as 9.56 and the normalized values (C) in the above formula were calculated.

**Table 4.** Normalized Direct Relationship Matrix (C)

CRITERIA	K1	K2	K3	K4	K5
K1	0	0,25	0,18	0,21	0,23
K2	0,23	0	0,21	0,25	0,25
K3	0,21	0,22	0	0,23	0,23
K4	0,27	0,26	0,21	0	0,26
K5	0,24	0,26	0,20	0,26	0

## 6.5. Creation of the Aggregate Relationship Matrix

Aggregate Relationship Matrix (F) values were calculated using the C values in Table 4. These values are shown in Table 5 below.

Relationship between the criteria values (Di and Rj) consisting of Step 7, row and column sums are calculated and added to the last row and last column of Table 5.

**Table 5:**  $F=C*(1-C)^{-1}$  Aggregate Relationship Matrix (F)

CRITERIA	K1	K2	K3	K4	K5	Di
<b>K1</b>	2,66	2,95	2,44	2,85	2,91	<b>13,81</b>
<b>K2</b>	3,03	2,95	2,63	3,06	3,11	<b>14,77</b>
<b>K3</b>	2,89	3,00	2,34	2,92	2,97	<b>14,13</b>
<b>K4</b>	3,18	3,29	2,73	2,99	3,25	<b>15,44</b>
<b>K5</b>	3,08	3,20	2,66	3,11	2,95	<b>15,00</b>
<b>Rj</b>	<b>14,85</b>	<b>15,38</b>	<b>12,80</b>	<b>14,93</b>	<b>15,19</b>	

### 6.6. Creating the Network Diagram

The threshold value was calculated as 2.925946 by using the Aggregate Relationship Matrix (F) values in Table 5.

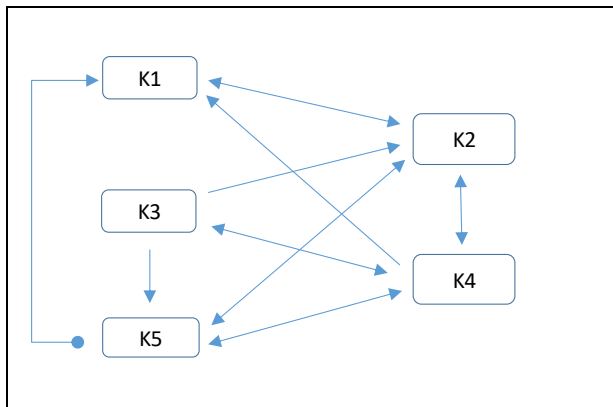


Figure 1. Relationship between Criteria

### 7. Determination of Criterion Weights

As a result of the data presented in Table 5, the  $D_i$  and  $R_j$  values were summed and the importance levels of the criteria were determined and presented in Table 6.

Table 6: Criterion Weights

Criteria	Weights
K4	0,2076
K5	0,2063
K2	0,2061
K1	0,1959
K3	0,184

### 7. Conclusion and Recommendations

Logistics and technology have their importance felt globally. In this context, companies use technology to make their logistics services more efficient and low costly. On the other hand, drone

technology is one of the newest technologies that will adapt to logistics in terms of structure.

In this study, the effects of drone vehicles on companies providing services in the field of logistics in Turkey were investigated and these effects were listed as criteria and their degree of impact was determined.

In this research process, a literature study was conducted under the name of innovation, new

technology and logistics terms. A table was created with the subject headings obtained as a result of the literature analysis and new criteria were determined. Subsequently, these criteria were presented to expert opinions and the tables created were analyzed with the DEMATEL method and the importance levels of the criteria were determined.

When the weighting levels of the criteria are examined according to the results of the DEMATEL analysis, the criterion with the highest value is K4 with 0,2076 points. The other criteria were ranked according to the degree of impact and their scores as K5 with 0,2063 points, K2 with 0,2061 points, K1 with 0,1959 points and finally K3 with 0,184 points. This study is thought to help different studies to be done by choosing a different MCDM method in future studies which these criteria can be used and may be increased or the number of experts on the subject.

In the answers received from the face to face meetings, seen that drone technology will be financially beneficial to logistics companies in the long run. It is thought that it will contribute positively to the competitive advantage of the companies, as well as to set new targets and improve the workflow. Again, it has been seen in the responses that it will increase efficiency in logistics operations and contribute to the expansion of the service network. Understood that concerns such as the insufficient internet infrastructure and the possibility of cyber attacks in the answers of the face to face meetings.

The point that drone technology will have the most impact on logistics companies is the increase in the market share of the company. Companies that have included technology in their activities from the past to the present and remain up-to-date have been more permanent in the market compared to other companies. Examples of this are Nokia<sup>TM</sup> and Apple<sup>TM</sup>.

The second criterion that drone tools have the most impact on is financial performance. It is foreseen that the investments of the company in the drone field will increase the awareness of the company. It is thought that the advertisement of the company will occur spontaneously and it will be an important step for the customers to choose the company. The logistics performance that drone

vehicles will affect is in the third place and is close to the first two criteria in terms of value.

In this process, it is seen that logistics operations are carried out more efficiently companies such as Amazon™ and Walmart™ are currently trying. The criterion for the reduction of logistics costs was found in the fourth place and it is predicted that it will affect the decrease in oil expenses by reducing the vans and distribution vehicles in logistics operations and the decrease in employee expenses with the decrease in the number of employees.

However, since it is thought that the application of traditional distribution methods will continue in regions where there is not much urbanization and this effect is in the fourth place. The last criterion is the reduction of security problems. As the reasons for this criterion being the last; The fact that the state has not made a wide regulation on drone vehicles and the internet infrastructures are not very developed that it cannot be predicted how fast the intervention will be in case of cyber attacks and accidents.

Recommendations that companies and researchers should follow and implement are presented;

- Simulation trials of drone vehicles should be carried out in logistics operations.
- Logistics companies should examine the research on drones and include pilot studies in their operations.
- The state needs to issue a comprehensive regulation on drone vehicles. Deterrent penalties should be issued against such vehicles and cyber attacks against the systems of these vehicles.
- It is expected that companies had drone vehicles in their logistics activities will provide a competitive advantage against other companies in the market.
- They can reduce their investment costs by conducting a joint operation with researchers since it is costly to invest in drone vehicles and qualified personnel to use them in the first phase.
- The studies of other companies in the world can be taken as an example and applied in order to be protected from cyber attacks and so companies can produce their own software.

As a result, it is predicted that drone technology will be a part of logistics companies in the future and create awareness exactly. It is expected that

companies that include drone vehicles in their logistics activities will provide a competitive advantage against other companies in the market surely.

#### **Ethical Approval**

Not applicable

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## Appendix A

In this section, the following questions about the effects of drone technology on logistics and its application in the logistics industry also future predictions were asked to the 4 different experts who have worked on different logistics and innovations. The purpose of asking these questions is to place the result of the study on a solid ground and to increase the accuracy of the information obtained with DEMATEL method.

### *Face to Face Meetings*

In order to verify the results obtained under this title, 4 questions submitted to expert opinions and the answers given by 4 experts to these questions will be presented. Following the text, the questions and the answers given by the experts are in Appendix A. The validity of the findings obtained by consulting expert opinions was tried to be checked with the four questions presented and the answers given to these questions to ensure accuracy.

### Questions;

Q1: Can drone technology be integrated into logistics? If so, what are the advantages and disadvantages?

Q2: Do you have any suggestions for integrating drone technology into logistics?

Q3: What is the impact on company profitability and logistics operations and how?

Q4: What are the difficulties or conveniences of integrating drone technology into logistics in Turkey?

## ANSWERS

### *Expert 1:*

Q1: Drone technology is being integrated into logistics today. Technically there is no problem but an action plan should be followed under two main headings;

a. First of all, it is necessary that the specifications, permits, definitions and prohibitions of drone flying in civil areas not only in Turkey but also in all countries should be regulated and developed to allow this. If the states do not allow and prohibit that, integration will not be possible no matter how ready the drones and companies are.

b. It is necessary to define and adapt the components of drone technology such as mobility, payload capacity, range, and payload according to logistics objectives and produce technical and practical solutions. Technical developments can be carried out much faster with the clarification and progress of the specification. In general, instead of saying that there are disadvantages, it may be more accurate to say that there are limits. It is possible to overcome the limits with technique and practice.

Q2: The suggestions can be made very broad and unlimited in knowing what can be done with a drone today and the current and developing technical capacities of drones. However, it is possible to design and manufacture any kind of drone today for using that the logistics company will determine in line with its own goals. If it is put into the framework then suggestions can be worked on.

Q3: Drone increases Logistics diversity in the operation, the shipment carrying capacity, the ability to serve more customers in a wider geographical area, competitiveness in the market and opens an important window for the company to set new targets.

As it will require investment in the first stage, there will be figures that reduce profitability from a financial point of view but if the ROI (return of investment) expectations of the project which is well-constructed and whose feasibility will be determined as a correct investment are set

realistically. It would definitely be a good investment.

Q4: I think that the relevant specification and applications that mentioned should be revised accordingly. This will ultimately be a commercial project so like every commercial project, the legal, financial and official sides of the business need to be updated and followed in a consistent and sustainable manner.

Logistics companies of foreign origin already have access to information on how to carry out comprehensive R&D and economic modeling of such projects in their own centers. There is no obstacle for domestic logistics companies to enter this operation according to their own vision, possibilities and goals also it is a subject that should definitely be evaluated for their competitive positions.

*Expert 2:*

Q1: Yes, it can be integrated which is what amazon already does and it delivers cargo by drone at points where the highway is troublesome. Advantage is low cost (no personnel, transportation etc.), disadvantage is high investment cost and profit cannot be made in a short time.

Q2: IOT technology must have a strong infrastructure. E.g; Thanks to drones when the detergent of the washing machine runs out so the automatic demand is sent to Amazon via the system and the cargo is delivered from Amazon to those living in a remote location. By the way, it is important that if we take into account that the payment is by credit card, data security must be handled carefully.

Q3: It provides profit in the long run and creates awareness for the company but this decision is directly related to the company's strategy. If the company does not want to grow or to take risks, it may be naturally not to have so big investments.

Q4: First of all, the addresses defined on the maps must be updated and internet infrastructure

also be robust. Keeping the databases up-to-date is a very sensitive criterion in such an application.

*Expert 3:*

Q1: Drone technology has started to be integrated into logistics services. However, it should be considered that this integration is at the pilot level for now. Because drone technology will be able to serve a limited area in logistics services at the moment (lack of sufficient carrying capacity). Battery technology is also an important criterion. A vehicle leaving the logistics center with a driver and a delivery person can deliver with a single tank of fuel until the end of the day. But when we consider the similar service for the drone, how many deliveries will it have with a full battery? Will there be intermediate charging stations? Will intermediate charging stations be safe? How many deliveries will it have during the day? When the technical team will arrive up to the response of when there is a drone accident happened? etc.

Before the inclusion of drone technology in logistics services, the preparation of drone legislation, the authorities and responsibilities of public institutions should be determined. The possibility of competing companies to interfere with each other's drone vehicles should be eliminated, etc. As a result, it can be included but the current initial investment costs and operating costs are high and it will be necessary to wait a little longer for it to be included in logistics services.

Q2: In the first stage, costs need to be reduced. If door-to-door delivery is to be made and there must be smart mail acceptance systems as in Tesla vehicles. The product transported by drone should be able to leave directly without waiting at the delivery point or it can be used for urgent deliveries at the first stage (medicine, etc.).

Q3: Comments made without concrete calculations in terms of profitability will remain subjective but my general opinion is that there is not much feasibility in terms of both initial investment cost and operating cost (for now). However, besides not being a profitable operation, it has the potential



to have a positive impact on service. It can also be used in terms of advertising and awareness.

Q4: It will not be very attractive due to the high initial investment costs unless it is domestic and national. Even if the initial investment cost is low, there is a possibility that the subsequent operating costs will be high when it is not domestic and national (such as color lettering and toners purchased later).

They are just beginning to use scientific methods even in the normal distribution operations of our logistics companies. Human resource management is problematic in Turkey. First of all, we must use the resources that we have efficiently. Working an employee for an extra 8+2 hours without working overtime is not efficiency. It is to offer opportunities and directions that will produce the added value that that employee produces in 10 hours or in 8 hours. If we do not learn to use the resources we have efficiently, none of the technological innovations offered will save us.

*Expert 4:*

Q1: I think it will provide a great advantage in terms of speed in normal situations and light deliveries. But I think it will be much more useful especially in emergencies and disasters because time is very important and transportation becomes more difficult. But it is at a disadvantage in terms of security and reliability. I think the error rate will be high due to the damage rate and the possibility of not being able to deliver to the right person/address every time. In this regard, methods can be developed to increase security (key, password, etc.) and ensure reliability (packaging, transportation technique, etc.).

Q2: Extra applications are required to overcome the security problem.

Q3: I believe it will benefit both of them. It can do more harm than good however, if security issues are not resolved.

Q4: I do not think that our country is very open to innovations. So I don't believe, it will be easy. At least for the beginning, I think it would be better to apply it in big cities.