INTEGRATED SWOT ANALYSIS WITH MULTIPLE PREFERENCE RELATIONS FOR SELECTION OF THE MARMARA REGION ORGANIZED INDUSTRIAL ZONES LOGISTICS STRATEGIES

(ÇOKLU TERCİH İLİŞKİLERİ ile ENTEGRE SWOT ANALİZİ ile MARMARA BÖLGESİ ORGANİZE SANAYİ BÖLGELERİNİN LOJİSTİK STRATEJİLERİNİN SEÇİMİ)

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LIST OF SYMBOLS

AHP	: Analytical Hierarchy Process
ANP	: Analytical Network Process
ARAS-F	: Fuzzy Additive Ratio Assessment
BSC	: Balanced Score Card
BWM	: Best Worst Method
COPRAS-F	: Fuzzy Complex Proportional Assessment
DEMATEL	: Decision-Making Trial and Evaluation Laboratory
DMs	: Decision Makers
ELECTRE	: Elemination and Choice Translating Reality
FAD	: Fuzzy Axiomatic Design
FUZZY MOORA	: Fuzzy Multi-Objective Optimization by Ratio Analysis
FQSPM	: Fuzzy quantitative strategic planning matrix
GDM	: Group Decision Making
GSM	: Grand Strategy Matrix
HOQ	: House of Quality
IOWG	: Induced Order Weighted Geometric Operator
IMPR	: Intuitionistic Multiplicative Preference Relations
MADM	: Multi-Attribute Decision Making
MA-OWA	: Majority Additive-Ordered Weighting Averaging
MCDM	: Multi Criteria Decision Making
M	: Member
OIZs	: Organized Industrial Zones
OWA	: Ordered Weighting Averaging
OWG	: Order Weighted Geometric
PROMETHEE	: Preference Ranking Organization Method for Enrichment Of Evaluations
SAW	: Simple Additive Weighting

TOPSIS	: Technique for Order Preference by Similarity to Ideal Solution
VIKOR	: Viekriterijumsko Kompromisno Rangiranje
QFD	: Quality Function Deployment
QGID	: Quantifier Guided Importance Degree Evaluations
QSPM	: Quantitative Strategic Planning Matrix
WASPAS	: Weighted Aggregated Sum Product Assessment
$\mathbf{CL_{ij}}$	: Consistency Level
$\mathbf{CP_i}$ **and** $\mathbf{CP_j}$	: Wholeness Values
$\mathbf{cp^{yl}_{ij}}$	: Estimation of Preference
$\mathbf{H^{l}_{ij}}$	: The Sets of Intermediate Alternative that can be used to Estimate p_{ij}
$\mathbf{a_y}$	: Intermediate Alternative
$\mathbf{\tilde{p}_{ij}}$	: Fuzzy linguistic variables
$\mathbf{\varepsilon p_{ij}}$	: Error
$\mathbf{p_{ij}}$	: Preference Value
#EV	: Number of Known Preference Values
$\mathbf{\alpha_{ij}}$	: A Parameter To Audit The Impact Of Wholeness
Q	: Fuzzy Quantifier
$\mathbf{QGID^{k}_{i}}$	: Quantifier Guided Importance Degrees
W	: Weights Vector
$\mathbf{A^{+}}$	: For The Positive Ideal Solution, Largest Values of The Column Values
$\mathbf{A^{-}}$	: For The Negative Ideal Solution, Minimum Values Of The Column
PIS	: Positive Ideal Solution
NIS	: Negative Ideal Solution
CCi	: Closeness Coefficient of Each Alternative
$\mathbf{S^{+}_{i}}$	: The Deviations of The Criterias From PIS
$\mathbf{S^{-}_{i}}$	: The Deviations of The Criterias From NIS

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ABSTRACT

Today, organized industrial zones have a major role in the economic and industrial improvement of our country. It would be right to advance with appropriate strategies to ensure the continuous improvement of these places. Current situation analysis is required to determine the right strategies. In these regions where industrial activities are so intense, logistical activities should be emphasized in order to carry out activities such as transportation, storage, customs, packing, distribution of the product / service resources in a controlled and effective way.

The aim of this paper is to apply SWOT analysis by presenting a new group decision making (GDM) approximation which takes multiple preference formats and incomplete preference formats into consideration and associates several formats of evaluations into one uniform group decision by means of fuzzy set theory.

The Marmara Region Organized Industrial Zones (OIZs) were chosen as the application area of methodology and weights of SWOT groups, factors and sub-factors were acquired by using multiple preference relations and incomplete preference relations techniques. By means of SWOT matrix, alternative logistics strategies are developed and by using multiple preference relations technique with TOPSIS methodology best strategy for the logistics development of Marmara Region OIZs has been chosen.

Evaluation model of the study has four main groups (Strengths, Weaknesses, Opportunities, Threats) and there are 12 factors under the SWOT groups and 38 sub-factors under the SWOT factors. As a result of the evaluations, Strengths group seems with the highest importance level than the other groups. “S22: Border gates to be closer to the production centers” seems with the highest importance level among the other factors.

When we look at the importance degrees of alternative strategies, “WO1: Strengthening of the OIZs infrastructure and making the connection routes to the main transportation arteries” has chosen as the best strategy for the logistics development of Marmara Region OIZs.

ÖZET

Günümüzde Organize Sanayi Bölgeleri, ülkemizin ekonomik ve endüstriyel anlamda gelişmesinde büyük rol oynamaktadırlar. Bu sanayi bölgelerinin sürekli gelişiminin sağlanabilmesi için uygun stratejilerle ilerlenmesi gerekmektedir. Doğru stratejilerin belirlenebilmesi için ise mevcut durum analizinin yapılması doğru olacaktır. Endüstriyel faaliyetlerin yoğun olduğu bu bölgelerde nakliye, depolama, gümrük, ambalajlama, ürün / hizmet kaynaklarının kontrollü ve etkili bir şekilde dağıtımı gibi faaliyetlerin gerçekleştirilmesi için lojistik faaliyetler üzerinde durulmalıdır.
Bu çalışmanın amacı, çoklu tercih ilişkileri ve eksik tercih ilişkileri teknikleri ile yeni bir grup karar verme (GDM) yaklaşımı sunarak SWOT analizini uygulamak ve çeşitli değerlendirme formatlarını bulanık küme teorisi aracılığıyla bir tekdüze grup kararı ile ilişkilendirmektir.

Metodolojinin uygulama alanı olarak Marmara Bölgesi Organize Sanayi Bölgeleri (OSB'ler) seçilmiş ve çoklu tercih ilişkileri ile eksik tercih ilişkileri teknikleri kullanılarak SWOT grupları, faktörleri ve alt faktörlerine ait ağırlıklar elde edilmiştir. SWOT matrisi sonucu alternatif lojistik stratejiler geliştirilmiş ve çoklu tercih ilişkileri tekniği ile TOPSIS metodolojisi kullanılarak Marmara Bölgesi OSB' lerinin lojistik açıdan gelişmesi için en iyi strateji seçilmiştir.

Çalışmanın değerlendirme modeli dört ana gruptan (Güçlü Yönler, Zayıf Yönler, Fırsatlar, Tehditler) oluşmakta olup SWOT grupları altında 12 faktör, SWOT faktörleri altında ise 38 alt faktör bulunmaktadır. Değerlendirmeler sonucunda Güçlü Yönler grubunun, diğer gruplara göre en yüksek önem seviyesine sahip olduğu görülmüştür.

"S22: Sınır kapılarının üretim merkezlerine daha yakın olması" diğer faktörler arasında en yüksek önem düzeyine sahip olan faktör olarak belirlenmiştir.

Alternatif stratejilerin önem derecelerine baktığımızda ise "WO1: OSB altyapısının güçlendirilmesi ve ana ulaşım arterlerine bağlantı yollarının oluşturulması", Marmara Bölgesi OSB'lerinin lojistik açıdan gelişmesi için en iyi strateji olarak seçilmiştir.

1. INTRODUCTION

Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis is used as a strategic planning tool by both researchers and practitioners in order to obtain a systematic approach. With SWOT analysis, enterprise's strategic factors can be determined (Aktan, 2008). But the lack of the SWOT analysis is that it cannot be digitized. It is inadequate to determine the importance degrees of the possible alternatives therefore Multi Criteria Decision Making techniques can help to define the importance degrees of SWOT factors.

In decision making problems, opinions of experts can be subjective and uncertain. To reduce this uncertain and subjective nature group decision making (GDM) approach is suggested. In GDM process, decision makers (DMs) who have different backgrounds, experiences and ideas are determines the alternatives and they can provide their preferences in different formats which takes multiple preferences relations into account. (Büyüközkan & Güleryüz, 2015)

It should also be known that DMs may not always have the complete information about the subject or they may not make a comparison among the alternatives. Because of these reasons they may provide their preferences with missing elements. In this situations, by using the incomplete preference relations in GDM, the missing values of the evaluations can be obtained and the evaluation would be stronger. (Büyüközkan & Güleryüz, 2015)

In this study, Marmara Region Organized Industrial Zones which has the most organized industrial zone of Turkey and at the same time the most economically developed Region, was chosen as the application area.

Organized Industrial Zones are highly important areas for the industrial development in Turkey. Strategic planning process is of great importance to use OIZs more effectively and efficiently. Logistics activities are important in the strategic planning process for the development of Organized Industrial Zones. Identifying the correct logistics strategies for Marmara Region OIZs, will increase customer satisfaction, production efficiency and quality, will provide cost advantage and will enable the creation of more efficient stock plan.

In this study, evaluations were taken from people in different fields in order to make a healthier analysis to select the most appropriate logistics strategy for Marmara Region Organized Industrial Zones. Different evaluations are combined with the techniques used, and incomplete evaluations are completed by using incomplete preference relations technique.

The objective of this study is to apply an integrated SWOT analysis in GDM approach for Marmara Region Organized Industrial Zones. The approach involves multiple preference formats and incomplete preference formats and associates discrete statements into one final group decision by using the fuzzy set theory. By identifying the weights of the SWOT factors using the proposed methodology, the weights of the possible strategies can be computed. In this application, SWOT factors have been determined for Marmara Region OIZs and alternative logistics strategies are developed and by using the proposed methodology the weights and the importance degrees of the factors are determined. To identify the importance degrees of alternative strategies, TOPSIS methodology is used with multiple preference relations technique. Weights of the alternative strategies are determined based on each criteria by the experts in different formats and after unifying different individual assessments, Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methodology is used to select the best logistics strategy among the alternatives for the development of Marmara Region OIZs.

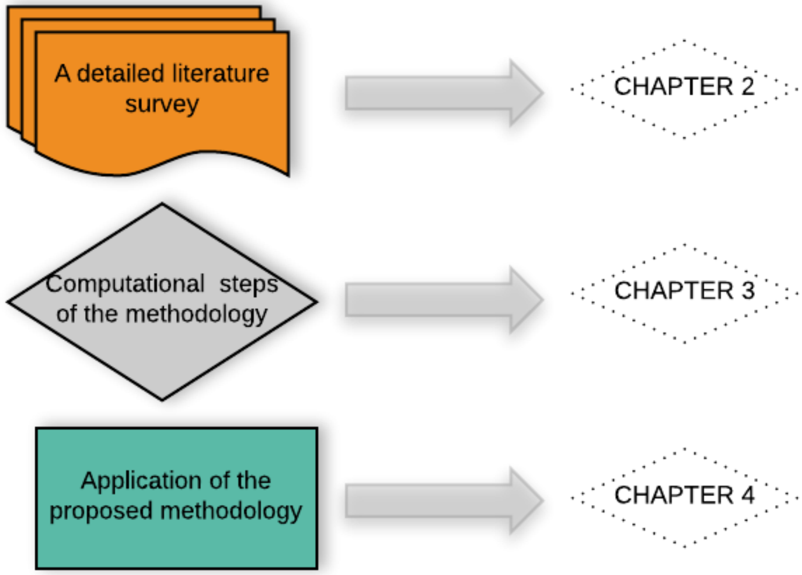

Figure 1.1: The plan of study

The detailed plan of the paper is as follows. In section 2, detailed literature survey is given for SWOT analysis, multi and incomplete preference relations techniques. Section 3 provides computational steps of multi preference and incomplete preference relations with SWOT analysis. Section 4 presents the case study, the application area of the proposed methodologies and presents the alternative strategies which developed by the SWOT factors. Section 5 gives obtained results and section 6 concludes the study and gives future research directions.

2. LITERATURE SURVEY

2.1 SWOT Analysis

SWOT analysis is a very frequently used method for companies and provides them to examine their internal and external factors which are, strengths and weaknesses of a and the opportunities and threats (Kahraman et al., 2007). SWOT analysis helps companies to define their current situation and allows a long term growth by determining the factors that will ensure growth and eliminating those that will cause failure (Aktan, 2008). To develop and choose an appropriate strategy is the main purpose of the SWOT analysis.

Although, SWOT analysis is a very useful and simple method, there are some limitations. One of the primary constraint of this method is that the importance degrees of the factors in the decision making process cannot be measured quantitatively. Multi Criteria Decision Making (MCDM) methods can be used for digitizing the SWOT analysis.

Digitization of SWOT analysis is firstly used with Analytical Hierarchy Process (AHP) technique by Kurttila et al. (2000) to review the strategic significance of certification of forest Region. Chang & Huang (2005), Kahraman et al. (2007), Talaei et al. (2012), Chanthawong & Dhakal (2015) and Padash et al. (2016) also proposed a quantified SWOT by using AHP technique in different areas. It is known that with AHP, the decision maker can only give judgements by comparing the one alternative against another or one factor against another. As the number of members and the number of factors increase, the binary comparison matrices become even more complex.

Groselj & Stirn (2014), Lallo et al. (2016) used SWOT analysis with Analytical Network Process (ANP) in the areas of environmental management and forests certification, respectively.

Yüksel & Dağdeviren (2005) suggested digitize SWOT analysis with ANP and AHP to rank strategies and compared the results obtained from ANP and AHP. Đaković et al. (2015) presented renewable energy strategies regarding biomass by using SWOT analysis and selected the best strategy by using AHP and ANP techniques for comparable results.

Alptekin (2013) used SWOT analysis with Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to choose the best strategy for a furniture firm in Turkey.

Kandakoğlu et al. (2007) and Mahdavi et al. (2008) used SWOT analysis with both AHP and TOPSIS methodologies in different areas and Azimi (2011) used SWOT analysis with both ANP and TOPSIS methodologies in Iranian mining sector.

Some of the studies proposed SWOT analysis and Fuzzy AHP with Fuzzy TOPSIS, TOPSIS or Fuzzy ANP methodologies, such as Ekmekçioglu et al. (2011), Fouladgar et al. (2011), Sevkli et al. (2012), Esmaeili et al. (2014), Cebi et al. (2015) and Shahba et al. (2017) in different areas.

When we examine the literature, it can be seen that Fuzzy techniques also used with SWOT analysis. In some studies Fuzzy AHP is used with SWOT analysis by Liang and Chen (2016), Lee et al. (2006), Celik and Kandakoglu (2012), Azarnivand et al. (2014), Adar et al. (2014), Pamučar et al. (2015), Tavana et al. (2015), Friedrichsen et al. (2016) and Rahati et al. (2016) in different areas.

As it can be seen from Table 2.1, Fuzzy TOPSIS, Fuzzy SWOT analysis, Fuzzy logic, Fuzzy ANP, Fuzzy QFD, Fuzzy set theory, Fuzzy comprehensive appraisal, Fuzzy Cognitive Maps, Fuzzy quantitative strategic planning matrix (FQSPM), Fuzzy Additive Ratio Assessment (ARAS-F), Fuzzy Complex Proportional Assessment, Entropy Weight Fuzzy Comprehensive Evaluation, Nonhomogeneous uncertain preference information, VIKOR, QSPM (Quantitative Strategic Planning Matrix), WASPAS (Weighted Aggregated Sum Product Assessment), QFD, interval type-2, fuzzy sets, DEMATEL, Compromise ratio method, Fuzzy distance measure, Simple Additive Weighting (SAW), Nonhomogeneous preference information, Permutation method, Fuzzy ELECTRE, PROMETHEE method, Interval-Valued Intuitionistic Fuzzy, Best Worst Method (BWM) techniques are also combined with SWOT analysis in decision making problems.

However, there are no examples in the literature of combining SWOT analysis with Multiple Preference Relations and Incomplete Preference Relations techniques together. This paper suggests a new approach to digitized SWOT analysis by using GDM approaches that considers Multiple Preference Relation and Incomplete Preference Relations.

Also when the literature survey is examined, it can be seen that there are no such studies on determining Marmara Region Organized Industrial Zones logistics strategies with proposed techniques or with any other techniques which are combined with SWOT analysis.

A detailed literature research on the studies which use SWOT analysis with MCDM methodologies proposed in Table 2.1.

Table 2.1a: Studies associated with SWOT analysis on Multi Criteria Decision Making

Authors	Objective of the study	Methodology	Area	Type
Kurttila et al. (2000)	To present a hybrid approach of SWOT analysis with AHP technique to improve the quantitative information basis of strategic planning process.	SWOT analysis, AHP	Forest certification	Case Study
Chang & Huang (2005)	To propose a quantified SWOT by using AHP technique to suggest an adoptable competing strategy for ports.	SWOT analysis, AHP	Container ports in East Asia	Case Study
Yüksel & Dağdeviren (2005)	To suggest digitize SWOT analysis with ANP and AHP to rank strategies and to compare the results obtained from ANP and AHP.	SWOT analysis, ANP, AHP	Prioritization of strategies	Case Study
Liang & Chen (2006)	To propose environmental evaluation of international distribution centers in Pacific-Asian Region.	SWOT analysis, Fuzzy quantified, Fuzzy AHP	Location selection	Case Study
Lee et al. (2006)	To evaluate locations developing global logistics hub in Pacific-Asian Region.	SWOT analysis, Fuzzy AHP	Location selection	Case Study
Kahraman et al. (2007)	To determine and evaluate the alternative strategies for e-Government in Turkey	SWOT analysis, AHP	E-Government in Turkey	Case Study
Kandakoğlu et al. (2007)	To digitize SWOT analysis with AHP and TOPSIS techniques to select the most suitable shipping registry.	SWOT analysis, AHP, TOPSIS	Shipping registry selection	Case Study
Çelik et al. (2008)	To present strategies on Turkish container ports by using hybrid methodology.	SWOT analysis, Fuzzy axiomatic design (FAD), Fuzzy TOPSIS	Turkish container ports	Case Study
Mahdavi et al. (2008)	To determine alternative strategies of IT industry in Iran by using SWOT analysis and to select the best strategy by using AHP and TOPSIS methodologies.	SWOT analysis, AHP, TOPSIS	Information technology industry in Iran	Case Study

Table 2.1b: Studies associated with SWOT analysis on Multi Criteria Decision Making

Authors	Objective of the study	Methodology	Area	Type
Kheirkhah et al. (2009)	The apply fuzzy SWOT approach to create strategies to reduce the dangers of transporting hazardous material in Iran.	Fuzzy SWOT approach	Hazardous materials transportation in Iran	Case Study
Ekmekçioglu et al. (2011)	To select the best strategic alternative for nuclear power plant site in Turkey by digitizing SWOT analysis with fuzzy TOPSIS and fuzzy AHP methods.	SWOT analysis, Fuzzy TOPSIS, Fuzzy AHP	Nuclear power plant site selection in Turkey	Case Study
Fouladgar et al. (2011)	To define the current situation of the mining sector in Iran to identify alternative strategies and evaluation of the strategies by using Fuzzy AHP and Fuzzy TOPSIS methodologies.	SWOT analysis, Balanced Score Card, Fuzzy AHP, Fuzzy TOPSIS	Iranian mining sector	Case Study
Arabzad et al. (2011)	To evaluate suppliers by using SWOT analysis and criterias are calculates by Fuzzy TOPSIS methodology and results used as an input for linear programming to allocate orders.	SWOT analysis, Fuzzy TOPSIS, Mixed integer Linear programming	Supplier selection and order allocation	Case Study
Azimi et al. (2011)	To propose an integrated SWOT analysis with ANP and VIKOR techniques to determine strategies for the Iranian mining sector.	SWOT analysis, ANP, VIKOR	Iranian mining sector	Case Study
Monavari et al. (2011)	To determine coastal zone tourism strategies by using SWOT analysis and QSPM technique is used to order strategies.	SWOT analysis, QSPM Technique	Sustainable tourism management	Case Study
Azimi et al. (2011)	To develop an integrated SWOT analysis with ANP and VIKOR to determine and ranking strategies for Iranian mining sector.	SWOT analysis, ANP, TOPSIS	Iranian mining sector	Case Study

Table 2.1c: Studies associated with SWOT analysis on Multi Criteria Decision Making

Authors	Objective of the study	Methodology	Area	Type
Zavadskas et al. (2011)	To evaluate management effectiveness in construction enterprises by SWOT analysis and digitizing criteria's with AHP and ranking alternatives by permutation method.	SWOT analysis, AHP, Permutation method	Construction enterprises management	Case Study
Amin et al. (2011)	To propose digitize fuzzy SWOT analysis for supplier selection problem and fuzzy linear programming is used to determine the order quantity from each supplier.	SWOT analysis, Fuzzy logic, Fuzzy linear programming	Supplier selection and order allocation	Case Study
Ghorbani et al. (2011)	To prioritized strategies in SWOT analysis by TOPSIS methodology by associating fuzzy logic.	SWOT analysis, Fuzzy set theory, TOPSIS	-	Numerical Example
Marbini et al. (2012)	To propose compromise ratio method in SWOT analysis to select the best growth strategy for Sunlite company in Canada.	SWOT analysis, Compromise ratio method, Fuzzy distance measure	Solar panels in Canada	Case Study
Talaei et al. (2012)	To identify the low-carbon energy technologies that are compatible with the energy sector of Iran, by using SWOT analysis and weighting the technological alternatives by using AHP.	SWOT analysis, AHP	Iran's energy sector	Case Study
Sevkli et al. (2012)	To propose a quantitative SWOT analysis by using ANP methodology and to compare results with the results obtained by using AHP, ANP, Fuzzy AHP, Fuzzy ANP with SWOT analysis.	SWOT analysis, Fuzzy AHP, Fuzzy ANP, AHP, ANP	Turkish airline industry	Case Study
Babaesmailli et al. (2012)	To develop a fuzzy methodology by using ANP to digitize strategies obtained from SWOT analysis.	SWOT analysis, Fuzzy logic, Fuzzy ANP	Manufacturing firm in Iran	Case Study

Table 2.1d: Studies associated with SWOT analysis on Multi Criteria Decision Making

Authors	Objective of the study	Methodology	Area	Type
Celik & Kandakoglu (2012)	To propose a fuzzy quantified SWOT analysis for flagging out problem in the Turkish shipping industry.	SWOT analysis, Fuzzy AHP	Turkish maritime industry	Case Study
Baş (2012)	To propose an integrated SWOT analysis with Fuzzy TOPSIS methodology combined with AHP technique.	SWOT analysis, Fuzzy TOPSIS, AHP	Electricity supply chain in Turkey	Case Study
Lee (2012)	To propose a SWOT analysis with Fuzzy ANP together with the grand strategy matrix method (GSM) in location selection problem in China.	SWOT analysis, Fuzzy ANP, GSM	Location selection	Case Study
Pur & Tabriz (2012)	To identify the weights of SWOT factors by using fuzzy QFD and to evaluate alternative strategies for the organization by HOQ (House of Quality).	SWOT analysis, Fuzzy QFD	Petrokaran Film Factory	Case Study
Kazaz et al.(2013)	To evaluate current situation of construction firms by using SWOT analysis and identify firm's main goals by using the fuzzy model and select appropriate strategies.	SWOT analysis, Fuzzy set theory	Construction firms in Turkey	Case Study
Tamošaitienė et al.(2013)	To identify the most efficient ways to locate high-rise buildings in Vilnius by using SWOT analysis with SAW technique to rank the best alternatives of high-rise buildings location.	SWOT analysis, Simple Additive Weighting (SAW)	Location of high-rise buildings in Vilnius	Case Study
Liu et al. (2013)	To combine the SWOT analysis and fuzzy comprehensive appraisal to analyze China's offshore wind industry competitiveness.	SWOT analysis, Fuzzy comprehensive appraisal	China's Offshore Wind Industry	Case Study

Table 2.1e: Studies associated with SWOT analysis on Multi Criteria Decision Making

Authors	Objective of the study	Methodology	Area	Type
Ren et al. (2013)	To analyze the current situation of hydrogen economy in China and creating alternative strategies with SWOT analysis and combining goal programming and fuzzy theory to prioritize the strategies.	SWOT analysis, Goal programming, Fuzzy set theory	Hydrogen economy in China	Case Study
Alptekin (2013)	To propose an integrated SWOT analysis with TOPSIS methodology to select the best strategy among the alternatives.	SWOT analysis, TOPSIS	Furniture firm in Turkey	Numerical Example
Baykasoğlu & Gölcük (2014)	To propose an integrated SWOT analysis with TOPSIS method and Fuzzy Cognitive Maps for strategy selection problem.	SWOT analysis, TOPSIS, Fuzzy Cognitive Maps	Strategy selection	Case Study
Azarnivand et al. (2014)	To selection of the superior strategy for reviving the lake's water resources by using SWOT analysis with Fuzzy AHP.	SWOT analysis, Fuzzy AHP	Water and environmental management in Iran	Case Study
Peng et al. (2014)	To propose a quantified SWOT analysis to evaluate alternatives by using nonhomogeneous preference information methodology.	SWOT analysis , Nonhomogeneous preference information	Shareholders of a forest holding	Numerical Example
Groselj et al. (2014)	To present an approach combining SWOT analysis with fuzzy AHP/ANP and to evaluate possible scenarios in case study.	SWOT analysis, GDM, ANP, AHP, Fuzzy logic	Forest management	Case Study
Groselj & Stirn (2014)	To propose an approach combining SWOT analysis with ANP methodology and to apply proposed approach in environmental management problem.	SWOT analysis, ANP	Environmental management	Case Study
Esmaeili et al. (2014)	To propose a quantitative SWOT analysis by using Fuzzy AHP and Fuzzy TOPSIS.	SWOT analysis, Fuzzy AHP, Fuzzy TOPSIS	Oil industry	Case Study

Table 2.1f: Studies associated with SWOT analysis on Multi Criteria Decision Making

Authors	Objective of the study	Methodology	Area	Type
Lashgari et al. (2014)	To evaluate outsourcing strategies by using SWOT analysis with QSPM and WASPAS methodologies for quantitative evaluation of strategies.	SWOT analysis, QSPM (Quantitative Strategic Planning Matrix), WASPAS (Weighted Aggregated Sum Product Assessment)	Healthcare services outsourcing	Case Study
Cebi et al. (2015)	To determine the most appropriate cutting technologies used in shipyards.	SWOT analysis, Fuzzy AHP, TOPSIS, Fuzzy information axiom	Shipyard industry	Case Study
Tavana et al. (2015)	To propose an integrated SWOT analysis with intuitionistic fuzzy AHP methodology to evaluate criterias for outsourcing reverse logistics.	SWOT analysis, Intuitionistic fuzzy AHP	Reverse logistics	Case Study
Adar et al. (2015)	To present the current situation of sewage sludge in Turkey and to evaluate sewage sludge technologies with SWOT analysis and fuzzy AHP techniques.	SWOT analysis, Fuzzy AHP	Sewage sludge in Turkey	Case Study
Pamučar et al. (2015)	To determine the development strategy for integrated transport in the Lafarge Beocin cement plant.	SWOT analysis, Fuzzy AHP	İntegrated transport	Case Study
Nasrabadi & Sobhanallahi (2015)	To select the best strategy for the distribution of a book company by using SWOT analysis with fuzzy GDM and OWA methods.	SWOT analysis, ordered weighted average method (OWA), Fuzzy GDM	Distribution of book company	Case Study
Akhavan et al. (2015)	To present a systematic approach for an effective partner selection by combining SWOT analysis with fuzzy QSPM and fuzzy MCDM methodologies.	SWOT analysis, FQSPM, ARAS-F, COPRAS-F, Fuzzy MOORA, and Fuzzy TOPSIS	Partner selection	Case Study

Table 2.1g: Studies associated with SWOT analysis on Multi Criteria Decision Making

Authors	Objective of the study	Methodology	Area	Type
Garg et al. (2015)	To determine the most preferable choice of noise barriers available for traffic noise abatement by using SWOT analysis with Fuzzy TOPSIS methodology.	SWOT analysis, Fuzzy TOPSIS	Road traffic noise	Case Study
Đaković et al. (2015)	To present renewable energy strategies regarding biomass by using SWOT analysis and to select the best strategy by using AHP and ANP techniques for comparable results.	SWOT analysis, AHP, ANP	Energy policy in Serbia	Case Study
Barak & Toloo (2015)	To create strategic plans with SWOT analysis and weightining strategies by using FQSPM model and prioritized by QFD matrix to accomplish strategic plans.	SWOT analysis, Quality Function Deployment (QFD), Fuzzy Quantitative Strategic Planning Matrix (FQSPM)	Textile and Clothing Company	Case Study
Yuan et al. (2015)	To propose SWOT analysis for supermarket fresh food suppliers and evaluating the suppliers by using Entropy Weight Fuzzy Comprehensive Evaluation.	SWOT analysis, Entropy Weight Fuzzy Comprehensive Evaluation	Supplier selection	Case Study
Chanthawong & Dhakal (2015)	To present biofuel development strategies in Thailand by using SWOT analysis with AHP technique.	SWOT analysis, AHP	Biodiesel and bioethanol policy development in Thailand	Case Study
Zare et al. (2015)	To analyze the electricity supply chain in north-west Iran by using SWOT analysis and prioritizing SWOT factors by combining AHP with fuzzy TOPSIS.	SWOT analysis, AHP, Fuzzy TOPSIS	Electricity supply chain	Case Study

Table 2.1h: Studies associated with SWOT analysis on Multi Criteria Decision Making

Authors	Objective of the study	Methodology	Area	Type
Lallo et al. (2016)	To analyze the main factors influencing the diffusion of the Forest Stewardship Council (FSC) smallholder certification in Europe by using SWOT analysis with ANP technique.	SWOT analysis, ANP	Forests Certification in Europe	Case Study
Friedrichsen et al. (2016)	To create strategies for commercialization of academic research by using SWOT analysis and evaluating alternatives by using fuzzy ANP technique.	SWOT analysis, Fuzzy AHP	Commercialization of academic research	Case Study
Baykasoğlu & Gölcük (2016)	To present SWOT analysis with interval type-2 fuzzy TOPSIS and interval type-2 fuzzy DEMATEL methodologies.	SWOT analysis, interval type-2, fuzzy sets, TOPSIS, DEMATEL	Industrial engineering department	Numerical Example
Moazeni (2016)	To identify institutional-managerial structure of Tehran city by using SWOT analysis and using Fuzzy QSPM technique to prioritize strategies.	SWOT analysis, Fuzzy quantitative strategic planning matrix (fuzzy QSPM)	Institutional-managerial structure of Tehran city	Case Study
Rahati et al. (2016)	To analyze health network of Kashan University of Medical Science by combining SWOT analysis with Fuzzy AHP technique.	SWOT analysis, Fuzzy AHP	Health Network Of Kashan University Of Medical Science	Case Study
Ramkumar et al. (2016)	To identify the risk factors of outsourcing e-procurement services to a third-party by using SWOT analysis, and to propose a suitable risk assessment methodology based on a modified fuzzy ANP.	SWOT analysis, ANP, Fuzzy inference system	Risk assessment	Case Study

Table 2.1i: Studies associated with SWOT analysis on Multi Criteria Decision Making

Authors	Objective of the study	Methodology	Area	Type
Padash et al. (2016)	To propose a strategic environmental management plan in the Mond protected area in southern Iran by using SWOT analysis with AHP technique.	SWOT analysis, AHP	Environmental management in marine protected area	Case Study
Dimic et al. (2016)	To propose hybrid SWOT–Dematel ANP model for strategic transport management Serbian Oil Industry.	SWOT analysis, DEMATEL, ANP	Transport Management	Case Study
Shakerian et al. (2016)	To evaluate and rank strategies obtained by SWOT for business strategies and evaluating strategies by using fuzzy TOPSIS methodology.	SWOT analysis, Fuzzy TOPSIS	Human resources and business strategies in organizations	Case Study
Chitsaz & Azarnivand (2016)	To prioritize water shortage alleviation strategies in an arid Region by using SWOT analysis with BMW, AHP and IOWA methodologies.	SWOT analysis, Best Worst Method (BWM), AHP, IOWA	Water scarcity management	Case Study
Shahba et al. (2017)	To identify strategies for mine waste management by using SWOT analysis and evaluating the best strategy by using fuzzy AHP and fuzzy TOPSIS methodologies.	SWOT analysis, Fuzzy AHP, Fuzzy TOPSIS	Mine waste management	Case Study

2.2 Multiple Preference Relations

Preference relations are methods that frequently used in decision making and describes decision makers opinions about the possible alternatives of problems in different formats. Some of the preference formats that are used in the literature: importance degree (Büyüközkan & Çifçi 2012)., (Büyüközkan & Çifçi 2015), (Büyüközkan & Güleryüz 2015), linguistic preference relations (Xu et al., 2011), (Büyüközkan & Çifçi 2012), (Büyüközkan & Çifçi 2015), (Büyüközkan & Güleryüz 2015), preference orderings (Büyüközkan & Çifçi 2012), (Büyüközkan & Çifçi 2015), (Büyüközkan & Güleryüz 2015), fuzzy preference relations (Dong & Zhang, 2013), (Lee, 2012), multiplicative preference relations (Jiang & Xu, 2013), selected subset (Büyüközkan & Çifçi 2012), (Büyüközkan & Çifçi 2015) intuitionistic multiplicative preference relations (Xia & Xu, 2013), (Xia et al., 2013), (Jiang & Xu, 2013) utility functions (Dong & Zhang, 2013) , multi-dimensional preference relations (Rianthong et al., 2016), (Zhang et al., 2015).

Multi preference relations approach allows decision makers to present their preferences in various ways who have different backgrounds and different perspectives. It provides flexibility to decision makers by applying different forms of judgements. This approach also helps to achieve a higher contentment level on the decision making process. There is a deficient part of this format that is unable to deal with incomplete information. To cope with this deficiency, this study also uses incomplete preference relations.

The studies with multi preference relations are summarized in Table 2.2, based on the literature research.

Table 2.2a: Studies with multi preference relations

Authors	Objective of the study	Methodology	Area	Type
Büyüközkan & Feyzioğlu (2005)	To propose a new approach by taking into account QFD with multiple preference relations in fuzzy GDM perspective.	Multiple preference relations, Fuzzy GDM, QFD	Word processing software development	Numerical Example
Büyüközkan et al. (2006)	To present a new fuzzy GDM approach with multiple preference relations to respond CNs in product development with QFD.	Multi preference relations, Fuzzy GDM, QFD	Hatch door development of a car	Numerical Example
Jiang et al. (2012)	To define the compatibility to measure the intuitionistic multiplicative preference information and to develop consensus models.	GDM with intuitionistic multiplicative preference relations	Schools in a university	Numerical Example
Li et al. (2012)	To propose the QFD technique by determining the customer requirements.	GDM, multi-format preference analyses in QFD	Product development of personal digital assistant in an electric corporation	Case Study
Wang (2012)	To present a nonlinear programming approach to define relative importance weights of customer requirements.	QFD, Multi preference, Nonlinear programming	Pencil design	Numerical Example
Xia & Xu (2012)	To introduce the intuitionistic multiplicative preference relation based on the interval-valued multiplicative preference relation.	GDM, Intuitionistic multiplicative preference relation	Internet service and its monthly bill shared among the four students	Numerical Example
Xia et al. (2013)	To examine multiplicative preference relations under intuitionistic environments.	Intuitionistic multiplicative preference relations	-	Numerical Example

Table 2.2b: Studies with multi preference relations

Authors	Objective of the study	Methodology	Area	Type
Dong & Zhang (2013)	To examine the multi-person decision making problem with different preferences like preference orderings, utility functions, multiplicative preference relations and fuzzy preference relations.	MPDM, preference orderings, utility functions, multiplicative preference relations and fuzzy preference relations	Education, causes of misbehavior of the students in the classroom	Numerical Example
Zhou et al. (2013)	To develop a new compatibility for the uncertain multiplicative linguistic preference relations based on the LCOWGA operator and using it to define the optimum weights of experts in GDM and analyzing the problem in a supplier selection problem.	GDM with multiplicative linguistic preference relation	Supplier selection	Numerical Example
Jiang & Xu (2013)	To establish a transformation mechanism to transform an IMPR to a corresponding IFPR and to develop some ordered weighted operators for aggregating intuitionistic multiplicative information, including the IMOWA, IMOWG, GIMOWA and GIMOWG operators.	Intuitionistic multiplicative preference relations	-	Numerical Example
Büyüközkan & Çifçi (2013)	To implement the QFD technique in sustainable supply chain by using multi preference formats and incomplete information to present a novel approach of group decision making	QFD, incomplete preference, multiple preference	Turkish logistic sector	Case Study

Table 2.2c: Studies with multi preference relations

Authors	Objective of the study	Methodology	Area	Type
Urena et al. (2014)	To make a review and analyze the methods about estimation of missing preferences in GDM process.	GDM, multiplicative preference relations and incomplete preference relations	-	Numerical Example
Xia & Chen (2014)	To examine the consistency of interval multiplicative preference relations in group desicion making.	GDM, Interval multiplicative preference relations	-	Numerical Example
Büyüközkan & Çiftçi (2015)	To implement the integrated QFD methodology and two GDM approaches which includes incomplete and multiple preferences.	Fuzzy GDM in QFD with multiple incomplete preference relations	Portable entertainment and game systems design	Case Study
Büyüközkan & Güleryüz (2015)	To use QFD methodology in CPD for IT planning with multiple preference relations and incomplete preference relations.	Fuzzy GDM in QFD with multiple and incomplete preference relations	Turkish software company	Case Study
Zhang et al. (2015)	To examine the fuzzy multi-attribute group decision making problems with multidimensional preference information in the form of pairwise alternatives and incomplete weight information.	Fuzzy multi-attribute GDM with multi-dimensional preference relations and incomplete weight information	Air-fighter plane selection	Case Study
Zhang et al. (2015)	To propose an approach to measure the group consensus in MADM with seven different decision makers' preference information on alternatives.	Multiple attribute decision-making with multiple preference formats	Robot selection	Numerical Example

Table 2.2d: Studies with multi preference relations

Authors	Objective of the study	Methodology	Area	Type
Rianthong et al. (2016)	To develop a stochastic programming model to design the optimal sequence of hotels that allows customers to meet hotels at the minimum search cost and maximum benefit earned from hotels.	Multi criteria decision making with multi-dimensional preferences	Hotel booking from online travel agencies	Case Study
Zhang (2016)	To develop several independent and correlative interval valued intuitionistic multiplicative aggregation operators for dealing with GDM problems which the preferences of DM's are dependent.	GDM, interval-valued intuitionistic multiplicative preference relations	Supplier selection	Case Study

2.4 Incomplete Preference Relations

In the decision-making process, decision makers are expected to give complete linguistic preference relations when evaluating the alternatives. Although different forms of jurisdictions from decision makers by using multi preference relations approach, decision makers may have different experiences and backgrounds, it is possible that experts do not have all information about problems. This situation can cause that decision makers may not represent any preference among the alternatives. This could occur when decision maker does not have complete information about the subject or when he/she does not able to decide among the alternatives. (Büyüközkan & Çifçi, 2015)

The literature review is summarized in Table 2.3 about the studies with incomplete preference relations between the years 2011 and 2017. It can be clearly seen that incomplete preference relations implemented to different areas with different techniques and the literature review shows that so much studies have been made on Group Decision Making (GDM) with incomplete preference relations.

Table 2.3a: Studies with incomplete preference relations, 2011-2017

Authors	Objective of the study	Methodology	Area	Type
Dopazo & Ruiz – Tagle (2011)	To find the missing informations by using incomplete pairwise comparison matrices and identify a similarity function and a parametric compromise function by establishing an optimization problem.	GDM, Incomplete information, Logarithmic goal programming	-	Numerical Example
Xu et al. (2011)	To show that the priority vector and additive consistent incomplete fuzzy preference relations developed by Xu and Chen doesn't always valid in general situations.	GDM, Incomplete reciprocal relations, Additive transitivity consistency	-	Numerical Example
Büyüközkan & Çiftçi (2012)	To propose a QFD methodology extended by GDM approach which involves incomplete information of decision makers and determine the design requirements on collaborative software process in a Turkish software company.	QFD, GDM, Incomplete Preference Relations	Turkish software company	Case Study
Lee (2012)	To develop a new group decision making method with incomplete fuzzy preference relations.	GDM, Incomplete fuzzy preference relations, Additive consistency, order consistency	-	Numerical Example
Zhu & Xu (2012)	To reduce the four steps of GDM problems into two steps (aggregation and exploitation) by developing a new fuzzy linear programming method.	GDM, fuzzy preference relations, fuzzy linear programming method	-	Numerical Example
Xu (2012)	To develop a consensus reaching process of GDM, by making use of the multiplicative transitivity properties.	GDM, incomplete multiplicative preference relation	Financial merger strategies of companies	Numerical Example

Table 2.3b: Studies with incomplete preference relations, 2011-2017

Authors	Objective of the study	Methodology	Area	Type
Wang & Li (2012)	To propose a linear programming technique for multidimensional analysis of preference method by solving MAGDM problems with interval-valued intuitionistic fuzzy multi-attribute group decision making framework.	MAGDM, incomplete pairwise comparison preference, linear programming	Education	Numerical Example
Gong et al. (2012)	To present optimal priority methods on the incomplete intuitionistic fuzzy preference relation and the incomplete interval preference relation to universalize the least squares method to IFPR and IPR based on the multiplicative consistent conditions given in the study.	GDM, Least square method, Incomplete intuitionistic fuzzy preference relation, Incomplete interval preference relation	-	Numerical Example
Zhang et al. (2012)	To propose a linear optimization model to solve some problems on individual consistency construction.	Linear optimization models, GDM, fuzzy preference relations	-	Numerical Example
Yang & Wang (2012)	To present a linguistic decision aiding technique called multi-criteria semantic dominance based on incomplete preference information.	Linguistic modeling, incomplete preferences	Branch office of a multinational IT firm	Numerical Example
Nahm et al. (2012)	To propose new methods for customer preference and customer satisfaction ratings.	QFD, incomplete customer preferences, new rating method	Car door design	Numerical Example
Yan & Ma (2013)	To refer the two types of uncertainties underlying QFD, which are fuzzy preference relation and fuzzy majority, for developing a new GDM method.	GDM, fuzzy preference relations, uncertain QFD	A Chinese restaurant	Numerical Example

Table 2.3c: Studies with incomplete preference relations, 2011-2017

Authors	Objective of the study	Methodology	Area	Type
Huang et al. (2013)	To propose a novel method for decision making by incomplete information based on evidence distance with using of DS theory to widen the AHP, to develop the DS/AHP method proposed by Utkin and Simanova.	AHP, incomplete preferences, Dempster–Shafer evidence theory	Course selection	Case Study
Büyüközkan & Çiftçi (2013)	To implement the QFD technique in sustainable supply chain by using multi and incomplete preferences to present a novel approach of group decision making.	QFD, incomplete preference, multiple preference	HAVI Logistics Turkey	Case Study
Chen et al. (2013)	To present a novel methodolgy by using fuzzy preference relations based on the additive consistency.	GDM, incomplete fuzzy preference relations, additive consistency, order consistency	-	Numerical Example
Xu et al. (2013)	To present a logarithmic least squares method to rank alternatives in group decision making.	GDM, incomplete fuzzy preference relations, Logarithmic least squares method	-	Numerical Example
Xu & Wang (2013)	To present the eigenvector method to priority for an incomplete fuzzy preference relation.	Incomplete fuzzy preference relation, Eigenvector method	-	Numerical Example
Urena et al. (2014)	To make a review and analyze the methods about estimation of missing preferences in GDM process.	GDM, multiplicative preference relations and incomplete preference relations	-	Numerical Example
Jiang et al. (2014)	To propose a model for GDM with incomplete IMPR and its consistency property by presenting two approaches which involves estimating and adjusting step	GDM, Intuitionistic multiplicative preference relation, incomplete intuitionistic multiplicative preference relation	Training venue in communication drills	Numerical Example

Table 2.3d: Studies with incomplete preference relations, 2011-2017

Authors	**Objective of the study**	**Methodology**	**Area**	**Type**
Xu et al. (2014)	To attain precedence vector for GDM problems with a chi-square method in situations where DMs evalutions on alternatives are furnished.	Incomplete reciprocal preference relation, GDM, Chi-square method	-	Numerical Example
Xu et al. (2014)	To propose methods for constructing additive consistent IFPRs based on acceptable incomplete IFPRs.	Incomplete interval fuzzy preference relation, Additive consistent,GDM	Selection of potential suppliers for the Pars Solar Company	Case Study
Meng & Chen (2014)	To improve a new algorithm for the GDM with incomplete fuzzy preference information.	GDM, AHP, incomplete fuzzy preference relations	-	Numerical Example
Xu & Zhang (2014)	To present an interval programming with using the main structure of LINMAP to solve the MAGDM problems.	MAGDM, Incomlete preference, Hesitant fuzzy set, Interval programming	Energy project selection	Numerical Example
Xu & Cai (2014)	To develop a more rational estimation procedure for incomplete IV-IPR procedure and develop an approach to GDM with incomplete IV-IPRs.	GDM, Incomplete Interval-Valued Intuitionistic Preference Relations	Evaluation of the international exchange doctoral students	Numerical Example
Liu & Zhang (2014)	To propose a new algorithm ,which consists of four stages, to solve the GDM problem with incomplete interval fuzzy preference relations.	Incomplete interval fuzzy preference relations, Topsis, GDM, consistency, goal programming	Partnership selection	Numerical Example
Vetschera et al. (2014)	To present a comprehensive computational study on the effects of providing different forms of incomplete preference information in group decision models.	Incomplete preference information, additive group decision models	-	Numerical Example

Table 2.3e: Studies with incomplete preference relations, 2011-2017

Authors	Objective of the study	Methodology	Area	Type
Park (2014)	To examine the characteristics of potential games concerning Nash equilibria and defining Nash equilibrium for games with incomplete preferences.	Incomplete preference relations, Nash equilibrium	-	Numerical Example
Wu et al. (2014)	To propose a new trust based consensus model for social network in a 2-tuple linguistic context under incomplete information.	Incomplete linguistic information, GDM	-	Numerical Example
Dong et al. (2015)	To develop two integrated approaches for MCGDM problems with using TFAHP integrate with TFPG (TFWPG) operator, recovery methods and extent analysis method.	Incomplete information, triangular fuzzy power geometric operator, GDM	Small hydropower investment projects selection	Numerical Example
Xu et al. (2015)	To propose a new method, which is called LDM, for the priority vector derivation from incomplete reciprocal preference relations based on the transfer relationship between reciprocal and multiplicative relationship preferences.	Incomplete reciprocal preference relation, GDM, Least deviation method	-	Numerical Example
Wang & Chen (2015)	To develop a SA-based permutation method for MCDA problems under incomplete preference information within the environment of interval type -2 fuzzy sets.	Incomplete preference information, annealing-based permutation method	-	Numerical Example
Urena et al. (2015)	To prove the mathematical equivalence between the set of reciprocal intuitionistic fuzzy preference relations and the set of asymmetric fuzzy preference relations.	GDM, incomplete reciprocal intuitionistic preference relations	-	Numerical Example

Table 2.3f: Studies with incomplete preference relations, 2011-2017

Authors	Objective of the study	Methodology	Area	Type
Wang & Xu (2015)	To focus on the incomplete linguistic preference relations and to discuss the consistency.	Incomplete linguistic preference relation, Consistency	The level risk of energy channels	Case Study
Zhang et al. (2015)	To develop two estimation procedures to determine the uncertain information in an expert's incomplete hesitant fuzzy preference relation.	GDM, Incomplete hesitant fuzzy preference	Portfolio selection	Numerical Example
Zhang & Guo (2016)	To examine the fusion of heterogeneous incomplete hesitant preference relations beneath the GDM settings.	GDM, heterogeneous incomplete hesitant preference relations	Supplier selection and selection of a loading hauling system	Numerical Examples
Vetschera (2016)	To develop methods to derive a complete order relation of alternatives from the stochastic information.	Incomplete information, Multiple criteria analysis	Comparison of different approaches	Numerical Example
Liang et al. (2016)	To develop a social ties based approach in group decision making	GDM, Incomplete additive preference relations, linear programming	Selection of the best destination for a vacation trip	Numerical Examples
Zhang et al. (2016)	To propose a hybrid consensus model for group decision problems with incomplete reciprocal preference relations.	GDM, Incomplete reciprocal preference relations, Multiplicative consistency analysis	-	Numerical Example

3. MULTIPLE PREFERENCE RELATIONS WITH SWOT ANALYSIS AND TOPSIS

3.1 About Multiple Preference Relations Technique

3.1.1 Complete Preference Relations

In decision making problems, expert opinions are taken and evaluations are made. But taking evaluations from one expert can cause unhealthy results. For this reason, GDM approach is frequently used in decision making problems. The GDM approach ensures that more than one DM takes part in decision making problem and avoids making evaluations according to a single DM.

In GDM process, DMs ideas or backgrounds can be different. This situation can cause to have evaluations in different formats. DMs can give their evaluations by linguistically, numerically, by subsets or by varying on their information levels. The commonly used preference formats in literature are given in Part 2.

In this study, the following formats are used by DMs.

- Importance degree vector: DMs presented their evaluations from 0 to 1 and if it is close to 1 that it is more important.
- Ordered vector: DMs rank order the criterias according to importance they prefer and 1 means that it is more important.
- Linguistic importance vector: DMs presented their preferences in linguistic terms according to importance they prefer.
- State of importance without identifying degree: DMs presented their preferences by explaining that some criterias are more important than the others without identifying degree.
- Subset of criteria' s: DMs chosen a subset of criterias and explained that the criterias contained in the subset are more important to them.

The computational steps of these formats are given in Part 3.2.

To deal with these different formats of evaluations, complete preference relations can be used. With this technique, different forms of evaluations can be consolidated under one group decision. The advantages of this technique can be summarized as follows.

- Gives flexibility to DMs during giving evaluations.
- As it based on GDM, it gives better solutions.
- It allows different types of assessments to be grouped under a single group.

Although there are significant advantages of complete preference relations technique, it has disadvantage. The missing evaluations made by DMs cannot be resolved with this technique. To cope with this disadvantage, incomplete preference relations are used.

3.1.2 Incomplete Preference Relations

As it mentioned above, DMs can give different forms of evaluations in GDM process. It is expected that DMs will give their assessments with complete preferences. But sometimes, DMs may not have complete information or enough experience about the question. In this situations, it can be difficult for DMs to decide among the alternatives and they can give incomplete evaluations.

Incomplete evaluations are another form of linguistic preference relations where DMs do not have enough information. To deal with this uncertain and incomplete evaluations in GDM, incomplete preference relations are used. With incomplete preference relations technique, missing values can be estimated with the help of known values.

	F 1	F 2	F 3
F 1	-	?	?
F 2	✓	-	✓
F 3	?	?	-

→

	F 1	F 2	F 3
F 1	-	✓	✓
F 2	✓	-	✓
F 3	✓	✓	-

Figure 3.1: Presentation of incomplete preference relations

By including this technique in GDM, decision making process can be more stronger and in better quality.

The advantages of this technique can be summarized as follows.

- Deal with constraints arising from evaluations.
- Ensures healthier assessments.
- It ensures the completion of the missing evaluations.

In this study, incomplete preference relations is used under multiple preferences relations as an evaluation format of decision makers. The computational steps are given in Part 3.2.

3.2 Computational Steps of Multi Preference Relations with SWOT Analysis

In this section, the proposed approach is described as follows based on the studies Büyüközkan & Çifçi (2013), Büyüközkan & Çifçi (2015) and Büyüközkan & Güleryüz (2015):

Step 1 - Determining the SWOT factors of the strengths, weaknesses, opportunities, and threats: In this step, the SWOT factors of the selected area is described by benefiting from the literature researches and expert opinions.

Step 2 - Determining the strategies: After determining the SWOT factors in the previous step, possible strategies for the selected area is determined in this step with the help of the experts opinions.

Step 3 - Calculating the priorities of the SWOT factors: The importance ratings of SWOT factors are determined in this step. However, some decision-makers may offer missing information. To overcome this issue, incomplete preference relations approach is used in this study.

Step 3.1 – Unifying different individual evaluations: Decision-makers may provide their preferences in different formats as described below:

1) DMs may present an importance degree vector $(u_1, \ldots, u_N)$ where $u_i \in [0,1]$ i = 1, …., N. If u_i is close to 1, then it is more important. With the formula below we can turn it to relevance of relative importance:

$$z_{ij} = u_i/u_j \text{ for all } 1 \leq i \neq j \leq N \qquad (1)$$

2) DMs may offer an ordered vector (o(1), …, o(N)). In that o(i) represents importance ranking of SWOT factors i. If i is the most important factor, then 1 and if least important, then N. With the formula below we can turn it to relevance of relative importance:

$$z_{ij} = 9^{u_i - u_j} \text{ for all } 1 \leq i \neq j \leq N$$

where (2)

$$u_i = (N - o(i))/(N - 1)$$

3) DMs may present a linguistic importance vector ($s_1, \ldots, s_N$) where s_i, i = 1, …, N. The presented linguistic vectors can be "Not Important (NI), Some Important (SI), Moderately Important (MI), Important (I) and Very Important (VI)." The fuzzy membership functions for linguistic terms for fuzzy triangular quantification can be expressed as NI = (0.00, 0.00, 0.25), SI = (0.00, 0.25, 0.50) MI = (0.25, 0.50, 0.75), I = (0.50, 0.75, 1.00) and VI = (0.75, 1.00, 1.00). With the formula below we can turn it to relevance of relative importance:

$$z_{ij} = 9^{b_i - b_j} \text{ for all } 1 \leq i \neq j \leq N \quad (3)$$

4) DMs may describe the importance of SWOT factors but not stating the rating clearly. So,

zij = 9 and zij = 1/9, is i is more important than j
and zij = 1 if nothing mentioned. (4)

5) DMs may select just a subset of SWOT factors (R') that is found significant. For this situation, SWOT factors in the set of R' are equally important and dominate those in R/R'. Also those in R/R' are even to each other. Relevance of relative importance can be given as,

$$xij = \begin{cases} 9, & i \in R', j \in R/R' \\ 1/9, & i \in R/R', j \in R' \\ 1, & \text{otherwise} \end{cases} \quad (5)$$

for all $1 \leq i \neq j \leq N$

6) DMs may present an uncertain matrix, where some values are deficient. By benefiting from the Table 3.1, the importance degrees of SWOT factors, fuzzy linguistic variables $\tilde{p}_{ij} = (p^{l}_{ij}, p^{m}_{ij}, p^{u}_{ij})$ are aimed to be found.

Table 3.1: Corresponding linguistic terms for evaluation

Linguistic terms	Fuzzy scales
None (N)	(0, 0, 1)
Very low (VL)	(0, 0.1, 0.2)
Low (L)	(0.1, 0.2, 0.3)
Fairly low (FL)	(0.2, 0.3, 0.4)
More or less low (ML)	(0.3, 0.4, 0.5)
Medium (M)	(0.4, 0.5, 0.6)
More or less good (MG)	(0.5, 0.6, 0.7)
Fairly good (FG)	(0.6, 0.7, 0.8)
Good (G)	(0.7, 0.8, 0.9)
Very good (VG)	(0.8, 0.9, 1)
Excellent (E)	(0.9, 1, 1)

The assessed preferences are defuzzified once the DMs have constructed and evaluated the pair-wise comparison matrices of interdependent elements, that are missing, by the formula below:

$$F(\tilde{p}_{ij}) = \frac{1}{2}\int_0^1 (\inf_{x\in\mathfrak{R}} \tilde{p}_{ij}^a + \sup_{x\in\mathfrak{R}} \tilde{p}_{ij}^a) \, da \tag{6}$$

Then, missing values in a DMs evaluation, can be calculated. Given a mutual preference relationship, Eq. (7) to (9) can be used to compute the preference value p_{ij}($i \neq j$) in three ways: (Herrera et al., 2007)

- From $p_{ij} = p_{iy} + p_{yj} - 0.5$, we acquire the prediction (7)

  $cp_{ij}^{y1} = p_{iy} + p_{yj} - 0.5$

- From $p_{yj} = p_{yi} + p_{ij} - 0.5$, we acquire the prediction (8)

  $cp_{ij}^{y2} = p_{yj} - p_{yi} + 0.5$

- From $p_{iy} = p_{ij} + p_{jy} - 0.5$, we acquire the prediction (9)

  $cp_{ij}^{y3} = p_{iy} - p_{jy} + 0.5$

It is presumed that the priority value of one factor over itself is always equal to 0.5.

Estimating the consistency level of each preference relation: For estimating the consistency level of incomplete preference relations, the sets below can be used:

$$H_{ij}^1 = \{y \neq i, j \mid (i, y), (y, j) \in EV\} \tag{10}$$

$$H_{ij}^2 = \{y \neq i, j \mid (y, i), (y, j) \in EV\} \tag{11}$$

$$H_{ij}^3 = \{y \neq i, j \mid (i, y), (j, y) \in EV\} \tag{12}$$

In equations above (10)-(12), H_{ij}^1, H_{ij}^2 and H_{ij}^3 are described which are the sets of intermediate alternative a_y ($y \neq i, j$) which enables to estimate the priority value $p_{ij}(i \neq j)$ and EV is the set of evaluated factors by the DMs. The consistency level CL_{ij} interrelated with priority value $p_{ij}(i \neq j) \epsilon$ EV,

$$CL_{ij} = (1 - a_{ij}).(1 - \mathcal{E}p_{ij}) + a_{ij}.\frac{CP_i + CP_j}{2} \quad (13)$$

$$aij \in [0,1]$$

CL_{ij} is defined as a linear compound of the average of the wholeness values related with the two alternatives involved in that preference degree CP_i and CP_j . In the Eq. (14) , #EV is defined as the number of the priority values which are provided by the members.

$$CP_i = \frac{\#\,(EV)}{2(n-1)} \quad (14)$$

To compute the related error εp_{ij} ,

$$\varepsilon p_{ij} = \frac{2}{3}.\frac{\mathcal{E}p^1{}_{ij} + \mathcal{E}p^2{}_{ij} + \mathcal{E}p^3{}_{ij}}{K} \quad (15)$$

where

$$\varepsilon P_{ij}^1 = \begin{cases} \dfrac{\sum_{j \in H_{ij}^h} |cp_{ij}^{kh} - p_{ij}|}{\#\,(H_{ij}^h)} & ,\text{if}(\#(H_{ij}^h) \neq 0);\, h \,\epsilon \{1,2,3\} \\ 0 & ,\text{otherwise} \end{cases} \quad (16)$$

and (17)

$$K = \begin{cases} 3, \text{if } (\#\,(H_{ij}^{1}) \neq 0) \wedge (\#\,(H_{ij}^{2}) \neq 0) \wedge (\#\,(H_{ij}^{3}) \neq 0) \\ 2, \text{if } (\#\,(H_{ij}^{a}) \neq 0) \wedge (\#\,(H_{ij}^{b}) \neq 0) \wedge (\#\,(H_{ij}^{c}) \neq 0);\ a, b, c \in \{1,2,3\} \\ 1, \ \text{otherwise} \end{cases}$$

In the evaluation of the consistency level, α_{ij}, a parameter to audit the impact of wholeness, can be computed as in the Eq. (18):

$$a_{ij} = 1 - \frac{\#(EV_i) + \#(EV_j) - \#(EV_i \cap EV_j)}{4(n-1) - 2} \quad (18)$$

If CL_{ij} is not less than 0.5, then p_{ij} is consistent. DMs should revise their preferences if p_{ij} is not coherent and $\varepsilon p_{ij} \neq 0$. If p_{ij} is not coherent and $\varepsilon p_{ij} = 0$, that means more known preference values are needed.

Step 3.2 - Collecting the evaluations: Each assessment is aggregated to define a common group of views in this step. With this step dominant opinions of DMs are reflected.

The order weighted geometric (OWG) operator is defined by the following formula:

$$\phi^{G}\{(\overline{w}^{k1}, p_{ij}^{k1}), \ldots (\overline{w}^{kL}{}_{k}, p_{ij}^{kL_k})\} = \prod_{l=1}^{L_k} \left(p_{ij}^{k[l]}\right) \quad (19)$$

Here, $\{1, \ldots, L_k\} \rightarrow \{1, \ldots, L_k\}$ is a permutation such that $\overline{w}^{kl} \geq \overline{w}^{k[l+1]}$, $l = \{1, \ldots, L_k - 1\}$, so $\overline{w}^{k1}$ is the lth largest value in the set $(\overline{w}^{k1}, \ldots, \overline{w}^{kL}{}_{k})$. Proportional quantifiers such as “most”, is represented by fuzzy subsets of the unit interval [0,1]. When the ratio t is suitable with the purpose of the quantifier it demonstrates then for any t ϵ [0,1], Q(t) indicates the degree. For a non-decreasing relative quantifier, Q, the weights can be acquired with the formula below:

$$W_k = Q(k/K) - (Q(k-1)/K),\ \ k = 1, \ldots, K \tag{20}$$

where Q(t) is described as (Büyüközkan & Çiftçi , 2015)

$$Q(t) = \begin{cases} 0, & \text{if } t < s \\ \dfrac{t-s}{v-s}, & \text{if } s \leq t \leq v \\ 1, & \text{if } t \geq v \end{cases} \tag{21}$$

If we show an example for relative quantitative determinants; “most” (0.3, 0.8), “at least half” (0, 0.5) and “as many as possible” (0.5, 1). The fuzzy quantifier Q is symbolized by ϕ_Q^G. For this reason, the whole multiplicative relative importance is acquired as follows:

$$p_{ij}^k = \Phi_Q^G\left(p_{ij}^{k1}, p_{ij}^{k2}, \ldots, p_{ij}^{kL_k}\right),\ 1 \leq i \neq j \leq N \tag{22}$$

Step 3.3 – Identifying the importance of SWOT groups and SWOT factors: To define importance weights of SWOT factors, the evaluations of the DM group aggregated in the matrix P^k which acquired from the Eq.(22) ,must be utilized. Next, the importance of one factor against other in a fuzzy majority sense will be measured. Benefiting from OWG operator, Φ_Q^G, given in Herrera et al. (2001), we have;

$$\mathrm{QGID}_i^k = 1/2\left(1 + \log_9 \phi_Q^G\,(p_{ij}^k : j = 1, \ldots, N)\right) \tag{23}$$

for all i = 1,…., N.

The importance degrees in percentage for the group k is given below, thereafter normalization:

$$\mathrm{QGID}_i^k = \mathrm{QGID}_i^k / \sum_i \mathrm{QGID}_i^k \tag{24}$$

.

These steps have to be perminant at every level of the evalution model.

3.3 Computational Steps of Multiple Preference Relations with TOPSIS

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method is proposed by Hwang and Yoon in 1981 for solving the decision making problems. In this method it is considering that the selected alternative should have the shortest distance from the positive ideal solution and the farthest from the negative ideal solution.

In this part of the study, alternative strategies are evaluated by using multiple preference relations technique, by two DM groups of 20 experts. After calculating priorities of alternative strategies by each sub-factor, TOPSIS methodology is used to ranked the strategies. In the continuation of Step 3.3, the following steps are implemented to select the best strategy. (Alptekin, 2013)

Step 4 – Creation of the decision matrix consisting of alternative strategies and criterias: The decision matrix includes alternative strategies in the rows and the criteria in the columns which created by unifying different individual assessments of decision makers by using multiple preference techniques. Decision matrix was formed by following the steps in Step 3 of part 3.2.

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix}$$

Step 5 – Normalization of decision matrix: The normalized decision matrix is formed according to the form below using the matrix A_{ij}.

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}} \quad \text{where} \quad i=1,2,\dots,m; \quad j=1,2,\dots,n \tag{25}$$

Step 6 – Obtaining a weighted normalized decision matrix: A weighted decision matrix is formed by multiplying the weights of the criteria of the elements in each column of the normalized decision matrix.

$$v_{ij} = w_i * r_{ij} \quad \text{where } i=1,2,\dots,m; j=1,2,\dots,n \tag{26}$$

$$V_{ij} = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \dots & w_n r_{1n} \\ w_1 r_{21} & w_2 r_{22} & \dots & w_n r_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ w_1 r_{m1} & w_2 r_{m2} & \dots & w_n r_{mn} \end{bmatrix}$$

Step 7 – Determining the Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS): For the positive ideal solution, the largest values of the column values in the weighted decision matrix are selected, and for the negative ideal solution, the minimum values of the column values in the weighted decision matrix are selected.

$A^{*}=\left\{(\max_{i} v_{ij} \middle| j\in J),(\min_{i} v_{ij} \middle| j\in J^{'}\right\}$, $A^{*}=\{v_{1}^{*},v_{2}^{*},...,v_{n}^{*}\}$ for Positive Ideal Solution (27)

$A^{-}=\left\{(\min_{i} v_{ij} \middle| j\in J),(\max_{i} v_{ij} \middle| j\in J^{'}\right\}$, $A^{-}=\{v_{1}^{-},v_{2}^{-},...,v_{n}^{-}\}$ for Negative Ideal Solution (28)

Step 8– Calculation of the distance of each alternative from PIS and NIS: For each alternative strategy, the deviations of the criterias from the positive and negative ideal solutions are calculated.

$$S_{i}^{*}=\sqrt{\sum_{j=1}^{n}(v_{ij}-v_{j}^{*})^{2}} \tag{29}$$

$$S_{i}^{-}=\sqrt{\sum_{j=1}^{n}(v_{ij}-v_{j}^{-})^{2}} \tag{30}$$

Step 9– Calculation of the closeness coefficient of each alternative (CCi): The closeness values according to the ideal solution are computed by following form.

$$C_{i}^{*}=\frac{S_{i}^{-}}{S_{i}^{-}+S_{i}^{*}}, 0\le C_{i}^{*}\le 1 \tag{31}$$

Step 10– Ranking of the alternatives: Finally, alternative strategies are ranked according to their importance, and the optimal strategy for selecting the logistics strategies of Marmara Region OIZs is obtained.

4. CASE STUDY

In this section, an application is examined in order to implement the proposed methodologies in the selected area. In this application, by benefiting from the literature research and expert's opinions the SWOT factors and sub-factors have been determined for the Marmara Region OIZs considering the logistics activities and alternative strategies are developed by using SWOT matrix. (Dağlar, 2015), (Kök, 2010), (Darby, 2008), (Trakya Development Agency, 2011), (Özden, 2016), (Trakya Development Agency, 2013), (Trakya Development Agency, 2014), (Güney Marmara Kalkınma Ajansı, 2012), (Güney Marmara Kalkınma Ajansı, 2012).

By using the proposed methodology the weights of the factors and sub-factors are determined. After determining the weights of the factors and sub-factors, alternative strategies are weighted by each sub-factor by using multiple preference relations technique and strategies are ranked by using TOPSIS methodology.

4.1 Application Area: Marmara Region Organized Industrial Zones

Marmara Region is the most developed Region of Turkey in terms of economy and the Region where the Organized Industrial Zones are occupied the most. OIZs are the organizations where there are many products in and out, and in which logistics strategies should be given importance. Determining and selecting the right logistics strategies by analyzing the current situation will improve the efficiency and effectiveness of the Marmara Region Organized Industrial Zones and will improve customer satisfaction and reduce costs.

In this application, evaluations were taken from two different groups and a total of 20 experts. The first group DM1 has 10 experts consists of senior managers of OIZs and the second group DM2 has 10 experts consists of engineers and managers working in the factories located OIZs.

There are a total of 84 OIZs in Marmara Region in Edirne, Tekirdağ, Kırklareli, Çanakkale, Bursa, Balıkesir, Bilecik, Yalova, Kocaeli, Sakarya and Istanbul cities as it can be seen from Figure 4.1.

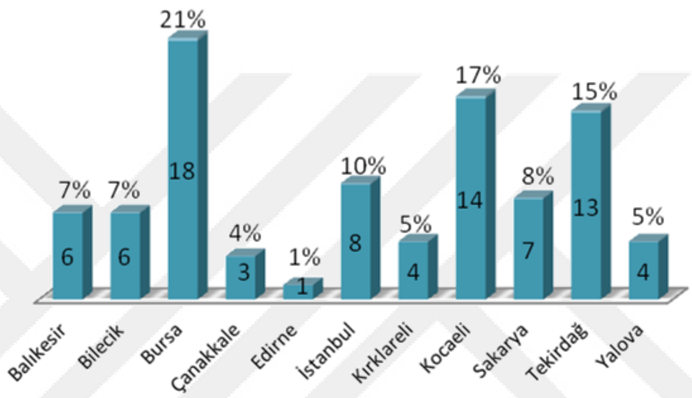

Figure 4.1: The number of OIZs in Marmara Region in terms of cities

The experts we have taken evaluations for the application are located in the cities of Edirne, Tekirdağ, Kırklareli, Istanbul, Kocaeli, Bursa and they gave all the evaluations considering the Marmara Region OIZs.

4.2 Application Steps of Proposed Methodology

Figure 4.2 shows the presentation of the proposed methodology.

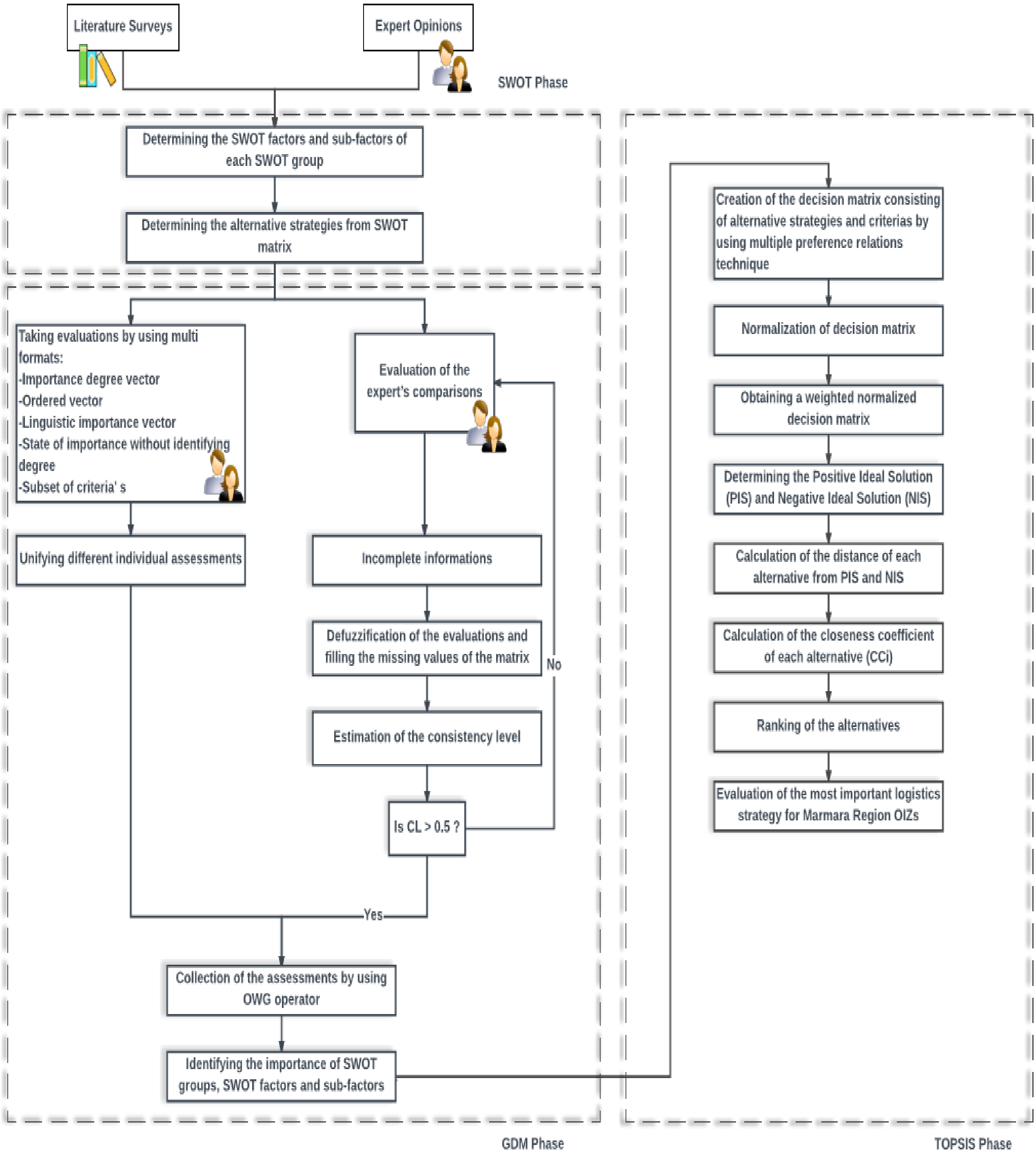

Figure 4.2: Application steps of multiple and incomplete preference relations in SWOT analysis and TOPSIS method for strategy selection

Step 1 - Identifying the SWOT factors of the strengths, weaknesses, opportunities, and threats: In this step, the SWOT factors of the Marmara Region OIZs are described by benefiting from the literature researches and experts opinions.

SWOT analysis is created for Marmara Region OIZs considering the logistics activities. The SWOT analysis is given on Table 4.1.

Step 2 - Determining the strategies: After determining the SWOT factors in the previous step, alternative strategies for the development of Marmara Region OIZs logistics activities are determined in this step with the help of the experts opinions. Alternative strategies are given on Table 4.1.

Table 4.1: Internal and External Strategic Factors of Marmara Region OIZs

Internal Factors / **External Factors**	**Strengths (S)** S1: Educational advantages of the Region S11: The presence of logistics training in the Regional universities and the presence of people trained in logistics in the Region S12: The young and dynamic population to be open to learning and innovation S13: The presence of advanced universities in terms of research activities S2: The presence of free zones, container ports and border gates S21: The presence of the free zones in or near the OIZs S22: Border gates to be closer to the production centers S23: The presence of the container ports S3: Technological and industrial factors S31: Ensuring greater efficiency in production due to the advanced technology in the industry of the Region S32: Ability of the companies to establish supply chain S33: To have an industry structure suitable for clustering	**Weaknesses (W)** W1: Disadvantages of port and OIZs capacity W11: The lack of port capacity (ship berthing areas, docks, etc.) W12: Due to the fertile land in the Region, OIZs cannot expand and jam in their own fields W13: The lack of full capacity of OIZs W2:Cost disadvantages W21: The high cost of road transport W22: The high price of land W23: The high cost of port costs W3: Disadvantages in transportation, custom clearance and entrepots W31: Although some of the OIZs in the Region are close to the main transportation artery, the lack of a direct connection W32: The lack of railway connections in the most of the OIZs W33: Customs clearance cannot be made within the OIZs W34: The lack of a sufficient number of entrepot
Opportunities(O) O1: Geographical advantages of the Region O11: Location of the Region that provides transition between Europe and Asia O12: A Region has a coast with Marmara sea and the black sea O13: Region to be on the international road routes O14: Region to be suitable for the dissemination of the railway network O2: Port and trade advantages O21: The two major ports of Ro-Ro transport of Turkey's (Ambarlı and Haydarpasa) to be in this Region O22: Turkey's most important trade center of Istanbul to take part in this Region O23: Increased international trade O3: Importance given to logistic projects O31: Establishment of a new OIZ and logistics base project in Yalova that will be one of the most important industrial projects in the Marmara Region O32: Increasing awareness of the logistics village projects O33: Developing intermodal transportation with BALO (Western Anatolian Logistics Organizations) project and spreading to a wider service network	SO1 Strategy: Giving importance to the logistics villages and logistics base projects SO2 Strategy: Increasing the number of free zones for boosting cross-border trade and investment with neighbor countries	WO1 Strategy: Strengthening of the OIZs infrastructure and making the connection routes to the main transportation arteries WO2 Strategy: Increasing the port capacity and increasing the number of entrepots
Threats (T) T1: Disadvantages in export T11: Some of the exporters prefer not to take part in the OIZs because of distant from the ports T12: Far east market start to pull the global companies T13: Reduction of exports to neighboring countries due to the confusion T2: Lack of capital, legal legislations and government grants T21: Lack of government grants made to the Region OIZ's T22: The lack of legal legislations T23: Need of intensive capital T3: Political and economic disadvantages T31: Political crises in the country T32: Fluctuations in foreign exchange rates T33: Increases in gasoline prices	ST1 Strategy: Ensuring the development by ensuring OIZs as an attractive places for qualified population and investors ST2 Strategy: Expansion of railway/maritime integrated transportation to the OIZs and making Regional ports compatible with combined transportation	WT1 Strategy: Saving costs by carrying loads of different institutions together WT2 Strategy: Ensuring the development of the railway network to establishment of connection with OIZs and ports

Step 3 - Calculating the priorities of the SWOT factors: After the SWOT factors identified, DM's were consulted in order to calculate the priorities of SWOT group, SWOT factor and sub-factor.

Step 3.1 – Unifying different individual evaluations

Step 3.1.1- Evaluation of SWOT groups (Strengths, Weaknesses, Opportunities and Threats)

a- DM 1:

- M1 presents an ordering vector of {1, 3, 2, 4}
- M2 evaluates each SWOT group in linguistic terms {I, VI, MI, NI}
- M3 gives a subset of SWOT groups {S} that is found important.
- M4 says opportunities group important than strengths and threats group, strengths group important than weaknesses and threats group.
- M5 presents an importance degree vector {1.0, 0.3, 0.8, 0.6}
- M6 evaluates each SWOT group in linguistic terms {SI, VI, I, MI}
- M7 presents an ordering vector of {1, 3, 2, 4}
- M8 presents an importance degree vector {1.0, 0.9, 0.7, 0.8}
- M9 presents an importance degree vector {1.0, 0.7, 0.8, 0.9}
- M10 gives a subset of SWOT groups {S, O} that is found important.

By using the conversion functions given in Section 3- Step 3.1, importance relation matrices P^{11} to P^{110} are computed.

P^{11} =

1.00	4.33	2.08	9.00
0.23	1.00	0.48	2.08
0.48	2.08	1.00	4.33
0.11	0.48	0.23	1.00

P^{12} =

1.00	0.58	1.73	5.20
1.73	1.00	3.00	9.00
0.58	0.33	1.00	3.00
0.19	0.11	0.33	1.00

P^{13}=

1.00	9.00	1.00	1.00
0.11	1.00	1.00	1.00
1.00	1.00	1.00	9.00
1.00	1.00	0.11	1.00

P^{17}=

1.00	4.33	2.08	9.00
0.23	1.00	0.48	2.08
0.48	2.08	1.00	4.33
0.11	0.48	0.23	1.00

P^{14}=

1.00	9.00	0.11	9.00
0.11	1.00	0.11	1.00
9.00	9.00	1.00	9.00
0.11	1.00	0.11	1.00

P^{18}=

1.00	1.11	1.43	1.25
0.90	1.00	1.29	1.13
0.70	0.78	1.00	0.88
0.80	0.89	1.14	1.00

P^{15}=

1.00	3.33	1.25	1.67
0.30	1.00	0.38	0.50
0.80	2.67	1.00	1.33
0.60	2.00	0.75	1.00

P^{19}=

1.00	1.43	1.25	1.11
0.70	1.00	0.88	0.78
0.80	1.14	1.00	0.89
0.90	1.29	1.13	1.00

P^{16}=

1.00	0.19	0.33	0.58
5.20	1.00	1.73	3.00
3.00	0.58	1.00	1.73
1.73	0.33	0.58	1.00

P^{110}=

1.00	9.00	1.00	9.00
0.11	1.00	0.11	1.00
1.00	9.00	1.00	9.00
0.11	1.00	0.11	1.00

Calculation of member's importance matrices are given below, to define this step more clearly.

M1: The ordered importance vector of M1 can be transformed into a relative importance relation by using Eq.(2) as $P_{12}^{11} = 9^{u_i - u_j} = 9^{1-0,33}$ where u_1= (4-1)/(4-1)=1 and u_2= (4-3)/(4-1)=0.33.

M2: The linguistic terms of M2 can be converted into a relative importance relation using Eq.(3) as $P_{12}^{12} = 9^{0,75-1} = 0.58$.

M3: For P_{12}^{13} where i=1 and j=2, i ∈ R', j ∈ R/R' notation is provided for the subset which member chose. Using Eq.(5), P_{12}^{13} is computed as 9.

M4: The member says opportunities group important than strengths and threats group, strengths group important than weaknesses and threats group but doesn't mention about the relative importance between weaknesses and threats. Using Eq.(4) P_{12}^{14} is computed as 9.

M5: The importance degree vector of M5 is transformed into a relative importance relation using Eq. (1), as P_{12}^{15}= 1.0/0.3= 3.33

M6: The linguistic terms of M6 can be transformed into a relative importance relation using Eq.(3) as $P_{12}^{16} = 9^{0,25-1}$ = 0.19.

M7: The ordered importance vector of M7 can be transformed into a relative importance relation by using Eq.(2) as $P_{12}^{17} = 9^{u_i - u_j} = 9^{1-0,33}$ where u_1= (4-1)/(4-1)=1 and u_2= (4-3)/(4-1)=0.33.

M8: The importance degree vector of M8 is transformed into a relative importance relation using Eq. (1), as P_{12}^{18}= 1.0/0.9= 1.11

M9: The importance degree vector of M9 is transformed into a relative importance relation using Eq. (1), as P_{12}^{19}= 1.0/0.7= 1.43

M10: For P_{12}^{110} where i=1 and j=2, i ∈ R', j ∈ R/R' notation is provided for the subset which member chose. Using Eq.(5), P_{12}^{110} is computed as 9.

Step 3.2 - Collecting the evaluations: The matrices P^{11}-P^{110} are collected with the help of the Eq. (19)-(22) and the OWG operator is used with the fuzzy linguistic quantifier "at least half – (0, 0.5)" to find the importance relation matrix of the group (Büyüközkan & Çiftçi , 2015). It's weighting vector is found as (0.2, 0.2, 0.2, 0.2, 0.2, 0, 0, 0, 0, 0).

Then using the Eq. (19), group importance relation matrix is as follows:

P^1=

1.00	3.68	1.35	5.76
0.27	1.00	0.57	1.56
0.74	1.75	1.00	2.74
0.17	0.64	0.36	1.00

As an example for P_{12}^{1},

$P_{12}^{1} = \prod_{l=1}^{10}\left(p_{12}^{1[l]}\right) = \Phi_Q^G\left(p_{12}^{11}, p_{12}^{12}, p_{12}^{13}, p_{12}^{14}, p_{12}^{15}, p_{12}^{16}, p_{12}^{17}, p_{12}^{18}, p_{12}^{19}, p_{12}^{110}\right) = 4.33^{0.2}$ x $0.58^{0.2}$ x $9^{0.2}$ x $9^{0.2}$ x $3.33^{0.2}$ x 0.19^{0} x 4.33^{0} x 1.11^{0} x 1.43^{0} x 9^{0} = 3.68

Step 3.3 - Identifying the importance of SWOT groups: Obtaining priorities from the evaluation matrix Eq. (19)-(22) are used to compute the weighting vector (0.5, 0.5, 0, 0) by using the fuzzy linguistic quantifier "at least half" (Büyüközkan & Çiftçi , 2015) . After, using the Eq. (23)-(24), group total importance values of P^1 are calculated.

The importance values of the DM 1 calculated as (0.648, 0.352, 0.530, 0.250) which are then normalized as (0.364, 0.198, 0.298, 0.140). Calculation steps are as follows:

$QGID_1^1 = 1/2\left(1 + \log_9 \phi_Q^G\,(p_{1j}^4 : j = 1,2,3,4)\right)$ = 1/2 (1+$\log_9$ ($1^{0.5}$ x $3.68^{0.5}$ x 1.35^{0} x 5.76^{0}) =0.648

$QGID_1^2 = 1/2\left(1 + \log_9 \phi_Q^G\,(p_{1j}^4 : j = 1,2,3,4)\right)$ = 1/2 (1+$\log_9$ ($0.27^{0.5}$ x $1^{0.5}$ x 0.57^{0} x 1.56^{0}) = 0.352

$QGID_1^3 = 1/2\left(1 + \log_9 \phi_Q^G\,(p_{1j}^4 : j = 1,2,3,4)\right)$ = 1/2 (1+$\log_9$ ($0.74^{0.5}$ x $1.75^{0.5}$ x 1^{0} x 2.74^{0}) = 0.530

$QGID_1^4 = 1/2\left(1 + \log_9 \phi_Q^G\,(p_{1j}^4 : j = 1,2,3,4)\right)$ = 1/2 (1+$\log_9$ ($0.17^{0.5}$ x $0.64^{0.5}$ x 0.36^{0} x 1^{0}) = 0.250

b- DM 2:

- M1 presents an importance degree vector {0.9, 0.7, 0.8, 1.0}
- M2 presents an ordering vector of {1, 4, 2, 3}
- M3 evaluates each SWOT group in linguistic terms {VI, I, MI, SI}
- M4 says opportunities group important than threats group, strengths group important than weaknesses and threats group and weaknesses important than opportunities group .
- M5 says opportunities group important than strengths, weaknesses and threats groups.
- M6 gives a subset of SWOT groups {W, T} that is found important.
- M7 presents an importance degree vector {0.9, 0.8, 1.0, 0.6}
- M8 presents an ordering vector of {1, 3, 2, 4}
- M9 evaluates each SWOT group in linguistic terms {I, SI, VI, MI}
- M10 presents an importance degree vector {0.9, 0.8, 0.7, 0.7}

Matrices P^{21}-P^{23} are calculated as follows:

P^{21} =

1.00	1.29	1.13	0.90
0.78	1.00	0.88	0.70
0.89	1.14	1.00	0.80
1.11	1.43	1.25	1.00

P^{22} =

1.00	9.00	2.08	4.33
0.11	1.00	0.23	0.48
0.48	4.33	1.00	2.08
0.23	2.08	0.48	1.00

$P^{23}=$

1.00	1.73	3.00	5.20
0.58	1.00	1.73	3.00
0.33	0.58	1.00	1.73
0.19	0.33	0.58	1.00

$P^{27}=$

1.00	1.13	0.90	1.50
0.89	1.00	0.80	1.33
1.11	1.25	1.00	1.67
0.67	0.75	0.60	1.00

$P^{24}=$

1.00	9.00	9.00	9.00
0.11	1.00	9.00	9.00
0.11	0.11	1.00	9.00
0.11	0.11	0.11	1.00

$P^{28}=$

1.00	4.33	2.08	9.00
0.23	1.00	0.48	2.08
0.48	2.08	1.00	4.33
0.11	0.48	0.23	1.00

$P^{25}=$

1.00	1.00	0.11	1.00
1.00	1.00	0.11	1.00
9.00	9.00	1.00	9.00
1.00	1.00	0.11	1.00

$P^{29}=$

1.00	3.00	0.58	1.73
0.33	1.00	0.19	0.58
1.73	5.20	1.00	3.00
0.58	1.73	0.33	1.00

$P^{26}=$

1.00	0.11	1.00	0.11
9.00	1.00	9.00	1.00
1.00	0.11	1.00	0.11
9.00	1.00	9.00	1.00

$P^{210}=$

1.00	1.13	1.29	1.29
0.89	1.00	1.14	1.14
0.78	0.88	1.00	1.00
0.78	0.88	1.00	1.00

Calculation of member's importance relation matrices are shown below, to define this step more clearly.

M1: The importance degree vector of M1 is transformed into a relative importance relation using Eq. (1), as P_{12}^{21}= 0.9/0.7= 1.29

M2: The ordered importance vector of M2 can be transformed into a relative importance relation by using Eq.(2) as $P_{12}^{22} = 9^{u_i - u_j} = 9^{1-0}$ where u_1= (4-1)/(4-1)=1 and u_2= (4-4)/(4-1)=0.

M3: The linguistic terms of M3 can be transformed into a relative importance relation using Eq.(3) as $P_{12}^{23} = 9^{1-0.75} = 1.73$.

M4: The member says opportunities group important than threats group, strengths group important than weaknesses and threats group and weaknesses important than opportunities group. Using Eq.(4) P_{12}^{24} is computed as 9.

M5: The member says opportunities group important than strengths, weaknesses and threats groups but doesn't mention about the relative importance between the other groups. Using Eq.(4) P_{12}^{25} is calculated as 1.

M6: For P_{12}^{26} where i=1 and j=2, i ∈ R', j ∈ R/R' notation is provided for the subset which member chose. Using Eq.(5), P_{12}^{26} is computed as 0.11.

M7: The importance degree vector of M7 is transformed into a relative importance relation using Eq. (1), as P_{12}^{27}= 0.9/0.8= 1.13

M8: The ordered importance vector of M8 can be transformed into a relative importance relation by using Eq.(2) as $P_{12}^{28} = 9^{u_i - u_j} = 9^{1-0.33}$ where u_1= (4-1)/(4-1)=1 and u_2= (4-3)/(4-1)=4.33.

M9: The linguistic terms of M9 can be transformed into a relative importance relation using Eq.(3) as $P_{12}^{29} = 9^{0.75-0.25} = 3$.

M10: The importance degree vector of M10 is transformed into a relative importance relation using Eq. (1), as P_{12}^{210}= 0.9/0.8= 1.13

Step 3.2 - Collecting the evaluations: The matrices P^{11}-P^{110} are collected with the help of the Eq. (19)-(22) and the OWG operator is used with the fuzzy linguistic quantifier "at least half – (0, 0.5)" to find the importance relation matrix of the group (Büyüközkan & Çiftçi , 2015). It's weighting vector is found as (0.2, 0.2, 0.2, 0.2, 0.2, 0, 0, 0, 0, 0).

Then using the Eq. (19), group importance relation matrix is as follows:

P^2=

1.00	2.83	1.48	2.83
0.35	1.00	0.81	1.55
0.68	1.23	1.00	2.98
0.35	0.64	0.34	1.00

As an instance for P_{12}^{2},

$P_{12}^{2} = \prod_{l=1}^{10}\left(p_{12}^{2[l]}\right) = \Phi_{Q}^{G}\left(p_{12}^{21}, p_{12}^{22}, p_{12}^{23}, p_{12}^{24}, p_{12}^{25}, p_{12}^{26}, p_{12}^{27}, p_{12}^{28}, p_{12}^{29}, p_{12}^{210}\right) = 1.29^{0.2} \times 9^{0.2} \times 1.73^{0.2} \times 9^{0.2} \times 1^{0.2} \times 0.11^{0} \times 1.13^{0} \times 4.33^{0} \times 3^{0} \times 1.13^{0} = 2.83$

Step 3.3 - Identifying the importance of SWOT factors: Obtaining priorities from the evaluation matrix Eq. (19)-(22) are used to compute the weighting vector (0.5, 0.5, 0, 0) by using the fuzzy linguistic quantifier "at least half" (Büyüközkan & Çiftçi , 2015). After, using the Eq. (23)-(24), group total importance values of P^2 are calculated.

The importance values of the DM 2 calculated as (0.618, 0.382, 0.480, 0.331) which are then normalized as (0.341, 0.211, 0.265, 0.183). The calculation steps are as follows:

$QGID_{2}^{1} = 1/2\left(1 + \log_9 \phi_{Q}^{G}\left(p_{2j}^{4} : j = 1,2,3,4\right)\right) = 1/2\ (1+\log_9\ (1^{0.5} \times 2.83^{0.5} \times 1.48^{0} \times 2.83^{0}) = 0.618$

$QGID_{2}^{2} = 1/2\left(1 + \log_9 \phi_{Q}^{G}\left(p_{2j}^{4} : j = 1,2,3,4\right)\right) = 1/2\ (1+\log_9\ (0.35^{0.5} \times 1^{0.5} \times 0.81^{0} \times 1.55^{0}) = 0.382$

$QGID_{2}^{3} = 1/2\left(1 + \log_9 \phi_{Q}^{G}\left(p_{2j}^{4} : j = 1,2,3,4\right)\right) = 1/2\ (1+\log_9\ (0.68^{0.5} \times 1.23^{0.5} \times 1^{0} \times 2.98^{0}) = 0.480$

$QGID_2^4 = 1/2(1 + \log_9 \phi_Q^G (p_{2j}^4: j = 1,2,3,4))$ = 1/2 (1+$\log_9$ ($0.35^{0.5}$ x $0.64^{0.5}$ x 0.34^0 x 1^0) = 0.331

Step 3.1.2 - Evaluation of SWOT factors of the Strengths group:

a- DM 1:

- M1 presents an ordering vector of {3, 1, 2}
- M2 gives linguistic vector{VI, I, MI}
- M3 gives a subset of SWOT factors {S2} that is found important.
- M4 says S2 is important than S1 and S1 is important S3.
- M5 presents an importance degree vector {0.4, 1.0, 0.8}
- M6 gives linguistic vector{I, MI, VI}
- M7 presents an ordering vector of {2, 3, 1}
- M8 presents an importance degree vector {0.8, 1.0, 0.9}
- M9 presents an importance degree vector {0.8, 0.9, 1.0}
- M10 gives a subset of SWOT factors {S2} that is found important.

The member's importance relation matrices P^{11}-P^{110} are created with the help of the Eq. (1)-(5).

Step 3.2 - Collecting the evaluations: The matrices P^{11}-P^{110} are collected with the help of the Eq. (19)-(22) and the OWG operator is used with the fuzzy linguistic quantifier "at least half – (0, 0.5)" to find the importance relation matrix of the group (Büyüközkan & Çiftçi , 2015). It's weighting vector is found as (0.2, 0.2, 0.2, 0.2, 0.2, 0, 0, 0, 0, 0).

Then using the Eq. (19), group importance relation matrix is as follows:

P^1=

1.00	0.25	1.35
4.02	1.00	3.50
0.74	0.29	1.00

As an instance for P^1_{12},

$P^1_{12} = \prod_{l=1}^{10}\left(p_{12}^{1[l]}\right) = \Phi_Q^G\left(p_{12}^{11}, p_{12}^{12}, p_{12}^{13}, p_{12}^{14}, p_{12}^{15}, p_{12,}^{16}, p_{12}^{17}, p_{12}^{18}, p_{12}^{19}, p_{12}^{110}\right) = 0.11^{0.2}$ x $1.73^{0.2}$ x $0.11^{0.2}$ x $0.11^{0.2}$ x $0.40^{0.2}$ x 1.73^{0} x 3^{0} x 0.80^{0} x 0.89^{0} x 0.11^{0} = 0.25

Step 3.3 - Identifying the importance of SWOT factors: Obtaining priorities from the evaluation matrix Eq. (19)-(22) are used to compute the weighting vector (0.67, 0.33, 0) by using the fuzzy linguistic quantifier "at least half" (Büyüközkan & Çiftçi , 2015). After, using the Eq. (23)-(24), group total importance values of P^1 are calculated.

The importance values of the DM 1 calculated as (0.394, 0.711, 0.359) which are then normalized as (0.269, 0.485, 0.245).

b- DM 2:

- M1 presents an importance degree vector {0.8, 1.0, 0.9}
- M2 presents an ordering vector of {2, 1, 3}
- M3 gives linguistic vector{MI, I, VI}
- M4 says S2 is important than S1 and S2 is important than S3.
- M5 says S1 is important than S3 and S1 is important than S2.
- M6 gives a subset of SWOT factors {S2} that is found important.
- M7 presents an importance degree vector {0.8, 1.0, 0.9}
- M8 presents an ordering vector of {2, 1, 3}
- M9 gives linguistic vector{I, SI, MI}
- M10 presents an importance degree vector {0.9, 0.9, 0.8}

Step 3.2 - Collecting the evaluations: The matrices P^{21}-P^{210} are collected with the help of the Eq. (19)-(22) and the OWG operator is used with the fuzzy linguistic quantifier "at least half – (0, 0.5)" to find the importance relation matrix of the group (Büyüközkan & Çiftçi , 2015). It's weighting vector is found as (0.2, 0.2, 0.2, 0.2, 0.2, 0, 0, 0, 0, 0).

Then using the Eq. (19), group importance relation matrix is as follows:

P^2=

1.00	0.69	1.52
1.45	1.00	2.20
0.66	0.45	1.00

Step 3.3 - Identifying the importance of SWOT factors: Obtaining priorities from the evaluation matrix Eq. (19)-(22) are used to compute the weighting vector (0.67, 0.33, 0) by using the fuzzy linguistic quantifier "at least half" (Büyüközkan & Çiftçi , 2015). After, using the Eq. (23)-(24), group total importance values of P^1 are calculated.

The importance values of the DM 2 calculated as (0.472, 0.557, 0.377) which are then normalized as (0.336, 0.396, 0.268).

Step 3.1.3 - Evaluation of SWOT factors of the Weaknesses group:

a- DM 1:

- M1 presents an ordering vector of {3, 1, 2}
- M2 gives an incomplete evaluation matrix.

	W1	W2	W3
W1	*	X	X
W2	M	*	VL
W3	X	X	*

- M3 gives a subset of SWOT factors {W3} that is found important.
- M4 says W3 is important than W1 and W2 is important W1.
- M5 presents an importance degree vector {0.3, 0.8, 0.7}
- M6 gives linguistic vector{MI, I, VI}
- M7 presents an ordering vector of {3, 1, 2}
- M8 presents an importance degree vector {0.5, 1.0, 0.9}
- M9 presents an importance degree vector {0.8, 1.0, 0.9}

- M10 gives a subset of SWOT factors {W2} that is found important.

The member's importance relation matrices P^{11}-P^{110} are created with the help of the Eq. (1)-(18).

Conversion of the incomplete preference matrix of M2 into a relative importance relation, the calculation steps are as follows:

Known values are defuzzified using Eq. (6). As an example for defuzzification P_{21}^{12} is computed as $F(P_{21}^{12}) = \frac{1}{2}\int_0^1 (0.4 + 0.6)\, da = 0.5$.

Eq. (7) to (9) are used to estimate the missing values.

Iteration 1. First set of elements to estimate is {(1,3) , (3,1)}. With calculation process we have,

$H_{13}^{1} = \emptyset$ as $cp_{13}^{21} = p_{12} + p_{23} - 0.5$ = unknown

$H_{13}^{2} = \{1\}$ as $cp_{13}^{22} = p_{23} - p_{21} + 0.5$ = 0.1-0.5+0.5= 0.1

$H_{13}^{3} = \emptyset$ as $cp_{13}^{23} = p_{12} - p_{32} + 0.5$ = unknown

Thereby, cp_{13} = 0.1.

$H_{31}^{1} = \emptyset$ as $cp_{31}^{21} = p_{32} + p_{21} - 0.5$ = unknown

$H_{31}^{2} = \{1\}$ as $cp_{31}^{22} = p_{21} - p_{23} + 0.5$ = 0.5-0.1+0.5= 0.9

$H_{31}^{3} = \emptyset$ as $cp_{31}^{23} = p_{32} - p_{12} + 0.5$ = unknown

Thereby, cp_{31} = 0.9.

Iteration 2. Second set of elements to estimate is {(1,2), (3,2)}. With calculation process we have,

$H_{12}^{1} = \emptyset$ as $cp_{12}^{31} = p_{13} + p_{32} - 0.5$ = unknown

$H_{12}^{2} = \emptyset$ as $cp_{12}^{32} = p_{32} - p_{31} + 0.5$ = unknown

$H_{12}^{3} = \{1\}$ as $cp_{12}^{33} = p_{13} - p_{23} + 0.5$ = 0.1-0.1+0.5= 0.5

Thereby, $cp_{12} = 0.5$.

$H_{32}^{1} = \emptyset$ as $cp_{32}^{11} = p_{31} + p_{12} - 0.5$ = unknown

$H_{32}^{2} = \emptyset$ as $cp_{32}^{12} = p_{12} - p_{13} + 0.5$ = unknown

$H_{32}^{3} = \{1\}$ as $cp_{32}^{13} = p_{31} - p_{21} + 0.5$ = 0.9-0.5+0.5= 0.9

Thereby, cp_{32}= 0.9.

After missing values are found, consistency should be estimated. The consistency level matrix is computed as Table 4.2

Table 4.2: Consistency matrices of M2

	W1	W2	W3
W1	-	0.58	0.50
W2	0.58	-	0.58
W3	0.50	0.58	-

As an example for computing the consistency level, P_{12}^{13} is shown below using Eq. (13)-(18).

EV1= 1 {(2,1)}

EV2= 2 {(2,1), (2,3)}

EV3= 1 {(2,3)}

CP1= 0.25, CP2= 0.50, CP3=0.25

$$a_{12} = 1 - \frac{1 + 2 - 1}{4(3 - 1) - 2} = 0.67$$

CL_{12}= (1-0.67)x(1-0) + 0.67x[(0.25+0.50)/2] = 0.58.

After missing values are completed, importance relation matrices is shown below for M2.

P^{22} =

0.50	0.50	0.10
0.50	0.50	0.10
0.90	0.90	0.50

Step 3.2 - Collecting the evaluations: The matrices P^{11}-P^{110} are collected with the help of the Eq. (19)-(22) and the OWG operator is used with the fuzzy linguistic quantifier “at least half – (0, 0.5)” to find the importance relation matrix of the group (Büyüközkan & Çiftçi , 2015). It’s weighting vector is found as (0.2, 0.2, 0.2, 0.2, 0.2, 0, 0, 0, 0, 0).

Then using the Eq. (19), group importance relation matrix is as follows:

P^{1}=

0.87	0.30	0.18
2.55	0.87	0.52
3.48	1.19	0.87

Step 3.3 - Identifying the importance of SWOT factors: Obtaining priorities from the evaluation matrix Eq. (19)-(22) are used to compute the weighting vector (0.67, 0.33, 0) by using the fuzzy linguistic quantifier “at least half” (Büyüközkan & Çiftçi , 2015). After, using the Eq. (23)-(24), group total importance values of P^{1} are calculated.

The importance values of the DM 1 computed as (0.387, 0.632, 0.702) which are then normalized as (0.225, 0.367, 0.408).

b- DM 2:

- M1 presents an importance degree vector {0.6, 0.8, 0.6}
- M2 presents an ordering vector of {1, 3, 2}
- M3 gives linguistic vector{MI, VI, I}

- M4 says W3 is important than W2 and W1 is important than W2.
- M5 says W3 is important than W1 and W2 is important than W1.
- M6 gives a subset of SWOT factors {W1} that is found important.
- M7 presents an importance degree vector {0.7, 1.0, 0.5}
- M8 presents an ordering vector of {3, 1, 2}
- M9 gives an incomplete evaluation matrix.

	W1	W2	W3
W1	*	X	ML
W2	X	*	FG
W3	X	X	*

- M10 presents an importance degree vector {0.6, 0.9, 0.8}

as (0.225, 0.367, 0.408).

The member's importance relation matrices P^{21}-P^{210} are created with the help of the Eq. (1)-(18).

Step 3.2 - Collecting the evaluations: The matrices P^{21}-P^{210} are collected with the help of the Eq. (19)-(22) and the OWG operator is used with the fuzzy linguistic quantifier "at least half – (0, 0.5)" to find the importance relation matrix of the group (Büyüközkan & Çiftçi , 2015). It's weighting vector is found as (0.2, 0.2, 0.2, 0.2, 0.2, 0, 0, 0, 0, 0).

Then using the Eq. (19), group importance relation matrix is as follows:

P^2=

1.00	1.18	0.72
0.85	1.00	0.61
1.39	1.64	1.00

Step 3.3 - Identifying the importance of SWOT factors: Obtaining priorities from the evaluation matrix Eq. (19)-(22) are used to compute the weighting vector (0.67, 0.33, 0) by using the fuzzy linguistic quantifier "at least half" (Büyüközkan & Çiftçi ,

2015). After, using the Eq. (23)-(24), group total importance values of P^1 are calculated.

The importance values of the DM 2 calculated as (0.512, 0.475, 0.587) which are then normalized as (0.325, 0.302, 0.373).

Using the same rationale, all factors and sub- factors of the SWOT groups are assessed and priorities are determined. The final evaluations of the SWOT groups, SWOT factors and sub-factors are shown in the Table 4.3.

Table 4.3a: Final result of SWOT groups, SWOT factors and sub-factors

SWOT group	Group weight score	SWOT factors	Local weight score DM 1	Local weight score DM 2	SWOT sub-factors	Local weight score DM 1	Local weight score DM 2	Overall weight score
Strengths	0.353	S1	0.269	0.336	S11	0.355	0.459	**0.043**
					S12	0.390	0.210	0.032
					S13	0.255	0.330	0.031
		S2	0.485	0.396	S21	0.336	0.295	**0.049**
					S22	0.385	0.371	**0.059**
					S23	0.279	0.334	**0.048**
		S3	0.245	0.268	S31	0.340	0.279	0.028
					S32	0.312	0.403	0.032
					S33	0.348	0.318	0.030
Weaknesses	0.204	W1	0.225	0.325	W11	0.204	0.329	0.015
					W12	0.403	0.460	0.024
					W13	0.392	0.211	0.017
		W2	0.367	0.302	W21	0.328	0.347	0.023
					W22	0.466	0.361	0.028
					W23	0.206	0.293	0.017
		W3	0.408	0.373	W31	0.279	0.322	0.024
					W32	0.227	0.197	0.017
					W33	0.269	0.268	0.021
					W34	0.225	0.212	0.017

Table 4.3b: Final result of SWOT groups, SWOT factors and sub-factors

SWOT group	Group weight score	SWOT factors	Local weight score DM 1	Local weight score DM 2	SWOT sub-factors	Local weight score DM 1	Local weight score DM 2	Overall weight score
Opportunities	0.281	O1	0.511	0.346	O11	0.258	0.321	**<u>0.035</u>**
					O12	0.225	0.238	0.028
					O13	0.318	0.253	0.034
					O14	0.199	0.188	0.023
		O2	0.257	0.300	O21	0.229	0.328	0.022
					O22	0.399	0.402	0.031
					O23	0.372	0.270	0.025
		O3	0.232	0.353	O31	0.253	0.369	0.026
					O32	0.433	0.309	0.031
					O33	0.314	0.322	0.026
Threats	0.162	T1	0.315	0.313	T11	0.341	0.324	0.017
					T12	0.372	0.300	0.017
					T13	0.287	0.376	0.017
		T2	0.491	0.370	T21	0.505	0.513	0.035
					T22	0.230	0.216	0.016
					T23	0.265	0.270	0.019
		T3	0.194	0.317	T31	0.309	0.394	0.015
					T32	0.389	0.418	0.017
					T33	0.302	0.188	0.010

After determining the weights of SWOT groups, factors and sub-factors, alternative strategies were first evaluated by decision makers with multiple preference relations techniques according to each sub-factor. The averages of the weights we obtained as a result of DM1 and DM2 are formed our decision matrix based on alternative strategies and sub-factors. The importance of each alternative and the distance between the positive ideal solution vector and the negative ideal solution vector are computed by using TOPSIS methodology in the steps of Step 4 to Step 10.

Step 4 – Creation of the decision matrix consisting of alternative strategies and criterias

The decision matrix is formed by unifying different individual assessments by using Eq. (1)-(24). For 38 sub-factor, 8 alternative strategies are evaluated. Members in DM1 and DM2 gave their preferences in same formats as they used when evaluating criterias. Table 4.4 gives the decision matrix.

Table 4.4: Decision matrix consisting of alternative strategies and criterias

	S11	S12	S13	S21	S22	S23	S31	S32	S33	W11	W12	W13	W21	W22	W23	W31	W32	W33	W34
SO1	0.141	0.174	0.165	0.145	0.140	0.108	0.141	0.127	0.123	0.100	0.129	0.116	0.109	0.126	0.123	0.112	0.114	0.149	0.138
SO2	0.114	0.111	0.107	0.171	0.171	0.106	0.115	0.120	0.117	0.108	0.112	0.116	0.106	0.118	0.103	0.112	0.102	0.188	0.109
WO1	0.108	0.099	0.152	0.120	0.139	0.101	0.120	0.105	0.108	0.108	0.196	0.196	0.116	0.200	0.099	0.196	0.124	0.132	0.104
WO2	0.093	0.089	0.104	0.136	0.129	0.183	0.099	0.101	0.102	0.187	0.104	0.120	0.122	0.116	0.179	0.115	0.115	0.131	0.192
ST1	0.187	0.175	0.149	0.086	0.082	0.092	0.175	0.111	0.112	0.094	0.091	0.127	0.103	0.103	0.090	0.110	0.096	0.079	0.089
ST2	0.141	0.150	0.118	0.130	0.136	0.180	0.141	0.160	0.150	0.166	0.132	0.129	0.146	0.116	0.177	0.131	0.147	0.111	0.127
WT1	0.110	0.102	0.088	0.101	0.092	0.093	0.101	0.172	0.182	0.098	0.096	0.095	0.185	0.098	0.102	0.104	0.112	0.098	0.109
WT2	0.106	0.099	0.117	0.111	0.111	0.137	0.107	0.103	0.106	0.139	0.141	0.101	0.113	0.122	0.128	0.120	0.190	0.112	0.133

	O11	O12	O13	O14	O21	O22	O23	O31	O32	O33	T11	T12	T13	T21	T22	T23	T31	T32	T33
SO1	0.144	0.110	0.147	0.107	0.124	0.158	0.160	0.180	0.197	0.121	0.112	0.153	0.145	0.136	0.143	0.132	0.133	0.120	0.120
SO2	0.185	0.107	0.166	0.106	0.105	0.144	0.150	0.133	0.126	0.111	0.101	0.161	0.181	0.120	0.113	0.113	0.121	0.114	0.115
WO1	0.126	0.098	0.124	0.122	0.098	0.106	0.112	0.117	0.127	0.102	0.143	0.115	0.129	0.181	0.193	0.120	0.117	0.118	0.104
WO2	0.118	0.181	0.130	0.117	0.182	0.107	0.129	0.107	0.115	0.156	0.110	0.109	0.138	0.098	0.104	0.097	0.098	0.093	0.100
ST1	0.082	0.095	0.088	0.098	0.091	0.136	0.101	0.125	0.096	0.098	0.111	0.133	0.079	0.130	0.126	0.188	0.186	0.178	0.111
ST2	0.127	0.179	0.137	0.149	0.181	0.134	0.134	0.141	0.124	0.182	0.133	0.118	0.121	0.120	0.121	0.127	0.133	0.105	0.148
WT1	0.099	0.093	0.095	0.111	0.092	0.103	0.094	0.095	0.102	0.093	0.103	0.101	0.093	0.096	0.094	0.116	0.109	0.172	0.182
WT2	0.120	0.135	0.113	0.190	0.127	0.111	0.118	0.103	0.112	0.137	0.187	0.110	0.113	0.119	0.106	0.106	0.103	0.101	0.120

Step 5 – Normalization of decision matrix:

Decision matrix is then normalized by using Eq. (25).

Step 6 – Obtaining a weighted normalized decision matrix:

In this step, each column of the normalized decision matrix is multiplied with the weights of criteria of the element.

Step 7 – Determining the Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS):

Ideal solution values A^+ and A^- are calculated by using Eq. (27)-(28)

A^+= { 0.21597; 0.14897; 0.14145; 0.15677; 0.18737; 0.16464; 0.15751; 0.17769; 0.17577; 0.14765; 0.25125; 0.16995; 0.18142; 0.24171; 0.12999; 0.17298; 0.13045; 0.14603; 0.12404; 0.15660; 0.12288; 0.13887; 0.11906; 0.09432; 0.18673; 0.15202; 0.16206; 0.21176; 0.17170; 0.20086; 0.15832; 0.17392; 0.27064; 0.12398; 0.14632; 0.18891; 0.20546; 0.13079}

A^-= { 0.10782; 0.07611; 0.07563; 0.07293; 0.09035; 0.08316; 0.08957; 0.10404; 0.09809; 0.07449; 0.11702; 0.08253; 0.10134; 0.11829; 0.006557; 0.09120; 0.06610; 0.06135; 0.05743; 0.06944; 0.06327; 0.07344; 0.06133; 0.04689; 0.12115; 0.08862; 0.08552; 0.10360; 0.08813; 0.10849; 0.09957; 0.07596; 0.14406; 0.06025; 0.07527; 0.09973; 0.10759; 0.07231}

Step 8 – Calculation of the distance of each alternative from PIS and NIS:The distance of each alternative from PIS (S_i^+) and NIS (S_i^-) are calculated by using Eq. (29)-(30)

S_i^+= {0.305160; 0.364400; 0.325800; 0.400293; 0.419433; 0.293090; 0.447151; 0.376084}

S_i^-= {0.278537; 0.249758; 0.299038; 0.213834; 0.233508; 0.266416; 0.178591; 0.192327}

Step 9 – Calculation of the closeness coefficient of each alternative (CCi):

The closeness coefficient of each alternative (C_i^{+}) are computed by using Eq. (31). Calculation of closeness coefficient of SO1 is given below as an instance.

$$C_1^* = \frac{0.278537}{0.278537 + 0.305160} = 0.4772$$

Step 10– Ranking of the alternatives:

By comparing CC_i values, alternative strategies are ranked order as shown in the Table 4.5.

Table 4.5: The closeness coefficient of each alternative

Alternatives	C_i^{+}	Rank
SO1	0.4772	2
SO2	0.4067	4
WO1	0.4786	1
WO2	0.3482	6
ST1	0.3576	5
ST2	0.4762	3
WT1	0.2854	8
WT2	0.3384	7

5. OBTAINED RESULTS AND DISCUSSIONS

In this study, in order to determine appropriate strategies, firstly SWOT analysis has used to analyze the current status of Marmara Region OIZs to determine the criterias to determine and select the best strategy in this direction.

Strategic factors and alternative strategies are evaluated for Marmara Region OIZs for the logistics development. Taking evaluations from experts in various formats using the multiple preference and incomplete preference relations techniques, has enabled the study to give more reliable results. In the points where the experts cannot evaluate the subject, the incomplete preference relations technique was used and the multiple preference relations technique was used according to the form the experts preferred in the evaluation points.

5.1 Results for Criteria Evaluations

According to the application on Marmara Region OIZs, logistics criterias are evaluated by DM groups. Table 4.3 gives the final results of priorities of SWOT groups, SWOT factors and sub-factors.

In Table 4.3, SWOT group weight scores are calculated by getting the average of two decision maker groups evaluations. When calculating the overall weights of SWOT sub-factors, the average of the decision makers evaluations for SWOT factors and sub-factors are computed and each average local weight is multiplied with its group weight.

As shown in the Table 4.3 , priority values between SWOT groups appears as strengths (0.353), weaknesses (0.204), opportunities (0.281) and threats (0.162).

Considering the overall weight scores of the SWOT sub-factors, “S22: Border gates to be closer to the production centers” seem to be with the highest importance within the

SWOT sub-factors. In the continuation, "S21: The presence of the free zones in or near the OIZs", "S23: The presence of the container ports.", "S11: The presence of logistics training in the Regional universities and the presence of people trained in logistics in the Region" and "O11: Location of the Region that provides transition between Europe and Asia" from opportunities group are the other important sub-factors, respectively.

5.2 Results for Alternative Strategies

According to the application on Marmara Region OIZs to select the best logistics strategy, alternative strategies are evaluated by DM groups. Table 4.5 gives the final results of priorities of the alternative strategies.

As shown in Table 4.5 "WO1: Strengthening of the OIZs infrastructure and making the connection routes to the main transportation arteries" strategy is with the highest importance within the alternative strategies. As a result of evaluations, it was found that OIZs in Marmara Region should firstly strengthen its infrastructure on such as energy and transportation. Provision of infrastructure development will increase the productivity of the OIZs as well as making the OIZs more attractive places with the development of the transportation infrastructure.

Following top 5 strategies chosen as the best strategies to implement for the development of Marmara Region OIZs in terms of logistics.

- WO1: Strengthening of the OIZs infrastructure and making the connection routes to the main transportation arteries
- SO1: Giving importance to the logistics villages and logistics base projects
- ST2: Expansion of railway/maritime integrated transportation to the OIZs and making Regional ports compatible with combined transportation

- SO2: Increasing the number of free zones for boosting cross-border trade and investment with neighbor countries
- ST1: Ensuring the development by ensuring OIZs as an attractive places for qualified population and investors

The proposed approach allows practitioners to decide on the factors that should prioritize when determining and selecting the logistics strategies of Marmara Region OIZs. This study is helpful for OIZs for strategic planning process on logistics.

6. CONCLUSION AND PERSPECTIVES

This study presented an integrated SWOT analysis with multiple preference and incomplete preference relations approaches and a case study on Marmara Region OIZs to select the best logistics strategy.

SWOT analysis is a commonly used method for organizations to develop strategies by investigating internal and external environment. SWOT analysis can be digitized by using Multi Criteria Decision Making techniques to define the importance degrees of SWOT factors.

Group members may provide their assessments in different ways or they can provide their preferences in uncertain way. Multi preference relations helps to consolidate different assessments and incomplete preference relations helps to define the incomplete evaluations. When we examine the literature it is easy to see that many studies have done with multiple preference relations and studied in various areas but there are no such studies which uses SWOT analysis with both multiple preference and incomplete preference techniques in the application area of Marmara Region OIZs. Besides using multiple preference and incomplete preference techniques to determine the weights of the criterias in SWOT analysis, TOPSIS methodology is also used in this study with multiple preference relations technique in order to weight alternative strategies based on criterias to select the best strategy. The contributions of this study can be summarized as follows:

- A detailed literature research has been done on the methodologies applied in the study.

- On behalf of the digitization of evaluations made as a result of the SWOT analysis, Multiple Preference Relations and Incomplete Preference Relations techniques has been used together with group decision making perspective.
- There are no such studies on the application of group decision making in Marmara Region OIZs to select the best logistics strategy. With this study, for the first time in the literature, logistics strategies has been determined and selected for the Marmara Region OIZs by using SWOT analysis, multiple preference relations, incomplete preference relations and TOPSIS methodologies.

By using integrated SWOT analysis with multiple preference and incomplete preference relations in various areas, further studies could be done to enlarge the assessment.

The study has also some limitations as it only has evaluations from the experts whose are located in the cities of Edirne, Tekirdağ, Kırklareli, Istanbul, Kocaeli, Bursa. The evaluations of the study can be expanded by taking evaluations from experts in the entire Marmara Region OIZs.

As a future work, multiple preference and incomplete preference relations could also be used with different techniques such as VIKOR, PROMETHEE to weight the alternatives.

The proposed methodology can be extended by including different aggregation operators in collection of the assessments such as ordered weighted averaging (OWA), majority additive OWA (MA-OWA) or induced ordered weighted geometric (IOWG) operators.

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