T.C
ISTANBUL AYDIN UNIVERSITY
INSTITUTE OF SOCIAL SCIENCES

COUNTRY RISK ASSESSMENT BY APPLYING MULTI-CRITERIA DECISION-MAKING METHODS: A CASE STUDY RANKING COUNTRIES IN THE MIDDLE EAST & NORTH AFRICA

THESIS

Ahmad MOHAMMADI DEHCHESHMEH

Department of Business
Business Management Program

Thesis Advisor: Assist. Prof. Dr. Nima MIRZAEI

JUNE, 2018

T.C
ISTANBUL AYDIN UNIVERSITY
INSTITUTE OF SOCIAL SCIENCES

COUNTRY RISK ASSESSMENT BY APPLYING MULTI-CRITERIA DECISION-MAKING METHODS: A CASE STUDY RANKING COUNTRIES IN THE MIDDLE EAST & NORTH AFRICA

THESIS

Ahmad MOHAMMADI DEHCHESHMEH
(Y1512130004)

Department of Business
Business Management Program

Thesis Advisor: Assist. Prof. Dr. Nima MIRZAEI

JUNE, 2018

T.C.
İSTANBUL AYDIN ÜNİVERSİTESİ
SOSYAL BİLİMLER ENSTİTÜSÜ MÜDÜRLÜĞÜ

Yüksek Lisans Tez Onay Belgesi

Enstitümüz İşletme İngilizce Ana Bilim Dalı İşletme Yönetimi İngilizce Yüksek Lisans Programı **Y1512.130004** numaralı öğrencisi **Ahmad MOHAMMADI DEHCHESHMEH**'ın **"COUNTRY RISK ASSESSMENT BY APPLYING MULTI CRITERIA DECISION MAKING METHODS: A CASE STUDY RANKİNG COUNTRIES IN THE MIDDLE EAST & NORTH AFRICA"** adlı tez çalışması Enstitümüz Yönetim Kurulunun 11.05.2018 tarih ve 2018/14 sayılı kararıyla oluşturulan jüri tarafından oybirliği ile Tezli Yüksek Lisans tezi olarak kabul edilmiştir.

Öğretim Üyesi Adı Soyadı	İmzası

Tez Savunma Tarihi : 21/06/2018 – 14:00

1)Tez Danışmanı: Dr. Öğr. Üyesi Nıma MIRZAEI ....

2) Jüri Üyesi : Dr. Öğr. Üyesi Volkan ÇAKIR ....

3) Jüri Üyesi : Prof. Dr. Mustafa Nafiz DURU ....

Not: Öğrencinin Tez savunmasında **Başarılı** olması halinde bu form **imzalanacaktır**. Aksi halde geçersizdir.

FOREWORD

This master thesis where written during the time-period from May 2017 until June 2018 under the teaching supervision of Assist. Prof. Dr. Nima MIRZAEI.
The intent of the thesis is to rank countries in the Middle East and North Africa using Multi-Criteria Decision-Making Methods, TOPSIS, ELECTRE, and PROMETHEE.
Hereby I want to thank my supervisor of being a great help during the development of this thesis.

June 2018 **Ahmad MOHAMMADI DEHCHESHMEH**

ABBREVIATIONS

MCDM : Multi-Criteria Decision Making
MODM : Multi-Objective Decision Making
MADM : Multi-Attribute Decision Making
MENA : Middle East and North Africa
UN : United Nation
IMF : The World Bank
DEA : Data Envelopment Analysis
GDP : Gross Domestic Product
SFA : Stochastic Frontier Analysis
BI : Blacksmith Index
EPA : Environmental Protection Agency
FSE : Fuzzy Synthetic Evaluation
PPP : Purchasing Power Parity
WQI : Water Quality Index
OECD : Organization for Economic Cooperation and Development
TOPSIS : Technique for Order Preference by Similarity to Ideal Solution
ELECTRE : ELimination Et Choix Traduisant la REalité
PROMETHEE : The Preference Ranking Organization METhod for Enrichment Evaluations
GAIA : Graphical Astronomy and Image Analysis
SAFE : Sustainability Assessment by Fuzzy Evaluation

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ÇOK KRİTERLİ KARAR VERME YÖNTEMLERİNİ UYGULAYARAK ÜLKERLERE İLİŞKİN RİSK DEĞERLENDİRİLMESİ: ORTA DOĞU VE KUZEY AFRİKA'DAKİ ÜLKELERİ SIRALAMAK İÇİN BİR ÖRNEK ÇALIŞMASI

ÖZET

Orta Doğu ve Kuzey Afrika (MENA) bölgeleri onlarca yıldır birçok yabancı yatırımcının ilgisini çekmesine rağmen şu anki jeopolitik durum onları hoş karşılamıyordur. O bölgedeki savaş, terrör, ayaklanma ve siyasi değişimlerin sonuçları, bir çok uluslararası şirketin o bölgedeki gelecek planlarını yeniden düşünmeye veya o bölgedeki yatırımlarını geri çekmeye mecbur bırakmıştır. Diğer taraftan MENA'nın, bölgedeki daha az rakip ile gelişen pazarına inanan şirketler de vardır. yapılacak en iyi yatırım kararlarının veya gelecekte ki işbirliklerinin sınırlandırılabilmesi için, güncel durum, analiz ve öngörüleri için, oluşabilecek durumları da gözardı ederek, sözkonusu ülkeyi alakadar eden faktörlere bağlı, kapsamlı ve detaylı bir araştırmanın zorunlu olduğunun altını çizmekte fayda var. Çok kriterli karar verme analizi, yatırımcılara bir takım ilgili kriterlerin arasından en iyi seçeneği bulmakta yardımcı olabilir. Bu araştırmada yirmi temel göstergeye dayanarak yirmi üç ülkenin sıralanması için TOPSIS, ELECTRE ve PROMETHEE gibi iyi bilinen üç çok kriterli karar verme yöntemi kullanılmıştır. Bu araştırma için gerekli olan veriler, hükümetlerin 2000 ve 2015 arası yayınladığı sayıları içeren erişilebilir veri bankalarından alınmıştır. Bu bulguların sonuçları, sözde Arap Baharı ve Arap Baharı sonrası ortamında sürekli hareket halinde olan Orta Doğu ve Kuzey Afrika bölgesine ilgi duyan karar vericiler, politika belirleyenler, paydaşlar, araştırmacılar ve başka ilgili taraflara bir takım ülke sıralamasını getirir.

Anahtar Kelimeleri: *Çok kriterli karar verme, Orta Doğu ve Kuzey Afrika, TOPSIS, ELECTRE, PROMETHEE ülkelere ilişkin risk sıralaması, uluslararası yatırımcılar.*

COUNTRY RISK ASSESSMENT BY APPLYING MULTI-CRITERIA DECISION-MAKING METHODS: A CASE STUDY RANKING COUNTRIES IN THE MIDDLE EAST & NORTH AFRICA

ABSTRACT

The Middle East and North Africa (MENA) region has been attracting many foreign investors for decades, but the current geopolitical situation has not shown a welcoming face towards them. Consequences of war, terror, riots and political changes in the region have forced many international companies to reconsider their future plans in the region or withdraw their investments from the region. On the other hand, there are also companies that have faith in the emerging market of the MENA with fewer competitors in the region. It should be hereby emphasized that narrowing down the best possible investment decision or decisions on future cooperation need accurate research on the current situation as well as an analysis and forecast of the upcoming situation in terms of various factors within the country concerned and also the region. The Multi-Criteria Decision Making (MCDM) analysis can help investors to choose the best alternative from a set of relevant criteria. In this research, three well-known MCDM methods, TOPSIS, ELECTRE, and PROMETHEE, were used to rank twenty-three countries based on twenty key indicators. The data required for this study was collected from the accessible databanks comprising the numbers published by the governments within the years 2000-2015. The outcome of these findings provides a set of country rankings for an interested group of decision makers, policy makers, stakeholders, researchers and other involved parties who are interested in the Middle East and North Africa region which is constantly on the move in the so-called Arab Spring or post-Arab Spring environment.

Keywords: *Multi-Criteria Decision Making, Middle East and North Africa, TOPSIS, ELECTRE, PROMETHEE Country Risk Ranking, International investors.*

1. INTRODUCTION

1.1 Study Topic

Consequences of war, terror and political changes in the Middle East and North Africa region has significantly increased the risk of investments compared to previous decades. Many foreign investors have always seen the Middle East and North Africa as a region with enormous potential with many different resources. Still considering the uncertain instability and risk in the MENA that has undergone a lot of changes, mainly affected by the consequences of the so-called Arab Spring in late 2010 and early 2011, yet international firms are willing to take a calculated risk and invest in the region. For instance, the contract concluded between Iran and the French Energy Giant Total on July 2017, worth nearly $5bn, aims to develop an offshore gas field in the Persian Gulf. There are many consulting firms that assist such companies throughout their project plan. Such firms analyze different indicators of a particular country that could affect the investor’s future in that region. In this study, twenty-three countries of the Middle East and North Africa (MENA) region are ranked based on their financial, political and economic sectors with the help of selected Multi-Criteria Decision Making (MCDM) methods.

1.2 Purpose of Thesis

In this study, twenty-three MENA countries have been graded and ranked using the Multi-Criteria Decision-Making Methods TOPSIS, ELECTRE and PROMETHEE. The result of this study will equip an interested group of decision makers, policy makers, stakeholders, researchers and other parties with a list of scored and ranked countries in the targeted MENA region, in the post-Arab Spring period.

1.3 The Middle East and North Africa

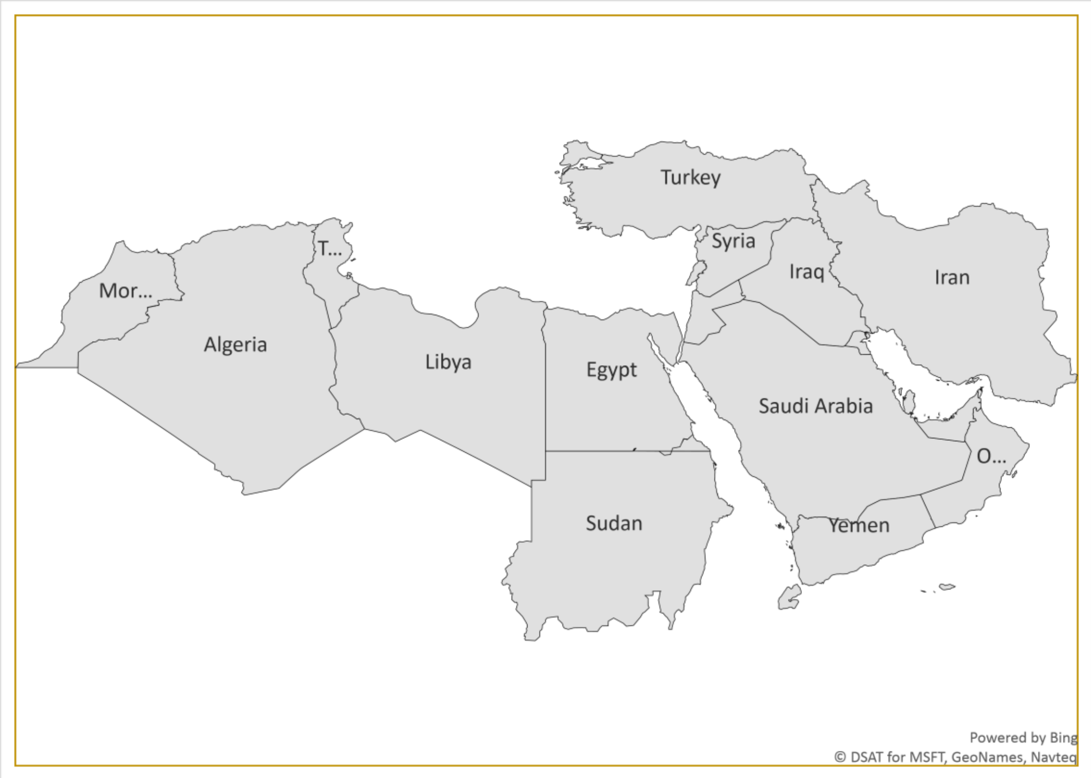

Figure 1.1: The Middle East and North Africa Geographic Map

The Middle and North Africa (MENA) region from the geographic standpoint, starts in the northwest of Africa, Morocco to the southwest of Asia Iran and in the north starting from Turkey to Yemen in the south. Also, there are other countries in this territory that are respectively counted as the MENA region. For instance, Afghanistan, Armenia, Georgia, and Pakistan are such countries that have direct and indirect influences on the region.

The MENA region has an important role in the global economic stability because of its geographic position and its rich natural resources. Since the end of 2010, the MENA region has significantly grown in geopolitical importance due to the so-called Arab spring that includes a set of decisive events in the MENA region ranging from peaceful protests through public acts of violence and (attempted) changes of governments by force to civil wars as well as foreign interventions.

The following chapter, the Literature review, summarizes prior research on ranking countries of the world considering different fields and indicators. Moreover, it also reviews Multi-Criteria Decision-Making methods used in different case studies.

2. LITERATURE REVIEW

There are several methods and techniques available in the academic literature that focus on ranking and analyzing countries in terms of qualitative and quantitative characteristics of different indicators and sectors within the country. In the following, the variety of research and projects are done on country ranking has been demonstrated, it has been covering agriculture, economy, healthcare efficiency, supplier management and a research done on happiness and life satisfaction of different nations.

The research done by (Phillis, Grigoroudis, and Kouikoglou, 2011) discusses a sustainability ranking and improvement of 128 countries based on changes within the regions depending on 75 different indicators such as climate changes, pollution, economic and political changes throughout the time period from 1990 to 2011. Data for each indicator were collected from United Nation (UN) database. The model has divided the structure of sustainability into two components: a) ecological sustainability and b) societal or human sustainability. The ecological components are water quality, land integrity, air quality and biodiversity. The human or societal on the other hand focus on the political aspects of the countries, the educational level, economic welfare, and health.

All together, they have created the Sustainability Assessment by Fuzzy Evaluation (SAFE) model which is capable of handling quantitative, qualitative and mixed data using fuzzy logic. SAFE uses a linear interpolation between sustainable and unsustainable criteria with a series of normalized indicators between zero and one which resulted in a ranking list.

An Economic and Environmental assessment (Madaleno, Moutinho and Robaina, 2016) that focuses on twenty-six European countries using Data Envelopment Analysis (DEA) techniques tried to estimate the efficiency of those countries in the years 2001 to 2012 considering the country's capital, labor forces, renewable energy and fossil fuels as input-oriented and output-oriented as Gross Domestic Product

(GDP) per capita, GDP per labor, and fossil fuel used per GDP and renewable energy per GDP and GDP per greenhouse gasses are indicators used in the research project which has derived its data from the European Environments Agency and Eurostat. It must be noted that by considering different input- and output-oriented indicators, the result of economic and environmental estimation will be different. In this paper, energy forces are one of the key inputs that must be considered among other factors to estimate energy efficacy in the production processes.

Ranking a country does not have to be necessarily based on economic, political indicators. The ranking done on the cross-healthcare efficiency among homogeneous countries is a case study that the modern and non-parametric estimators such as Stochastic Frontier Analysis (SFA), DEA estimator and Malmquist Productivity index were used. Data used in this research was taken from World Bank websites and the data used by the similar research including 191 countries and 30 OECD countries (Gearhart, 2016).

Ranking countries based on toxic pollution sites is another similar case as well. In this research low- and middle-income countries were ranked using Blacksmith Index (BI), a risk-ranking tool in more than 3000 different sites in 48 countries, the data was collected from Environmental Protection Agency (EPA) (Caravanos *et al.*, 2014).

A country can also be ranked due to some of its risk factors within itself to improve its performances on a bigger scale. In the research done by (Ameyaw and Chan, 2015), public-private water supply projects in developing countries were evaluated and ranked according to 40 risk factors using Fuzzy Synthetic Evaluation (FSE); the data was collected from the published research activities and literature on the relevant topic as well as a survey done with industry practitioners (Caravanos *et al.*, 2014). One of the most important key factors of success in any project is to identify the relevant risk components that will affect the project and then manage those risks. In the paper presented here, a questionnaire survey was prepared including 40 different risk factors, the feedback was collected and then analyzed using FSE.

Developed and developing countries are trying to monitor each other in terms of various indicators, these monitoring will help those countries to understand if the right path or right policy was taken respective to its current situation, observing how and where the state of the country is at present. Moreover, when a country is being ranked, the performance of the country for the past years is calculated and compared with other states and nations. In the research done by (Beaulier *et al.*, 2016) 156 countries' economic institutions have been ranked and compared with the Fraser Institute's Economic Freedom of the World (EFW) rankings using ordinal methodology. The results are mostly alike with not a significant difference. Furthermore, EFW (Economic Freedom Dataset, published in Economic Freedom of the World) has measured and ranked 152 countries based on the summer index of giving scores from zero to ten. The scores were based on five areas: the size of the government, legal and property rights, access to sound money, and, regulation of credit and labor and business. The date was collected from hundreds of scholar papers.

The hypothesis that was tested by (Tarek and Ahmed, 2017) states: "*Poor government leads to higher accumulation of the Middle East and North Africa MENA public debt over the period*". The data used in the considered research is covering the year 1996 to 2015 among 17 countries in the MENA region that was collected from World Databank, IMF (International Financial Statistics), and Worldwide Governance Indicators. The data was analyzed on STATA 11 Software and has proven that only three indicators support this hypothesis: *Political Stability*, *Absence of Violence* index, *Regulatory Quality* index and *Rule of the Low* index.

In another research, done by (Bai, Hira and Deshpande, 2015), countries were analyzed based on their economic development and growth and then ranked among 20 countries based on 21 different economic parameters. The Factor Analysis process was applied on the data collected from IMF and the compared their economic development using SPSS software. Some of the economic parameters chosen are as follows: gross domestic product per capita, implied Purchasing Power Parity (PPP), total investment, gross national saving, imports and exports of goods populations and general government total expenditure.

A research was done by (Cordero, Salinas-Jiménez and Salinas-Jiménez, 2017) that focuses on the happiness and the life satisfaction or the happiness economics of 16 OECD countries is another example that can be obtained by ranking countries in terms of related indicators. The wellbeing ranking approach was used in this research considering a set of indicators, health, education, income, gender, religious, unemployed and GDP per capita are just some examples that can affect the level of satisfaction. The data used in this study is borrowed from the World Values Survey (2005-2006 WVS).

After surveying the literature on various research projects done to rank countries due to a specific outcome, the following part of this chapter will discover publications that have used Multi-Criteria Decision Making (MCDM) methods in different areas.

2.1 Multi-Criteria Decision Making (MCDM)

Choosing and making a right and effective decision has become an important action in today's ultra-modern world. The act of choosing the right decision based on the preferences of the decision maker(s) between one or many courses of action is called Decision Making. In the early seventies, the theory of Multi-Criteria Decision making was designed for more systematic and rational decision-making problems, especially cases, where multiple of all the different criteria needed to be considered simultaneously. Later on, the Uncertainty and Chaos theory along with Multi-Criteria Decision making theory was developed and the Uncertainty of Fuzzy Set was introduced by Zadeh helped to fusion the MCDM and Fuzzy set by Carlsson and Fuller which served to uncover many multi-decision problems (Abdullah, 2013).

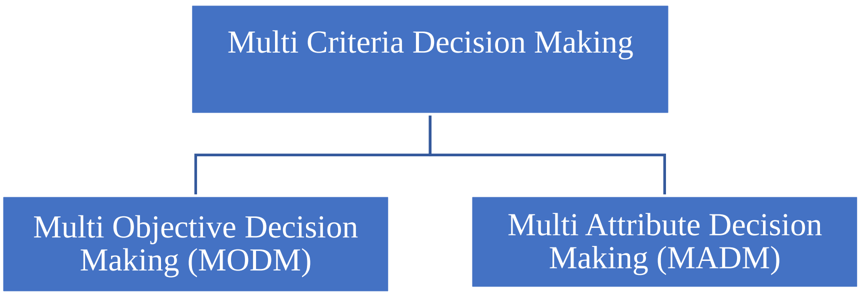

Figure 2.1: The Multi-Criteria Decision-Making Classification

Figure 2.1 shows a classification of MCDM, Multi-Attribute Decision Making (MADM) and Multi-Objective Decision Making (MODM). As it shown in table … In MADM the preferences are depending on the set of attributes given whereas in MODM the preferences are based on the set of objectives given. In MADM the objectives are implicit in nature but in MODM the objectives are explicit with a specific mathematical formulation for objective functions. Moreover, MODM is more suitable for the evaluation of continuous alternatives with an infinite number of possible values of the outcome, which have the form of vectors of the decision variable, decision problems in design and engineering are such examples. On the other hand, MADM approaches consider a few and a finite number of alternatives such as most policy decision problems. Besides, in the MADM problems, all possible outcome can be seen at the beginning of the problem whereby in the MODM problems there is an infinite possible solution and outcome to the problem at the beginning of the problems (Kumar *et al.*, 2017).

Table 2.1: The Difference Between MODM & MADM

	MADM	**MODM**
Criteria	Attribute	Objective
Objective or Goal	Implicit	Explicit
Attribute	Explicit	Implicit
Constraints	Inherent	Explicit
Alternative	Finite Number	Infinite Number
Usage	Selection/ Evaluation	Design

In the following part, the process of solving MCDM problems has been described and shown in Figure 2.2.

(a) Finding and selecting the right alternatives and criteria.

The alternatives and criteria are chosen based on the problem given. Sometimes the needed alternatives are chosen based on literature papers or based on the decision maker(s) knowledge.

(b) Criteria weighting

Determining criteria’s weight can be said to be one of the important and difficult steps in MCDM problems. In this step, the importance of individual criteria is shown as a number and if all the weight of criteria to be summed it must be equal to one so that all alternatives can be compared with each other. In some problems, the weight can be calculated and, in some problems, the weights are driven from the published literature or given the experts.

(c) Evaluation

There are many different methods available depending on the decision-making problems and the availability of data.

(d) Final treatment and aggregation the calculations

Once the method is chosen, the method that can easily use and rank the best alternative for the decision maker(s).

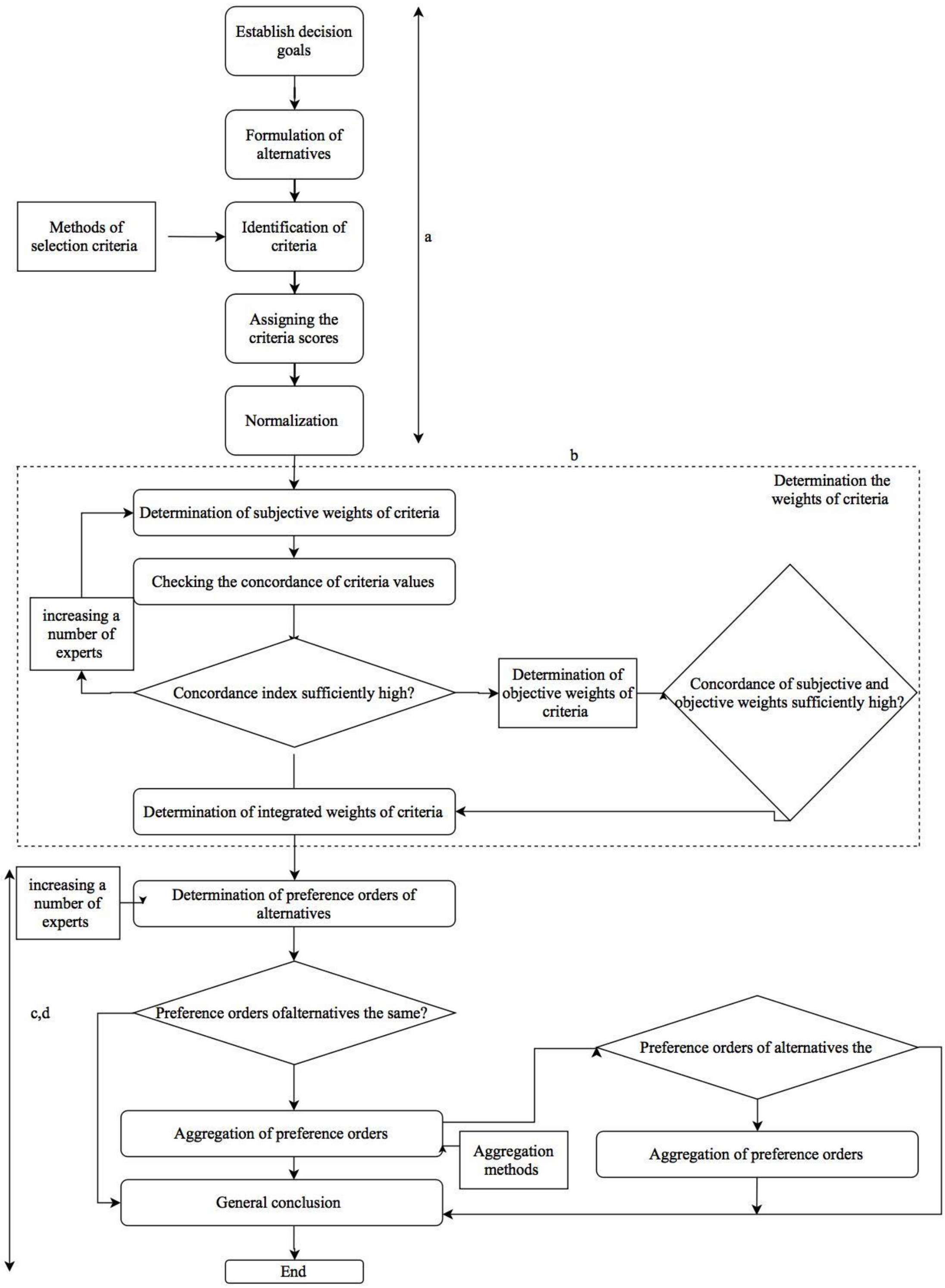

Figure 2.2: The Multi-Criteria Decision-Making process (Wang et al., 2009a)

Based on figure 2.2, the primary step “Methods of Selection Criteria” is designed to formulate and normalize a set of criteria. And then in the following step, the importance of each selected criteria is given a weight “Criteria Weight”. Furthermore, by applying one of the MCDM methods on a set of criteria, the acceptable alternatives are ranked and scored. In the final step, if the alternatives ranked-order is the same as the other MCDM methods, the process is ended if not the ranking results would be calculated again till best scheme is selected (Wang *et al.*, 2009)

In this part, the relevant information collected from scientific literature are synthesized into a summary, describing different approaches and methods in MCDM with their steps and the area of application. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), ELimination Et Choix Traduisant la REalité (ELECTRE) and The Preference Ranking Organization METhod for Enrichment Evaluations (PROMETHEE) have been used and evaluated in this case study.

2.1.1 Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) by Hwangand Yoon 1982

TOPSIS is a well-recognized MCDM method in ranking problems, such as water resource management, economy and environment and project management. The focus of this method is the distance between the ideal alternatives and non-ideal alternatives that carries the shortest distance to the ideal criteria which consider as the best alternative (Radmehr and Araghinejad, 2015). For instance, TOPSIS was used to locate the best possible region to build solar photovoltaic farms in the southeast of Spain (Sánchez-Lozano, García-Cascales and Lamata, 2016). The rank was obtained based on the best alternative that carries the closest result to the positive ideal solution among the 10-selected criteria.

TOPSIS was used to analyze the business competition in the research done by (Torlak *et al.*, 2011) where domestic Turkish airlines were compared to each other in order to rank air carries opportunities according to the performance of their 9 key criteria.

TOPSIS was practiced in the field of energy planning and strategy-decision making problems in the research done by (Cayir Ervural *et al.*, 2017) whereby a hybrid methodology for Turkey’s energy sector strategy was suggested using TOPSIS and SWOT (*Strengths Weaknesses Opportunities Threats)*. Another scope of TOPSISI is in the energy consumption sector wherein the research was done by (Akbaş and Bilgen, 2017), different models were studied on energy saving and energy resources efficiently in order to control operations at wastewater treatment plants.

With using TOPSIS a methodology was presented in the research done by (Bilbao-terol *et al.*, 2014) which included an evaluation and measurement of the investment sustainability within the sovereign bonds. The study case was applied on three European countries after all counties were considered with regard to their most frequently used sustainability: the ecological footprint, the environmental performance index, and the adjusted net saving.

The performance of banks has an important effect on developing the economy of a country. Moreover, it becomes an important fact for the investors that are willing to invest in that country. The research done by (Mandic *et al.*, 2014) has proposed a mode that assists investor in having a better understanding to analyze the financial banking system and their performances in Serbian using TOPSIS considering eight criteria equity, net interest income, liquid assets, cash, portfolio, core business net income, sources and earnings before taxes.

A model was introduced to assist maintenance management strategy of a power plant in Turkey by (Can, Ünlüsoy, and Eren, 2017). Using this model, there would be a 77% improvement in the selected equipment maintenance compared to the model not being used. Another case that TOPSIS was used in is in the research done by (Othman *et al.*, 2015) where a technique was developed to understand and rank the relationship between psychosocial stresses of the Malaysian seafarers based on the factors affecting their performance that cause injuries and sometimes casualties.

Another utilization of TOPSIS was undergone in the research done by (Yan *et al.*, 2017) in waterway congestions when dynamic risk conditions are involved in the Yangtze River in China. Due to congestion problems in waterway transportation, it is necessary to make a flexible decision according to the available risk conditions. TOPSIS was used to choose the best alternative according.

2.1.2 ELimination Et Choix Traduisant la REalité (ELECTRE) by Benayaoun et al. 1966

The next popular method in MCDM is ELECTRE. ELECTRE has several different versions in different areas such as Energy Management, Financial Management, Business Management, Information Technology and Communication and etcetera. Even though this method has many different versions but they all follow the same fundamental which compares a relation between all the alternatives, considering two at the time. For instance, in supply chain management, finding the right supplier can be an MCDM problem, since they all carry a various criterion. In the paper done by (Wan, Xu and Dong, 2017) the best possible supplier was chosen using ELECTRE considering 23 different criteria that are related to the suppliers and the materials used. Some of these criteria are quality, price and time, supply chain support, cost, and service performance.

Another case that ELECTRE was used is in service ranking prediction when consumers have inappropriate prediction while selecting a trustworthy decision. In the research done by (Ma *et al.*, 2017) the services environments were ranked to help and predict a promising idea to overcome these inappropriate choices. ELECTRE can also be applied in credit ranking assessment where managers in financial institutions determine a person's wealth based on the proposed terms of loans and many supplementary criteria collected from the applicants. These institutions use rating models to have an estimation of their clients that are not paying back their debt on time.

In the research done by (Gastelum Chavira *et al.*, 2017) ELECTRE was used considering 8 criteria to create a preference in the form of valued outranking that decision makers could choose from and generate a credit ranking for themselves. Business plans and public policies are also can be evaluated and ranked using ELECTRE.

In the research done by (Dias *et al.*, 2016) 28 stakeholders based on their objectives as criteria were ranked using ELECTRE with the impact of changes in policies that were collected from a qualitative Delphi survey.

In the research of (Del Vasto-Terrientes *et al.*, 2015) ELECTRE was used to propose a complementation assessment system on Water Quality Index (WQI) for destination marketing organizations so that the strong and weak points of official tourist destination websites considering all 123 indicators be detected.

Another outranking example using ELECTRE is the research done by (Kumar, Singh and Kharab, 2017) analyzing the operational performance of cellular mobile phones in Delhi among 6 major telecom companies considering 6 criteria.

2.1.3 The Preference Ranking Organization METhod for Enrichment Evaluations (PROMETHEE) by Brans Jean-Poerre 1982

The Preference Ranking Organization METhod for Enrichment Evaluations (PROMETHEE) was first designed by (Brans 1982) and later on was extended by (Brans and Vincke, 1985). PROMETHEE like ELECTRE is an outranking method with mathematical properties and particular friendliness of use when it comes to imperfect criteria. Moreover, because of its availability to ranked simple and limited but efficient data, it can be applied in many fields. This method considers the deviations that each criterion shows to alternatives. For instance, the research done by (Peng and Xiao, 2013) focuses on the evaluation of material selection using PROMETHEE since material selection uses a massive number of characteristics, including quantitative and qualitative data.

Another field that PROMETHEE was used is *social sustainability assessment of small hydropower* done by (Wu *et al.*, 2017) in social sustainability. This method can easily handle the correlation and uncertainty among indicators for social sustainability problems. Public recognition, energy reserves, the policy of small hydropower, management level, the risk of damage, employment creation, human health and Impact on the landscape were the indicators used in this problem.

Research done by (Saldanha *et al.*, 2017) has shown that how PROMETHEE can have a variety of usage in many fields. The purpose of this research is to find the solution of minimizing the heat-transfer within the area and the resolve and optimize a shell and tube heat exchanger in pumping power.

In another case done by (Veza, Celar, and Peronja, 2015) that trying to rank industrial enterprises based on enterprise's capabilities, where each enterprise has given 14 specific capabilities. PROMETHEE is also used to rank the sustainability of countries.

In the research done by (Antanasijević *et al.*, 2017) the sustainability of 30 European countries based on 38 different indicators over a ten year period (2004-2014) was ranked and it has revealed that the major countries in Europe have an overall of improvement in the studied period, where only two countries that have not made an over progress and improvement are Greece and Ireland. The indicators selected are eco-efficiency and economic development, competitiveness, access to labor market, innovation, public finance sustainability, health, employment, consumption and production patterns, monetary poverty, biodiversity, energy, resource use and waste, land use, transport and mobility, climate change and freshwater resource, the data was taken from Eurostat database.

Another usage of PROMETHEE is in the research done by (Andreopoulou *et al.*, 2016) where 30 enterprises' websites in the field of renewable energy based on 18 criteria were ranked. Another example that PROMETHEE was used is in the research done by (Afful-Dadzie, Oplatková and Nabareseh, 2015) that helped select the right start-up businesses in a public venture capital financing, there is a high risk of investment in developing country where most of the selected criteria are subjective or hold uncertain. This method was applied to find the potential and ideal candidates in a highly competitive environment in Ghana where the Government publicly run a venture capital to help start-up businesses grow. The criteria were collected from a set of literature and past studies: product or service characteristics, employment creation, entrepreneur's personality, entrepreneur's experience, Market characteristics and Financial characteristics are the criteria used in this research.

When it comes to selecting a suitable supplier and sources in information systems field to reduce and minimize the costs, outsourcing become a common and important strategy. In the research done by (Chen, Wang and Wu, 2011) four potential suppliers based on seven criteria were ranked using PROMETHEE and had provided a list of ranking for decision makers aiming to improve the efficiency of their outsourcing decision-making process.

A similar example in resource management is the research done by (Amaral and Costa, 2014) in the improvement of hospital resources in Brazil that has consequences on the quality and the services offered by these hospitals. PROMETHEE elects the best and ideal decision in resource management where outranking method considered in the context of hospital services.

Enterprise resource planning system plays an important role in any organization, where there are a great uncertainty and changes on all bases within and outside of the organizations. Therefore, the firms are willing to have a well-established system to resist of occurring any problem. The research done by (Kilic, Zaim and Delen, 2015) used PROMETHEE in a small-medium enterprise to address the enterprise resource planning system selection problem since the firms are facing a mulita criteria problems and it successfully ranked the alternatives and identified the best system.

A case study was done on a state-owned energy company (Hernandez-Perdomo, Mun and Rocco, 2017) where a methodology was presented to evaluate and rank projects by the firms based on the challenges that decision-makers have to take to maintain economic growth, sustainability, social responsibility and shareholder value within the firms. PROMETHEE was applied to rank this project because of its practical advantages among other methods in mulita criteria decision making.

The following table shows the different area of application for TOPSIS, ELECTRE, and PROMETHEE.

Table 2.2: The MCDM Methods Used in Different Fields

Method	Area of Application	Reference
TOPSIS	Supply Chain Management	(Patil and Kant, 2014; Kusi-Sarpong *et al.*, 2015; Uygun and Dede, 2016; Kang and Hwang, 2017; Yazdani *et al.*, 2017)
	Water Management	(Estay-Ossandon, Mena-Nieto and Harsch, 2017; Ameri, Pourghasemi and Cerda, 2018)
PROMETHEE	Strategy Selection Business Management	(Kusumawardani and Agintiara, 2015; Shakerian, Dehnavi and Ghanad, 2016; Zavadskas *et al.*, 2017)
	Strategy Management Risk Analysis	(Vinodh and Jeya Girubha, 2011; Vetschera and De Almeida, 2012; Ameri, Pourghasemi and Cerda, 2018)
ELECTRE	Outranking	(Chen, 2014; Celik and Taskin Gumus, 2016; El Mokrini *et al.*, 2016; Nikouei, Oroujzadeh and Mehdipour-Ataei, 2017)
	Energy management Financial management Business management Information technology & Communication	(Bojković, Anić and Pejčić-Tarle, 2010; Kaya and Kahraman, 2011; Fancello, Carta and Fadda, 2014; Ishizaka and Nemery, 2014; Kumar *et al.*, 2016; Lian and Ke, 2016; Certa *et al.*, 2017; Mousavi, Gitinavard and Mousavi, 2017)

In the next chapter, the methodology the three methods selected in this research is entirely discussed and shown.

3. METHODOLOGY

After going through research and papers on Mulita Criteria Decision Making TOPSIS, ELECTRE and PROMETHEE methods were chosen. The following is a general description of each method.

3.1 TOPSIS Hwangand Yoon 1982

As mentioned in the previous part, TOPSIS is one of the well-known methods in the MCDM. This concept is focused on the distance between the ideal and non-ideal alternatives from the entire set of the alternatives. The steps are articulated as following (C. L. Hwang, 2012):

Step 1: Forming a performance decision matrix.

In this step the chosen alternatives and criteria were presented in a decision matrix as shown in the following;

Here, $i = 1,2, \ldots, m, \;\; j = 1,2, \ldots , n$

$$\begin{pmatrix} X_{11} & X_{12} & \ldots & X_{n} \\ X_{21} & X_{22} & \ldots & X_{2n} \\ X_{m1} & X_{m2} & \ldots & X_{mn} \end{pmatrix} \qquad (1)$$

Step 2: Normalizing the established matrix by the given formula:

There are a lot of different formulas that can normalize heterogeneous data collected from different resources with different units into a dimensionless unit. Especially in cases where ranking and rating decisions are needed to be calculated.

The following is the formula used in this case study.

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m}(x_{ij})^2,}} \; j = 1, \ldots, n \; i = 1, \ldots, m \qquad (2)$$

$$\begin{pmatrix} n_{11} & n_{12} & \ldots & \ldots n_{n} \\ n_{21} & n_{22} & \ldots & n_{2n} \\ n_{m1} & n_{m2} & \ldots & n_{mn} \end{pmatrix}$$

Step 3: The weighted normalized decision matrix is calculated in this step:

$$v_{ij} = w_j . n_{ij} , j = 1, \dots, n , i = 1, \dots, m, \quad (3)$$

$$\begin{pmatrix} v_{11} & v_{12} & \dots & v_n \\ v_{21} & v_{22} & \dots & v_{2n} \\ v_{m1} & v_{m2} & \dots & v_{mn} \end{pmatrix}$$

Step 4: ideal and non-ideal alternatives are determined as follow:

$$A^+ = \{v_1^+, \dots, v_n^-\} = \left(max_i v_{ij}, j \in J ; min_i v_{ij}, j \in J'\right) i = 1,2, \dots, m \quad (4)$$

$$A^- = \{v_1^+, \dots, v_n^-\} = \left(min_i v_{ij}, j \in J ; max_i v_{ij}, j \in J'\right) i = 1,2, \dots, m \quad (5)$$

Step 5: In this step, the Euclidean distances among the ideal and non-ideal alternatives would be calculated respectively as follow:

$$d_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+ \right)^2} \quad (6)$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^- \right)^2} \quad (7)$$

Step 6: by using the following equation the relative closeness to the final ideal solution can be shown as below:

$$R_i = \frac{d_i^-}{d_i^+ + d_i^-} \quad (8)$$

Step 7: Then the results would be ranked.

3.2 ELECTRE by Benayaoun et al. 1966

ELECTRE is one of the useful MCDM methods for ranking the best set of alternatives based on different criteria. In this outranking concept, the first alternative is compared with the rest of alternative at a time and then rank the output in an appropriate form. The following steps will go through the method (Benayoun, Roy and Sussman, 1966):

Step 1: Forming a performance decision matrix.

In this step the chosen alternatives and criteria were presented in a decision matrix as shown in the following;

Here, $i = 1,2, \dots, m, \ \ j = 1,2, \dots , n$

$$\begin{pmatrix} X_{11} & X_{12} & \dots & X_n \\ X_{21} & X_{22} & \dots & X_{2n} \\ X_{m1} & X_{m2} & \dots & X_{mn} \end{pmatrix} \tag{9}$$

Here, $i = 1,2, \dots, m, \ \ j = 1,2, \dots \ , n$

Step 2: Normalizing the established matrix by the given formula:

There are a lot of different formulas that can normalize heterogeneous data collected from different resources with different units into a dimensionless unit. Especially in cases where ranking and rating decisions are needed to be calculated.

The following is the formula used in this case study.

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m}(x_{ij})^2,}} \ j = 1, \dots, n \ i = 1, \dots, m \tag{10}$$

$$\begin{pmatrix} n_{11} & n_{12} & \dots & \dots n_n \\ n_{21} & n_{22} & \dots & n_{2n} \\ n_{m1} & n_{m2} & \dots & n_{mn} \end{pmatrix}$$

Step 3: The weighted normalized decision matrix is calculated in this step:

$$v_{ij} = \ w_j . n_{ij} \ , j = 1, \dots, n \ , i = 1, \dots, m, \tag{11}$$

$$\begin{pmatrix} v_{11} & v_{12} & \dots & v_n \\ v_{21} & v_{22} & \dots & v_{2n} \\ v_{m1} & v_{m2} & \dots & v_{mn} \end{pmatrix}$$

Step 4: Calculating the concordance and discordance stet for each alternative.

By comparing each alternative with the other the concordance set would be evaluated from the equation below: if one alternative grater or equal to the other alternative is considered under the concordance set and shown by C.

$$C(p, q) = \{j, v_{pj} \geq v_{qj}\} \tag{12}$$

And the discordance set would be the alternatives that are worse than other and shown by D.

$$D(p, q) = \{j, v_{pj} < v_{qj}\} \tag{13}$$

Step 5: Building the concordance matrix

In this part weight of the selected concordance set of alternatives are added.

$$C_{pq} = \sum_{j^*} w_{j^*} \quad (14)$$

Step 6: Defining the discordance matrix

The discordance matrix is created by dividing the set of discordance to the total value of the whole set.

$$D_{pq} = \frac{(\sum_{j^0} |v_{pj^0} - v_{qj^0}|)}{(\sum_j |v_{pj} - v_{qj}|)} \quad (15)$$

Step 7: Creating the effective concordant matrix

In the previous part, the concordant matrix was calculated and by converting the concordant matrix to effective concordant matrix helps to show a better judgment when one alternative to is compared with other and is shown as $\bar{C}$.

$$\bar{C} = \sum_{p=1}^{m} \sum_{q=1}^{m} C_{pq} / m(m-1) \quad (16)$$

And then a Boolean matrix is bullied from the equation below:

$$f_{pq} = \begin{cases} 1 \; C_{pq} > \bar{C} \\ 0 \;\; C_{pq} < \bar{C} \end{cases} \quad (17)$$

Step 8: Creating the effective discordant matrix

To calculate the effective discordant matrix the following equations are used.

$$\bar{d} = \sum_{p=1}^{m} \sum_{q=1}^{m} d_{pq} / m(m-1) \quad (18)$$

And then a Boolean matrix is bullied from the equation below:

$$g_{pq} = \begin{cases} 1 \; d_{pq} > \bar{d} \\ 0 \;\; d_{pq} < \bar{d} \end{cases} \quad (19)$$

Step 9: calculating the global matrix

The global matrix (H) is calculated by multiplying matrixes (F) to (G). It shows that the alternative A1 is preferred to A2 when comparing the concordance and discordance of their criteria.

$$h_{pq} = f_{pq} . g_{pq} \quad (20)$$

3.3 PROMETHEE

PROMOTHE is another outranking method used to solve Multi-Criteria Decision-Making problems. In this method firstly, all pairs of alternatives are to be compared to each criterion and then PROMETHEE can assist a specific preferential function to describe the differences between each alternative's preferences on every criterion. These preference functions which have a value ranged from zero to one, are there for the decision makers to describe the preference deference from their point of view. The closest range is? to one, the larger the difference. The range zero shows that there are no preferential differences between the pairs. The following steps will lead through the method;

Step 1: Forming a performance decision matrix.

In this step the chosen alternatives and criteria were presented in a decision matrix as it has shown in the following;

Here, $i = 1,2,\dots,m,\ \ j = 1,2,\dots\ ,n$

$$\begin{pmatrix} X_{11} & X_{12} & \dots & X_{n} \\ X_{21} & X_{22} & \dots & X_{2n} \\ X_{m1} & X_{m2} & \dots & X_{mn} \end{pmatrix} \tag{21}$$

Step 2: Normalizing the established matrix by the given formula:

There are a lot of different formulas that can normalize heterogeneous data collected from different resources with different units into a dimensionless unit. Especially in cases where ranking and rating decisions are needed to be calculated.

The following is the formula used in this case study.

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m}(x_{ij})^2,}}\ j = 1,\dots,n\ i = 1,\dots,m \tag{22}$$

$$\begin{pmatrix} n_{11} & n_{12} & \dots & \dots n_{n} \\ n_{21} & n_{22} & \dots & n_{2n} \\ n_{m1} & n_{m2} & \dots & n_{mn} \end{pmatrix}$$

Step 3: The differences between each alternative with respect to the other one must be evaluated. Moreover, the differences in criteria value of alternatives must be calculated pairwise.

Step 4: Choose the preference function, PROMETHEE has seven types of preference functions which have ranged from zero to one. (In this research usual function was chosen because any parameter such as preference and indifference thresholds are not needed.)

$$p_i(i,i') = 0 \quad IF\ R_{ij} \leq\ R_{i'j} \tag{23}$$

$$p_i(i,i') = 1 \quad IF\ R_{ij} >\ R_{i'j} \tag{24}$$

Step 5: determine the combined preference function with weights;

$$\pi(i,i') = \sum_{j=1}^{m} p_j(i,i') w_j \tag{25}$$

Where w_j is the weight of relative importance of the j^{th} criteria.

Step 6: (n – 1) can be related to each alternative that can result into a positive or negative outranking flow, therefore calculating the leaving and entering outranking is necessary and are given as flowed;

The leaving flow is a measure of the strength of the alternatives.

The leaving flow:

$$\phi^+(i) = \frac{1}{n-1} \sum_{j'=1}^{n} \pi(i,i'), \quad (i \neq i') \tag{26}$$

The entering flow measures the weakness of the alternatives.

The entering flow:

$$\phi^-(i) = \frac{1}{n-1} \sum_{j'=1}^{n} \pi(i,i'), \ \ (i \neq i') \tag{27}$$

Step 7: In this step, PROMETHEE II has provided a net outranking flow of decision alternatives which has been shown in the following;

$$\phi(i) = \phi^+ - \phi^-\ (i) \tag{28}$$

Step 8: Ranking the net outranking flow considering $\phi(i)$ from the highest to the lowest alternative.

In the following chapter, the data and the resources selected is shown and discussed.

3.4 Equal Weight Method

The Equal Weight method (EW) represent a uniform distribution of weight when the decision makers have minimal knowledge about the priorities as shown in the following weight formula (Roszkowska, 2013):

$$W_j(EW) = \frac{1}{n}, \quad (29)$$

Where $j = 1,2, \dots, n$.

Table 3.1: The Formulas Used for Each Method

TOPSIS	ELECTRE	PROMETHEE
$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m}(x_{ij})^2}},$	$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m}(x_{ij})^2}},$	$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m}(x_{ij})^2}},$
$j = 1, \dots, n\ i = 1, \dots, m$	$j = 1, \dots, n\ i = 1, \dots, m$	$j = 1, \dots, n\ i = 1, \dots, m$
$v_{ij} = w_j . n_{ij}$,	$v_{ij} = w_j . n_{ij}$,	$p_i(i, i') = 0 \quad IF\ R_{ij} \leq R_{i'j}$
$j = 1, \dots, n,\ i = 1, \dots, m,$	$j = 1, \dots, n,\ i = 1, \dots, m,$	$p_i(i, i') = 1 \quad IF\ R_{ij} > R_{i'j}$
$d_i^+ = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^+\right)^2}$	$C(p, q) = \{j,\ v_{pj} \geq v_{qj}\}$	$\pi(i, i') = \sum_{j=1}^{m} p_j(i, i') w_j$
$d_i^- = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^-\right)^2}$	$D(p, q) = \{j,\ v_{pj} < v_{qj}\}$	
$R_i = \frac{d_i^-}{d_i^+ + d_i^-}$	$C_{pq} = \sum_{j^*} w_{j^*}$	$\phi^+(i) = \frac{1}{n-1}\sum_{j'=1}^{n} \pi(i, i'),\ (i \neq i')$
	$D_{pq} = \frac{(\sum_{j^0} \lvert v_{pj^0} - v_{qj^0} \rvert)}{(\sum_j \lvert v_{pj} - v_{qj} \rvert)}$	$\phi^-(i) = \frac{1}{n-1}\sum_{j'=1}^{n} \pi(i, i'),\ (i \neq i')$
	$\overline{C} = \sum_{p=1}^{m}\sum_{q=1}^{m} C_{pq} / m(m-1)$	$\phi(i) = \phi^+ - \phi^-(i)$
	$\overline{d} = \sum_{p=1}^{m}\sum_{q=1}^{m} d_{pq} / m(m-1)$	
	$h_{pq} = f_{pq} . g_{pq}$	

In the following chapter, Data Collection will be describing the data resources and the alternatives, and the criteria used in this problem.

4. DATA COLLECTION

Going through the different publications and research that are mentioned in the literature review helped to understand and analyze the important indicators that are related to this research, the data related to each indicator was collected from the following databanks.

- The World Bank *www.data.worldbank.org*
- International Monetary Fund (IMF) *www.imf.org*
- United Nations (UN) *ww.data.un.org*

The member governments submit a yearly report on different sectors within the country in those databanks to ensure the stability of the international monetary system by monitoring the economic and financial policies. Unfortunately, there are some missing data in these databanks, therefore, our data (table 4.3 and table 4.4) has narrowed down to twenty-three countries and twenty indicators in MENA between the year 2000 and 2015.

4.1 Countries

The chosen countries in table 4.1 play an important role in the region because of their natural resources, human power, foreign investments and their location. Afghanistan, Armenia, Azerbaijan, Bahrain, Cyprus, Egypt, Georgia, Iran, Iraq, Israel, Jordan, Kazakhstan, Kuwait, Libya, Oman, Pakistan, Qatar, Saudi Arabia, Sudan, Syrian Arab Republic, Tunisia, Turkey and the Yemen Republic are the countries selected as alternatives in this study.

Table 4.1: The Selected Countries in The MENA (Alternatives)

Alternatives	Countries
A_1	Afghanistan
A_2	Armenia
A_3	Azerbaijan
A_4	Bahrain
A_5	Cyprus
A_6	Egypt
A_7	Georgia
A_8	Iran
A_9	Iraq
A_{10}	Israel
A_{11}	Jordan
A_{12}	Kazakhstan
A_{13}	Kuwait
A_{14}	Libya
A_{15}	Oman
A_{16}	Pakistan
A_{17}	Qatar
A_{18}	Saudi Arabia
A_{19}	Sudan
A_{20}	Syrian
A_{21}	Tunisia
A_{22}	Turkey
A_{23}	Yemen

4.2 Indicators

In this research, the chosen indicators or criteria in table 4.2 are based on two fundamental, recently published papers and the availability of data within the country. Choosing a right indicator needed research and studies on different topics and sector of a country to understand country's key factors that are responsible for a country's stability, development and the relation to other nations around the world. Therefore, if an indicator of a country is compared with respect to the same indicator of another region (country), it can create a list of countries that are performing better than others. In other words, a ranking of countries in terms of their performances in different indicators and sectors will result.

Table 4.2: The Selected Indicators (Criteria)

Criteria	Indicator	Criteria weight
C_1	Crop production index (2004-2006 = 100)	0.045454545
C_2	Current account balance (BoP, current US$)	0.045454545
C_3	Deposit interest rate (%)	0.045454545
C_4	Exports of goods and services (BoP, current US$)	0.045454545
C_5	Foreign direct investment, net (BoP, current US$)	0.045454545
C_6	GDP (current US$)	0.045454545
C_7	General government final consumption expenditure (current US$)	0.045454545
C_8	GNI (current US$)	0.045454545
C_9	Imports of goods and services (BoP, current US$)	0.045454545
C_{10}	Inflation, GDP deflator (annual %)	0.045454545
C_{11}	Labor force, total	0.045454545
C_{12}	Military expenditure (% of GDP)	0.045454545
C_{13}	Natural gas (including LNG) - production "Terajoules"	0.045454545
C_{14}	Time required to start a business (days)	0.045454545
C_{15}	Total reserves (includes gold, current US$)	0.045454545
C_{16}	Unemployment, total (% of total labor force) (modeled ILO estimate)	0.045454545
C_{17}	Fuel oil - Production (Metric tons, thousand)	0.045454545
C_{18}	Primary income payments (BoP, current US$)	0.045454545
C_{19}	International tourism, number of arrivals	0.045454545
C20	Political Stability and Absence of Violence/Terrorism: Percentile Rank	0.045454545

In this case study, the judgment of the "the true" weights are vague and cannot exactly be evaluated with numerical values in practice or if so, it would be probably time-consuming and challenging and it must be consulted by experts. Hence, the Equal weight method was used in this study.

Table 4.3: The Data Collected from the Data Banks

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_1	C_1	C_1	C_1	C_1	C_1	C_1	C_1	C_1	C_1	C_2
A_1	106.3842857	-4158557748	6	2045964813	84300002.97	11742998528	1516465311	11836053495	7686802408	7.5144745	6482579.067	1.753038794	6326.188293	8.166666667	5970221198	8.586666616	0	140588965.2	0	1.500844397
A_2	98.21571429	-644673304.1	9.377212397	1870120770	374390364.4	7304570043	849275209.8	7639767896	3395714609	3.827336337	1456846	3.447689984	0	12.38461538	1253092143	23.51333326	0	387286151.9	564312.5	41.85964762
A_3	100.0657143	6456432563	10.288125	18976217938	397899500	36436635624	3867322630	33766383312	10261355313	7.490099145	4221263.733	3.37554037	437961	37.30769231	5628569510	7.206666629	1757.533333	3172969688	1252000	24.47337208
A_4	108.0721429	1399124043	2.154322917	15624129172	310603899.4	21190082197	2960026649	19203762650	10925402550	5.734040474	540518.1333	3.811014823	396629.0667	9.311111111	3572607757	4.139999978	2591.8	6030125813	7531750	32.92794704
A_5	87.52214286	-1306672102	4.335625	10271964810	249462121.9	20391207326	3490697250	19850205078	10910081892	2.088217689	542025.2	1.944291164	0	8	2519597100	6.720000092	374	5676080344	2426250	61.92964503
A_6	102	-2246131250	7.42125	36316306250	-4076943750	1.73505E+11	20202143439	1.71447E+11	47261600000	9.337000942	24873670.47	2.430242244	1798040.266	15.19230769	21210456052	10.57333317	9835.266667	3401175000	8894706.25	20.46945546
A_7	90.90857143	-1150403286	8.740621482	3495224757	-770180940.9	9700925565	1757599214	9604566304	5387388935	5.590054615	2137813.6	3.392726864	658.4514492	10	1463892292	13.81333338	10.2	597056415.9	2071500	36.32699165
A_8	100.9742857	-2025085548	12.86471436	29727000000	-39000000	3.26564E+11	36132926153	3.26976E+11	17503000000	19.08730211	23911982.87	2.683124143	4560958.173	22.42307692	14156029152	12.16666679	26577.70674	604000000	2726625	16.20234604
A_9	104.8014286	57511666667	7.3555	54547650000	-1339287500	1.39129E+11	30042896817	1.40293E+11	39419762500	9.215669883	6977413.667	3.015769804	205648.8542	30	45516559759	18.2266667	10857.46667	2342025000	920250	2.708794063
A_{10}	96.89642857	5058250000	3.240514397	70641768750	-1699637500	2.00151E+11	46276973560	1.94645E+11	68905587500	1.893476536	2999324.733	6.807611162	96273.86667	17.69230769	49572421507	7.953333314	2843.333333	10617362500	2183031.25	12.03393923
A_{11}	102.5292857	-1713705298	4.361197917	9716026745	-1605317812	20768741898	4207451988	20851657344	15329322127	4.848972861	1539683.667	5.382616749	7568.862	19.5	8998119783	13.49333331	1161.82	753526560.8	3251750	32.01249301
A_{12}	111.6192857	191196925.3	10.5	49649911517	-5892797216	1.13869E+11	11848270815	1.01216E+11	36124922737	12.83286153	8351611.533	1.032495486	1116707.039	24.76923077	17279304197	7.460000038	3273.533333	14410570452	3259000	51.6913264

Table 4.4: The Data Collected from the Data Banks

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}
A_{13}	114.4678571	35776039799	3.292455729	67395882421	5228532791	1.03918E+11	17832186435	1.13126E+11	31266041420	5.167615908	1365855.133	4.709538742	497408.4667	34.09230769	19878697575	1.926666665	9853.066667	1387774526	189500	54.60821126
A_{14}	103.3221429	-7360443750	2.580555556	32447407143	1862357143	48475331827	5817248856	51264587068	18813764286	8.986695767	2201752.267	1.821649364	431775.9333	35	69668486476	19.16666705	4631.6	2184342857	1195312.5	39.26926723
A_{15}	111.8314286	2966698915	3.4306875	31079981312	-525766783	47390588427	9825390117	45041201210	21093371773	10.53360985	1196272.133	11.63797403	918722.7999	20.66923077	9347798978	7.706666724	2642.4	3003307392	765538.4615	72.94846369
A_{16}	98.41857143	-2839808125	6.172569444	22051344375	-1895750000	1.56199E+11	15623137600	1.61743E+11	33917851875	5.89713058	53170279.53	3.761953544	1214989.722	21.61538462	11917398649	6.106666597	2874.2144	3779434375	1425575	3.532727806
A_{17}	107.7828571	35770132118	2.744881655	1.28349E+11	5627299231	97340508158	13892101648	1.15503E+11	56143051282	13.8244695	893884.8	2.322647067	3398795.066	8.311111111	16394659654	0.686666673	457.3333333	16578183132	11498937.5	84.41719767
A_{18}	91.56	68567657639	3.76	2.28305E+11	-11079182731	4.48624E+11	1.01649E+11	4.55605E+11	1.42446E+11	4.424037036	9084242.6	9.158765455	2497121.506	36.89230769	3.42655E+11	5.513333321	25502.2	7958110356	359062.5	34.40593287
A_{19}	97.99571429	-3174656405	0.990747512	6112067502	-1475778776	46733182715	4499062454	41850779438	7986409596	14.80931314	10260410.8	3.961470102	243567.2667	37.33333333	729557455.3	14.73333352	474.7333333	2403662558	4170666.667	2.686493965
A_{20}	91.07857143	528992201.4	6.549568171	12252029927	-803211603.3	26439983632	3409269618	25602424463	11519116420	6.951190273	5352849.4	5.140119538	102002.796	25.42307692	18199095808	10.0733333	4421.64	1334966136	6350312.5	23.68783046
A_{21}	98.68928571	-1852586132	5	17185847501	-1193034080	36935528153	6415994244	35252482742	19189078535	3.870313008	3608193.933	1.52787762	25700.6	11	6299631819	14.07999992	550.8	1846898891	25463500	40.8284167
A_{22}	101.24	-2967406250	27.04588542	1.36792E+11	-8521187500	5.64431E+11	77954282170	5.57919E+11	1.61873E+11	16.13501119	24070106.53	2.716760606	1872955.058	9.538461538	71720893825	10.09999994	5549.533333	11087000000	5446333.333	18.48780969
A_{23}	108.3607143	-5145625000	14.43452381	8148118423	-244952960.9	24111269479	3221346634	22646388756	10524055386	11.92243284	5818780.467	5.053816026	296392.8333	41.5	5732394496	15.83333346	549.2	1674829726	635887.5	5.654212544

In the following chapter, the calculated results from the three methods are shown and discussed.

5. DISCUSSION RESULTS

This chapter discusses the calculated results that were obtained from the different methods used in this case study. The given data was first calculated using TOPSIS and ELECTRE in excel platform in a highly precise way. And further on, the third method, PROMETHEE was introduced in order to demonstrate better and more accurate results.

5.1 TOPSIS

The Euclidean distances between the ideal and non-ideal of each alternative were calculated in table 5.1. For instance, the distance between the ideal and the non-ideal point of Afghanistan is 0.113082891 and 0.039831610. In the next step after calculating the final ideal solution for all alternatives, table 5.2 was designed to show the final ranking results of the selected MENA countries using TOPSIS.

Table 5.1: The Ideal and Non-ideal Distances results using TOPSIS

Countries	d+	d-
Afghanistan	0.113082891	0.039831610
Armenia	0.112659132	0.040796566
Azerbaijan	0.106733698	0.041454117
Bahrain	0.105790158	0.044979918
Cyprus	0.108827418	0.046288380
Egypt	0.092126865	0.044466039
Georgia	0.111017067	0.040082123
Iran	0.090963147	0.061909809
Iraq	0.095954311	0.054241309
Israel	0.093339239	0.051152511
Jordan	0.109646396	0.038041689
Kazakhstan	0.100148706	0.042052861
Kuwait	0.096941905	0.061953530
Libya	0.106217971	0.038186855
Oman	0.103905652	0.04825266
Pakistan	0.097259966	0.052727211
Qatar	0.087443774	0.075067648
Saudi Arabia	0.071944213	0.096736666
Sudan	0.110987212	0.033510114
Syrian	0.105436826	0.040266515
Tunisia	0.104223577	0.053094244
Turkey	0.082748172	0.072880532
Yemen	0.115696108	0.033806080

Table 5.2: Ranking the Middle East and North Africa countries using TOPSIS

Rank	Countries	R_i
1	Saudi Arabia	0.573489220
2	Turkey	0.468297494
3	Qatar	0.461922290
4	Iran	0.404975548
5	Kuwait	0.389901255
6	Iraq	0.361137754
7	Israel	0.354016829
8	Pakistan	0.351544792
9	Tunisia	0.337496691
10	Egypt	0.325536963
11	Oman	0.317121420
12	Cyprus	0.298411772
13	Bahrain	0.298334515
14	Kazakhstan	0.295727128
15	Azerbaijan	0.279740386
16	Syrian	0.276359586
17	Armenia	0.265852401
18	Georgia	0.265270271
19	Libya	0.264443068
20	Afghanistan	0.260482884
21	Jordan	0.257581303
22	Sudan	0.231908196
23	Yemen	0.226124318

As it can be seen in table 5.2, the top five countries which have the highest score among other countries studied in this research are Saudi Arabia followed by Turkey, Qatar, Iran and Kuwait, where all the selected criteria were considered and compared to each other using TOPSIS. This table can show to its audiences a general idea of how well these countries are performing contrasted with each other in the region. So, if these countries are tagged for any foreign investments, partnership or any open market in different sectors and industries in the future this table can be helpful.

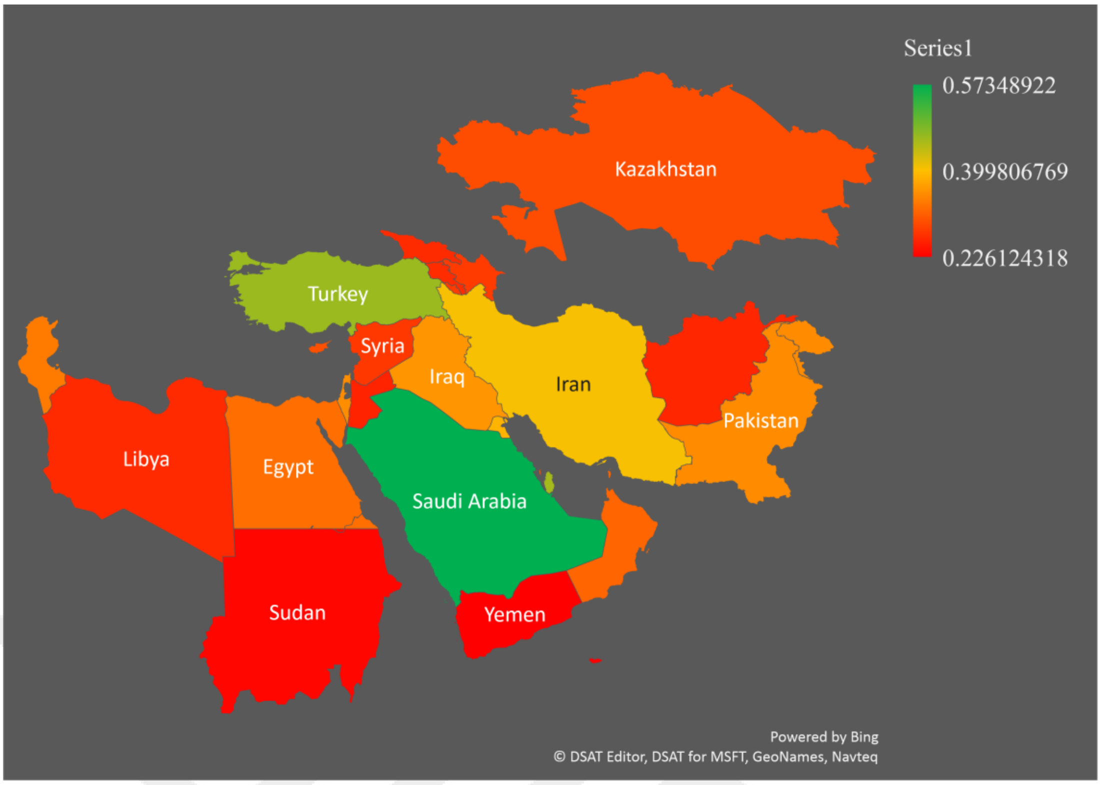

Figure 5.1: The Middle East and North Africa Map chart using TOPSIS

Based on the results from TOPSIS figure 5.1 was created, in this map chart, the twenty-three countries of the MENA region are presented in different colors from the highest rank (score 0.57348922) to lowest (score 0.226124318). Those countries which have a better score with higher ranks are colored green and light green, see Saudi Arabia, Turkey, and Qatar. As the scores and rankings move down, the colors are changing to dark yellow and orange, for instance, Iran, Kuwait, Iraq and at the lowest ranked countries are colored dark red, for instance, Afghanistan, Jordan, Sudan and Yemen.

Both table 5.2 and figure 5.1 can give us a general overview of the situation in the chosen MENA countries. So, it becomes more likely that Saudi Arabia is targeted by foreign investors since it has been ranked with the highest score as the first country in the MENA region. Saudi Arabia is neighboring with Qatar, Iraq, Jordan, and Oman therefore, it is important to considerate its neighboring countries in terms of changes in different aspects which can influence Saudi Arabia.

5.2 ELECTRE

The second method applied in this research was ELECTRE where the following table has been obtained.

Table 5.3: Ranking the Middle East and North Africa countries using ELECTRE

Rank	Country	Score
1	Egypt, Arab Rep.	6
2	Yemen, Rep.	6
3	Israel	5
4	Turkey	5
5	Kazakhstan	4
6	Azerbaijan	3
7	Libya	3
8	Bahrain	2
9	Iraq	2
10	Jordan	2
11	Saudi Arabia	2
12	Syrian Arab Republic	1
13	Afghanistan	0
14	Iran, Islamic Rep.	0
15	Qatar	0
16	Kuwait	-1
17	Georgia	-2
18	Sudan	-2
19	Pakistan	-3
20	Oman	-4
21	Cyprus	-6
22	Armenia	-10
23	Tunisia	-12

Table 5.3 shows the new ranking that was done using ELECTRE. In this method, each country has given a score that was calculated with respect to other alternatives and criteria in this research. As shown ELECTRE assigned the highest scores to Egypt, Yemen, Israel, Turkey, and Kazakhstan. Both Egypt and Yemen have the same score of 6 and both Israel and Turkey have 5 scores followed by Kazakhstan with a score of 4. In this method countries like Saudi Arabia, Kuwait and Iran are placed below the top ten countries ranked by ELECTRE.

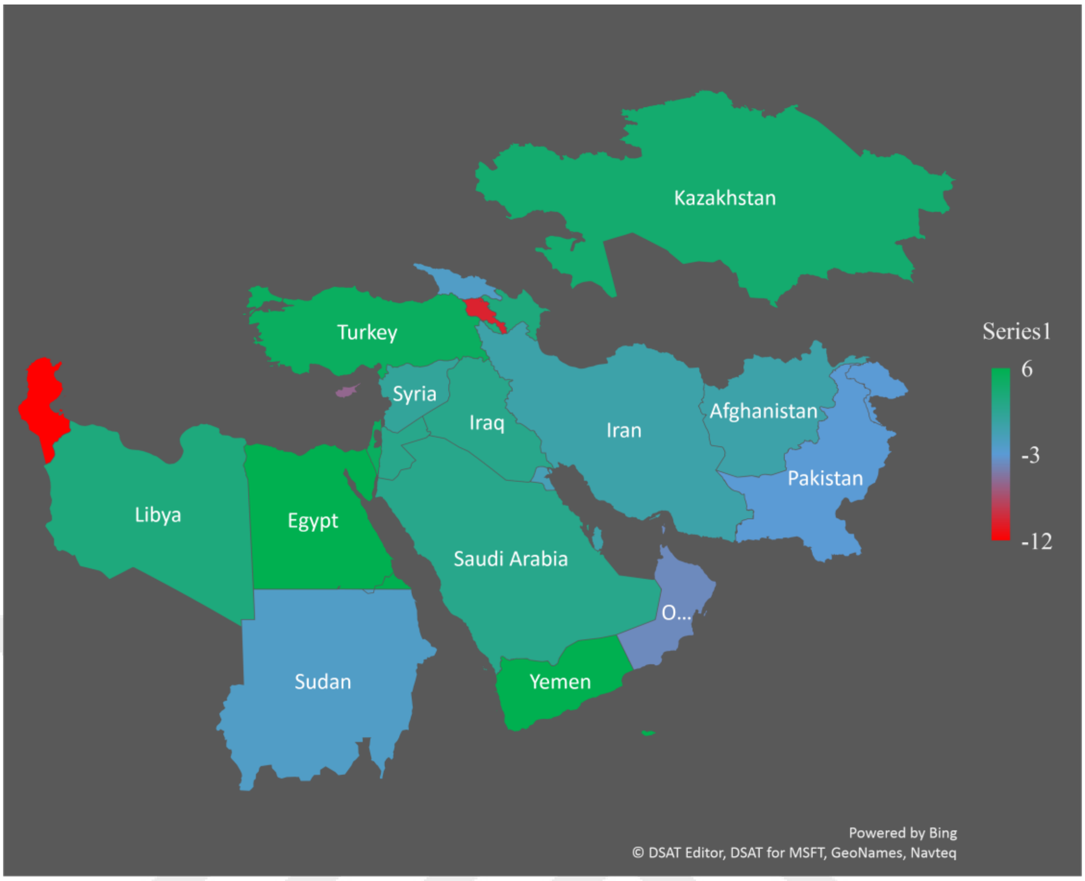

Figure 5.2: The Middle East and North Africa Map chart using ELECTRE

The map chart in figure 5.2 was created based on the results given by ELECTRE, but as it can be seen in this map chart most of the unexpected countries were marked as green. Therefore, by comparing the result of TOPSIS and ELECTRE, it is clear that ELECTRE is not a suitable method to use in such ranking as it has also shown in table 5.3 and figure 5.2. Therefore, PROMETHEE was introduced to carry on the calculations. The results are actually too close to each other and not clear.

5.3 PROMETHEE

The following table was calculated using PROMETHEE in Visual PROMETHEE.

Table 5.4: Ranking the Middle East and North Africa countries using PROMETHEE

Rank	Country	Phi	Phi+	Phi-
1	Saudi Arabia	0.3729	0.4974	0.1245
2	Turkey	0.2493	0.3814	0.1321
3	Qatar	0.238	0.3234	0.0854
4	Iran	0.1061	0.2341	0.128
5	Kuwait	0.0566	0.1557	0.0991
6	Israel	0.0555	0.1477	0.0921
7	Oman	0.0441	0.1383	0.0942
8	Egypt	0.0007	0.0917	0.091
9	Bahrain	-0.0066	0.0853	0.092
10	Kazakhstan	-0.0097	0.1104	0.1201
11	Tunisia	-0.0107	0.1065	0.1172
12	Pakistan	-0.0116	0.0914	0.1029
13	Cyprus	-0.034	0.0937	0.1277
14	Jordan	-0.0637	0.0503	0.114
15	Afghanistan	-0.0695	0.0573	0.1267
16	Iraq	-0.0752	0.0685	0.1437
17	Azerbaijan	-0.0879	0.0397	0.1275
18	Georgia	-0.0881	0.0491	0.1372
19	Armenia	-0.0959	0.0572	0.1531
20	Syrian	-0.0994	0.0317	0.1311
21	Libya	-0.1328	0.0287	0.1615
22	Yemen	-0.1521	0.0569	0.209
23	Sudan	-0.1863	0.0111	0.1973

Table 5.4 above shows the results of the final ranking in the selected MENA countries based on PROMETHEE, each country (alternative) has given a Phi^+, Phi^- and Phi scores. For instance, Phi^+ (positive outranking flow) of Saudi Arabia shows how much better Saudi Arabia is than other countries. Moreover, the highest value of Phi^+ is preferable alternatives than others. And Phi^- shows the negatives outranking flow where expresses how the alternative (Saudi Arabia) outranked by other alternatives (countries) and Phi (net flow) is the subtraction of negative form positive outranking whereby the highest net flow considers the best alternative.

As it can be seen in table 5.4 Saudi Arabia has been raked in the first place with the highest net flow of 0.3729 followed be turkey 0.2493 at the second place and Qatar 0.238 at the third place.

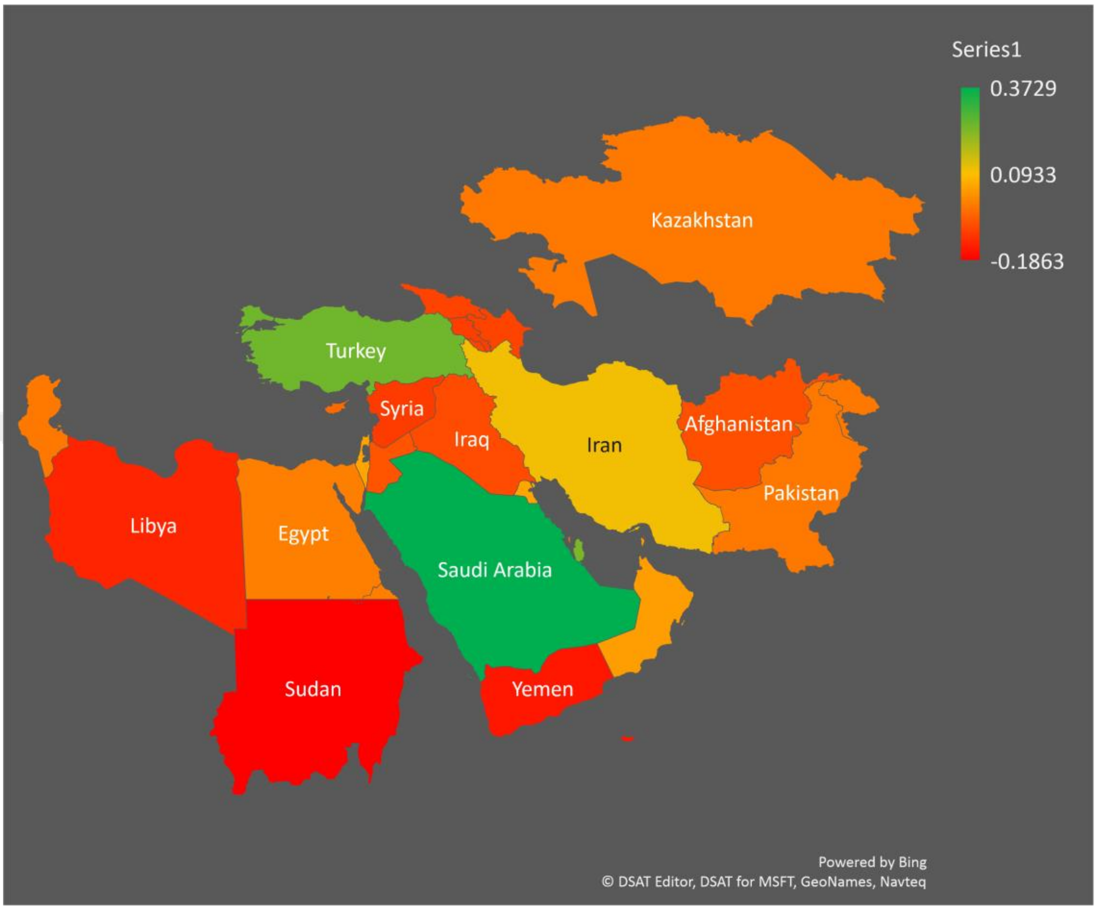

Figure 5.3: The Middle East and North Africa Map chart using PROMETHEE

The map chart in figure 5.3 is based on the results provided by the PROMETHEE method which was applied on twenty-three countries in the MENA region. In this map chart, the countries are shown from the highest score (green areas) 0.3729 to lowest score -0.1863 (red areas), and the range of colors between top countries to least favored countries are shown by yellow and orange.

In this part, the Graphical Astronomy and Image Analysis (GAIA) which is the descriptive counterpart of PROMETHEE has been applied and discussed.

The GAIA began by creating a multidimensional with as many dimensions based on the used criteria in this problem (twenty). But with the assistance of a mathematical method call Principal Components Analysis, the number of dimensions has reduced considering minimizing the loss of information.

Standard GAIA analysis includes U and V only which has been shown in figure 5.4 whereby, U is the first principal component that contains the highest possible quantity of data. And, V is the second principal component which providing the highest additional data orthogonal to U.

Figure 5.4: The GAIA PLANE (Alternatives)

In figure 5.4 all countries are represented by a single point on the GAIA plane based on their indicators evaluation. Countries with a similar action profile are located closer to each other.

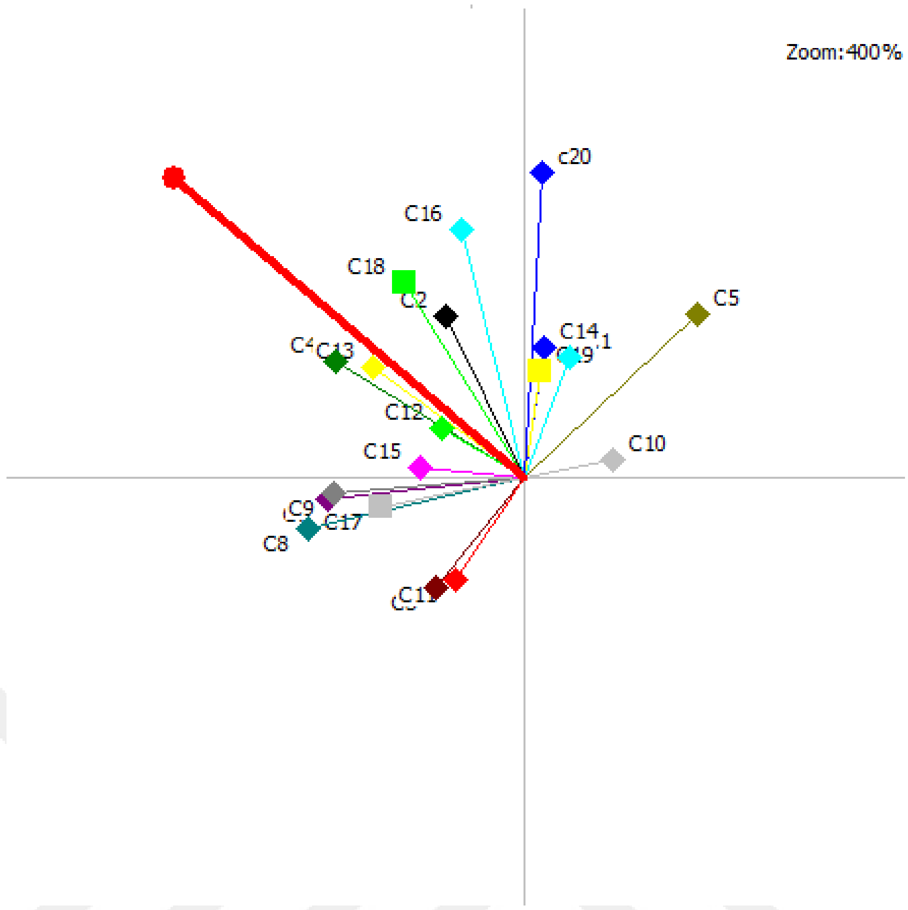

Figure 5.5: The GAIA Plane for Criteria

In figure 5.5, each criterion has been represented by an axis drawn out from the center of GAIA plane. Furthermore, the closes the criteria axis the similar their performances to each other for instance, natural gas production (C13) and Export of good and services (C4). And the import of good and services (C9) with General government final consumption expenditure (C7) and other indications that are located close to each other in figure 5.5. On the other hand, the axis that is pointing on the opposite directions have confliction towards the rest of criteria, for instance, inflation C10 is conflicting with most of the other indicators. Additionally, from the above figure, it is possible to understand and identify the indicators that have similar preferences and indicators that are conflicting with other indicators so further on an appropriate decision can be made.

The thicker red axis is an additional axis called decision axis in the GAIA plane which represents the weighting of the criteria. Decision axis can indicate which criteria are corresponded respected to PROMETHEE ranking.

In the following the four highest ranking countries Saudi Arabia, Turkey, Qatar, Iran and the lowest ranked country Sudan were further analyzed using GAIA web. Figure 5.6, figure 5.7, figure 5.8 and figure 5.9 and figure 5.10 they all express the influences of specific criteria on the preference result and ranking with a graphical representation of the net flow scores for each criterion where the criteria axis in the GAIA web are in the same orientation as in GAIA plane as well as PI the decision axis.

In the following (figures 5.6 to figure 5.10) as the radius where the net flow passes through decreases, the preferred choice also gets lower. For instance, in figure 5.6 shows that Saudi Arabia is performing strongly in most of its indicators which has created a larger range of newt flow in the GAIA web as in figure 5.10 Sudan has a smaller radius compare to Saudi Arabia therefore, it has a lower favor compared to the rest of the countries.

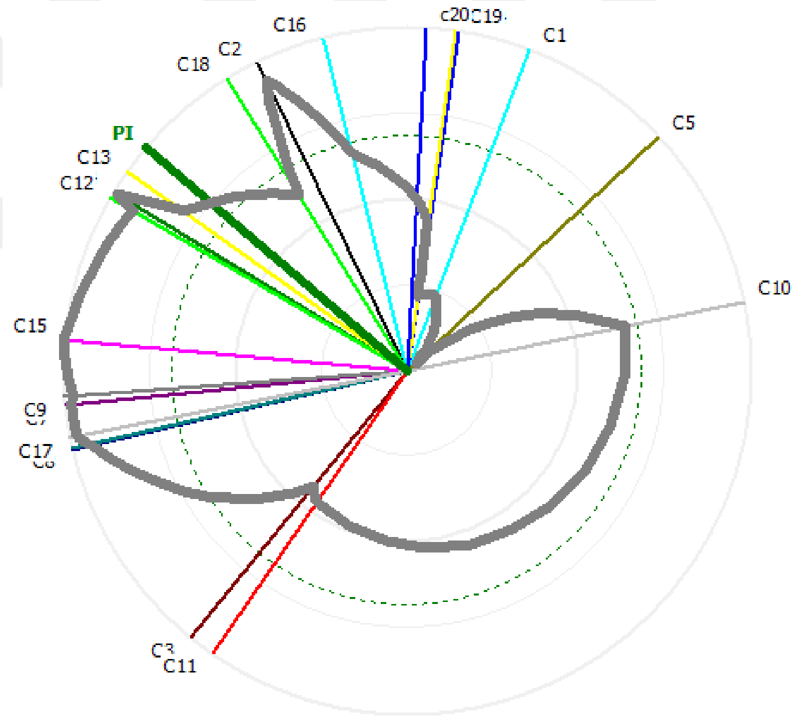

Figure 5.6: The GAIA Web of Saudi Arabia

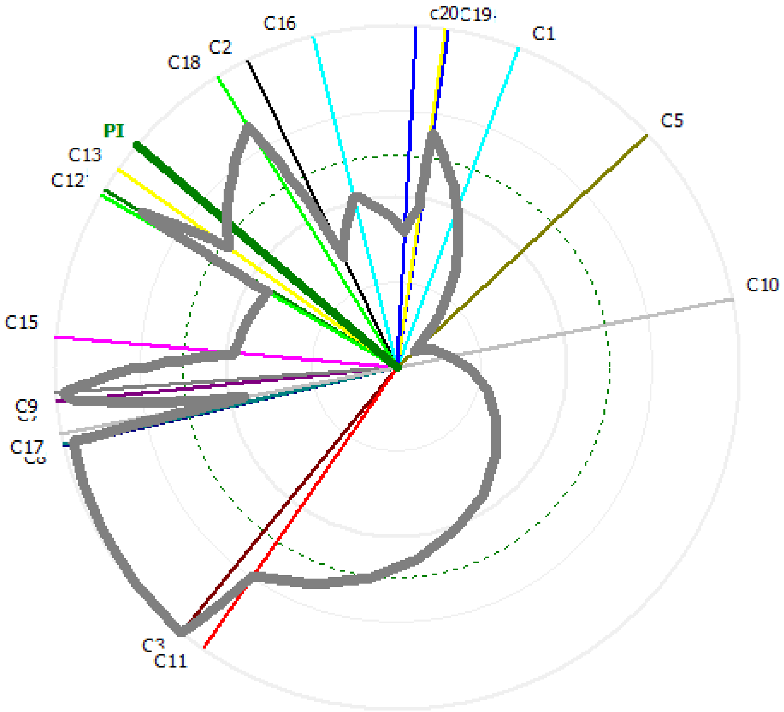

Figure 5.7: The GAIA Web Turkey

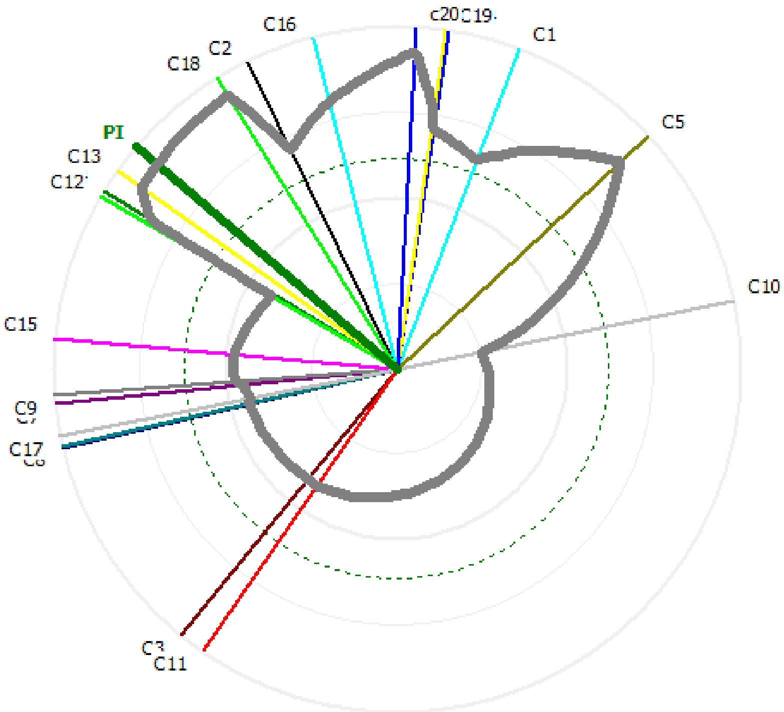

Figure 5.8: The GAIA Web Qatar

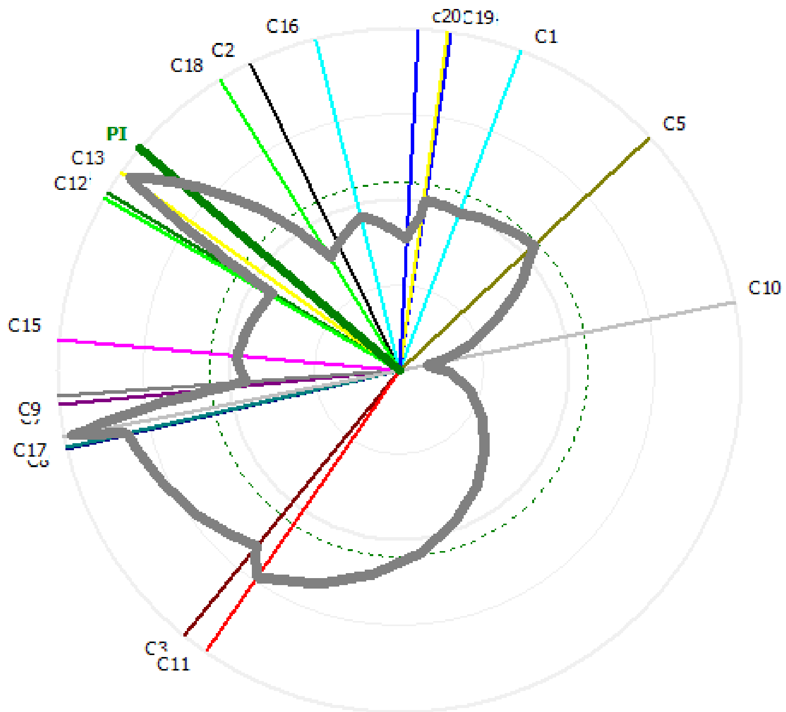

Figure 5.9: The GAIA Web Iran

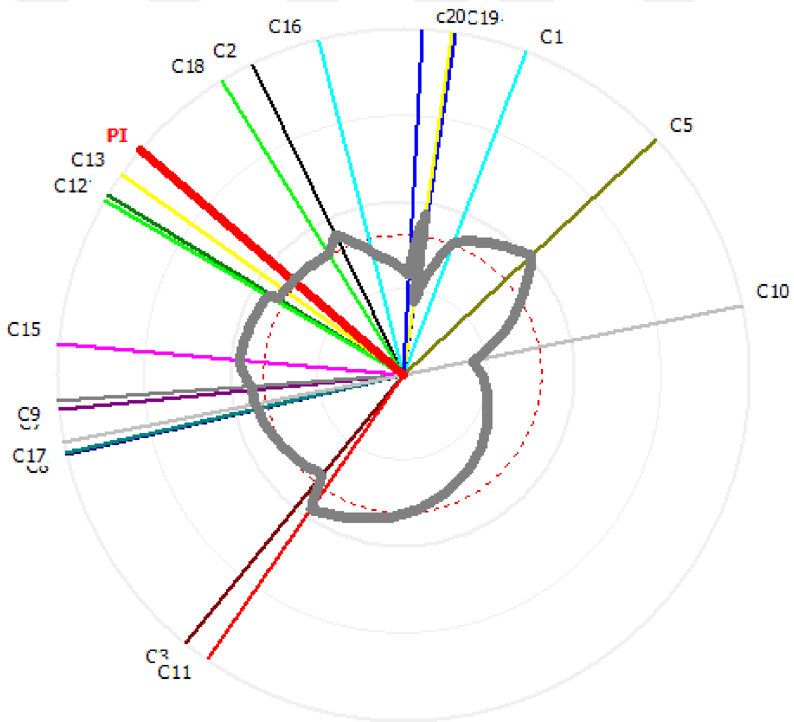

Figure 5.10: The GAIA Web Sudan

In the flowing, the action profile of the highest ranked country and the lowest ranked country has been discussed.

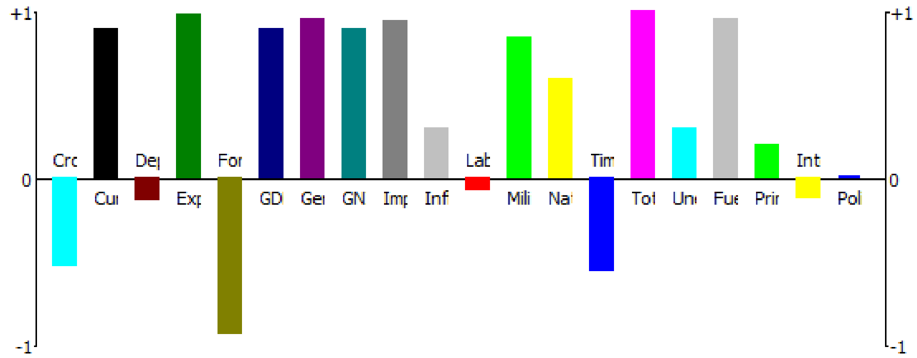

Figure 5.11: The Action Profile of Saudi Arabia

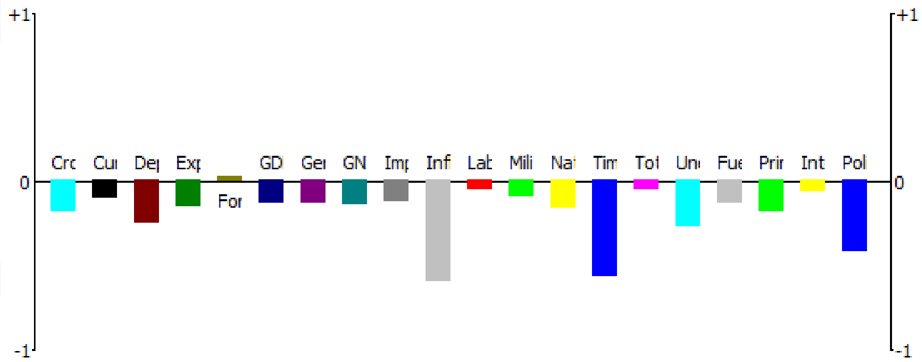

Figure 5.12: The Action Profile of Sudan

The figure 5.11 and figure 5.12 are action profile of Saudi Arabia, the first ideal country, and Sudan the last ideal country that were created in visual PROMETHEE. In these graphs countries, performances are analyzed based on the indicators used in this problem. As it can be shown Saudi Arabia has a better condition to Sudan when two countries are compared. These figures can also identify, the strongest indicators in each country compare to all other used indicators in this research.

In the next chapter conclusion, the summary of the work done in this research as well as the further studies that can be done will be discussed.

6. CONCLUSION

Terror, political changes, a significant drop in the oil price and many more conflicts in the Middle East and North Africa has been affected many foreign and domestic investors in the region. But still, MENA has not been abandoned left alone. Some companies see this as an opportunity in the emerging market with fewer competitors. There are many international firms willing to find a way to invest or maintain their interstates in the MENA region. In this research twenty-three countries in the NENA was ranked based on their financial, political and economic performances during the year 2000-2015.

An uncertainty is not predictable therefore there is a risk of doing an action. That risk can be minimaxed and calculated with a right tool and knowledge. The same function was applied in this research where there are risks of failing in investing in MENA. The findings of this case study provide a significant MENA country ranking for different parties operating in this region, in particular, decision makers, policymakers, stakeholders, and researchers.

In order to accomplish this research first, it needed to understand different indicators of a country and how one or many indicators can have an impact on a country. Therefore, by clarification and analyzing different published paper and research based on ranking countries in terms of one sector or an indicator, the needed indicators were selected. Secondly, the data needed for each indicator was collected from the accessible databanks such as International Monetary Fund (IMF), the World Bank, United Nation (UN), form the year 2000 to 2015. But disappointedly some of the countries in MENA did not have a completed data set for their indicators. Consequently, some of the indicators and countries needed to be limited at that early steps. Thirdly, Multi-Criteria Decision Making was introduced to carry the calculations accordingly, a variety of different literature and papers were considered and at the end, TOPSIS, ELECTRE, and PROMETHEE were selected. Finally, the MCDM methods were applied and three ranking was obtained. TOPSIS and PROMETHEE could fulfill the purpose of this research and ranked countries in the

MENA region. But ELECTRE was not a suitable method in such problem and it could not obtain a reliable result. Therefore, the research was carried on using only TOPSIS and PROMETHEE. Both TOPSIS and PROMETHEE have ranked Saudi Arabi, Turkey, Qatar, and Iran as their top four ranked countries in MENA. This result shows that these countries are reliable for further investigation based on investors' preferences in investment or other acts according.

Since there are still too many unsettled conflicts in the Middle East and North Africa and unanswered questions relating to the future of the region, it is difficult to present a general outlook for the upcoming years. Still, according to The World Bank Group, the economic growth in MENA is predicted to recover to 3,1% in 2018, which means a rise of 1,1% compared to the previous year and after this year, the rebound is considered likely to be in place, reaching 3.3% in 2019 and 3.2% in 2020 (The World Bank Group, 2018).

The challenging part of this research was selecting the indicators. There are many indicators that are some bounded together and dependent on each other and some not. One basically has the power to change the condition of a country, in a good or bad way. In MCDM problems it is wised to know each criteria's weight in the most precise way. But since each indicator has also many factors within the countries or different regions, giving weights to indicators needed a lot of investigations as well as the help of experts. Therefore, in this research, all the weight was given the same. In the further studies, it is considered to first catcalled weights of each selected indicators and then began with the calculations.

REFERENCE

Abdullah, L. (2013) 'Fuzzy Multi Criteria Decision Making and its Applications: A Brief Review of Category', *Procedia - Social and Behavioral Sciences*, 97, pp. 131–136. doi: 10.1016/j.sbspro.2013.10.213.

Afful-Dadzie, E., Oplatková, Z. K. and Nabareseh, S. (2015) 'Selecting start-up businesses in a public Venture capital financing using Fuzzy PROMETHEE', in *Procedia Computer Science*. Elsevier, pp. 63–72. doi: 10.1016/j.procs.2015.08.105.

Akbaş, H. and Bilgen, B. (2017) 'An integrated fuzzy QFD and TOPSIS methodology for choosing the ideal gas fuel at WWTPs', *Energy*. Pergamon, 125, pp. 484–497. doi: 10.1016/j.energy.2017.02.153.

Amaral, T. M. and Costa, A. P. C. (2014) 'Operations Research for Health Care Improving decision-making and management of hospital resources : An application of the PROMETHEE II method in an Emergency Department', *Operations Research for Health Care*. Elsevier Ltd, 3(1), pp. 1–6. doi: 10.1016/j.orhc.2013.10.002.

Ameri, A. A., Pourghasemi, H. R. and Cerda, A. (2018) 'Erodibility prioritization of sub-watersheds using morphometric parameters analysis and its mapping: A comparison among TOPSIS, VIKOR, SAW, and CF multi-criteria decision making models', *Science of the Total Environment*. Elsevier, 613–614, pp. 1385–1400. doi: 10.1016/j.scitotenv.2017.09.210.

Ameyaw, E. E. and Chan, A. P. C. (2015) 'Evaluation and ranking of risk factors in public-private partnership water supply projects in developing countries using fuzzy synthetic evaluation approach', *Expert Systems with Applications*. Pergamon, 42(12), pp. 5102–5116. doi: 10.1016/j.eswa.2015.02.041.

Andreopoulou, Z. *et al.* (2016) 'Renewable energy sources: Using PROMETHEE II for ranking websites to support market opportunities', *Technological Forecasting and Social Change*, 16 June. doi: 10.1016/j.techfore.2017.06.007.

Antanasijević, D. *et al.* (2017) 'A differential multi-criteria analysis for the assessment of sustainability performance of European countries: Beyond country ranking', *Journal of Cleaner Production*, 165, pp. 213–220. doi: 10.1016/j.jclepro.2017.07.131.

Bai, A., Hira, S. and Deshpande, P. S. (2015) 'An Application of Factor Analysis in the Evaluation of Country Economic Rank', in *Procedia Computer Science*. Elsevier, pp. 311–317. doi: 10.1016/j.procs.2015.06.036.

Beaulier, S. *et al.* (2016) 'An ordinal ranking of economic institutions', *Applied Economics*. Routledge, 48(26), pp. 2482–2490. doi: 10.1080/00036846.2015.1122736.

Benayoun, R., Roy, B. and Sussman, B. (1966) *ELECTRE: une méthode pour guider le choix en présence des points de vue multiples, SEMA-METRA International, Direction Scientifique*. Paris, France.

Bilbao-terol, A. *et al.* (2014) 'Using TOPSIS for assessing the sustainability of government bond funds $', *Omega*. Elsevier, 49, pp. 1–17. doi: 10.1016/j.omega.2014.04.005.

Bojković, N., Anić, I. and Pejčić-Tarle, S. (2010) 'One solution for cross-country transport-sustainability evaluation using a modified ELECTRE method', *Ecological Economics*. Elsevier, 69(5), pp. 1176–1186. doi: 10.1016/j.ecolecon.2010.01.006.

Brans, J. P. and Vincke, P. (1985) 'Note—A Preference Ranking Organisation Method', *Management Science*, 31(6), pp. 647–656. doi: 10.1287/mnsc.31.6.647.

C. L. Hwang, and K. Y. (2012) *Multiple Attribute Decision Making: Methods and Applications a State-of-the-Art Survey*. Springer Berlin Heidelberg. doi: 10.1007/978-3-642-48318-9.

Can, E., Ünlüsoy, S. and Eren, T. (2017) 'A combined goal programming – AHP approach supported with TOPSIS for maintenance strategy selection in hydroelectric power plants', *Renewable and Sustainable Energy Reviews*. Elsevier Ltd, 78(May 2016), pp. 1410–1423. doi: 10.1016/j.rser.2017.04.039.

Caravanos, J. *et al.* (2014) 'A simplified risk-ranking system for prioritizing toxic pollution sites in low- and middle-income countries', *Annals of Global Health*. Elsevier, pp. 278–285. doi: 10.1016/j.aogh.2014.09.001.

Cayir Ervural, B. *et al.* (2017) 'An ANP and fuzzy TOPSIS-based SWOT analysis for Turkey's energy planning', *Renewable and Sustainable Energy Reviews*, 12 August. doi: 10.1016/j.rser.2017.06.095.

Celik, E. and Taskin Gumus, A. (2016) 'An outranking approach based on interval type-2 fuzzy sets to evaluate preparedness and response ability of non-governmental humanitarian relief organizations', *Computers and Industrial Engineering*. Pergamon, 101, pp. 21–34. doi: 10.1016/j.cie.2016.08.020.

Certa, A. *et al.* (2017) 'ELECTRE TRI-based approach to the failure modes classification on the basis of risk parameters: An alternative to the risk priority number', *Computers and Industrial Engineering*. Pergamon, 108, pp. 100–110. doi: 10.1016/j.cie.2017.04.018.

Chen, T.-Y. (2014) 'Multiple criteria decision analysis using a likelihood-based outranking method based on interval-valued intuitionistic fuzzy sets.', *Information Sciences*. Elsevier, 286, pp. 188–208. doi: 10.1016/j.ins.2014.07.003.

Chen, Y.-H., Wang, T.-C. and Wu, C.-Y. (2011) 'Strategic decisions using the fuzzy PROMETHEE for IS outsourcing', *Expert Systems with Applications*. Pergamon, 38(10), pp. 13216–13222. doi: 10.1016/j.eswa.2011.04.137.

Cordero, J. M., Salinas-Jiménez, J. and Salinas-Jiménez, M. M. (2017) 'Exploring factors affecting the level of happiness across countries: A conditional robust nonparametric frontier analysis', *European Journal of Operational Research*. North-Holland, 256(2), pp. 663–672. doi: 10.1016/j.ejor.2016.07.025.

Dias, L. C. *et al.* (2016) 'A multi-criteria approach to sort and rank policies based on Delphi qualitative assessments and ELECTRE TRI: The case of smart grids in Brazil', *Omega (United Kingdom)*, 16 May. doi: 10.1016/j.omega.2017.04.004.

Estay-Ossandon, C., Mena-Nieto, A. and Harsch, N. (2017) 'Using a fuzzy TOPSIS-based scenario analysis to improve municipal solid waste planning and forecasting: A case study of Canary archipelago (1999–2030)', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2017.10.324.

Fancello, G., Carta, M. and Fadda, P. (2014) 'A decision support system based on electre III for safety analysis in a suburban road network', in *Transportation Research Procedia*. Elsevier, pp. 175–184. doi: 10.1016/j.trpro.2014.10.103.

Fourie, L. and Botha, I. (2015) 'Sovereign Credit Rating Contagion in the EU', *Procedia Economics and Finance*, 24(July), pp. 218–227. doi: 10.1016/S2212-5671(15)00651-6.

Gastelum Chavira, D. A. *et al.* (2017) 'A credit ranking model for a parafinancial company based on the ELECTRE-III method and a multiobjective evolutionary algorithm', *Applied Soft Computing Journal*. Elsevier, 60, pp. 190–201. doi: 10.1016/j.asoc.2017.06.021.

Gearhart, R. (2016) 'The robustness of cross-country healthcare rankings among homogeneous oecd countries', *Journal of Applied Economics*. Elsevier, 19(1), pp. 113–143. doi: 10.1016/S1514-0326(16)30005-8.

Hernandez-Perdomo, E. A., Mun, J. and Rocco, C. M. S. (2017) 'Active management in state-owned energy companies: Integrating a real options approach into multicriteria analysis to make companies sustainable', *Applied Energy*. Elsevier, 195, pp. 487–502. doi: 10.1016/j.apenergy.2017.03.068.

Ishizaka, A. and Nemery, P. (2014) 'Assigning machines to incomparable maintenance strategies with ELECTRE-SORT', *Omega (United Kingdom)*. Pergamon, 47, pp. 45–59. doi: 10.1016/j.omega.2014.03.006.

Kang, M. J. and Hwang, J. (2017) 'Interactions among Inter-organizational Measures for Green Supply Chain Management', *Procedia Manufacturing*. Elsevier, 8, pp. 691–698. doi: 10.1016/j.promfg.2017.02.089.

Kaya, T. and Kahraman, C. (2011) 'An integrated fuzzy AHP-ELECTRE methodology for environmental impact assessment', *Expert Systems with Applications*. Pergamon, 38(7), pp. 8553–8562. doi: 10.1016/j.eswa.2011.01.057.

Kilic, H. S., Zaim, S. and Delen, D. (2015) 'Selecting "the best" ERP system for SMEs using a combination of ANP and PROMETHEE methods', *Expert Systems with Applications*. Pergamon, 42(5), pp. 2343–2352. doi: 10.1016/j.eswa.2014.10.034.

Kumar, A. *et al.* (2017) 'A review of multi criteria decision making (MCDM) towards sustainable renewable energy development', *Renewable and Sustainable Energy Reviews*, pp. 596–609. doi: 10.1016/j.rser.2016.11.191.

Kumar, P., Singh, R. K. and Kharab, K. (2017) 'A comparative analysis of operational performance of Cellular Mobile Telephone Service Providers in the Delhi working area using an approach of fuzzy ELECTRE', *Applied Soft*

Computing Journal. Elsevier, 59, pp. 438–447. doi: 10.1016/j.asoc.2017.06.019.

Kumar, V. *et al.* (2016) 'Adaptation strategies for water supply management in a drought prone Mediterranean river basin: Application of outranking method', *Science of the Total Environment*. Elsevier, 540, pp. 344–357. doi: 10.1016/j.scitotenv.2015.06.062.

Kusi-Sarpong, S. *et al.* (2015) 'Green supply chain practices evaluation in the mining industry using a joint rough sets and fuzzy TOPSIS methodology', *Resources Policy*. Pergamon, 46, pp. 86–100. doi: 10.1016/j.resourpol.2014.10.011.

Kusumawardani, R. P. and Agintiara, M. (2015) 'Application of Fuzzy AHP-TOPSIS Method for Decision Making in Human Resource Manager Selection Process', in *Procedia Computer Science*. Elsevier, pp. 638–646. doi: 10.1016/j.procs.2015.12.173.

Lian, J. W. and Ke, C. K. (2016) 'Using a modified ELECTRE method for an agricultural product recommendation service on a mobile device', *Computers and Electrical Engineering*. Pergamon, 56, pp. 277–288. doi: 10.1016/j.compeleceng.2015.11.014.

Ma, H. *et al.* (2017) 'Time-aware trustworthiness ranking prediction for cloud services using interval neutrosophic set and ELECTRE', *Knowledge-Based Systems*, 27 September. doi: 10.1016/j.knosys.2017.09.027.

Madaleno, M., Moutinho, V. and Robaina, M. (2016) 'Economic and Environmental Assessment: EU Cross-country Efficiency Ranking Analysis', in *Energy Procedia*, pp. 134–154. doi: 10.1016/j.egypro.2016.12.111.

Mandic, K. *et al.* (2014) 'Analysis of the financial parameters of Serbian banks through the application of the fuzzy AHP and TOPSIS methods', *Economic Modelling*, 43, pp. 30–37. doi: 10.1016/j.econmod.2014.07.036.

El Mokrini, A. *et al.* (2016) 'Evaluating outsourcing risks in the pharmaceutical supply chain: Case of a multi-criteria combined fuzzy AHP-PROMETHEE approach', *IFAC-PapersOnLine*. Elsevier, 49(28), pp. 114–119. doi: 10.1016/j.ifacol.2016.11.020.

Mousavi, M., Gitinavard, H. and Mousavi, S. M. (2017) 'A soft computing based-modified ELECTRE model for renewable energy policy selection with unknown information', *Renewable and Sustainable Energy Reviews*. Pergamon, pp. 774–787. doi: 10.1016/j.rser.2016.09.125.

Nikouei, M. A., Oroujzadeh, M. and Mehdipour-Ataei, S. (2017) 'The PROMETHEE multiple criteria decision making analysis for selecting the best membrane prepared from sulfonated poly(ether ketone)s and poly(ether sulfone)s for proton exchange membrane fuel cell', *Energy*. Pergamon, 119, pp. 77–85. doi: 10.1016/j.energy.2016.12.052.

Othman, M. K. *et al*. (2015) 'The Malaysian Seafares Psychological Distraction Assessment Using a TOPSIS Method', *UMK Procedia*. Elsevier B.V., 3, pp. 40–50. doi: 10.1016/j.enavi.2015.12.005.

Patil, S. K. and Kant, R. (2014) 'A fuzzy AHP-TOPSIS framework for ranking the solutions of Knowledge Management adoption in Supply Chain to overcome its barriers', *Expert Systems with Applications*. Pergamon, 41(2), pp. 679–693. doi: 10.1016/j.eswa.2013.07.093.

Peng, A. H. and Xiao, X. M. (2013) 'Material selection using PROMETHEE combined with analytic network process under hybrid environment', *Materials and Design*. Elsevier, 47, pp. 643–652. doi: 10.1016/j.matdes.2012.12.058.

Phillis, Y. A., Grigoroudis, E. and Kouikoglou, V. S. (2011) 'Sustainability ranking and improvement of countries', *Ecological Economics*, 70(3), pp. 542–553. doi: 10.1016/j.ecolecon.2010.09.037.

Radmehr, A. and Araghinejad, S. (2015) 'Flood Vulnerability Analysis by Fuzzy Spatial Multi Criteria Decision Making', *Water Resources Management*, 29(12), pp. 4427–4445. doi: 10.1007/s11269-015-1068-x.

Saldanha, W. H. *et al.* (2017) 'Choosing the best evolutionary algorithm to optimize the multiobjective shell-and-tube heat exchanger design problem using PROMETHEE', *Applied Thermal Engineering*. Pergamon, 127, pp. 1049–1061. doi: 10.1016/j.applthermaleng.2017.08.052.

Sánchez-Lozano, J. M., García-Cascales, M. S. and Lamata, M. T. (2016) 'Comparative TOPSIS-ELECTRE TRI methods for optimal sites for photovoltaic solar farms. Case study in Spain', *Journal of Cleaner Production*, 127, pp. 387–398. doi: 10.1016/j.jclepro.2016.04.005.

Shakerian, H., Dehnavi, H. D. and Ghanad, S. B. (2016) 'The Implementation of the Hybrid Model SWOT-TOPSIS by Fuzzy Approach to Evaluate and Rank the Human Resources and Business Strategies in Organizations (Case Study: Road and Urban Development Organization in Yazd)', *Procedia - Social and Behavioral Sciences*. Elsevier, 230, pp. 307–316. doi: 10.1016/j.sbspro.2016.09.039.

Tarek, B. A. and Ahmed, Z. (2017) 'Governance and public debt accumulation: Quantitative analysis in MENA countries', *Economic Analysis and Policy*. Elsevier, 56, pp. 1–13. doi: 10.1016/j.eap.2017.06.004.

Toma, S. V., Chiriță, M. and Şarpe, D. A. (2011) 'Country risk analysis : Political and economical factors', *The 3rd World Multi conference on applied economics, business and development*, pp. 162–167. Available at: http://www.wseas.us/e-library/conferences/2011/Iasi/AEBD/AEBD-27.pdf.

Torlak, G. *et al.* (2011) 'Analyzing business competition by using fuzzy TOPSIS method: An example of Turkish domestic airline industry', *Expert Systems with Applications*, 38(4), pp. 3396–3406. doi: 10.1016/j.eswa.2010.08.125.

Uygun, Ö. and Dede, A. (2016) 'Performance evaluation of green supply chain management using integrated fuzzy multi-criteria decision making techniques', *Computers & Industrial Engineering*. Pergamon, 102, pp. 502–511. doi: 10.1016/j.cie.2016.02.020.

Del Vasto-Terrientes, L. *et al*. (2015) 'Official tourist destination websites: Hierarchical analysis and assessment with ELECTRE-III-H', *Tourism Management Perspectives*. Elsevier, 15, pp. 16–28. doi: 10.1016/j.tmp.2015.03.004.

Vetschera, R. and De Almeida, A. T. (2012) ‘A PROMETHEE-based approach to portfolio selection problems’, *Computers and Operations Research*. Pergamon, 39(5), pp. 1010–1020. doi: 10.1016/j.cor.2011.06.019.

Veza, I., Celar, S. and Peronja, I. (2015) ‘Competences-based comparison and ranking of industrial enterprises using PROMETHEE method’, in *Procedia Engineering*. Elsevier, pp. 445–449. doi: 10.1016/j.proeng.2015.01.389.

Vinodh, S. and Jeya Girubha, R. (2011) ‘PROMETHEE based sustainable concept selection’, *Applied Mathematical Modelling*. Elsevier, 36(11), pp. 5301–5308. doi: 10.1016/j.apm.2011.12.030.

Wan, S. ping, Xu, G. li and Dong, J. ying (2017) ‘Supplier selection using ANP and ELECTRE II in interval 2-tuple linguistic environment’, *Information Sciences*. Elsevier, 385–386, pp. 19–38. doi: 10.1016/j.ins.2016.12.032.

Wang, J.-J. *et al.* (2009) ‘Review on multi-criteria decision analysis aid in sustainable energy decision-making’, *Renewable and Sustainable Energy Reviews*, 13(9), pp. 2263–2278. doi: 10.1016/j.rser.2009.06.021.

Wu, Y. *et al.* (2017) ‘Social sustainability assessment of small hydropower with hesitant PROMETHEE method’, *Sustainable Cities and Society*. Elsevier, 35, pp. 522–537. doi: 10.1016/j.scs.2017.08.034.

Yan, X. P. *et al.* (2017) ‘Safety management of waterway congestions under dynamic risk conditions—A case study of the Yangtze River’, *Applied Soft Computing Journal*. Elsevier, 59, pp. 115–128. doi: 10.1016/j.asoc.2017.05.053.

Yazdani, M. *et al.* (2017) ‘A group decision making support system in logistics and supply chain management’, *Expert Systems with Applications*. Pergamon, 88, pp. 376–392. doi: 10.1016/j.eswa.2017.07.014.

Zavadskas, E. K. *et al.* (2017) ‘Integrated group fuzzy multi-criteria model: Case of facilities management strategy selection’, *Expert Systems with Applications*. Pergamon, 82, pp. 317–331. doi: 10.1016/j.eswa.2017.03.072.

RESUME

Ahmad M. Dehcheshmeh

Adress: Caferağa Mah., İleri Sk. No: 4/1, 34710 Kadıköy/İSTANBUL
Born: 16.11.1991 in Shahrekord, Iran
Tel.: +90 536 2967174
Email: dehcheshmeh.m.a@gmail.com

OBJECTIVE

Familiarise myself with specific empirical methods and their application in order to professionally do research on the Middle East focusing on risk analysis and problem solving and achieve my future career goal as a specialist for economy in the MENA region.

EDUCATION

- Sept.2015-current

Master of Business Administration *(English-taught Postgraduate Degree)*
Istanbul Aydın University/Faculty of Economics and Administrative Sciences, Turkey
- 120 ECTS
- GPA: 3,38 (German grading system: 1,7)
- Thesis on Country Risk Assessment in MENA

- Okt. 2014

Bachelor of Electronic and Electrical Engineering *(British Undergraduate Degree)*
University of Sunderland/Faculty of Applied Science, Malaysia
- *360 UK credits = 180 ECTS*
- *UK* degree score: Upper second class (German grading system: 1,7)
- Thesis on Human Interface Devices

- June. 2011

Secondary School Diploma
Sunway University College/Canadian International Matriculation Program, Malaysia

WORK EXPERIENCE

- Sept. 2016-current

Public Relations Manager / English Language Teacher
Okyanus College Istanbul, Turkey
- Privat School
- Full time position

SKILLS

LANGUAGES

Persian/Farsi	*native*
English:	*near native*
Turkish:	*intermediate*
German:	*elementary*

PROGRAMS

- MS Office (Word, Excel, PowerPoint, Visual C++)
- Proteus PCB Design & Simulation (basic level)
- MATLAB (basic level)

EXPERTISE

MCDM (Multiple criteria decision-making):

- Visual PROMETHEE (Program/Preference Ranking Organization Method for Enrichment of Evaluation)
- SDI Tools (Statistical Design Institute)
- TOPSIS (The Technique for Order of Preference by Similarity to Ideal Solution)
- ELECTRE (Elimination and Choice Expressing Reality)

Ahmad M. Dehcheshmeh