

**DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED
SCIENCES**

**DEVELOPING A SPREADSHEET BASED
DECISION SUPPORT SYSTEM USING
DEMATEL AND ANP APPROACHES**

**by
Mehmet Günal ÖLÇER**

**June, 2013
İZMİR**

DEVELOPING A SPREADSHEET BASED DECISION SUPPORT SYSTEM USING DEMATEL AND ANP APPROACHES

**A Thesis Submitted to the
Graduate School of Natural and Applied Sciences of Dokuz Eylül University
In Partial Fulfillment of the Requirements for the Degree of Master of Science
In Industrial Engineering**

**by
Mehmet Günal ÖLÇER**

**June, 2013
İZMİR**

M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled “**DEVELOPING A SPREADSHEET BASED DECISION SUPPORT SYSTEM USING DEMATEL AND ANP APPROACHES**” completed by **MEHMET GÜNAL ÖLÇER** under supervision of **ASST.PROF.DR. DERYA EREN AKYOL** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.



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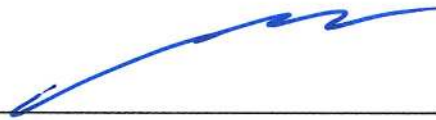
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Mehmet Günal ÖLÇER

DEVELOPING A SPREADSHEET BASED DECISION SUPPORT SYSTEM USING DEMATEL AND ANP APPROACHES

ABSTRACT

The purpose of this thesis is to rate countries for the use of international contractors by using MS Excel spreadsheet. The multi criteria decision making (MCDM) technique used throughout the research is Decision Making Trial and Evaluation Laboratory (DEMATEL) and Analytic Network Process (ANP) hybrid system.

Due to the improvements in communication technology, and aspiration for higher profit, in recent years, contractors tend to undertake contracts in international markets. However, there are many risks and opportunities involved in international construction projects which differ from country to country which might influence the go/no-go decision of the contractors. Not only do the host country conditions play an important role in the decision making process of the contractors, but also the capabilities, resources and risk appetite of the company affect this decision process.

In this thesis, an MS Excel spreadsheet based decision support system is developed to rate the countries considering the risks and opportunities offered by these countries which also makes it possible for the decision makers to enter their own criteria using the program. Using different sources, and based on the questionnaires obtained from 21 Turkish Contractors' Decision Makers, the possible criteria are determined. DEMATEL method has been used to measure the dependence between the criteria and the alternative countries are rated using ANP method. The approach is illustrated on a real example. The developed system (TEMPOS) is easy to use and can serve as a practical guiding framework for international contractors to evaluate countries under different criteria. However, based on the feedbacks obtained from the users of TEMPOS, an improved version of the program (TEMPOS β) is also developed.

Keywords: International construction, country rating, DEMATEL, ANP, multi criteria decision making, MS Excel spreadsheet

DEMATEL VE ANP YAKLAŞIMLARI KULLANILARAK HESAP ÇİZELGELERİNE DAYALI BİR KARAR DESTEK SİSTEMİ GELİŞTİRİLMESİ

ÖZ

Bu tezin amacı, MS Excel elektronik tablo kullanarak, uluslararası müteahhitlerin kullanabilmesi için ülkelerin puanlandırılmasıdır. Araştırmada çok kriterli karar verme tekniklerinden Karar Verme Deneme ve Değerlendirme Laboratuvarı (KVDDL) ve Analitik Ağ Süreci (AAS) melez sistemi kullanılmıştır.

Son yıllarda, haberleşme teknolojilerindeki gelişmeler ve daha fazla kar isteği nedenleri ile müteahhitler, uluslararası pazarlarda daha fazla iş yapmak için daha istekli hale gelmişlerdir. Ancak, uluslararası inşaat projeleri ülkeden ülkeye farklılık gösteren bir çok riskin yanı sıra fırsatı da bünyesinde barındırmaktadır. Bu riskler ve fırsatlar müteahhidin söz konusu ülkeye gidip gitmeme kararını yakından ilgilendirmektedir. Karar verme sürecinde sadece gidilecek ülkenin şartları değil ama aynı zamanda müteahhidin olanakları, kapasitesi, kaynakları ve risk alma isteği de belirleyici olmaktadır.

Bu tez ile, geliştirilen MS Excel hesap çizelgesi tabanlı karar destek sistemi, riskleri ve fırsatları dikkate alarak ülkeleri puanlandırmakta ve karar vericilere kendi kriterlerini de programa dahil etme olanağı vermektedir. Çeşitli kaynaklardan yararlanarak derlenen kriterlerden hangilerinin programda kullanılacağına, 21 Türk Müteahhitlik firmasının yetkililerinin görüşleri doğrultusunda karar verilmiştir. Programda, kriterler arasındaki bağımlılığın KVDDL metodu ile ölçülmesini takiben AAS yöntemi ile ülkeler puanlandırılmaktadır. Örneklerle karşılaştırmalı olarak da gösterilen programın, kullanımı oldukça basit olup uluslararası taahhüt işi yapan müteahhitlere ilgilendikleri ülkeleri farklı kriterlere göre değerlendirme olanağı da vermektedir. Öte yandan TEMPOS kullanıcılarının geri bildirimleri doğrultusunda (TEMPOSβ) sürümü de geliştirildi.

Anahtar sözcükler: Uluslararası inşaat, ülkelerin puanlandırılması, KVDDL, AAS, çok kriterli karar verme, MS Excel hesap çizelgesi

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CHAPTER ONE

INTRODUCTION

1.1 Background

The construction industry is one of the largest segments of the global economy. Construction market in the world contributes approximately 10% of total Gross Domestic Product (GDP) and the estimated volume construction output in the world was 4,900 billion US\$ in 2007 according to CICA (2012). (Figures 1.1 and 1.2)

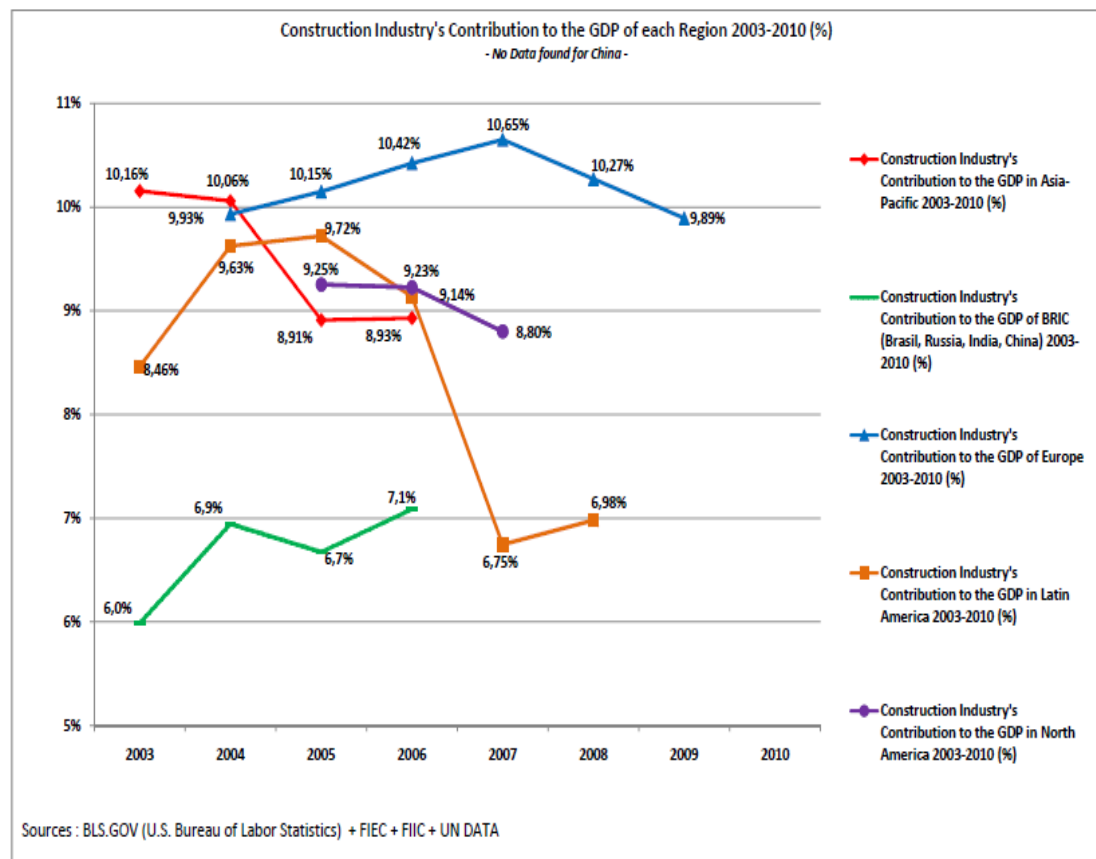


Figure 1.1 Construction industry's % contribution to the GDP of each region between 2003-2010 (CICA, 2012)

According to the reports published by Engineering News-Record (ENR) in the same year total revenue of TOP-225 International Contractors (IC) in the world was about 321 billion US\$ and total revenue of TOP-225 IC increased from 177 billion US\$ to 474 billion US\$ in eight years starting from 2005, ENR(2005-2012).

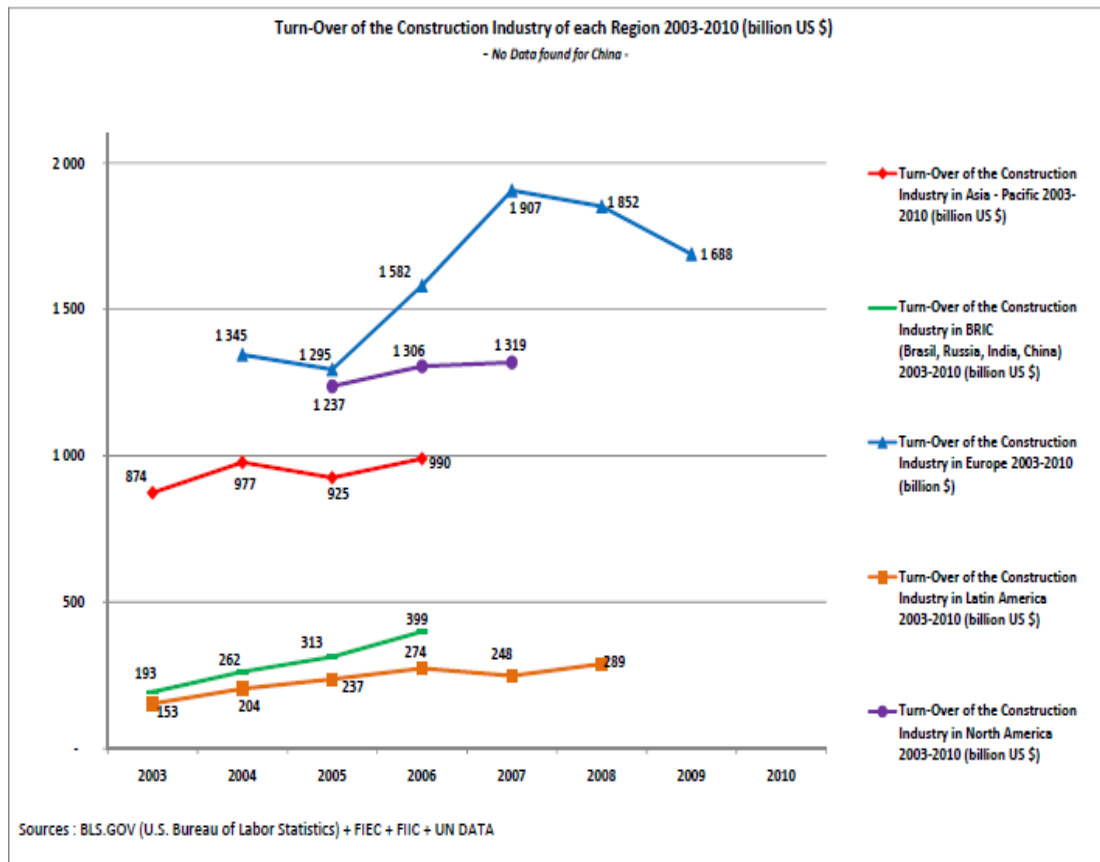


Figure 1.2 Turn-over of construction industry of each region (CICA, 2012)

Even though the recession, in three consecutive years starting in 2009, construction market expanded more than 2.7 times between 2005 and 2012. In the same period revenue of Turkish International Contractors (TIC) increased from 2.1 billion US\$ to 15.9 billion US\$ while the revenue of TOP-225 contractors, increased from 167 billion US\$ to 461 billion US\$, as seen in Figure 1.3

Number of TIC showed up in TOP-225 list is increased from 14 to 33, and the share of revenue increased from 1.2% to 3.4% as shown in Figure 1.4.



Figure 1.3 Construction volume of TOP-225 contractors and TCA members with respect to years

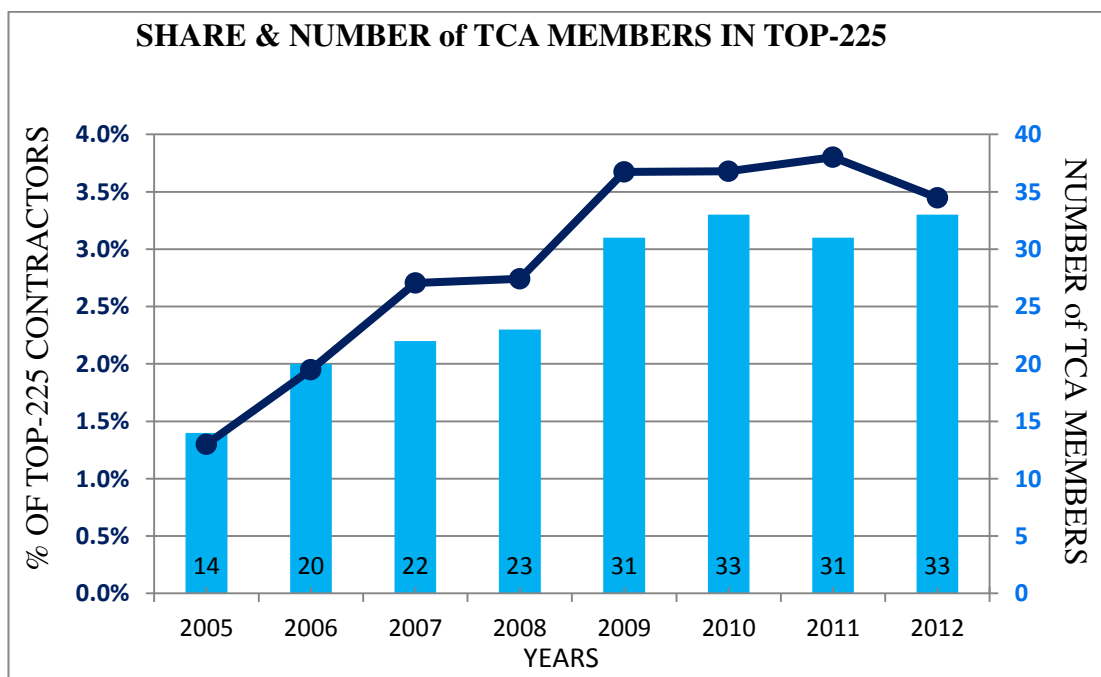


Figure 1.4 Number of TCA members listed in TOP-225 and the shares versus years

In recent eight years, revenue of international construction is distributed between countries as in Figure 1.5.

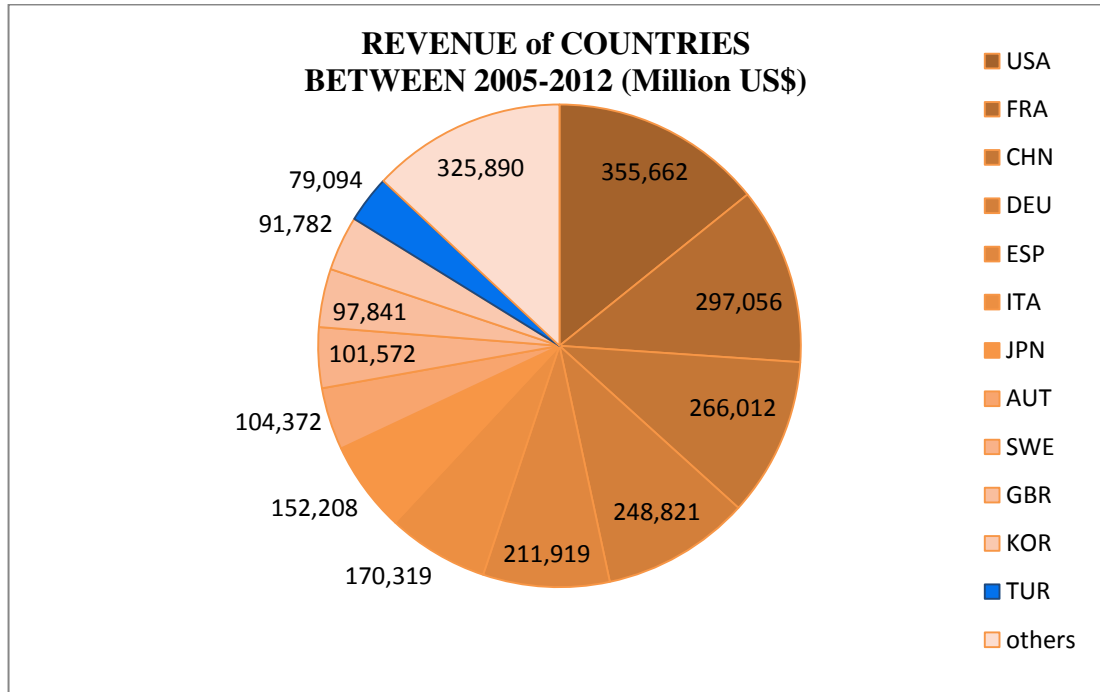


Figure 1.5 Sum of revenue of countries in TOP-225 between 2005-2012

Although Turkish Contractors Association (TCA) has 148 members, only 46 of them showed up at least one or more time in TOP-225 List in last 8 years. While 8 companies showed up in all lists, seven companies showed up only once in the lists between 2005 and 2012. 102 TCA members never showed up in TOP-225 list in the last 8 years.

The information about show ups of Turkish Contractors are given in Figure 1.6, Figure 1.7 and Figure 1.8 is the graph of the sorted revenues of contractors between 2005 and 2012 for different countries.



Figure 1.6 Number of TCA members listed in TOP-100 & TOP-225 versus years

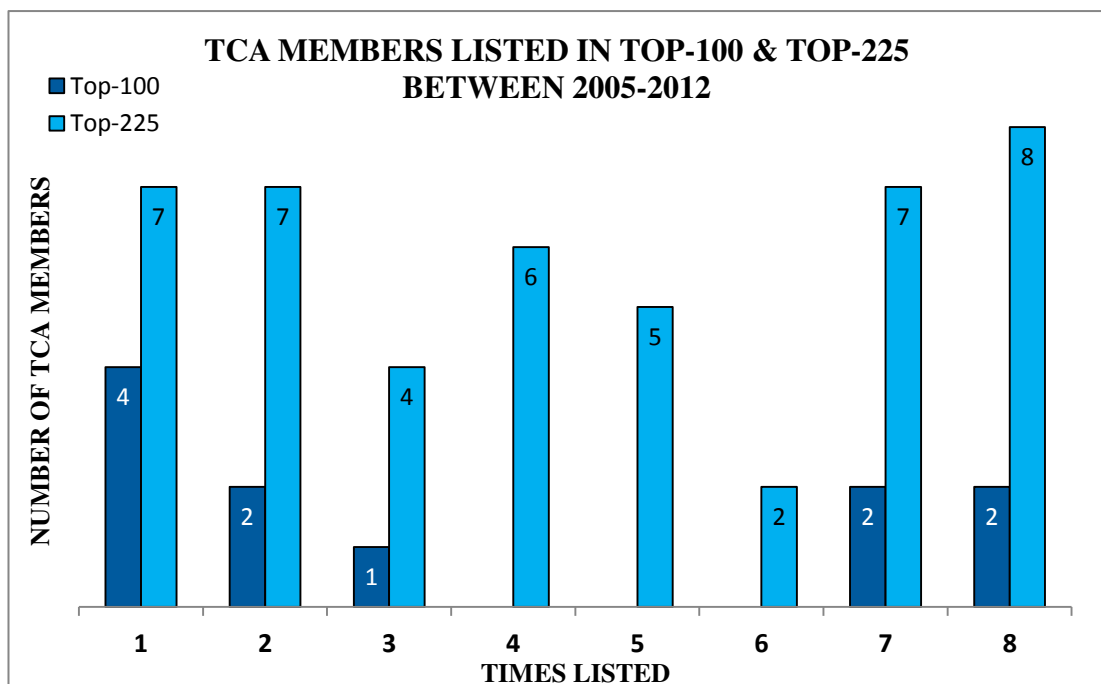


Figure 1.7 The number of TCA members and the number of times they are listed in TOP-225 and TOP-100 between 2005-2012

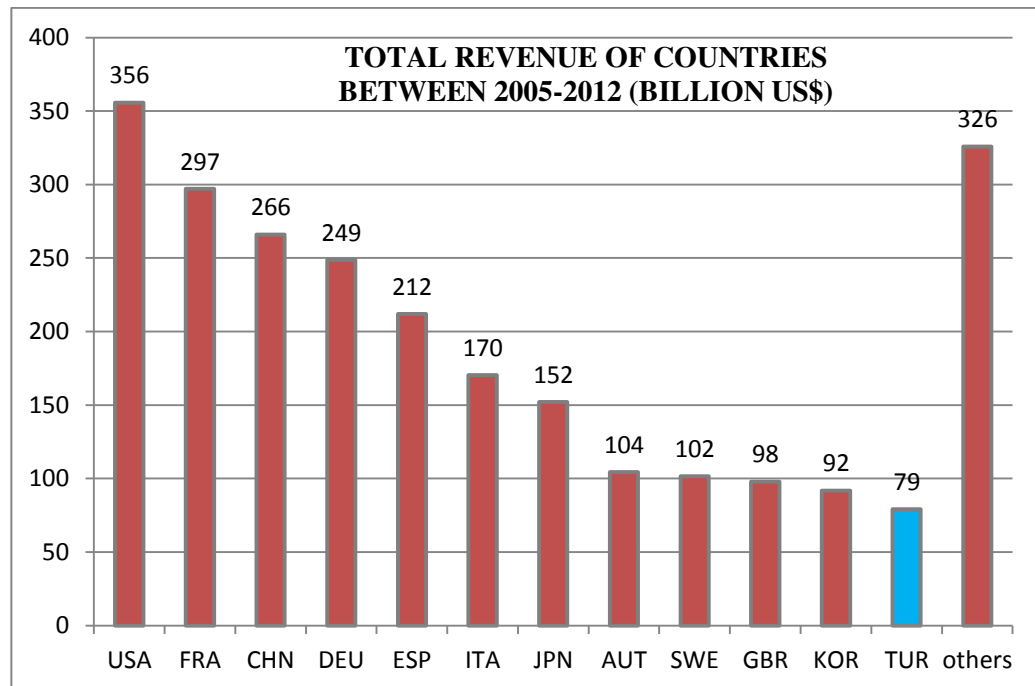


Fig 1.8 Total revenue of countries, in TOP-225, between 2005-2012

From the reports of CICA (2012) and ENR (2012), we see that international construction can roughly be estimated as approximately 5% of the total construction of the world, and in recent years, with the new opportunities via globalization and advances in communication technologies, the number of firms conducting operations in international markets is increasing constantly to take advantage of growing opportunities. However, besides the benefits offered in expanding operations in international markets, there are many risks (economic, political, social, cultural conditions, etc.) involved associated with target countries which complicate the market entry decision of the contractors.

In recent years, a large amount of research has been conducted on risk management in construction industry. However, research on country rating for international construction is not abundant.

For a contractor determining the foreign country to operate in is a strategic decision, however generally decisions are given depending on previous business relations, in the target country or by the common sense of decision makers (DM) due to the lack of necessary information. Decision making which depend on multiple

criteria needs collecting bunch of data from various sources related to the countries and processing the data to achieve a result that will support the decision.

The purpose of this research is to develop a decision support system to guide contractors for the go/no-go decision for international projects. For this reason, an MS-Excel based tool is developed which rates the countries under consideration using the criteria determined through interviews with several international contractors. DEMATEL method is used to determine the causal relationship among criteria and ANP is employed to determine the weights of the clusters which include various criteria. In rating process, some of the criteria which are related with the country specific information are rated by the program automatically while the rest of the criteria are rated by the decision maker based on his preferences.

Country rating is performed using 108 criteria that were gathered under 6 clusters namely Technical, Economical, Market Future, Political, Operational and Social (Appendix D). Being inspired by each cluster name initials, the developed program is named as TEMPOS.

The interesting idea of the program is that every decision maker will achieve a different result for the same country because each construction professional's subjective assessments will change depending on their relations with the target country, past experiences, abilities and risk appetite of the organizations of contractors. On the other hand, when the name of the target country is changed, the user of the program will achieve a different country score even if the decision maker maintains the same scores for the criteria under evaluation.

The reason for this is that the program defined scores for the criteria based on the information identifying the countries will change automatically as soon as target (destination) country is changed. It is possible to compare different countries according to criteria rated by the program while keeping the same scores for the criteria that need to be rated by the program user.

The procurement of new specialized software is not required to implement the decision support system developed and due to the widespread use of the MS Office package, the construction professionals are highly familiar with MS Excel and can implement the developed tool easily without having any difficulty.

In sum, the contribution of this thesis is three-fold: 1) identifying the criteria to be used in international market entry decisions through conducting surveys with international contractors, 2) developing a spreadsheet tool based on DEMATEL and ANP to support the decision making needs of international contractors, 3) ranking the risk scores of various countries to allow contractors to evaluate their foreign market entry decision.

The rest of the thesis is organized as follows: Chapter 2 presents the literature review. We explain the research methodology in Chapter 3. Chapter 4 describes the spreadsheet implementation on an example problem. Discussions and conclusions are provided in Chapter 5.

CHAPTER TWO

LITERATURE REVIEW

2.1 About

An extensive research is carried out, to obtain the previous researches with similar subjects, especially by means of internet. Addresses of the web sites used in research are listed below in alphabetical order.

<http://www.belgeler.com/>
<http://bookboon.com/>
<http://findebookee.com/>
<http://www.lexiguru.com/>
<http://www.lexiology.com/>
<http://www.sciencedirect.com/>
<http://www.tandfonline.com/>
<http://www.search-document.com/>
<http://tez2.yok.gov.tr/>

The search was made by using the following keywords: country rating, country risk rating, international construction, international contractor, DEMATEL, ANP, MS EXCEL, spreadsheet. To receive the latest information and data about new articles, numbers of e-mail alerts were created. Only the Microsoft Office programs are used for keeping and sorting the documents.

Literature review is mainly carried under two sub topics. These are:

- a) Literature review about country rating for international contractors.
- b) Literature review about DEMATEL and ANP hybrid method.

2.2 Literature Review About Risk Management for International Contractors

Although there are numerous researches on project management or risk management in construction industry, and a lot of researches and professional organizations regarding rating of countries from an economical or financial perspective, there are only a few researches related to country rating for international contractors.

Ashley & Bonner (1987) state that political risk identification, measurement, and management are the keys to successful international construction contracting. Multinational contractors are particularly sensitive to quick, unexpected change in the political environment and it is essential to identify primary political source risks and their impacts on project cash-flow elements. An appropriate definition of political risk and its components has continually plagued both academicians and corporate decision-makers. Political risk is subjective and business-specific event. What may represent high risk to one type of operation may not necessarily represent risk at all to another one. Thus political risk is defined in many ways. The probability of encountering political risk abroad is directly proportional to the relative stability of the host country's political system and political instability has its roots in various social; economic, and political factors.

Ashley & Bonner (1987) define the political risk variables as:

- Nature of firms operation
- Firm's relationship to government
- Firm's relationship to local power groups,
- Involvement of local business interests,
- Regional and external factors,
- Influence of (Independent) Power Groups
- Nationalist Attitude towards Firm
- Project Desirability
- Government Policy

Hastak and Shaked (2000) present a risk assessment model, namely the International Construction Risk Assessment Model (ICRAM-1), for international construction projects. The model supports the user in evaluating the risks in expanding the operations to international market. Model analyzes the risks at three levels, namely the country level, market level and project level. ICRAM-1 offers an approach to evaluate risk indicators and examines a specific project in international environment. (1) High risk indicators; (2) impact of country environment on a specific project; (3) impact of market environment on a specific project; and (4) overall project risk are obtained as the result of ICRAM-1 analysis.

According to Hastak and Shaked (2000), risk involved in an international operation can be analyzed by evaluating the political stability of a country and political risk assessment models primarily consider factors such as economic, financial, political, legal, and social conditions as well as policy and the foreign exchange systems of the host country. They analyze 73 risk indicators in three levels, namely macro level, market level and project level (see Figure 2.1.) and use Analytical Hierarchy Process (AHP) to calculate the relative importance of risk indicators in their model. ICRAM-1 is a structured approach to evaluate the risk indicators in international construction and designed for the examination of a specific project in a foreign country.

Hastak and Shaked (2000) conclude that ICRAM-1 is useful for 1) analyzing different countries with respect to a specific project, 2) comparing different types of projects in a specific country, 3) plotting risk assessment data over several years or periods will indicate the trend of risk indicators in that country and this data can be used to conduct simulation studies to determine the trends of risks, 4) the analysis conducted in the model is useful at the preliminary stage of a project/country evaluation, 5) evaluating several construction markets at the same time with respect to their risk and future potential and notes that the input provided by the user is subjective in nature and depends on the information available and the reliability of the sources and an in-depth risk analysis would be required if a decision were made to further explore the country/market/project.

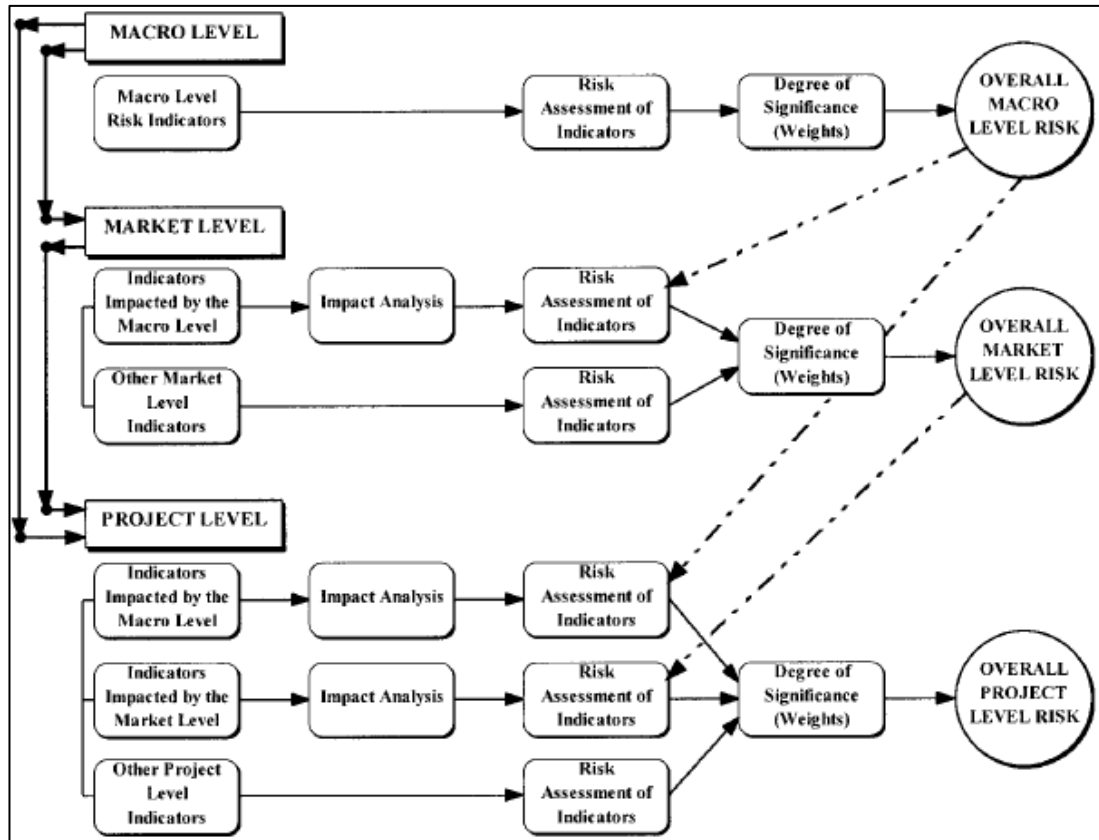


Figure 2.1 Framework of ICRAM-1 (Hastak & Shaked, 2000)

Riberio (2001) states that creating the present country risk work emerged from the necessity of finding conclusive answers on accepting some risks or not, especially the ones represented by the possibility of restriction of payment, imposed by a country.

Oz (2001) investigates the sources of competitive advantage of Turkish construction companies in international market, and applied Michael Porter's diamond framework to Turkish construction Industry. Oz (2001) considers the strengths and weakness of Turkish construction companies as in Table 2.1.

Table 2.1 Strengths and weakness of Turkish construction companies

<u>Framework component</u>	<u>Strengths</u>	<u>Weakness</u>
Factor conditions	Relatively lower wages and ease of communication with Turkish workers.	Wages of Turkish workers are tending to increase.
	Quality of educational standards of Turkish engineers especially achieved by some universities.	Lack of on the job training for middle level staff.
		Inability to offer financial packages.
Demand conditions	Good track record.	Stagnant domestic market.
	Rising quality of work.	
Related and supporting industries	Strong supplementary industries for construction industry.	Weak competitive position of Turkish consultancy firms.
		Lack of design capacity.
Context for firm strategy and rivalry	Competitive domestic industry.	Competition of Turkish firms among themselves overseas.
	Extensive diversification of construction firms.	Lack of formal organization of family owned companies.
	Entrepreneurial, risk-taking skills of contractors.	Extensive multi-level subcontracting of work.
	Good managerial and communication skills.	
	Ability to deal with bureaucracy.	
	Past record of good performance and good relationships.	

Table 2.1 Continued

<u>Framework component</u>	<u>Strengths</u>	<u>Weakness</u>
Chance events	1970's construction boom in Middle East and Africa.	Iran–Iraq war, Iraq's invasion of Kuwait;
	Opportunities in former Soviet countries in 1990's	Stagnation in Russian Federation.
	Geographical proximity and cultural and religious ties to 'promising' markets.	Payment problems in Libya.
The role of government	Occasional government support, such as tax incentives and rebates in early 1980s encouraged firms to go abroad.	Government's economic and financial policies including high interest rates, non-availability of export credit.
	Trade agreement with Russian Federation.	Lack of government support for overseas market development.
		Lack of coherent government policy for the industry. Inadequate building regulations and ineffective implementation.

Riberio (2001) concludes that country risk analysis is not an easy task and requires a holistic vision, specialized skills, persistent approach are necessary. Also following the standard procedures, coherency of studies using reliable data are important and after dealing with various aspects such as macroeconomic, socio-politic and financial aspects analysis has to clearly demonstrate the strengths and weakness of a country.

Ofori (2002) discusses relevant aspects of international construction and compared the international performance of construction firms in middle and low-income countries and examined the applicability of various analytical frameworks to international construction and states that international construction market is subject to many dynamic influences that can lead to changes in the volume, mix and distribution of demand and sources of competitiveness. According to the author, international construction firm faces several problems: physical, technological, financial, legal, socio-cultural and political. It is important that factors that contribute to the success of firms in this market are clearly understood.

Walewski and Gibson (2003) worked out to improve the understanding of risk identification and assessment techniques for international construction projects. They emphasize that the international construction market is always risky and contractors expend little time and effort on assessing and strategically planning for known, probable, or even unknown risks. According to the authors international project risk assessment planning is a process that assists all participants of the project to handle risks before they become significant problems, and only few contractors have developed a process to optimize the portfolio of project risks across the entire project life cycle.

Selecting which international markets to enter is a critical strategic decision that requires extensive environmental scanning, determination of strengths and weaknesses, and matching international market opportunities with company strengths. In their work, Dikmen and Birgonul (2004) develop a strategic decision support tool that can classify international projects according to the attractiveness of the project or market and the competitiveness of a company and propose a neural network model that encodes expert opinions based on previous projects carried out by Turkish contractors in overseas markets. The model can be used as a guide to construction professionals about which international projects to bid on and how to increase organizational intelligence using the experiences of Turkish contractors in international markets.

Sixteen criteria, considered in their network are listed below.

- Economic prosperity of host country
- Host country risk (political, legal, and financial)
- Cultural/religious similarities
- Distance between Turkey and host country
- Attitude of host government to Turkish contractors
- Construction demand in host country
- Size of project
- Type of project
- Technical complexity of project
- Type of client (government or private sector)
- Availability of funds for project
- Contract type
- Experience of company in similar works
- Existence of strict time limitations
- Existence of strict quality requirements
- Intensity of competition

In another work, Dikmen et al. (2005a) investigate the role of marketing, considering the marketing perception of Turkish contractors, general marketing practices, expected benefits and impact of marketing capability to create competitive advantage and concluded that marketing in Turkish construction industry is in its early stages and there is a long way to go and marketing capability is not seen as a strategic success factor by the majority of the Turkish contractors.

In a different study, Dikmen et al. (2005b) introduce the steps of ANP and present an application to demonstrate how each step is applied, throughout the research international market entry problem is set for the solution, objective and subjective criteria and interactions between parameters are considered. Demand conditions, level of competition, socio-political and economic conditions are considered as main parameters and Superdecisions software is used for the solution. The authors state

that ANP has been proven as an effective and reliable method for strategic problems such as international market selection.

The combined use of AHP and Delphi is an original approach that was explored by Arditi and Gunhan (2005a) and used to generate the relative weights of the various company strengths, threats, and opportunities associated with international construction, benefits and costs relative to individual countries, and international expansion modes.

According to Arditi and Gunhan (2005a), there are several reasons for contractors to expand their business into international markets and the international environment is complex and creates risks that are not well understood by companies. Therefore it is essential for contractors to follow a disciplined strategy to decide whether to enter international markets or not.

According to the study by Arditi and Gunhan (2005b), factors that give strength, threats and opportunities associated with international construction are sorted in descending order below.

Strengths of Construction Companies Relative to International Construction

- Track Record
- Specialist Expertise
- Project Management Capability
- International Network
- Technological Advantage
- Financial Strength
- Equipment, Material, and Labor Support

Threats Associated with International Construction

- Loss of Key Employees
- Shortage of Project Owners' Financial Resources
- Inflation and Currency Fluctuations

- Interest Rate Increases
- Foreign Competitors in Host Country
- Cultural Differences
- Bribery in Host Country

Opportunities Associated with International Construction

- Increased Long-Term Profitability
- Ability to Maintain Shareholders' Return
- Ability to Take Advantage of Globalization and Openness of Markets
- Availability of New Service Areas
- Availability of Beneficiary International Agreements
- Ability to Take Advantage of Privatization Programs in Emerging Economies
- Increased Chances for Technological Advancement

Watkins (2005) defines the country risk premium as an increment in interest rates that would have to be paid for loans and investment projects in a particular country compared to some standard.

Research by Cheng and Li (2005) is important because they mention that their research is probably the first time that an attempt has been made to apply ANP in project selection. Throughout the research authors also submit an illustrative research.

Master thesis written by Akcamete (2006) mainly concerns with international contractors aiming to assess the risks of construction market in different countries. The thesis presents a construction specific country risk breakdown structure and provides a systematic list to assess country risk before conducting business in foreign market and presents a model for the illustration of the application in an organization.

Akcamete (2006) declares that the number of studies that exclusively focused on construction specific country risks is quite low. The study lists 112 risks and the sources they are obtained. Risks are categorized under six main heading namely;

cultural, political, legal, construction market, financial and economic under these headings there are total 110 risks considered.

Akcamete (2006) proposes two different methods to rate the countries. In the first method, the program user gives probability and impact of risk values for each country by using 1-5 scale, the values for each risk are multiplied and divided to 5 to stay in 1-5 range, average of risks in each category composes the risk rating of categories', average of categories compose the risk rate of the country.

In the second method of Akcamete (2006), the program user gives relative importance weights for each risk. By normalizing relative importance weights for each sub-category, the weight of each risk in the list is calculated. These importance weights will be calculated only once and can be used for all countries. Later the values for each risk for a specific country is input, these values are multiplied by importance weights and averaged to rate the country risk.

In the following study, Beim & Levesque (2006) state: "To date, studies that focus on identifying a country for foreign direct investment list the factors one must consider, but the formal use of Multiple Criteria Decision Analysis (MCDA) methods has not been revealed in the literature. This article illustrates how the use of MCDA can facilitate the decision making process on which country to venture into".

Beim & Levesque (2006) outlined 9 researches between years 1976 and 2002, objectives and criteria of each research is considered under one of the five clusters. The clusters are namely: economic, political, legal, cultural and other.

In their analysis Beim & Levesque (2006) used the following clusters and criteria.

Cultural Perspective

- Language
- Local Customs

Economic Perspective

- Access to Financial Capital
- Ease of Profit Repatriation
- Financial Security
- GDP Growth Rate Estimate
- Purchasing Power Parity (PPP)
- Difficulty to Own and Operate Property

Legal Perspective

- Business Law
- Lack of Crime
- Environmental, Workplace and Product safety Regulations
- Labor Regulations
- Risks of Intellectual Property

Political Perspective

- Bureaucracy
- Lack of Corruption
- Government Stability
- Lack of Human Rights and Political Freedom

Beim & Levesque (2006) applied their model to a set of 14 alternatives/countries: Argentina, Brazil, Egypt, Germany, India, Indonesia, Iran, Japan, Mexico, Nigeria, Poland, Russia, South Africa and Turkey. The reason for choosing these nations are, they span stages of economic development and political climate and data availability.

Bu-Qammaz (2007) studied risk assessment of international construction projects using the ANP method and considered 28 risk factors under 5 clusters namely; country, inter-country, construction, project team, contractual issues. Bu-Qammaz (2007) proposed a risk assessment framework to assess risks related to the international construction projects. The purpose of the framework is implementation

about bidding decisions and providing risk rating for international construction project.

Han et al. (2007) take into account the following 64 criteria under 5 clusters for selecting candidate international construction projects.

Condition of host country and project owner

- 1.1 How fair are construction laws and regulations related to international contractors?
- 1.2 What is the extent of corruption in the host country?
- 1.3 How stable is the social situation in the host country?
- 1.4 Are there any restrictions on profit transfer?
- 1.5 How frequently do the laws and rules change?
- 1.6 How sufficient is the owner's funding?
- 1.7 How suitable is the owner's management ability?

Information on project acquisition and bidding

- 2.1 Is it possible to get preliminary information about the host country's conditions?
- 2.2 How proper are the prospects of the future economy in related industries?
- 2.3 Is it possible to get proper and competent bid information?
- 2.4 How sufficient is the estimation time?
- 2.5 What is the foreign-exchange rate risk?
- 2.6 How accurate is the estimated financing cost?
- 2.7 How accurate are bidding documents provided by the owner?
- 2.8. How accurately are the owner's requirements communicated?
- 2.9 How appropriate are contingency plans?
- 2.10 What is the level of competition?
- 2.11 How accurate is the cost estimation?

Project characteristics and contractual conditions

- 3.1 How adequate is the contract duration?
- 3.2 How fair are compensation and warrantee regulations?
- 3.3 How well is the escalation code included?
- 3.4 How clear is the contract document?
- 3.5 What is the quality of the specification codes?
- 3.6 How frequent are change orders?
- 3.7 What are the experience and technical performance ability of the contractor?
- 3.8 How does Force majeure affect the contract?
- 3.9 How are climate and weather conditions?
- 3.10 How accessible is the site?
- 3.11 Are there any differences in geography and site condition?
- 3.12 Is there social consensus on the project need?
- 3.13 How is the basic infrastructure in the surroundings of the site?
- 3.14 What is the quality of the owner-provided design?
- 3.15 What is the quality of the contractor's design?

Characteristics of organization and participants

- 4.1 How competent is the leadership of the project manager?
- 4.2 What is the quality of the welfare and incentives for the field staff?
- 4.3 How sufficient are the field engineers' technical ability and management skills?
- 4.4 How appropriate is the contractor's communication and collaboration system?
- 4.5 How committed is the firm's organization at both headquarters and the site?
- 4.6 Are there any language barriers?
- 4.7 How is cooperation with J/V and the consortium?
- 4.8 What is the quality of the payment and subcontractor bond agreement with J/V and the consortium?
- 4.9 How fair is the owner's representative?
- 4.10 How capable are the local subcontractors?
- 4.11 Does the owner intervene in selecting local subcontractors?
- 4.12 Are there payment delays, retention, or repudiation from the owner?
- 4.13 Do the owner's requirements create any excessive burden?

4.14 What is the quality of the claim and dispute resolution procedures?

Contractor's ability and capacity

- 5.1 How proper is document management?
- 5.2 Is there any delay in permissions?
- 5.3 How available is early mobilization?
- 5.4 How experienced are the laborers?
- 5.5 Is there any delay in procurements?
- 5.6 How well is material quality maintained through delivery, stock, and erection?
- 5.7 How efficient are equipment operations and optimized supply?
- 5.8 What are the design and engineering abilities of the contractor?
- 5.9 What is the technical ability of the construction work and quality control?
- 5.10 Is any rework necessitated by inadequate testing or pilot operations?
- 5.11 How is safety and environment management?
- 5.12 What is the quality of the firm's project planning and management?
- 5.13 How appropriate is the application of cost management tools?
- 5.14 What is the quality of cash flow management?
- 5.15 How appropriate is resource allocation?
- 5.16 Are there any interruptions caused by adjacent or related sites?
- 5.17 Is there any delay in commissioning or take-over?

Ozorhon et al. (2007) investigate the impact of host country conditions on international joint venture (IJV) performance which is defined as the performance of the project, the IJV partners, and the IJV organization itself. The results of the study suggest that project-related factors have a great impact on IJV performance, while the host country related risks do not. 5 constituent and 33 latent variables (listed below) are defined for the analysis by structural equation model (SEM).

Conditions of the host country

- 1.1 Level of political stability in the host country
- 1.2 Strength of macroeconomic conditions in the host country
- 1.3 Strength of the legal system in the host country
- 1.4 Strength of the relations between IJV partners and the host Country

Project-related factors

- 2.1 Completeness of payments by the client
- 2.2 Tolerance/flexibility of the client
- 2.3 Relations with other project parties
- 2.4 Competence of other project parties
- 2.5 Completeness of project definition
- 2.6 Availability of resources
- 2.7 Technical complexity of the project
- 2.8 Impact of external factors such as weather and soil conditions
- 2.9 Completeness of design
- 2.10 Completeness of the contract
- 2.11 Handling the project requirements such as quality, environment, health and safety
- 2.12 Penal sanctions for duration
- 2.13 Effectiveness of the project management functions (planning, coordinating, monitoring, controlling)

Project performance

- 3.1 Completing the project within budget
- 3.2 Completing the project within schedule
- 3.3 Achieving required quality
- 3.4 Satisfying the client

Partner performance

- 4.1 Sharing risks
- 4.2 Sharing resources (financial, etc.)
- 4.3 Decreasing costs
- 4.4 Learning management skills from your partner
- 4.5 Transferring technology/learning technical skills from your partner
- 4.6 Facilitating internationalization (market entry)
- 4.7 Increasing competitiveness (get the job)
- 4.8 Creating long-term relationships

4.9 Making more profit

Performance of the IJV management

- 5.1 Effectiveness of the strategic (upper management) control of the IJV
- 5.2 Effectiveness of the operational (daily activities) control of the IJV
- 5.3 Effectiveness of the organizational control of the IJV

According to Kim et al. (2007), because overseas construction projects tend to have a high possibility of loss/failure compared to domestic projects, risk management is becoming more emphasized and systemized in international projects so as to improve the quality of difficult decisions that normally encompass a higher level of risk exposures. The authors review basic decision-making processes in global construction projects, and present a web-based decision support system that is closely associated with relevant risks and each cycle of sequential decisions. Construction firms are expected to make better decision in pursuing international construction projects with a consideration of key risk factors at each stage of a project.

In the same year, Dikmen et al. (2007a) present a decision support tool to estimate the bid mark-up values by a systematic way instead of the estimation by intuition and identified the following 44 factors under 4 topics that may affect the mark-up value of an international project.

General

- Project size
- Contract duration
- Contract payment type
- Type of project
- Client type
- Size of the contractor company
- Level of experience of contractor in similar type of projects
- Level of experience of contractor in the host country

- Financial capability of the contractor
- Technical capability of the contractor
- Managerial capability of the contractor
- Planned % of subcontracted works
- Amount of cash required in advance

Risk

- Vagueness of design
- Lack of enough technical information
- Vagueness of contract conditions
- Unavailability of resources (material etc.) in the host country
- Lack of competence of local parties in the host country
- Unfavorable physical conditions that may affect productivity
- Technical and technological complexity of the project
- Strict quality requirements/specifications
- Tightness of the project duration/Existence of high penalty
- Lack of infrastructural and civil development in the host country
- Geographical distance between the host country and Turkey
- International relations of the host country with Turkey
- Economical/financial risk
- Foreign exchange rate/inflation rate fluctuation risk
- Immaturity/unreliability of the legal system
- Political risk
- Bureaucratic delays/difficulties
- Cultural differences between the host country and Turkey
- Security risk
- Existence of language barrier
- Level of experience of the client in similar projects
- Attitude of the client towards the contractor
- Availability of funds for the project

Opportunity

- Contractor's potential for gaining reputation/experience
- Potential for gaining similar future projects in the same country
- Immediate need to take a job
- Existence of local agents that help the contractor with the project
- General economic situation at the contractor's country
- Potential for scope changes (potential for higher profits)

Competition

- Number of bidders
- Presence of highly competitive bidders

Dikmen et al. (2007a) conclude that financial, economic, legal and political risks in the host country are far more important than logistical difficulties, international relations between the countries, cultural differences and language problems for Turkish contractors.

Dikmen et al. (2007b) developed a company specific generic risk model tool that can be used to estimate the cost overrun risk in international projects using influence diagrams and to propose a risk assessment procedure using fuzzy logic. According to Dikmen et al. (2007b) decisions to be made by contractors willing to conduct business in international markets can be grouped under 4 categories. These are: internalization decision, market selection decision, project selection decision, mark-up selection decision.

The authors state that Construction companies may benefit from a tool that helps them to assess the level of risk so that they can determine an appropriate mark-up. The proposed methodology uses the influence diagramming method for construction of a risk model and a fuzzy risk assessment approach for estimating a cost overrun risk rating. A computerized system has been developed for an international construction company and applicability of this system during risk assessment at the bidding stage has been tested by using real company and project information.

Osipova (2008) states that the research literature identifies several problem areas in risk management in construction. One of the problems is that project actors often focus on the short-term economical results and protect own interest rather than the project overall. Risk management in construction projects depends on the choice of contractual form and the content of the corresponding contractual documents.

Kim et al. (2009) point out that, early understanding of project conditions is crucial to proactively respond the situations. Particularly, international construction projects are affected by more complex and dynamic factors than domestic projects; frequently being exposed to serious external uncertainties such as political, economic, social, and cultural risks, as well as internal risks from within the project itself. The authors develop a structural equation model (SEM) to predict the project success of uncertain international construction projects with a multiple regression analysis and artificial neural network.

Han et al. (2010) point out that the international construction industry has changed drastically over the last decade in many ways, including: the terms of competition rules and delivery systems for the selection of contractors, financial resource diversity, leading contractors in the revenue rankings, the key products and new emerging markets and analyzes the common strategies and lessons obtained from the cases of leading global contractors that have sustained their growth in the competitive global construction during the last decade. Han et al. (2010) found out that those firms, which sustained their growth in international market, were quite proactive and responsive to changing markets by increasing their overseas revenues and enhancing their competency through more diversified products in order to stabilize their revenue structure and they significantly increased their upstream/downstream functional capabilities.

Table 2.2 summarizes the key changes confronting the international construction.

Table 2.2 Key changes confronting the international construction

Classification	Past	Present and future
• Tender conditions	• Exclusive (price-focused competition dominant) • Requires local contents • Mandatorily requires an engagement of local labor, equipment and materials, and local subcontractor	• Mutually negotiated (non-price factors are increasingly extended) • Diversified local requirements in both scopes and depths • More focuses on technology transfer, risk protection against owners
• Project types	• Infrastructure projects dominated • (typical quality level with standardized demands)	• Industrial facilities, project-financed developmental projects, package deals projects with substituting payment with its natural resources dominated (higher quality requirement with more diversified demands)
• Financial resources	• Owner's domestic capital, international loans or aids from world banks or other agencies	• Requires contractor's project financing, BOT types of project initiation
• Contractor selection	• Lowest-bid wins the deal	• Pre-tender negotiation or post-tender negotiation for adjusting contractual conditions are becoming common
• Selection criteria	• More emphasis on construction experience and expertise	• More focus on total capability for project development, financing, and management expertise

Table 2.2 Continued

Classification	Past	Present and future
•Level of competition	•Often involves a few or a designated number of competitors	•Often involves many competitors while emphasizing on financing arrangement
•Emerging markets	•Mostly developing economies (Middle East, Asia)	•Developing and resource-rich countries (Middle East, Central Asia, Africa, etc.)
•Corporate management	•Local context plays a key role	•Multi-nationalization (cross-national / cultural management context) becomes crucial

As in the reports of the PRS Group (2013) in the methodology of International Country Risk Guide (ICRG) there are 22 variables in three subcategories of risk: political, financial and economic. These three subcategories are based on 100, 50, 50 points. Total points from three subcategories are divided by 2 to achieve scores ranging from 0 to 100. Very Low risk is represented by (80 to 100 points) while (0 to 49) represents Very High Risk. Rating is based on “maximum is the best system”. ICRG provides ratings for 140 countries on monthly basis, and for an additional 26 countries on annual basis. ICRG calculates political, financial and economical rates separately. Some subcategories are also divided to sub-subcategories. The political risk assessments are made on the basis of subjective analysis while the financial and economic risk assessments are done according to objective data. After political, financial and economic risks are rated they are combined in a formula to provide the country’s overall risk rating.

In recent work, Zhang (2011) points out that implementing international projects in a foreign country is a high risk business activity and researches on this subject emphasize traditional risks but ignores an emerging new type of “social risk” and draws the attention readers to the differences in the social, economic and cultural

backgrounds among the international contractors and their partners have led to difficulties and occasional disputes among various participants in China.

Zhang (2011) concludes that top social risk factors include “social relations risk with various parties in the local region”, “dispute risk with local construction labor” and “permit or license risk in dealing with land use and construction planning issues due to policy changes”. Zhang (2011) also states that the major social risk factors do not affect the project’s quality, time and cost directly, their influence to project performance is indirect and significant. If they are not properly predicted, or addressed or regulated, their consequences could be severe.

Taroun & Lowe (2011) review the literature about risk assessment between years 1983-2009 and the results are as summarized below.

1. Probability-Impact modeling is predominant;
2. Traditionally the focus was on objective probability gradually subjective probability has become dominant.
3. Risk analysis of project duration or cost is prevalent;
4. Analysis of project performance risk is hardly mentioned in the literature.
5. No risk assessment approach is discovered that deploys a common scale to simultaneously assess the alternative impacts of a risk on the various project objectives.
6. Most of the existing approaches provide a risk rating; very few actually quantify risk.
7. The limitations of existing theories and tools indicate the need for improved alternatives.

Taroun & Lowe (2011) conclude that using ‘risk cost’ as a common scale within a belief-based decision making framework would be an innovative solution, overcoming current shortcomings and generally improving construction risk assessment.

According to the history written by Taroun & Lowe (2011) , firsts in the subject literature are as follows in chronological order are as follows:

- Cooper et al. (1985) defined “Risk Breakdown Structures” (RBS),
- Franke (1987) proposed using “risk cost”,
- Kangari and Riggs (1989) illustrated the use of “Fuzzy Sets Theory” (FST) as a risk assessment tool,
- Charette (1989) Probability-Impact-Predictability Model,
- Mustafa and Al-Bahar (1991) adopted the AHP to assess construction project risk,
- Mulholland and Christian (1999) use the PERT technique to develop a distribution of project duration,
- Hastak and Shaked (2000) deploy AHP within a framework for assessing international construction projects,
- Dey (2001) proposed a Decision Support System (DSS) for managing risks in the early stages of a construction project based on AHP and decision trees,
- Baccarini and Archer (2001) presented a methodology which calculates a risk score for project cost, time or quality,
- Jannadi and Almishari (2003) modeled risk by probability, severity of impact and exposure to all hazards of an activity and provided a software to generate risk scores,
- Dikmen and Birgonul (2006) use AHP within a multi-criteria decision making (MCDM) framework for risk and opportunity assessment of international construction projects
- Hsueh et al. (2007) used AHP and Utility Theory to develop a multi-criteria risk assessment model for construction joint ventures,
- Zeng et al. (2007) attempt to combine FST and AHP,
- Zhang and Zou (2007) combine FST and AHP under the title of “Fuzzy-AHP” approach.
- Dikmen et al. (2007 a) used case-based reasoning to estimate construction project mark-up.
- Dikmen et al. (2007b) proposed a fuzzy risk assessment methodology for assessing the risk of cost overrun for international construction projects,

- Han et al. (2008) proposed three dimensional (Significance-Probability-Impact) risk model,
- Zayed et al. (2008) used AHP to assign weights to risks, which is defined as the sum of the weighted risk effects of risk factors. However, the method of generating the project risk level, neglects the interdependencies between risks.
- Cioffi and Khamooshi (2009) presented a method for combining risk impacts and estimating the overall impact, at a given confidence level,

Key Consulting (2012) considers 5 risks and 9 benefits in the project selection process template where the weight of each risk and benefit item are assumed as equal. The template can compare up to 10 projects and draws a graph that horizontal axis represents the benefit scores while the vertical axis represents risks score and size of the bubbles is proportional to the estimated cost as seen on Figure 2.2

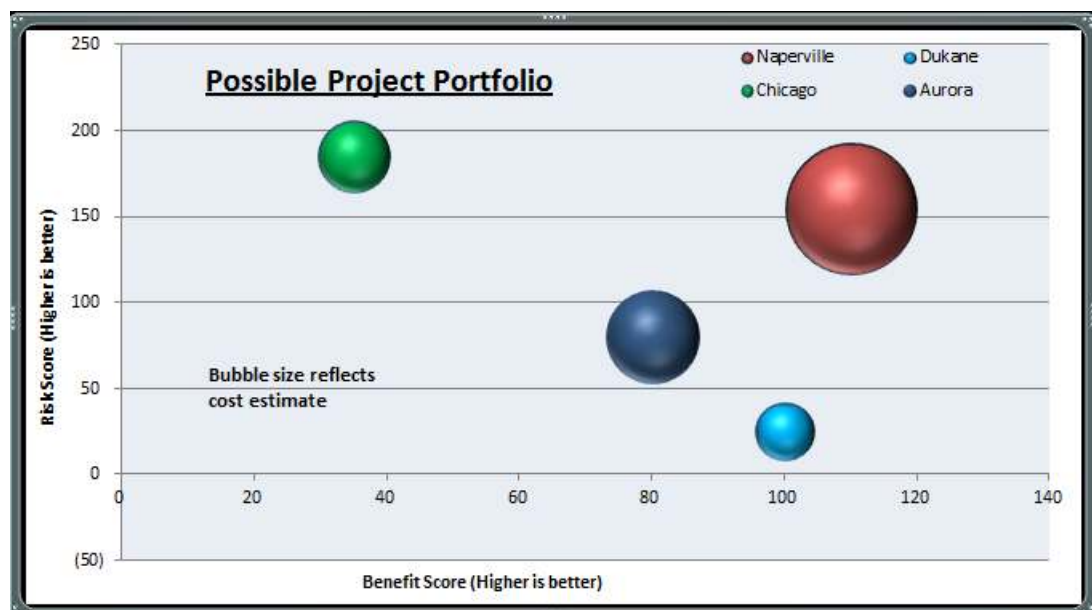


Figure 2.2 Key Consulting project selection template

Investment Support and Promotion Agency of Turkey (ISPAT), compares 13 countries by benchmarking Turkey under 8 clusters and 17 criteria. Each criterion is considered separately and the result is given in tabular form besides the graph. Input and output pages are shown in Figure 2.3 and Figure 2.4 respectively.

1	CRITERIA	2	COUNTRIES	3	CHARTS
	Business Efficiency - Attitudes and Values ☒ Attitudes toward globalization ☒ Flexibility and adaptability Business Efficiency - Finance ☐ Finance and banking regulation Business Efficiency - Labor Market ☐ Finance skills ☐ Qualified engineers ☐ Skilled labor ☐ Working hours Business Efficiency - Management Practices ☐ Competent senior managers ☐ Credibility of managers ☐ International experience Doing Business ☐ Registering property ☐ Starting a business Infrastructure - Basic Infrastructure ☐ Population - market size ☐ Population over 65 years ☐ Population under 15 years Infrastructure - Technological Infrastructure ☐ Development and application of technology International Trade ☐ Tariff barriers (Trade-weighted barriers, %) TTR ¹⁸		☒ Turkey ☒ United Kingdom ☒ Switzerland ☒ United States ☒ Slovak Republic ☒ Romania ☒ Poland ☒ Bulgaria ☒ Czech Republic ☒ Russian Federation ☒ Greece ☒ Ukraine ☒ Hungary ☒ France		   Please select a graphic type to complete the process
☐ Select all		☒ Select all			

Figure 2.3 ISPAT data input page (ISPAT, 2013)

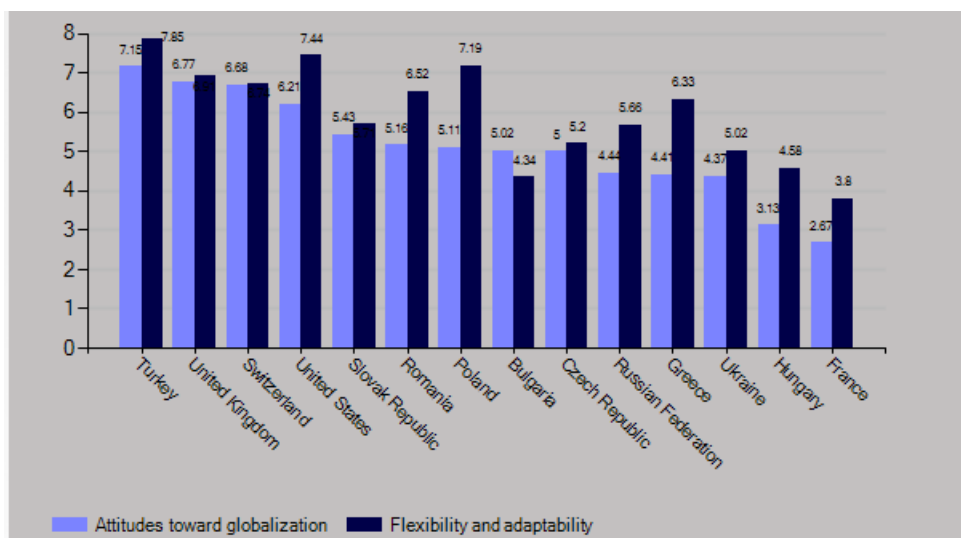


Figure 2.4 ISPAT output page (ISPAT, 2013)

2.3 Literature Review About DEMATEL and ANP Combined (Hybrid) Method

Most of the decision-making methods assume independence between the criteria/variables but this is not the case in real world problems and ANP is not limited by independent assumptions while the DEMATEL method is used to detect complex relationships and build the IRM of relations among criteria.

Yang et al. (2008) propose a novel hybrid MCDM model combined with DEMATEL and ANP to solve the dependence and feedback problems to suit the real world, because in multiple criteria decision making (MCDM) methods, the analytic network process (ANP) is used to overcome the problems of interdependence and feedback between criteria or alternatives. The ANP method currently deals with normalization in the supermatrix by assuming each cluster has equal weight. Although the method to normalize the supermatrix is easy, it ignores the different effects among clusters.

After giving an example to illustrate the proposed method, Yang et al. (2008) conclude that the combined ANP-DEMATEL method is more suitable in real world applications than the traditional ones.

Wu (2008) uses DEMATEL and ANP together for selecting a favorable knowledge management strategy. The author points out that ANP can deal with all kinds of interactions systematically and the DEMATEL not only can convert the relations between cause and effect of criteria into a visual structural model, but also can be used as a way to handle the inner dependences within a set of criteria.

For decision making about the personnel selection, Aksakal & Dagdeviren (2010) propose an algorithm by combined DEMATEL and ANP where criteria dependence values are calculated using the DEMATEL and the solution of the integrated approach is handled by the ANP method.

Yang & Tzeng (2011) state that as most importance-assessing methods used to demonstrate the importance among criteria by preference weightings are based on the

assumptions of additivity and independence but using such an additive model is not always feasible because of the dependence and feedback among the criteria. To solve this issue ANP is proposed by Saaty. However in ANP procedures, using average method (equal cluster-weighted) to obtain the weighted supermatrix seems to be irrational because there are different degrees of influence among the criteria. Due to the reasons above, Yang & Tzeng (2011) propose a MCDM technique combined with DEMATEL and cluster-weighted ANP method.

While Lu & Lin (2010) investigate strategic drivers for green innovation by the application of DEMATEL and ANP, Shahraki & Paghaleh (2011) rank the voice of customer using fuzzy DEMATEL and fuzzy ANP.

The purpose of the research by Vujanovic et al. (2012) is evaluation of vehicle fleet maintenance management indicators by application of DEMATEL and ANP. For determination of levels and intensities of interdependence as well as relative weight of selected indicators, DEMATEL and ANP methods have been combined.

DEMATEL is also used combined with some other MCDM techniques such as VIKOR, TOPSIS and Goal Programming besides ANP. Also the fuzzy DEMATEL is used with some other fuzzy MCDM techniques. One of the latest studies is on integrating fuzzy DEMATEL and fuzzy hierarchical TOPSIS methods for truck selection by Baykasoglu et al. (2013)

CHAPTER THREE

METHODOLOGY

A schematic representation of the research methodology is given in Figure 3.1. Firstly, the criteria used for evaluation in rating a country are determined. All criteria used are examined under six different clusters, namely Technical (T), Economical (E), Market Promotion (M), Political (P), Operational (O) and Social (S). The initials of the clusters, i.e. TEMPOS are used as acronyms for the developed program name. The first step involves the determination of the criteria in each cluster. Some of the criteria are the objective characteristics of the countries such as population, land area, inflation rate, gross domestic product (GDP) and for each particular country defined in the list of ISO 3166 (Appendix B) , the data and the scores for these criteria are installed into the system in advance. The remaining criteria are subjective characteristics of the countries such as language barrier, quality of materials, currency risk, delay in payments whose importance varies from user to user and the user can assign a score on a Likert scale between 1 and 5, in evaluating these criteria. Rating a criterion with a score of 1 means that the country with respect to the criterion is not attractive according to the opinion of program user while a score of 5 means that the country is very attractive according to the opinion of program user with respect to the criterion. For example if an international contractor prefers to work in a politically corrupt country, he is expected to rate New Zealand with the lowest rate 1, because New Zealand is supposed to be the cleanest country in the world, according to the World Bank. On the other hand if another program user prefers to work in non-corrupt country then the input score for the same country will be 5. If the criterion under consideration is not relevant to the user, the user has the option of leaving the score cell blank, in this case the criterion is not considered in the calculations.

Through Microsoft Excel spreadsheets, the integrated Decision Making Trial and Evaluation Laboratory (DEMATEL) and Analytic Network Process (ANP) approach is implemented and the weight of each cluster is determined. Finally, the program

user's subjective evaluation and the given country characteristics, the score of each country is determined.

The criteria determination process, the spreadsheet implementation and the details of the DEMATEL and ANP approaches are explained in the next subsections.

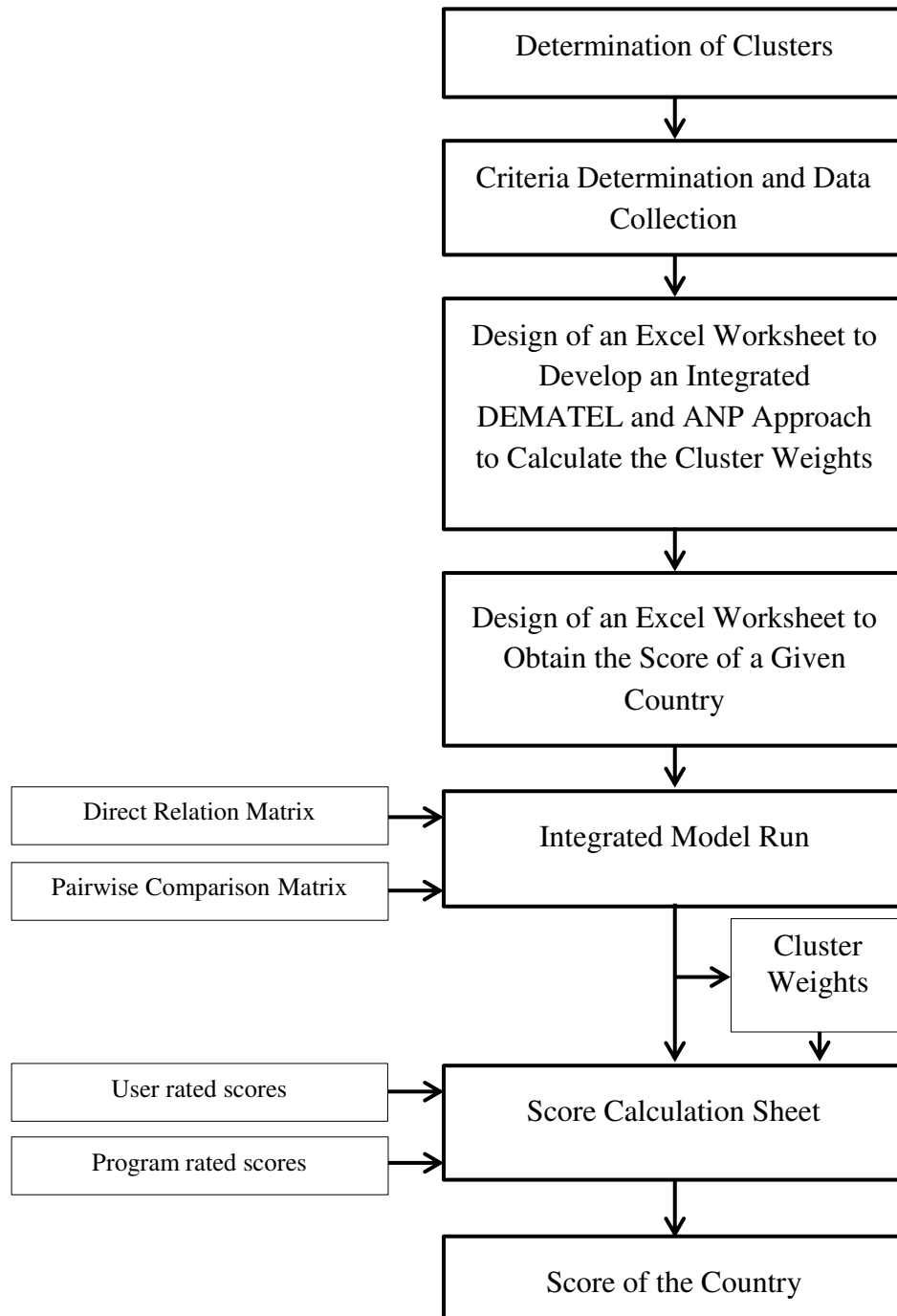


Figure 3.1 Schematic representation of research methodology

3.1 Criteria determination and data collection

In developing the Excel based model, three types of evaluation criteria are considered. Two of them are the program defined criteria which are mandatory to be included in the decision process. Program defined criteria can be divided into two categories: (1) Program Rated (PR) Criteria; (2) User Rated (UR) Criteria. The program rated criteria which include the objective characteristics of the country (given country related information) to be evaluated and the data for these criteria are mainly collected from the reports of the well-known authorities and establishments such as CIA (2013) The World Factbook, OECD (2013), The PRS Group (2013), The World Bank (2012), IFC(2013), TI (2013), WEF (2012).

The program defined program rated criteria (PDPR) are the objective criteria which are not affected from the evaluator's views, whereas the program defined user rated criteria (PDUR) are subjective which depend on the decision maker's judgment.

The third type of criteria is called the user defined user rated (UDUR) criteria which are the optional criteria defined by the program user himself which may include the subjective and/or the objective criteria. These criteria are not installed into the database of the system in advance, therefore are not given in the criteria list to the program user however they may be the criteria necessary from the decision maker's point of view relevant to his business and these criteria are entered into the system by the user. For example, the existence of direct flights from the homeland of the contractor to the destination country may be a very important criterion for the contractor and he can include this criterion in the evaluation process. It is possible to include any criterion that is not listed in the program database.

In total, 481 criteria are collected from 14 different sources (see Appendix A) where 231 are the objective criteria rated by the source documents while the remaining 250 are the subjective criteria which can be rated differently according to the opinion of the program user. After scanning the criteria list 184 duplicates were removed and the remaining 297 criteria on a questionnaire survey form were sent by

e-mails to 188 Turkish construction executives and construction practitioners operating in international markets for more than 10 years. The respondents were asked to check off the criteria from the list provided, which they believe are important based on their previous experience. 21 responses were received. Table 3.1 shows the total number of criteria in each cluster before and after the experts' evaluation.

Table 3.1 Number of criteria within each cluster

Type of Criteria	Number of Criteria sent through questionnaires		Number of criteria included in the model		
	PDPR	PDUR	PDPR	PDUR	UDUR
T: Technical	13	29	9	7	2
E: Economic & Financial	26	35	9	7	2
M: Market Promoting	26	18	9	7	2
P: Political	21	33	9	7	2
O: Operational	17	35	9	7	2
S: Social & Cultural	17	27	9	7	2
TOTAL	120	177	54	42	12

Appendix C contains the list of criteria submitted to the experts and how many times each criterion is checked off. After the experts' criteria evaluation through questionnaires, the 9 most rated objective criteria and the 7 most rated subjective criteria within each cluster are considered to be included in the program developed. Additionally, the developed program makes the entrance of two new criteria possible so that based on his preferences, the user can define maximum two criteria under each cluster. Therefore, each cluster in the program consists of 16 program defined criteria and two optional criteria which are not stored in the program database in advance, defined as UDUR criteria.

3.2 Combined DEMATEL and ANP approach

In this study, an integrated model is developed based on two different methods, namely, Decision Making Trial and Evaluation Laboratory (DEMATEL) and Analytic Network Process (ANP). First of all, in order to measure the degree of consistency among the pairwise judgments of the decision maker, consistency control is applied. Then, through combined use of DEMATEL and ANP methods, cluster weights are obtained.

Determining the score of a country for an international contractor under different complex criteria is a multi-criteria decision making problem and a robust solution should consider the interactions among criteria. Classical multi-criteria decision making methods such as AHP ignore the dependence among criteria. The analytic network process (ANP) proposed by Saaty (1996) can handle the interdependencies among the criteria in a systematic way. However, the Decision Making Trial and Evaluation Laboratory (DEMATEL) not only can convert the relations between cause and effect of criteria into a structural model, but also can be used as a way to handle the inner dependences within a set of criteria (Tseng, 2009). Therefore, in this study the proposed tool incorporates a combined use of DEMATEL and ANP methods. The details about the methods used are explained in the next subsections.

3.2.1 Consistency Control

As explained before, in this study, consistency is controlled to check whether the pairwise judgments of program user is consistent or not. Since achieving full consistency is hard, the notion of a deviation from consistency is introduced as in AHP. Pairwise Comparison Matrix (PCM) is constructed between clusters. While using pairwise comparisons the relative importance of one criterion over another can be expressed using a scale from 1 to 5. The figures mean 1 equal, 2 moderate, 3 strong, 4 very strong, 5 extreme. Then the consistency of PCM is checked to determine whether the preferences of program user are consistent or not. If preferences are inconsistent then program user is instructed to restructure the PCM.

The steps of the consistency control are given below:

- a) PCM is normalized, by making the sum of each column equal to unity.
- b) According to the preference of program user, geometric mean or arithmetic mean of each row is calculated.
- c) The normalized (for geometric mean renormalization may be necessary) mean of each row is defined as Eigen Vector (W).
- d) Vector “D” is obtained by multiplying (PCM) by (W).
- e) Vector “E” is obtained by dividing vector “D” by vector “E”.
- f) Maximum Eigen value ($\lambda_{\max}$) is calculated as maximum component of vector “E”.
- g) Consistency Index, $CI=(\lambda_{\max}-N)/(N-1)$, where “N” is number of components of vector “E” is calculated.
- h) Consistency Ratio $CR=CI/RI$ is obtained. Randomness Index as a function of N is given below (Saaty, 1980).

Table 3.2 Randomness index depending on number of elements

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14
RI	0.00	.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.54	1.56	1.57

If $CR > 0.10$ then spreadsheet notifies the user to restructure the PCM and program does not run until PCM becomes consistent.

3.2.2 Decision Making Trial and Evaluation Laboratory (DEMATEL)

Decision-making trial and evaluation laboratory method was originally developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva (Gabus and Fontela 1973; Fontela and Gabus 1976). As stated by Yang et al. (2008), although ANP is used to deal with problems which have dependent criteria, the DEMATEL method is used to detect complex relationships and build the IRM (impact-relation map) of relations among criteria.

The steps of DEMATEL can be summarized as follows:

Step 1: Calculate the initial average matrix (Direct Relation Matrix). In this step, respondents are asked to indicate the degree of direct influence each factor (element) i exerts on each factor/element j , which is denoted by a_{ij} . The scales 0, 1, 2, 3 and 4 represent the range from “no influence”, “low influence”, “medium influence”, “high influence” to “very high influence”, respectively. The direct relation matrix A is shown below:

$$A = \begin{bmatrix} a_{11} & \dots & a_{1j} & \dots & a_{1n} \\ \vdots & & \vdots & & \vdots \\ a_{i1} & \dots & a_{ij} & \dots & a_{in} \\ \vdots & & \vdots & & \vdots \\ a_{n1} & \dots & a_{nj} & \dots & a_{nn} \end{bmatrix} \quad (1)$$

Step 2: Calculate the normalized initial direct relation matrix. The normalized initial direct relation matrix X can be obtained by normalizing the direct relation matrix A by s through Eqs. (2) and (3), in which all principal diagonal elements are equal to zero.

$$X = s \times A \quad (2)$$

$$s = \min \left[\frac{1}{\max_i \sum_{j=1}^n |a_{ij}|}, \frac{1}{\max_j \sum_{i=1}^n |a_{ij}|} \right] \quad (3)$$

Step 3: Derive the total influence matrix (total relation matrix). The total relation matrix T can be obtained using Eq. (4), where I is the identity matrix.

$$T = X(I - X)^{-1} \quad (4)$$

where $T=[t_{ij}]_{n \times n}$, for $i,j=1,2,\dots,n$. Let D and R to be $n \times 1$ and $1 \times n$ vectors representing the sum of rows and sum of columns of matrix T , respectively.

$$D = [D_i]_{n \times 1} = \left[\sum_{j=1}^n t_{ij} \right]_{n \times 1} \quad (5)$$

$$R = [R_j]_{1 \times n} = \left[\sum_{i=1}^n t_{ij} \right]_{1 \times n}' \quad (6)$$

Let D_i be the sum of i -th row in matrix T . Then D_i shows the total effects, both direct and indirect, that factor i has on the other factors. Let R_j denotes the sum of j -th column in matrix T . Then D_i shows the total effects, both direct and indirect, received by factor j from the other factors. When $j = i$, the sum $(D_i + R_i)$ gives an index representing the total effects both given and received by factor i . In other words, $(D_i + R_i)$ shows the degree of importance (total sum of effects given and received) that factor i plays in the system. In addition, the difference $(D_i - R_i)$ shows the net effect that factor i contributes to the system. When $(D_i - R_i)$ is positive, factor i is a net causer, i.e. factor i is affecting other factors, and when $(D_i - R_i)$ is negative, factor i is a net receiver, i.e. factor i is being influenced by other factors (Tzeng et al. 2007; Tamura et al., 2002).

Step 4: Set a threshold value and obtain the impact-relations map (*IRM*).

In order to keep the complexity of the IRM at a reasonable level, the decision-maker sets a threshold value α and some minor effects in matrix T are filtered. In other words, by this way only the effects greater than the threshold value would be chosen and shown in the IRM (Tzeng et al. 2007).

After comparing the elements of matrix T with the value of α , the elements of T whose values are less than α are assigned a value of zero, to yield a new matrix called α -cut total influence matrix T_α .

3.2.3 Analytic Network Process (ANP)

The analytic hierarchy process (AHP) proposed by Saaty (1980) has been widely used in multiple criteria decision making (MCDM) to evaluate alternatives since many years. AHP assumes that the criteria involved in a decision process are independent. However, this is not a valid assumption for most of the real-world applications. To solve this problem, Saaty (1996) proposed analytical network process (ANP) to overcome the problems of interdependence. ANP is not a completely new concept but an improvement of AHP, in other words, the general form of AHP. ANP handles dependence within a cluster and among different clusters and releases the restriction of hierarchical structure. The method can be summarized as follows.

Step 5: Compare the criteria in the whole system to form an unweighted supermatrix.

This is performed through pairwise comparisons between any two criteria to evaluate the importance/influence of a criterion compared to another criterion with respect to the interests or preferences of the decision maker. The relative importance value can be determined using a scale of 1–5 to represent equal importance to extreme importance (Saaty, 1980, 1996)

The general form of the supermatrix is given as follows:

$$W = \begin{matrix} & \begin{matrix} C_1 & \dots & C_j & \dots & C_n \\ e_{11} \dots e_{1m_1} & \dots & e_{j1} \dots e_{jm_j} & \dots & e_{n1} \dots e_{nm_n} \end{matrix} \\ \begin{matrix} C_1 \\ \vdots \\ C_i \\ \vdots \\ C_n \end{matrix} & \begin{bmatrix} W_{11} & \dots & W_{1j} & \dots & W_{1n} \\ \vdots & & \vdots & & \vdots \\ W_{i1} & \dots & W_{ij} & \dots & W_{in} \\ \vdots & & \vdots & & \vdots \\ W_{n1} & \dots & W_{nj} & \dots & W_{nn} \end{bmatrix} \end{matrix} \quad (7)$$

Where C_n denotes the n th cluster, e_{nm} denotes the m th criterion in the n th cluster, and W_{ij} is the principal eigenvector of the influence of the criteria in the j th cluster compared to the i th cluster. In addition, if the j th cluster has no influence on the i th cluster, then $W_{ij} = [0]$ (Yang and Tzeng, 2011).

Step 6: Obtain the weighted supermatrix W_w , by multiplying the unweighted supermatrix W by the normalized α -cut total influence matrix, T_s .

$$T_\alpha = \begin{bmatrix} t_{11}^\alpha & \dots & t_{1j}^\alpha & \dots & t_{1n}^\alpha \\ \vdots & & \vdots & & \vdots \\ t_{i1}^\alpha & \dots & t_{ij}^\alpha & \dots & t_{in}^\alpha \\ \vdots & & \vdots & & \vdots \\ t_{n1}^\alpha & \dots & t_{nj}^\alpha & \dots & t_{nn}^\alpha \end{bmatrix} \quad (8)$$

The α -cut total influence matrix T_α given in (8) is normalized by dividing its elements in row i by $d_i = \sum_{j=1}^n t_{ij}^\alpha$ and the normalized α -cut total influence matrix T_s is obtained.

The weighted supermatrix W_w is obtained by the following equation.

$$W_w = T_s \times W \quad (9)$$

$$T_s = \begin{bmatrix} t_{11}^s & \dots & t_{1j}^s & \dots & t_{1n}^s \\ \vdots & & \vdots & & \vdots \\ t_{i1}^s & \dots & t_{ij}^s & \dots & t_{in}^s \\ \vdots & & \vdots & & \vdots \\ t_{n1}^s & \dots & t_{nj}^s & \dots & t_{nn}^s \end{bmatrix} \quad (10)$$

$$W_w = \begin{bmatrix} t_{11}^s \times W_{11} & \dots & t_{1j}^s \times W_{12} & \dots & t_{1n}^s \times W_{1n} \\ \vdots & & \vdots & & \vdots \\ t_{i1}^s \times W_{i1} & \dots & t_{ij}^s \times W_{ij} & \dots & t_{in}^s \times W_{in} \\ \vdots & & \vdots & & \vdots \\ t_{n1}^s \times W_{n1} & \dots & t_{nj}^s \times W_{nj} & \dots & t_{nn}^s \times W_{nn} \end{bmatrix} \quad (11)$$

Step 7: Limit the weighted supermatrix by raising it to a sufficiently large power k ,

$$\lim_{k \rightarrow \infty} (W_w)^k \quad (12)$$

The weighted supermatrix W_w is multiplied by itself multiple times to obtain the limiting supermatrix (limiting weighted supermatrix) to obtain the ANP weights.

3.3 Spreadsheet Implementation

The developed decision support system is intended to be used by international contractors who are planning to undertake various projects in various countries. Therefore, it is important to have an effective and user friendly interface that can assist any contractor whose abilities and background are different from each other.

The users do not need to have any knowledge about the multi-criteria decision methods such as ANP, DEMATEL used in the system.

The developed program that will be used in rating the countries for international contractors is named as “TEMPOS” consisting of first letters of the cluster names, i.e. Technical (T), Economical (E), Market Promotion (M), Political (P), Operational (O) and Social (S). Through MS Excel spreadsheets the combined DEMATEL & ANP approach is implemented.

TEMPOS workbook is composed of 6 worksheets. The names and functions of each worksheet are described in the Table 3.3. As can be seen in the below table, the user interface has been designed in Microsoft Excel as two separate sheets. In the sheet named as the “Input-Output”, the user fills in the cells of the pairwise comparison matrix (PCM) and the direct relation matrix (DRM), the data entry field for geometric or arithmetic mean, threshold value (α) are also filled in by the program user. Consistency ratio, DEMATEL and ANP calculations are performed automatically hidden from the user and the cluster weights and the causal diagram are displayed.

In the “Score Calculation” sheet, the user chooses the country name from the dropdown country list and the user is asked to give scores to the criteria provided in the list and the user is allowed to add maximum two more criteria under each cluster in the space provided for which the scores should also be entered into the system.

Additionally, this sheet contains the criteria which are rated by the program itself. When all the required fields are filled in, the score of the country under evaluation is

displayed on the screen. The highest score can be achieved is hypothetically 5.00. The details about the design of the user interface are explained in the next sections.

Table 3.3 Worksheets of the TEMPOS workbook

<i>Worksheet Name</i>	<i>Content and function of worksheet</i>	<i>Remarks</i>
<i>“Read Me”</i>	Some basic information, to make the user familiar with the developed program, can be written in this sheet.	Hidden. Does not function.
<i>“DEMATEL-ANP”</i>	All calculations necessary for consistency control, DEMATEL and ANP implementations are executed in this worksheet.	Hidden.
<i>“Codes & Criteria”</i>	This worksheet contains i. Names and ISO alpha-3 codes of 247 countries, ii. Names of 96 criteria, iii. Data for PDPR criteria provided from various sources iv. Calculation of scores for each country for each PDPR criteria using the data provided.	Hidden.
<i>“Calc”</i>	Some minor calculations, data for graphs and some information such as expiry date of the program, randomness index depending on number of clusters, are stored in this page.	Hidden.
<i>“Input-Output”</i>	Functions as user interface. PCM, DRM, arithmetic or geometric mean preference and threshold value (α) are the inputs entered into this worksheet. Then, CR, the graph showing the weight of clusters and casual diagram are displayed on this worksheet as outputs.	Visible.
<i>“Score Calculation”</i>	Functions as user interface. Country name to be evaluated and UR criteria scores are entered into this worksheet as inputs. Automatically calculated scores of PR criteria (obtained from the “Codes & Criteria” sheet), the scores and weights of each cluster and the country score are the outputs obtained from this worksheet.	Visible.

3.3.1 Calculating the Weight of Each Cluster

After the consistency control, MS Excel sheets are structured to run DEMATEL-ANP hybrid method to calculate the weights of clusters. Framework of the program is outlined in the Figure 3.2.

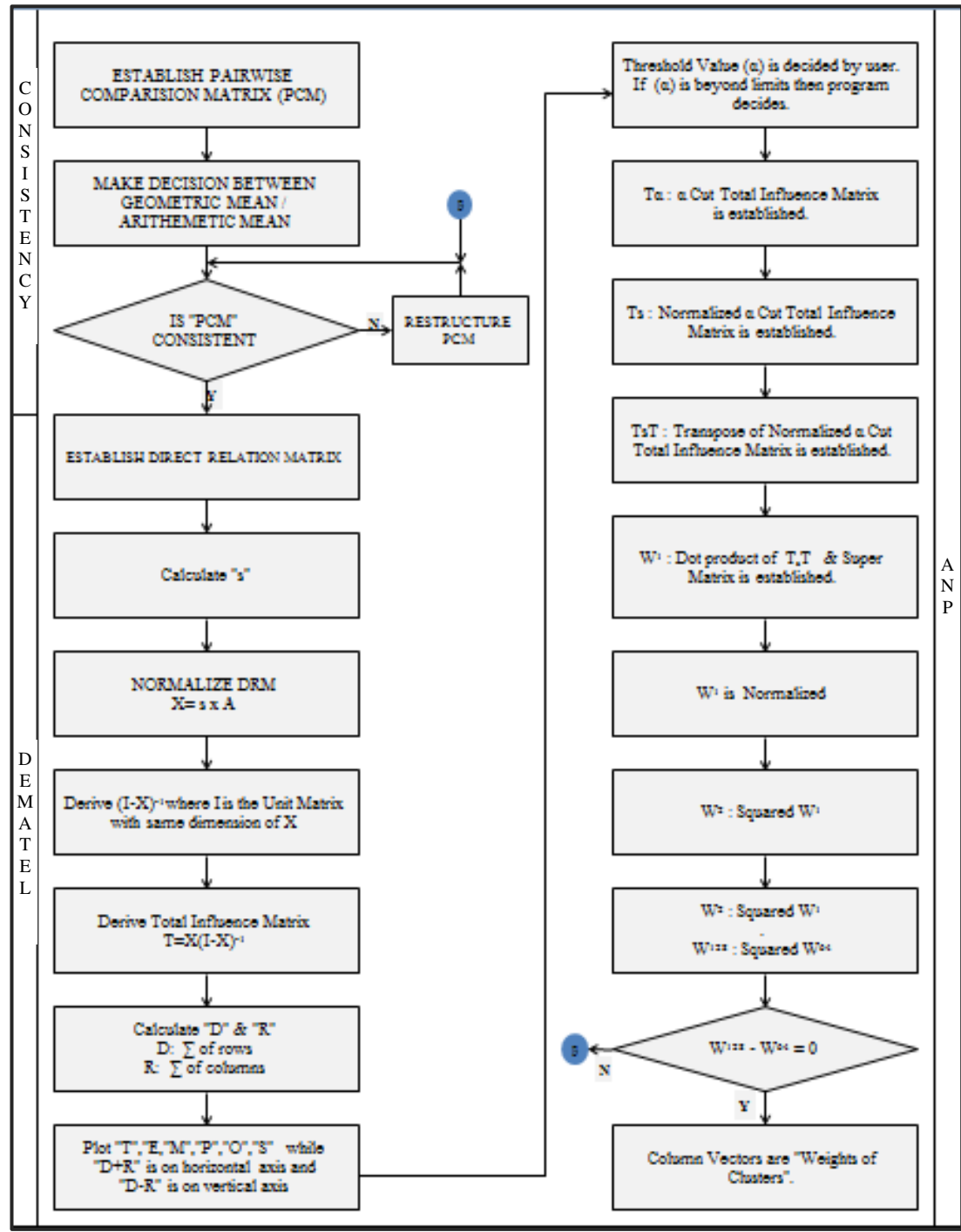


Figure 3.2 Framework of the program

3.3.1.1 Establishing a Pairwise Comparison Matrix

The first step is establishing the Pairwise Comparison Matrix (PCM) by a program user in the input-output sheet. PCM is a 6x6 matrix, where the diagonal is composed of ones. Program allows data entrance to gray cells only. If program user attempts to enter a value beyond the limits, program notifies the user.

The CLR (clear) button generated which is shown above the pairwise comparison matrix, runs a macro to prepare an empty PCM. The diagonal cells are filled in automatically by ones. Remaining empty gray cells need to be filled by program user. Attempt to fill any other cell will be rejected by the program.

For pairwise comparisons, maximum allowed score for gray cells is 5 while the minimum is 1/5. The values represent the relative importance of one cluster over another one. Program does not accept any value other than 5, 4, 3, 2, 1, 1/2, 1/3, 1/4, 1/5. Attempting to input an unacceptable value will result with the notification in Figure 3.3.

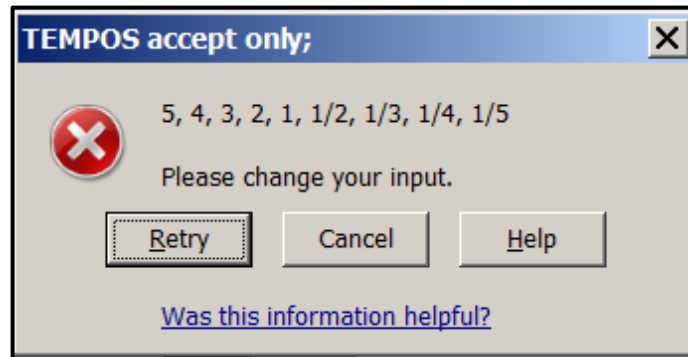


Figure 3.3 Unacceptable value notification

The used scores scale is as follows.

<u>Score</u>	<u>Represents</u>
1	Equal
2	Moderate
3	Strong
4	Very strong
5	Extreme

Light blue cells are calculated and filled automatically by the program as soon as the scores for the gray cells are entered. After the data entrance is completed, PCM turns into the following example matrix as in Figure 3.4.

1	Establish "Pairwise Comparison Matrix" (Scores between 1/5 to 5)						CLR	
	T	E	M	P	O	S		
T	1	4	5	5	1	3		
E	1/4	1	2	3	1	3		
M	1/5	1/2	1	1/2	1/3	2		
P	1/5	1/3	2	1	1/4	2		
O	1	1	3	4	1	4		
S	1/3	1/3	1/2	1/2	1/4	1		
2	Insert "A" for Arithmetic Mean or "G" for Geometric Mean						➡	G

Figure 3.4 Pairwise Comparison Matrix (PCM)

3.3.1.2 Arithmetic Mean or Geometric Mean Selection

To calculate the Consistency Ratio (CR) the program needs to be structured either to use arithmetic mean or geometric mean. Program user types "A" for arithmetic mean or "G" for geometric mean.

3.3.1.3 Consistency Control

The procedure for the calculation of CR is carried out in the worksheet named as *DEMATEL-ANP* as explained below for the example problem given in Figure 3.5.

- a) The sum of the values in each column of the *PCM* is obtained and each element in each column is divided by the corresponding column sums, to yield a normalized *PCM* (Figure 3.5).

D10		fx		=SUM(D4:D9)			
	C	D	E	F	G	H	I
3		T	E	M	P	O	S
4	T	1.000	4.000	5.000	5.000	1.000	3.000
5	E	0.250	1.000	2.000	3.000	1.000	3.000
6	M	0.200	0.500	1.000	0.500	0.333	2.000
7	P	0.200	0.333	2.000	1.000	0.250	2.000
8	O	1.000	1.000	3.000	4.000	1.000	4.000
9	S	0.333	0.333	0.500	0.500	0.250	1.000
10	Σ	2.983	7.166	13.500	14.000	3.833	15.000

Figure 3.5 Normalized PCM

- b) Figure 3.6 is, Eigen Vector W , obtained by calculating geometric or arithmetic mean of each row of the normalized PCM .

J14 f_x =GEOMEAN(D14:I14)										
	C	D	E	F	G	H	I	J	K	L
12	2	Normalized "PCM" = "PCM _n "						Geometric Mean	Aritmetic Mean	
13		T	E	M	P	O	S	Eigen Vector (W)		
14	T	0.335	0.558	0.370	0.357	0.261	0.200	0.339	0.349	0.347
15	E	0.084	0.140	0.148	0.214	0.261	0.200	0.164	0.173	0.174
16	M	0.067	0.070	0.074	0.036	0.087	0.133	0.072	0.076	0.078
17	P	0.067	0.046	0.148	0.071	0.065	0.133	0.081	0.086	0.089
18	O	0.335	0.140	0.222	0.286	0.261	0.267	0.243	0.257	0.252
19	S	0.112	0.046	0.037	0.036	0.065	0.067	0.056	0.059	0.060
20	Σ	1.000	1.000	1.000	1.000	1.000	1.000	0.946	1.000	1.000

Figure 3.6 Eigen Vector

- c) Figure 3.7 displays Vector "D" which is obtained by the multiplication of "PCM" and "W".

L23 f_x =MMULT(C23:H23;J\$23:J\$28)										
	C	D	E	F	G	H	I	J	K	L
22	"PCM"							Eigen V. (W)		D
23	1.000	4.000	5.000	5.000	1.000	3.000		0.349		2.286
24	0.250	1.000	2.000	3.000	1.000	3.000		0.173		1.104
25	0.200	0.500	1.000	0.500	0.333	2.000		0.076		0.479
26	0.200	0.333	2.000	1.000	0.250	2.000		0.086		0.548
27	1.000	1.000	3.000	4.000	1.000	4.000		0.257		1.587
28	0.333	0.333	0.500	0.500	0.250	1.000		0.059		0.378
29								1.000		6.383

Figure 3.7 Vector "D"

- d) Figure 3.8 displays vector "E", obtained by dividing "D" by "W".

H42 f_x =VLOOKUP(H40;RandomnessIndex;2)													
	A	B	C	D	E	F	G	H	I	J	K	L	M
31				D		Eigen V. (W)		E					
32				2.286		0.349		6.5562					
33				1.104		0.173		6.3761					
34				0.479		0.076		6.2653					
35				0.548		0.086		6.3872					
36				1.587		0.257		6.1760					
37				0.378		0.059		6.4232					
38	C												
39													
40													
41													
42													
43													

λ_{max}	6.5562
N	6.0000
CI: Consistency Index	0.1112
RI: Randomness Index	1.2400
CR=CI/RI: Consistency Ratio	0.0897

G for Geometric Mean
A for Arithmetic Mean
G

<.1	DIRECT RELATION MATRIX IS CONSISTENT
-----	--------------------------------------

Figure 3.8 Vector "E"

Screen is displayed as in Figure 3.9 or Figure 3.10 according to the value of CR.

e) If *PCM* is consistent ($CR < 0.1$) then the screen below appears,

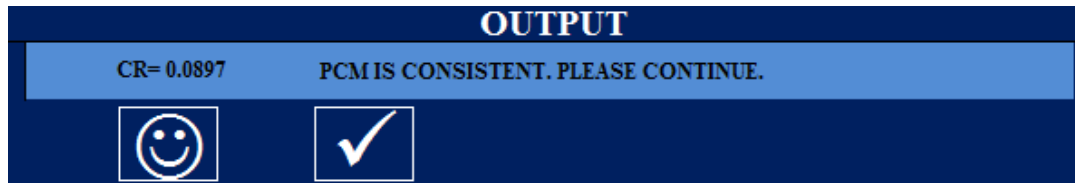


Figure 3.9 CR value and notice if PCM is consistent

Otherwise the screen notifies program user, to restructure PCM, as below.

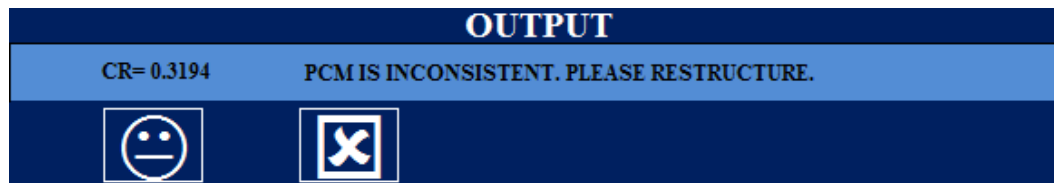


Figure 3.10 CR value and notice if PCM is inconsistent

3.3.1.4 Establishing Direct Relation Matrix (DRM)

Next step, after achieving a consistent PCM, Direct Relation Matrix (DRM) needs to be filled in by program user in the input-output sheet. DRM is also a 6x6 matrix, where the diagonal is filled automatically by zero values as seen below.

The clear button above the DRM also runs a macro to prepare an empty DRM. The diagonal cells are filled in automatically by zeros. Remaining empty gray cells need to be filled in by program user using an integer score between “0” and “4”. In this scale 0 means no influence, 1 low influence, 2 medium influence, 3 high influence and 4 represents very high influence. An empty DRM is shown in Figure 3.11.

Step 3: Direct Relation Matrix (DRM)

Scores range between
0.0 for "NO INFLUENCE" and
4.0 "VERY HIGH INFLUENCE"

CLR

	T	E	M	P	O	S
T						
E						
M						
P						
O						
S						

3

Input "THRESHOLD VALUE α "

↑

0.30

Figure 3.11 An empty Direct Relation Matrix (DRM)

The values in each cell represent the influence of the cluster listed on the column over the cluster listed on the row, in Figure 3.12.

Step 3: Direct Relation Matrix (DRM)

Scores range between
0.0 for "NO INFLUENCE" and
4.0 "VERY HIGH INFLUENCE"

CLR

	T	E	M	P	O	S
T	0	3	3	1	4	1
E	3	0	4	4	2	1
M	0	2	0	2	1	2
P	1	3	3	0	1	3
O	3	2	0	0	0	0
S	0	4	1	3	1	0

3

Input "THRESHOLD VALUE α "
 between 0.00 - 0.34

→

0.30

Figure 3.12 DRM with an acceptable α

A threshold value " α " is entered into the system by program user. Program informs the user about the limits of " α ". If " α " is beyond the limits then, program determines an applicable, the highest acceptable value as the threshold value and notifies the program user, as in the Figure 3.13.

Step 3: Direct Relation Matrix (DRM)
Scores range between
0.0 for "NO INFLUENCE" and
4.0 "VERY HIGH INFLUENCE" CLR

	T	E	M	P	O	S
T	0	3	3	1	4	1
E	3	0	4	4	2	1
M	0	2	0	2	1	2
P	1	3	3	0	1	3
O	3	2	0	0	0	0
S	0	4	1	3	1	0

3

Input "THRESHOLD VALUE α "
between 0.00 - 0.34

0.90

Calculations will base on an acceptable
"THRESHOLD VALUE α "

0.34

Figure 3.13 Notice of unacceptable α

3.3.1.5 Application of DEMATEL

After achieving a consistent PCM, spreadsheet runs the DEMATEL portion of the program using the "DEMATEL-ANP" sheet.

- a. Firstly, the value of "s" is obtained using Eq. (3) as shown in Figure 3.14.

K54			fx			=1/MAX(J47:J52;D53:I53)					
	A	B	C	D	E	F	G	H	I	J	K
	D E M A T E L	3	Direct Relation Matrix (DRM) = A (Direct Relation Matrix is obtained according to the considerations of the client. Scores range between 0.0 for "NO INFLUENCE" and 4.0 "VERY HIGH INFLUENCE").								
45			T	E	M	P	O	S	Σ		
46			0	3	3	1	4	1	12		
47			3	0	4	4	2	1	14		
48			0	2	0	2	1	2	7		
49			1	3	3	0	1	3	11		
50			3	2	0	0	0	0	5		
51			0	4	1	3	1	0	9		
52			Σ	7	14	11	10	9	7		
53											s= 0.0714
54											

Figure 3.14 Calculation of "s"

- b. Second step is obtaining the normalized DRM, X using Eq.(2), as shown on Figure 3.15.

D63		f_x		=D52*\$K\$54					
A	B	C	D	E	F	G	H	I	
55	D	Derivation of full direct/indirect influence matrix.							
56	E	S	NORMALIZED DIRECT RELATION MATRIX: $X = s \times A$						
57	M		T	E	M	P	O	S	
58	A		T	0.00	0.21	0.21	0.07	0.29	0.07
59	T		E	0.21	0.00	0.29	0.29	0.14	0.07
60	T		M	0.00	0.14	0.00	0.14	0.07	0.14
61	E		P	0.07	0.21	0.21	0.00	0.07	0.21
62	L		O	0.21	0.14	0.00	0.00	0.00	0.00
63		S	0.00	0.29	0.07	0.21	0.07	0.00	

Figure 3.15 Normalized Direct Relation Matrix (X)

- c. Following step is, establishing 6x6 unit matrix (I), Figure 3.16.

D68			f_x	1					
	A	B	C	D	E	F	G	H	I
65	D	Derivation of full direct/indirect influence matrix.							
66	E	6	I						
67	M		T	E	M	P	O	S	
68	A		T	1	0	0	0	0	
69	T		E	0	1	0	0	0	
70	T		M	0	0	1	0	0	
71	E		P	0	0	0	1	0	
72	L		O	0	0	0	0	1	
73		S	0	0	0	0	0	1	

Figure 3.16 6x6 Unit matrix (I)

- d. Fourth step, as in Figure 3.17, is composing the ($I-X$) matrix.

D77		f_x		=D68-D58					
	A	B	C	D	E	F	G	H	I
75	D	6	I - X						
76	E		T	E	M	P	O	S	
77	M		T	1.00	-0.21	-0.21	-0.07	-0.29	-0.07
78	A		E	-0.21	1.00	-0.29	-0.29	-0.14	-0.07
79	T		M	0.00	-0.14	1.00	-0.14	-0.07	-0.14
80	T		P	-0.07	-0.21	-0.21	1.00	-0.07	-0.21
81	E		O	-0.21	-0.14	0.00	0.00	1.00	0.00
82	L	S	0.00	-0.29	-0.07	-0.21	-0.07	1.00	

Figure 3.17 Matrix ($I-X$)

- e. Next step is computing the inverse, $(I-X)^{-1}$ and shown on Figure 3.18.

D86		f_x {=MINVERSE(D77:I82)}							
	A	B	C	D	E	F	G	H	I
84	D		7	$(I - X)^{-1}$					
85	E			T	E	M	P	O	S
86	M		T	1.27	0.60	0.55	0.41	0.54	0.30
87	A		E	0.47	1.52	0.70	0.65	0.48	0.38
88	T		M	0.17	0.42	1.26	0.38	0.25	0.30
89	E		P	0.30	0.62	0.57	1.37	0.34	0.44
90	L		O	0.34	0.35	0.22	0.18	1.18	0.12
91			S	0.24	0.62	0.43	0.52	0.31	1.23
92									

Figure 3. 18 Inverse of Matrix $(I-X)$

- f. Following step is the derivation of Total Influence (Total Relation) Matrix, T , using Eq.(4) and D_i , R_i , D_i+R_i , D_i-R_i values and ranking of D_i+R_i , D_i-R_i are also obtained in this sheet as illustrated in Figure 3.19.

D96		fx		=MMULT(\$D\$58:\$I\$58;D\$86:D\$91)											
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	
93				Set a Threshold value and obtain the DRM											
94	D E M A T E L	8	Total Influence Matrix: $T=X(I - X)^{-1}$						D	D+R		D-R			
95			T	E	M	P	O	S		Value	Rank	Value	Rank		
96			T	0.2737	0.6019	0.5534	0.4063	0.5399	0.3001	2.6754	4.4733	4	0.8775	1	
97			E	0.4737	0.5180	0.7017	0.6496	0.4760	0.3817	3.2006	6.3201	1	0.0811	4	
98			M	0.1692	0.4181	0.2579	0.3760	0.2464	0.3022	1.7698	4.4956	3	-0.9560	6	
99			P	0.3038	0.6155	0.5666	0.3730	0.3448	0.4408	2.6445	5.1487	2	0.1403	3	
100			O	0.3406	0.3458	0.2188	0.1799	0.1837	0.1188	1.3877	3.4904	6	-0.7150	5	
101			S	0.2369	0.6202	0.4274	0.5195	0.3120	0.2336	2.3495	4.1268	5	0.5722	2	
102		R	1.7979	3.1195	2.7258	2.5042	2.1027	1.7773							
103															
104	$\alpha=0.340$ (0.345 is the highest THRESHOLD VALUE)														

Figure 3.19 Calculating Total Influence Matrix (T), (D+R) and (D-R)

- g. α is the threshold value input by program user. But if the value of α entered is outside the defined limits then program assumes the upper limit for the value of α . The upper limit for α is, minimum of maximum of each row, while the lower limit is 0. Any value in Total Influence Matrix less than α is designated with different background and font colours and will be considered as 0 for the ANP computations. $D+R$ and $D-R$ values for each cluster are calculated and sorted in descending order as seen on Figure 3.20.

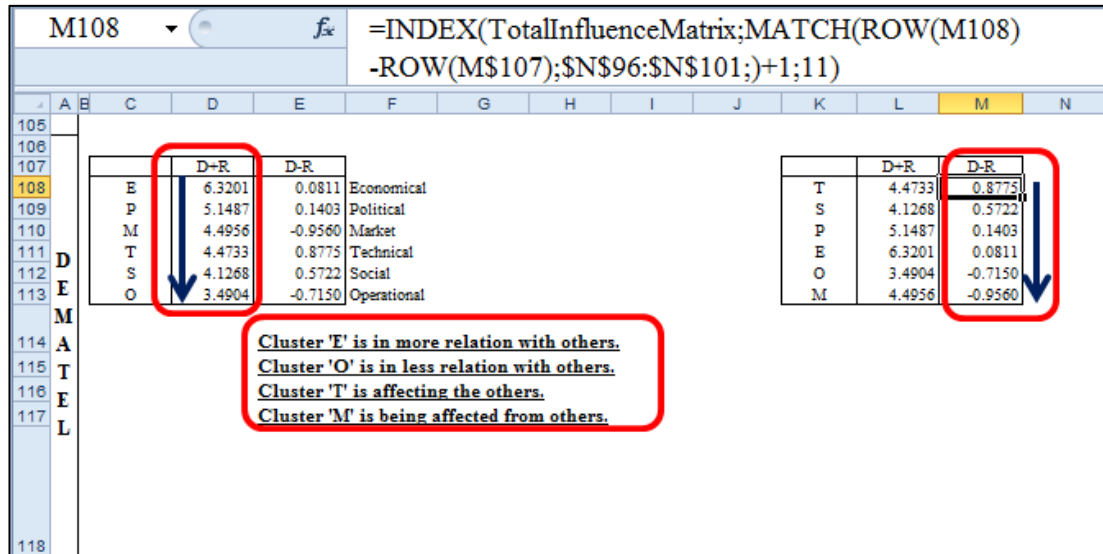


Figure 3.20 Ranking (D+R) and (D-R)

- h. Impact-Digraph-Map or Casual Diagram is also graphed where “D+R” is shown in the horizontal and “D-R” is shown in the vertical axis. Higher values of “D-R” represent the effecting clusters while the lower values represent the clusters which are being affected.
- i. Higher values of “D+R” represent the clusters which are in more relation with others while lower values of “D+R” represent the clusters that are in less relation with other clusters. As a result of these calculations hidden from the user, the impact-digraph-map is displayed on the screen as in Figure 3.21, when all the necessary fields are filled in by the program user in the “input-output” sheet.

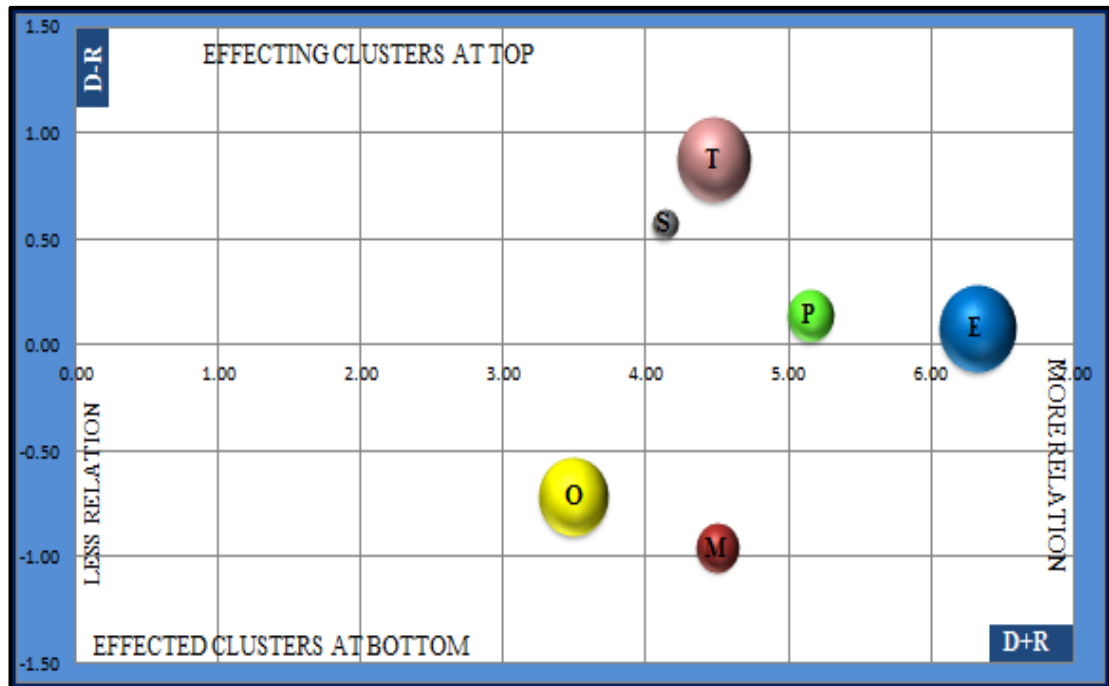


Figure 3.21 Casual Diagram or Impact-Digraph Map

3.3.1.6 Application of ANP

After the completion of DEMATEL calculations program starts executing the ANP computations through “*DEMATEL-ANP*” sheet.

- Firstly, “ α Cut Total Influence Matrix” (T_α) is obtained as below by comparing the elements of T by α as in Figure 3.22.

D121		fx		=IF(D96>\$D\$104;D96;0)						
	A	B	C	D	E	F	G	H	I	J
119	ANP		13	Ta : α Cut Total Influence Matrix						
120				T	E	M	P	O	S	sum
121		T		0.0000	0.6019	0.5534	0.4063	0.5399	0.0000	2.1016
122		E		0.4737	0.5180	0.7017	0.6496	0.4760	0.3817	3.2006
123		M		0.0000	0.4181	0.0000	0.3760	0.0000	0.0000	0.7941
124		P		0.0000	0.6155	0.5666	0.3730	0.3448	0.4408	2.3406
125		O		0.3406	0.3458	0.0000	0.0000	0.0000	0.0000	0.6864
126		S		0.0000	0.6202	0.4274	0.5195	0.0000	0.0000	1.5670

Figure 3.22 α cut Total Influence Matrix

- b. The second, Figure 3.23, step is establishing the “Normalized α -cut Total Influence Matrix” (T_s).

D130		fx		=D121/SUM(\$D121:\$I121)						
	A	B	C	D	E	F	G	H	I	J
128			14	Ts : Normalized α Cut Total Influence Matrix						
129				T	E	M	P	O	S	sum
130	A N P	T		0.0000	0.2864	0.2633	0.1933	0.2569	0.0000	1.0000
131		E		0.1480	0.1618	0.2192	0.2030	0.1487	0.1193	1.0000
132		M		0.0000	0.5265	0.0000	0.4735	0.0000	0.0000	1.0000
133		P		0.0000	0.2629	0.2421	0.1593	0.1473	0.1883	1.0000
134		O		0.4962	0.5038	0.0000	0.0000	0.0000	0.0000	1.0000
135		S		0.0000	0.3958	0.2727	0.3315	0.0000	0.0000	1.0000

Figure 3.23 Normalized α -cut Total Influence Matrix

- c. Third step, Figure 3.24, is transposing T_s , matrix. Transpose matrix is designated as (T_s^T).

D139		fx		{=TRANPOSE(\$D130:\$I130)}						
	A	B	C	D	E	F	G	H	I	J
137			15	T_s^T : Transpose of Normalized α Cut Total Influence Matrix						
138				T	E	M	P	O	S	sum
139	A N P	T		0.0000	0.1480	0.0000	0.0000	0.4962	0.0000	0.6442
140		E		0.2864	0.1618	0.5265	0.2629	0.5038	0.3958	2.1373
141		M		0.2633	0.2192	0.0000	0.2421	0.0000	0.2727	0.9974
142		P		0.1933	0.2030	0.4735	0.1593	0.0000	0.3315	1.3607
143		O		0.2569	0.1487	0.0000	0.1473	0.0000	0.0000	0.5529
144		S		0.0000	0.1193	0.0000	0.1883	0.0000	0.0000	0.3076
145				1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	

Figure 3.24 Transposing T_s

- d. Fourth step is calling the Supermatrix, input by program user, shown in Figure 3.25.

D149		fx		=D4						
	A	B	C	D	E	F	G	H	I	
147			16	Supermatrix						
148				T	E	M	P	O	S	
149	A N P	T		1.000	4.000	5.000	5.000	1.000	3.000	
150		E		0.250	1.000	2.000	3.000	1.000	3.000	
151		M		0.200	0.500	1.000	0.500	0.333	2.000	
152		P		0.200	0.333	2.000	1.000	0.250	2.000	
153		O		1.000	1.000	3.000	4.000	1.000	4.000	
154		S		0.333	0.333	0.500	0.500	0.250	1.000	

Figure 3.25 Supermatrix

- e. Figure 3.26 shows the following step is establishing the dot product of T_s^T and supermatrix. This matrix is called W^1 .

D158		fx		=D139*D149					
	A	B	C	D	E	F	G	H	I
156	A N P	17	W ¹ : Dot product of T _s ^T & Supermatrix						
157			T	E	M	P	O	S	
158			T	0.0000	0.5920	0.0000	0.0000	0.4962	0.0000
159			E	0.0716	0.1618	1.0530	0.7888	0.5038	1.1873
160			M	0.0527	0.1096	0.0000	0.1210	0.0000	0.5455
161			P	0.0387	0.0676	0.9470	0.1593	0.0000	0.6630
162			O	0.2569	0.1487	0.0000	0.5892	0.0000	0.0000
163			S	0.0000	0.0397	0.0000	0.0942	0.0000	0.0000
164			Σ	0.4198	1.1195	2.0000	1.7526	1.0000	2.3958

Figure 3.26 W^1 : dot product of T_s^T and supermatrix

- f. Sixth step shown on Figure 3.27 is normalization of W^1 .

D158		fx		=D139*D149					
	A	B	C	D	E	F	G	H	I
166	A N P	18	W ¹ (NORMALIZED)						
167			T	E	M	P	O	S	
168			T	0.0000	0.5288	0.0000	0.0000	0.4962	0.0000
169			E	0.1706	0.1446	0.5265	0.4501	0.5038	0.4956
170			M	0.1254	0.0979	0.0000	0.0691	0.0000	0.2277
171			P	0.0921	0.0604	0.4735	0.0909	0.0000	0.2768
172			O	0.6119	0.1328	0.0000	0.3362	0.0000	0.0000
173			S	0.0000	0.0355	0.0000	0.0537	0.0000	0.0000
174			Σ	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Figure 3.27 Normalized of W^1

- g. Seventh is squaring the matrix W^1 to obtain W^2 and inspecting the difference between $(W^2 - W^1)$. The goal is achieving a converging matrix, where the difference needs to be a null matrix. If any component of the difference is not equal to 0 then, the background and the font color of this cell is light and dark red otherwise light and dark gray as in Figure 3.28.

D178		fx		=MMULT(D168:I168;D168:D173)											
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
176	A N P	19	w ²							w ² - w ⁱ					
177			T	E	M	P	O	S							
178			T	0.3938	0.1424	0.2784	0.4048	0.2664	0.2621	0.38645	-0.27842	-0.40483	0.22976	-0.26206	
179			E	0.4404	0.2743	0.2892	0.3384	0.1575	0.3161	-0.12976	0.23725	0.11175	0.34635	0.17948	
180			M	0.0231	0.0927	0.0843	0.0626	0.1116	0.0676	0.00518	-0.08426	0.00648	-0.11158	0.16004	
181			P	0.0781	0.1191	0.0748	0.0830	0.0761	0.1629	-0.05873	0.39867	0.00790	-0.07612	0.11387	
182			O	0.0536	0.3631	0.2291	0.0904	0.3705	0.1589	-0.23024	-0.22912	0.24582	-0.37054	-0.15887	
183			S	0.0110	0.0084	0.0441	0.0209	0.0179	0.0325	0.02710	-0.04412	0.03288	-0.01787	-0.03245	
184		Σ	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000						

Figure 3.28 Calculation of $(W^2 - W^1)$

- h. Eighth step is again squaring the previous matrix to obtain W^4 and inspecting the difference between $(W^4 - W^2)$ as in Figure 3.29.

D188		fx		=MMULT(D178:I178;D178:D183)											
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
188			19	W^4						$W^4 - W^2$					
187				T	E	M	P	O	S						
188				T	0.2730	0.2681	0.2772	0.2882	0.2926	0.2838	-0.12572	0.00124	0.11666	-0.02620	-0.02174
189	A			E	0.3393	0.2649	0.3017	0.3381	0.2826	0.3121	0.00942	-0.01245	0.00022	-0.12510	0.00400
190	N			M	0.0635	0.0851	0.0736	0.0627	0.0775	0.0712	0.00767	0.01068	-0.00009	0.03411	-0.00353
191	P			P	0.0973	0.0896	0.0933	0.0938	0.0853	0.0941	0.02949	-0.01850	-0.01074	-0.00922	0.06882
192				O	0.2150	0.2751	0.2379	0.2032	0.2440	0.2231	0.08796	-0.00880	-0.11284	0.12650	-0.06419
193				S	0.0120	0.0172	0.0163	0.0141	0.0180	0.0158	-0.00883	0.02783	0.00678	-0.00009	0.01665
194				Σ	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000					

Figure 3.29 Calculation of $(W^4 - W^2)$

- i. Ninth step is continuing the squaring operation to obtain W^8 and inspecting the difference between $(W^8 - W^4)$ as in Figure 3.30.

D198		fx		=MMULT(D188:I188;D188:D193)											
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
198			19	W^8						$W^8 - W^4$					
197				T	E	M	P	O	S						
198				T	0.2774	0.2790	0.2781	0.2772	0.2782	0.2777	-0.01091	-0.00090	0.01101	0.01442	0.00607
199	A			E	0.2990	0.3002	0.3000	0.2998	0.3009	0.3002	-0.03530	0.00166	0.03837	-0.01836	0.01188
200	N			M	0.0745	0.0740	0.0741	0.0743	0.0738	0.0741	0.01110	-0.00054	-0.01161	0.00362	-0.00293
201	P			P	0.0915	0.0913	0.0915	0.0916	0.0915	0.0916	-0.00164	0.00187	0.00211	-0.00620	0.00251
202				O	0.2420	0.2399	0.2408	0.2417	0.2400	0.2409	0.03517	-0.00283	-0.03847	0.00406	-0.01783
203				S	0.0156	0.0156	0.0156	0.0155	0.0155	0.0155	0.00157	0.00074	-0.00141	0.00247	0.00030
204				Σ	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000					

Figure 3.30 Calculation of $(W^8 - W^4)$

- j. Tenth step is continuing the squaring operation to obtain W^{16} and inspecting the difference between $(W^{16} - W^8)$ as in Figure 3.31.

D208		fx		=MMULT(D198:I198;D198:D203)											
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
208			19	W^{16}						$W^{16} - W^8$					
207				T	E	M	P	O	S						
208				T	0.2781	0.2781	0.2781	0.2781	0.2781	0.2781	0.00088	-0.00003	-0.00095	0.00010	-0.00038
209	A			E	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.00021	0.00003	-0.00024	0.00093	0.00021
210	N			M	0.0741	0.0741	0.0741	0.0741	0.0741	0.0741	-0.00015	0.00000	0.00017	-0.00027	-0.00002
211	P			P	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	-0.00018	0.00001	0.00020	0.00010	0.00012
212				O	0.2408	0.2408	0.2408	0.2408	0.2408	0.2408	-0.00083	-0.00001	0.00090	-0.00079	0.00012
213				S	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156	0.00007	0.00000	-0.00008	-0.00006	-0.00005
214				Σ	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000					

Figure 3.31 Calculation of $(W^{16} - W^8)$

- k. Eleventh step is continuing the squaring operation to obtain W^{16} and inspecting the difference between $(W^{32} - W^{16})$ as in Figure 3.32.

D218		fx		=MMULT(D208:I208;D208:D213)											
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
216			19	W^{32}						$W^{32} - W^{16}$					
217				T	E	M	P	O	S						
218			T	0.2781	0.2781	0.2781	0.2781	0.2781	0.2781		0.00000	0.00000	0.00000	0.00000	0.00000
219	A		E	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000		0.00000	0.00000	0.00000	0.00000	0.00000
220	N		M	0.0741	0.0741	0.0741	0.0741	0.0741	0.0741		0.00000	0.00000	0.00000	0.00000	0.00000
221	P		P	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914		0.00000	0.00000	0.00000	0.00000	0.00000
222			O	0.2408	0.2408	0.2408	0.2408	0.2408	0.2408		0.00000	0.00000	0.00000	0.00000	0.00000
223			S	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156		0.00000	0.00000	0.00000	0.00000	0.00000
224			Σ	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000						

Figure 3.32 Calculation of $(W^{32} - W^{16})$

Now the program achieved a null matrix, but it will continue two steps more because program is designed to run to calculate the difference between W^{128} and W^{64} to achieve the result. As soon as the result is achieved check mark sign appears like in the Figure 3.9.

If a null matrix is not obtained after seven iterations then program warns the program user, to modify the preferences. In case of necessity the warning sign, cross mark, will appear in “Input-Output” sheet just next to the consistency control sign as seen in Figure 3.10. This case never happened during hundreds times of testing the program.

- l. Twelfth step is continuing the squaring operation to obtain W^{32} and inspecting the difference between $(W^{64} - W^{32})$ as in Figure 3.33.

D228		fx		=MMULT(D218:I218;D218:D223)											
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
226			19	W^{64}						$W^{64} - W^{32}$					
227				T	E	M	P	O	S						
228			T	0.2781	0.2781	0.2781	0.2781	0.2781	0.2781		0.00000	0.00000	0.00000	0.00000	0.00000
229	A		E	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000		0.00000	0.00000	0.00000	0.00000	0.00000
230	N		M	0.0741	0.0741	0.0741	0.0741	0.0741	0.0741		0.00000	0.00000	0.00000	0.00000	0.00000
231	P		P	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914		0.00000	0.00000	0.00000	0.00000	0.00000
232			O	0.2408	0.2408	0.2408	0.2408	0.2408	0.2408		0.00000	0.00000	0.00000	0.00000	0.00000
233			S	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156		0.00000	0.00000	0.00000	0.00000	0.00000
234			Σ	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000						

Figure 3.33 Calculation of $(W^{64} - W^{32})$

- m. Figure 3.34 shows the final step for convergence program obtains W^{128} and inspects the difference between $(W^{128} - W^{64})$.

D238		f _x		=MMULT(D228:I228;D228:D233)											
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
236			19	W^{128}						$W^{128} - W^{64}$					
237				T	E	M	P	O	S						
238				0.2781	0.2781	0.2781	0.2781	0.2781	0.2781		0.00000	0.00000	0.00000	0.00000	0.00000
239				0.3000	0.3000	0.3000	0.3000	0.3000	0.3000		0.00000	0.00000	0.00000	0.00000	0.00000
240				0.0741	0.0741	0.0741	0.0741	0.0741	0.0741		0.00000	0.00000	0.00000	0.00000	0.00000
241				0.0914	0.0914	0.0914	0.0914	0.0914	0.0914		0.00000	0.00000	0.00000	0.00000	0.00000
242				0.2408	0.2408	0.2408	0.2408	0.2408	0.2408		0.00000	0.00000	0.00000	0.00000	0.00000
243				0.0156	0.0156	0.0156	0.0156	0.0156	0.0156		0.00000	0.00000	0.00000	0.00000	0.00000
244				Σ	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000					

Figure 3.34 Calculation of $(W^{128} - W^{64})$

The difference of final matrix is a null matrix. Therefore, for the example problem, an acceptable result is obtained. All column vectors are now identical and the values correspond to the weight of clusters.

3.4 Country Score Calculation

The general appearance of the “Score Calculation” sheet is as illustrated in Figure 3.35.

Left column is separated for the input area of PDUR and UDUR criteria. The middle column is the area for PDPR criteria while the right column contains the information about the results of the calculation.

CLR COPY		PROGRAM / USER DEFINED - USER RATED CRITERIA		PROGRAM DEFINED - PROGRAM RATED CRITERIA		DEU	GERMANY	4.6078
T	5	Availability of Construction Technologies & Skills	2.5	Number of Procedures Required to Start a Business	T	"Country Name" is input from dropdown list "3 Digit ISO Code" appears at the left. "Country Rate" appears at top right. Available 54 criteria out of possible 54.   		
	5	Procedure For Bidding & Design approvals	4.2	Quality of Port Infrastructure				
	5	Language Barrier	2.6	Availability of Scientists & Engineers				
	5	Delay In Design & Regulatory approvals	4.6	Quality of Air Transport Infrastructure				
	5	Quality of Materials	2.3	Starting a Business				
	5	Import Restrictions of Material, Equipment & Spares	3.4	Quality of Management Schools				
	5	Availability & Quality of Local Contractors	4.1	Extent of Staff Training				
	5		4.1	University - Industry Collaboration in R&D				
E	5	Currency Risk	4.2	Total Tax Rate	E	CLUSTER	SCORE (S_i)	WEIGHT (W_i)
	5	Delay In Payments	3.2	Government Debt		T: Technical Factors	4.48178	0.27811
	5	Contract Currency	4.5	Intensity of Local Competition		E: Economical Factors	4.80789	0.30000
	5	Money Transfer From Country	0.0	Oil Reserves		M: Market Factors	4.43622	0.07412
	5	Stability In Taxation Regime	3.8	Business Costs of Terrorism		P: Political Factors	4.55477	0.09144
	5	Custom Delays	4.1	Business Costs of Crime & Violence		O: Operational Factors	4.56987	0.24077
	5	Currency Exchange Restrictions	3.3	Soundness of Banks		S: Social Factors	4.71871	0.01556
	5		4.5	Inflation				
M	5	War	4.9	Time Required to Start a Business	M			
	5	Economic Crisis	3.5	Efficiency of Legal Framework In Settling Disputes				
	5	Terrorist Acts	3.3	Legal Rights Index				
	5	Bidding Volume Index	5.0	Country Risk				
	5	Enforceability of Contracts, Contract Issues & Conditions	4.1	Domestic Market Size Index				
	5	Likelihood of Project Success	2.4	Protecting Investors				
	5	Financing For Construction Projects	4.0	Resolving Insolvency				
	5		1.2	GDP				
	5		1.0	GDP As A Share of World GDP				

Figure 3.35 Part of country score interface

All criteria in this sheet are linked to another sheet, named “Codes & Criteria” as in Figure 3.36. This gives flexibility to the program user if it is necessary to modify any criterion.

The screenshot shows an Excel interface. The formula bar at the top displays the formula `=Codes & Criteria!$F$5`. Below it is a table with two main sections: 'PROGRAM / USER DEFINED - USER RATED CRITERIA' and 'PROGRAM DEFINED - PROGRAM RATED CRITERIA'. The first section has two rows with scores of 5. The second section has two rows with scores of 2.5 and 4.4.

PROGRAM / USER DEFINED - USER RATED CRITERIA		PROGRAM DEFINED - PROGRAM RATED CRITERIA	
5	Availability of Construction Technologies & Skills	2.5	Number of Procedures Required to Start a Business
5	Procedure For Bidding & Design approvals	4.4	Quality of Port Infrastructure

Figure 3.36 Criteria are linked to “Codes & Criteria” sheet

The “Score Calculation” sheet mainly consists of three columns. The first column contains PDUR and UDUR criteria names and cells which allows the user to rate each criterion on a scale from t1 to 5. In each cluster, there are seven criteria defined by the program and two rows are reserved for the possible entrance of UD criteria.

All UR criteria scores can be cleared by clicking the “CLR” button while the “COPY” button copies the score of the criterion at the top of each cluster to the remaining criteria of the same cluster. Because the two lines at the bottom of each cluster are reserved for the entrance of UDUR criteria, they are not filled in. The user of the program can define and rate his own criteria in this area.

The middle column is devoted for PDPR criteria whose scores are automatically filled in from the database stored in the “Codes & Criteria” sheet when the user selects the name of the country from the dropdown list provided as shown in Figure 3.37. There are 9 criteria defined under each cluster. As soon as the name of the country is selected from the dropdown list, ISO Alpha 3 Code of the country and the number of available data belonging to the program defined criteria appears in the screen.

ISOALPHA-3 contains 247 countries or territories, starting from AFGHANISTAN (AFG) and ending with ZIMBABWE (ZWE) and are included in the country list of the developed program. Figure 3.37 shows the dropdown list.

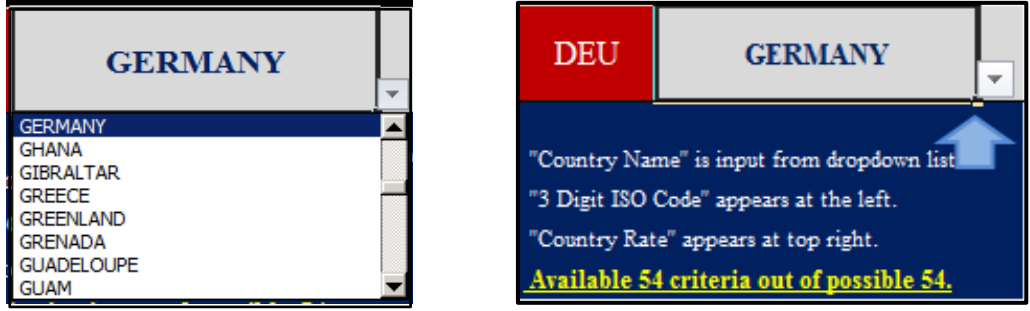


Figure 3.37 Dropdown list to choose country

3.4.1 PDPR Score Calculation of a Country

For calculation purpose PDPR criteria can be considered in two types. One type is low data value means positivity (lowest is the best) such as “Number of Procedures Required to Start a Business” or “Inflation Rate”. Equation (13) will be used to calculate this type of criteria.

$$S_j^k = 5 - 5 \times \frac{D_{jk} - M_j}{M_j - N_j} \quad (13)$$

The other type is high data value means positivity (highest is the best) such as “Quality of Port Infrastructure” or “GDP”. (14) will be used to calculate this type of criteria.

$$S_j^k = 5 \times \frac{D_j^k - M_j}{M_j - N_j} \quad (14)$$

Where;

S_j^k : Score of country k , with respect to criteria j ,

D_j^k : Data value of country k , for criteria j ,

M_j : Maximum data value for criteria j ,

N_j : Minimum data value for criteria j ,

j : 1.....54

k : ISO ALPHA 3 Code abbreviations for countries

Two examples below are given for the application.

3.4.1.1 Example 1

Criterion: “Number of Procedures Required to Start a Business” listed at the top of “Score Calculation” sheet. (High value means negativity.)

Country: Germany

Calculation:

“Number of procedures required to start business” is listed for all countries in the “Codes & Criteria” sheet. Nine procedures are required for Germany. For this criterion, Venezuela has the worst data score as 17 and Canada has the best data score with only 1 document requirement to start a business. The countries that data is not available for this criteria is not considered throughout the calculation. By the application of Eq.13 score of Germany for this criterion is calculated as;

$$S_1^{DEU} = 5 - 5 \times \frac{9 - 1}{17 - 1} = 2.50$$

3.4.1.2 Example 2

Criterion: “Quality of Port Infrastructure” listed at the second line of “Score Calculation” sheet. (Low value means negativity.)

Country: Germany

Calculation:

Data is retrieved from the “Codes & Criteria” sheet. Rate for this criterion for Germany is 6.0. Best rate is 6.8 for Singapore and Netherlands. The worst rate is 1.5 for Kyrgyzstan. The countries that data is not available for this criteria is not considered throughout the calculation. Eq.14 is used because low value means negativity and the score is calculated as

$$S_2^{DEU} = 5 \times \frac{6.0 - 1.5}{6.8 - 1.5} = 4.25$$

3.4.2 Overall Score Calculation

The scores of UR criteria are inserted manually by the program user.

After the calculation of all PR criteria and inserting the rates for UR criteria, program calculates the scores of each cluster for the investigated country. Empty cells are not considered in calculating the cluster scores. To calculate the score of any cluster i for country k denoted by (s_i^k) , the scores assigned to the user rated and program rated criteria are summed up and divided by number the total number of criteria considered and is obtained by the following formulation

$$s_i^k = \frac{\sum_{j=1}^N su_{ij}^k + \sum_{l=1}^9 sp_{il}^k}{N} \times \frac{5}{s_{max_i}}$$

where su_{ij}^k denotes the score of user rated criteria j in cluster i for country k , sp_{il}^k denotes score of program rated criteria l in cluster i for country k , N is the total number of user and program rated criteria included and s_{max_i} is the highest score achieved in cluster i over all the countries.

Excel formulation to calculate cluster scores is shown in Figure 3.38.

=MIN(5;AVERAGE(D4:D20;I4:I20) *5/'Codes & Criteria'!FD\$255)		
DEU	GERMANY	4.6078
CLUSTER	SCORE (S _i)	WEIGHT (W _i)
T: Technical Factors	4.48178	0.27811
E: Economical Factors	4.80789	0.30000
M: Market Factors	4.43622	0.07412
P: Political Factors	4.55477	0.09144
O: Operational Factors	4.56987	0.24077
S: Social Factors	4.71871	0.01556

Figure 3.38 Formulation of cluster score calculation

Final step is calculating the score of country k denoted by s_k is obtained by the weighted sum of the cluster scores for country k and is obtained as follows

$$s_k = \sum_{i=1}^6 w_i \times s_i^k$$

MS EXCEL formula for calculating the score of a country score is illustrated in Figure 3.39.

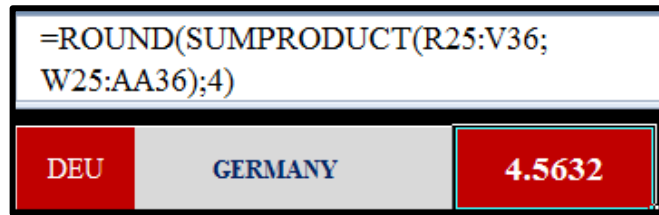


Figure 3.39 Formulation of country score calculation

For easy inspection, the score of the country is visually demonstrated by stars as seen on Figure 3.40. Number of stars are calculated by adding one to the integer part of the score.

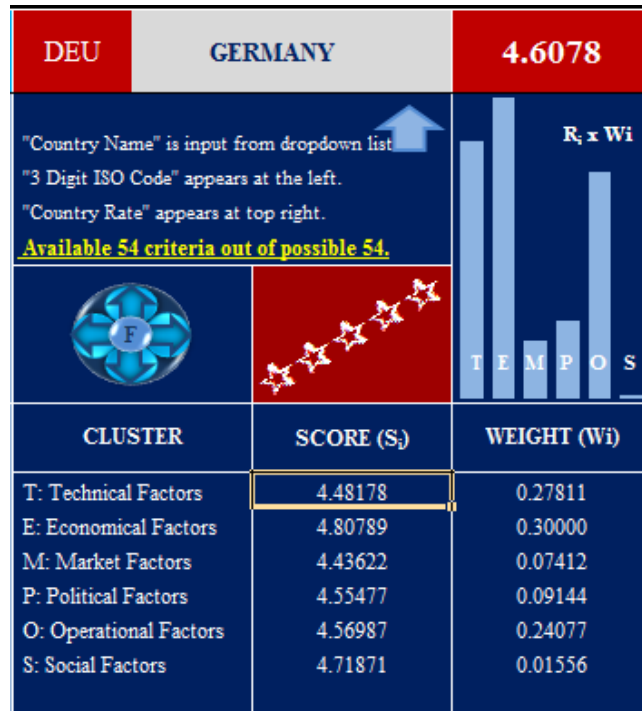


Figure 3.40 Visual inspection of country score

The bar-graph below the country score is the product of the score and weight of each cluster which gives an idea about the importance of each cluster which are also illustrated in this sheet.

Accessing to any visible spreadsheet in the workbook is easy by using the navigator. As soon as the pointer approaches to the navigator, it is visible on the screen where the navigator will transfer the user in the program in case the same spot is clicked on.

3.5 The Navigator

The navigator, in Figure 3.41, can transfer easily the PROGRAM USER to 6 different locations of the program depending on if the destination page is not hidden. These locations are, PCM, DRM and “Input-Output”, “Score Calculation”, “DEMATEL-ANP”, “Codes & Criteria” sheets. By clicking the nose of east arrow, PROGRAM USER transfers to “Score Calculation”, or clicking the “F” at the center toggles between “Input-Output” sheet and “Score Calculation” sheet.



Figure 3.41 The Navigator

CHAPTER FOUR

APPLICATION OF THE PROGRAM

4.1 User Experience of the TEMPOS

Expert-I, who experienced TEMPOS is a civil engineer and has experience for more than 30 years in project management and construction business. In the last 12 years, he is mainly involved in several projects for the construction of transportation structures such as highways, railways and bridges in international environment. He tested TEMPOS for Libya and Saudi Arabia. After third trial he achieved a consistent matrix. PCM and DRM constructed by him are demonstrated in Figure 4.1 and Figure 4.2 respectively.

Data entereence is possible only to "Gray Cells".						
I	Establish "Pairwise Comparision Matrix" (Scores between 1/5 to 5)					
	T	E	M	P	O	S
T	1	3	3	3	1/2	4
E	1/3	1	1	3	1/2	2
M	1/3	1	1	2	1/3	2
P	1/3	1/3	1/2	1	1/3	3
O	2	2	3	3	1	4
S	1/4	1/2	1/2	1/3	1/4	1

Figure 4.1 PCM constructed by Expert-I

Step 3: Direct Relation Matrix (DRM)
 Scores range between
 0.0 for "NO INFLUENCE" and
 4.0 "VERY HIGH INFLUENCE" CLR

	T	E	M	P	O	S
T	0	2	0	0	4	1
E	3	0	4	3	3	4
M	2	2	0	0	0	0
P	1	4	4	0	1	3
O	2	2	0	0	0	1
S	0	2	2	3	1	0

3

Input "THRESHOLD VALUE α "
 between 0.00 - 0.16

→

0.15

Figure 4.2 DRM constructed by Expert-I

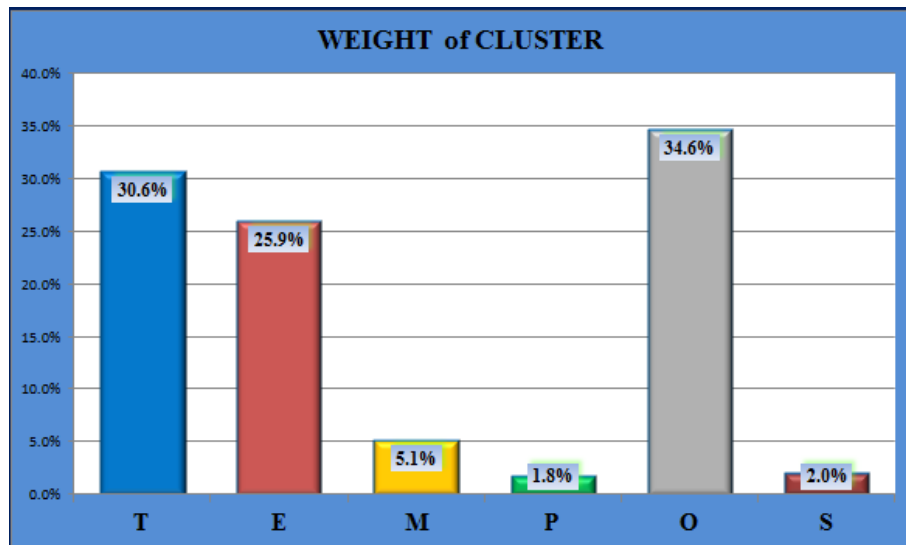


Figure 4.3 Cluster Weights based on the preferences of Expert-I

According to the preferences of Expert-I, graph of “Weight of Cluster” is obtained as given Figure 4.3 and “Casual Diagram” obtained is illustrated in Figure 4.4.

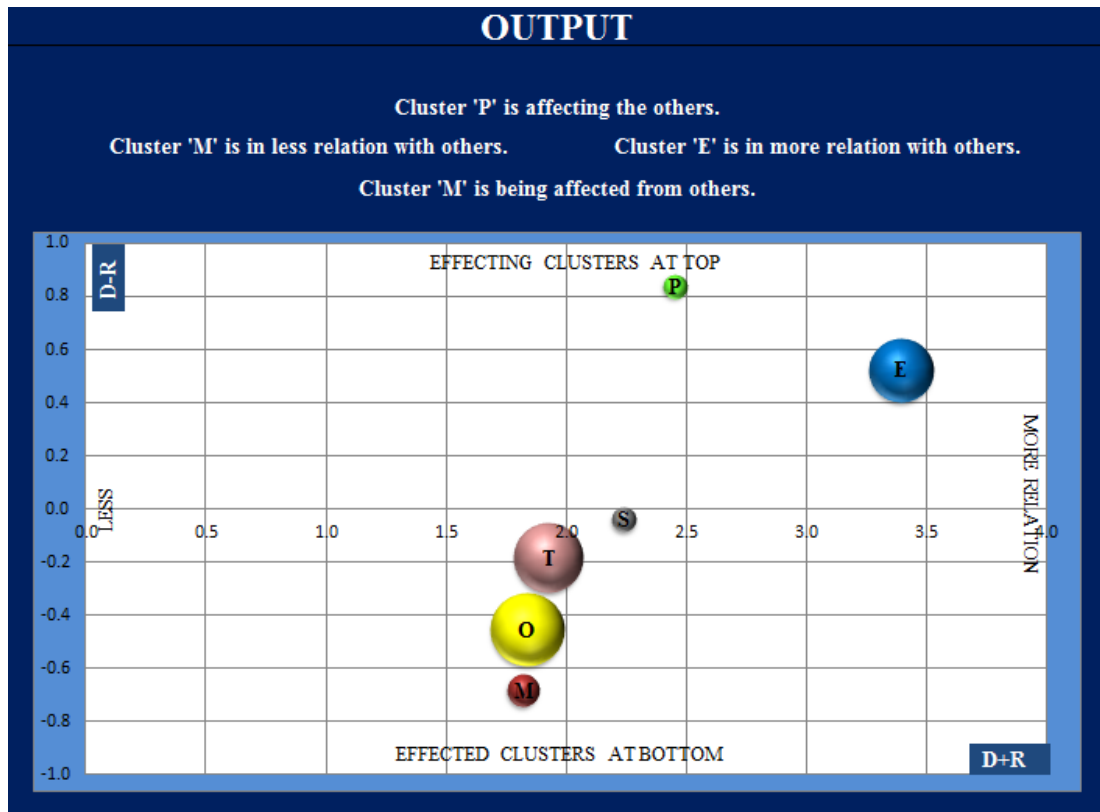


Figure 4.4 Casual diagram based on the preferences of Expert-I

Expert-I selected to use the geometric mean denoted by “G” and he used an α value of 0.15. He preferred to rate all UR criteria by using the “COPY” function. He used scores of 4-5-3-2-4-3 for clusters Technological, Economical, Market future, Political, Operational and Social respectively for Libya. He achieved the following result as shown in Figure 4.5.

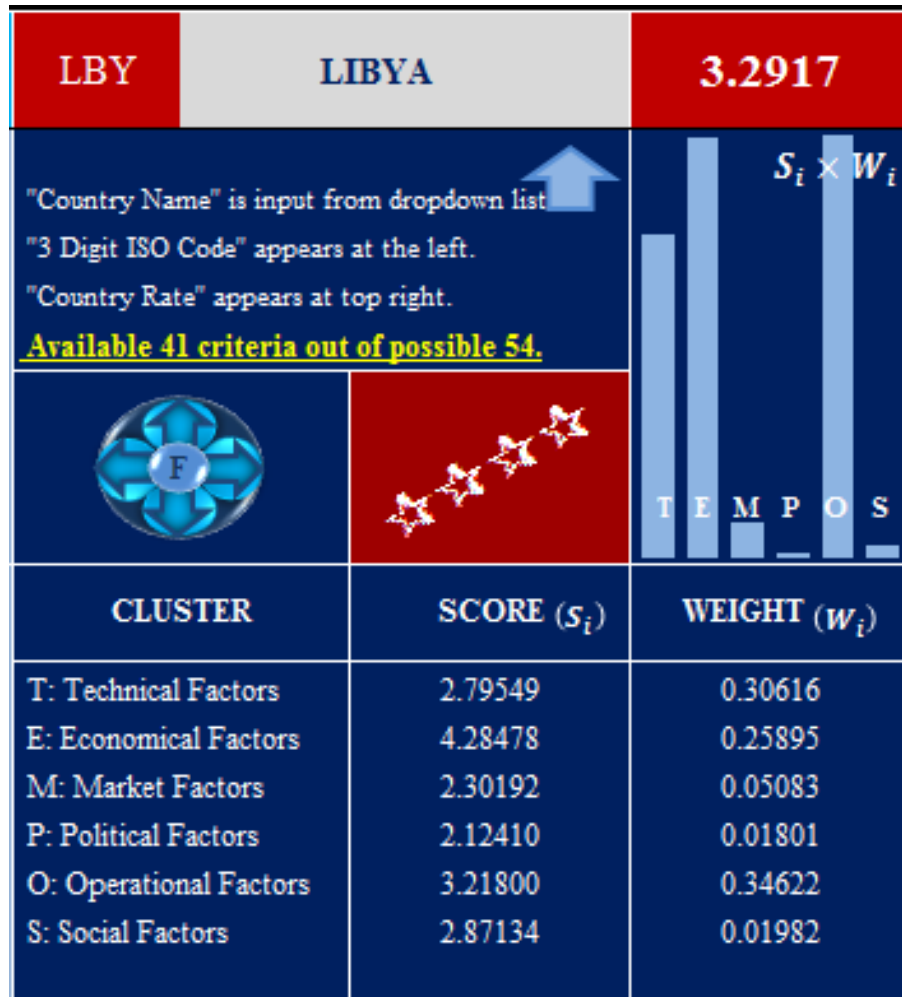


Figure 4.5 Score for Libya achieved by Expert-I

While calculating the score of Saudi Arabia, Expert-I didn't make any modification in the "Input-Output" sheet to keep the same preferences for PCM and DRM. He again used "COPY" function for UR criteria and used scores of 4-5-5-3-4-2 for Technological, Economical, Market future, Political, Operational and Social clusters respectively. The result is shown in Figure 4.6.

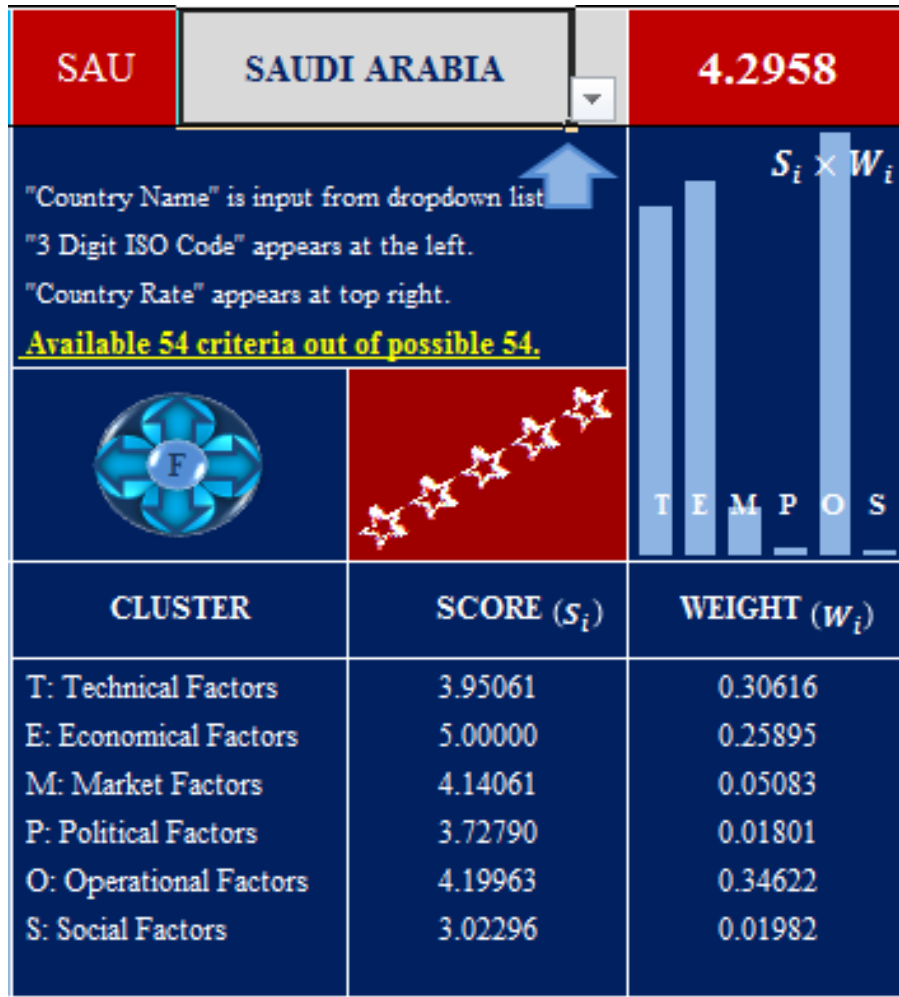


Figure 4.6 Score for Saudi Arabia achieved by Expert-I

To benchmark Libya and Saudi Arabia, Expert-I also calculated the score of country by keeping “mean” and “ α ” the same as in the previous score calculations. He used scores of 5-4-5-4-5-4 respectively for clusters Technological, Economical, Market future, Political, Operational and Social respectively for Turkey. The score achieved for Turkey is 3.9877 and is shown in Figure 4.7.

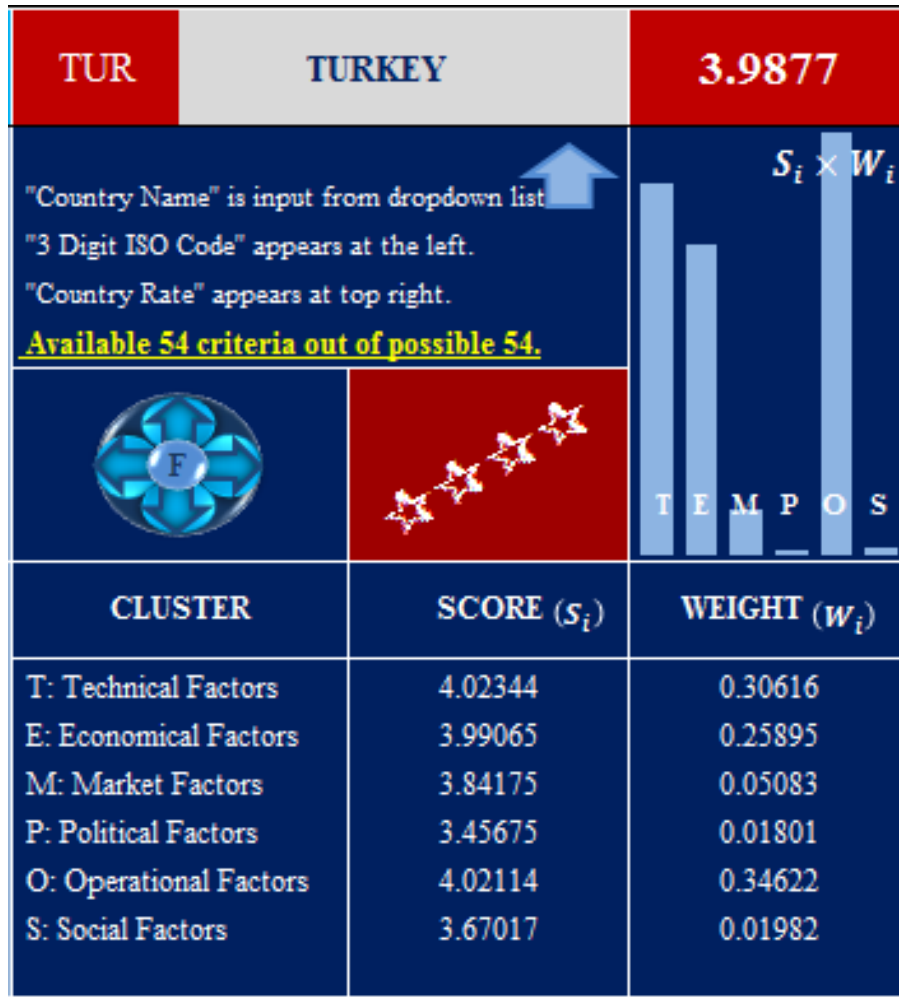


Figure 4.7 Score of Turkey achieved by Expert-I

Expert-I assessed the results as reasonable. Assessment of Expert-I by the author is as follows. Technical, Economical and Operational factors are very important according to the expert because the total weight of these three clusters is approximately 90% of the total weight. Market future, especially the political and social factors are not so important for the expert. It seems that the expert is highly interested in executing the contract and making profit. He is not interested in the future of the market and also he is not so much interested with social activities. He is not so much interested with the people, social activities and works of charity within the country. These types of contractors can be considered as “short term contractors”.

4.2 User Opinions

The developed tool is sent to seven international contractors to get their feedback about the use of the program. Users made the following remarks.

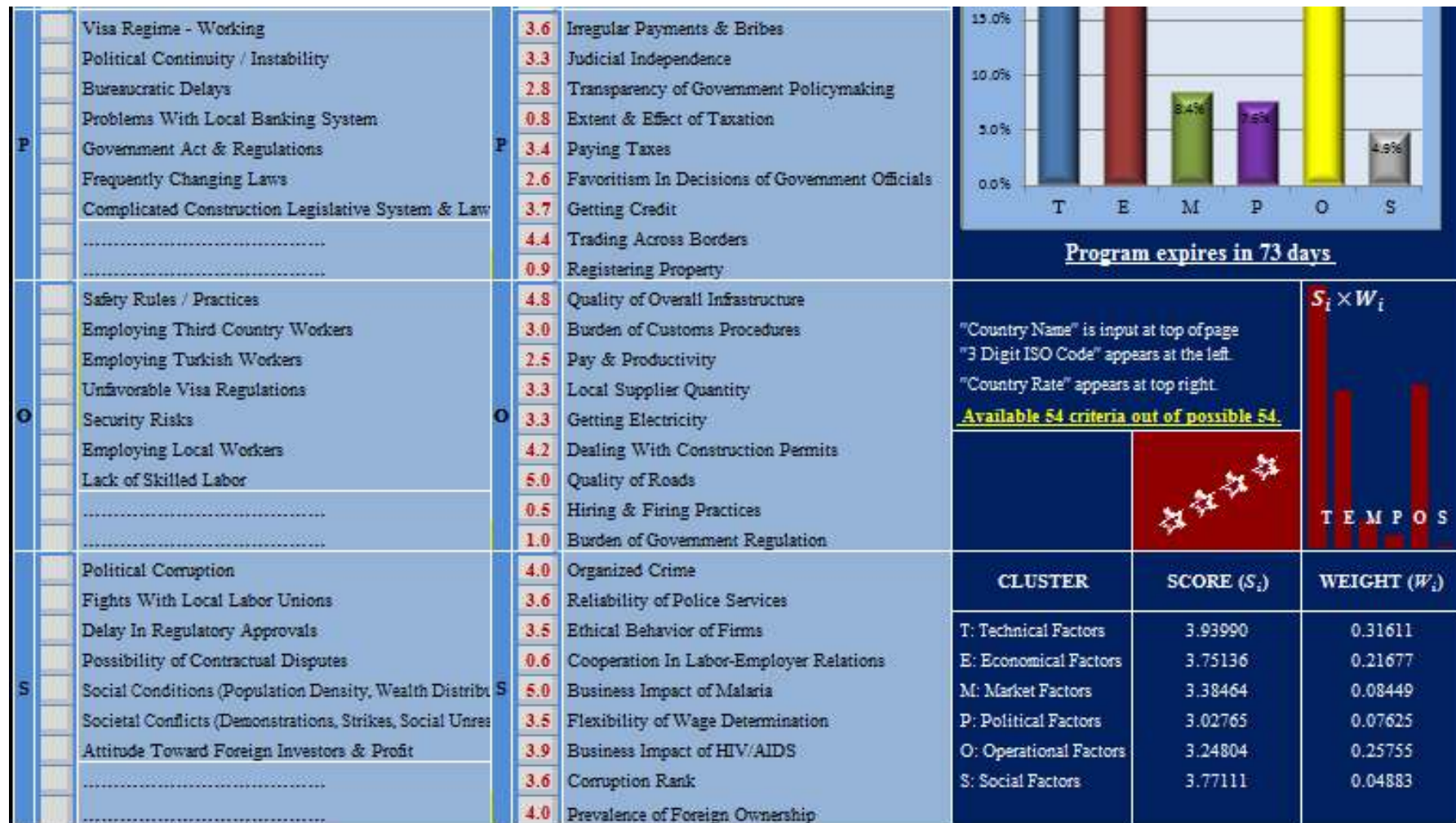
- a. The outlook of the interface can be improved to have a more professional view,
- b. Achieving consistency may need some trials,
- c. Data entry is time consuming,
- d. PCM and DRM seem to be similar items, program can be improved so that one of these matrixes may be ignored,
- e. Number of clusters may be decreased to 4 instead of 6. Especially between E–M and P-S there are bunch of intersecting criteria, instead of T-E-M-P-O-S, clusters can be listed as T-(E/M)-(P/S)-O and the revised program can be named as TEOS.

4.3 β Version of TEMPOS (TEMPOS β)

After receiving the comments of several experts another version of the program is developed to provide easy data input and is named as **TEMPOS β** . General view of TEMPOS β is given in Figure 4.8 and Figure 4.9. More information is given about **TEMPOS β** in the following section.

CLR COPY		PROGRAM / USER DEFINED - USER RATED CRITERIA	PROGRAM DEFINED - PROGRAM RATED CRITERIA	FRA	FRANCE	3.5961																																																	
T		Availability of Construction Technologies & Skills	3.8	"PAIRWISE COMPARISON MATRIX" (Scores between 1/5 to 5) Data Entry to Gray Cells Only <table><tr><th>CLR</th><th>T</th><th>E</th><th>M</th><th>P</th><th>O</th><th>S</th></tr><tr><td>T</td><td>1</td><td>4</td><td>5</td><td>5</td><td>1</td><td>3</td></tr><tr><td>E</td><td>☺</td><td>1</td><td>2</td><td>3</td><td>1</td><td>3</td></tr><tr><td>M</td><td></td><td></td><td>1</td><td>1/2</td><td>1/3</td><td>2</td></tr><tr><td>P</td><td>✓</td><td></td><td></td><td>1</td><td>1/4</td><td>2</td></tr><tr><td>O</td><td></td><td>73</td><td>54 / 54</td><td></td><td>1</td><td>4</td></tr><tr><td>S</td><td colspan="5">CR=0.0897 Consistent Matrix</td><td>1</td></tr></table>			CLR	T	E	M	P	O	S	T	1	4	5	5	1	3	E	☺	1	2	3	1	3	M			1	1/2	1/3	2	P	✓			1	1/4	2	O		73	54 / 54		1	4	S	CR=0.0897 Consistent Matrix					1
	CLR	T	E				M	P	O	S																																													
	T	1	4				5	5	1	3																																													
	E	☺	1				2	3	1	3																																													
	M						1	1/2	1/3	2																																													
	P	✓						1	1/4	2																																													
	O		73				54 / 54		1	4																																													
S	CR=0.0897 Consistent Matrix					1																																																	
	Procedure For Bidding & Design approvals	3.7																																																					
	Language Barrier	3.2																																																					
	Delay In Design & Regulatory approvals	4.3																																																					
	Quality of Materials	4.3																																																					
	Import Restrictions of Material, Equipment & Spares	4.3																																																					
	Availability & Quality of Local Contractors	3.0																																																					
		3.1																																																					
		4.1																																																					
E		Currency Risk	3.8	"DIRECT RELATION MATRIX" (Scores between 0 to 4) "0" means No Influence & "4" means Very High Influence <table><tr><th>CLR</th><th>T</th><th>E</th><th>M</th><th>P</th><th>O</th><th>S</th></tr><tr><td>T</td><td>0</td><td>3</td><td>3</td><td>1</td><td>4</td><td>1</td></tr><tr><td>E</td><td>3</td><td>0</td><td>4</td><td>4</td><td>2</td><td>1</td></tr><tr><td>M</td><td>0</td><td>2</td><td>0</td><td>2</td><td>1</td><td>2</td></tr><tr><td>P</td><td>1</td><td>3</td><td>3</td><td>0</td><td>1</td><td>3</td></tr><tr><td>O</td><td>3</td><td>2</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>S</td><td>0</td><td>4</td><td>1</td><td>3</td><td>1</td><td>0</td></tr></table>			CLR	T	E	M	P	O	S	T	0	3	3	1	4	1	E	3	0	4	4	2	1	M	0	2	0	2	1	2	P	1	3	3	0	1	3	O	3	2	0	0	0	0	S	0	4	1	3	1	0
	CLR	T	E				M	P	O	S																																													
	T	0	3				3	1	4	1																																													
	E	3	0				4	4	2	1																																													
	M	0	2				0	2	1	2																																													
	P	1	3				3	0	1	3																																													
	O	3	2				0	0	0	0																																													
S	0	4	1	3	1	0																																																	
	Delay In Payments	3.1																																																					
	Contract Currency	4.0																																																					
	Money Transfer From Country	0.0																																																					
	Stability In Taxation Regime	3.0																																																					
	Custom Delays	3.6																																																					
	Currency Exchange Restrictions	3.6																																																					
		4.5																																																					
		4.5																																																					
M		War	5.0	WEIGHT of CLUSTER (W_i) <table><tr><th>Cluster</th><th>Weight (W_i)</th></tr><tr><td>T</td><td>31.6%</td></tr><tr><td>E</td><td>21.7%</td></tr><tr><td>M</td><td>25.8%</td></tr></table>			Cluster	Weight (W _i)	T	31.6%	E	21.7%	M	25.8%																																									
	Cluster	Weight (W _i)																																																					
	T	31.6%																																																					
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		Terrorist Acts	3.3																																																				
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	Enforceability of Contracts, Contract Issues & Conditions	3.9																																																					
	Likelihood of Project Success	2.9																																																					
	Financing For Construction Projects	3.8																																																					
		0.9																																																					
		0.7																																																					

Figure 4.8 General layout of TEMPOS β (top ½)

Figure 4.9 General layout of TEMPOS β (bottom1/2)

4.3.1 Advantages and Disadvantages of TEMPOS β

Advantages of TEMPOS β can be listed as follows.

- a) Running program all in one sheet instead of two is more user friendly and effective,
- b) TEMPOS β consumes less memory which means achieving faster results and less working time,
- c) Easier printing because, all input and output are included in one page,
- d) Less time is needed for inputting data,
- e) There are various user defined functions, such as “Shift+Ctrl+H”, “Shift+Ctrl+M” and “Shift+Ctrl+V” and some others, which makes it easier to work with the program.

Disadvantages of TEMPOS β are discussed below.

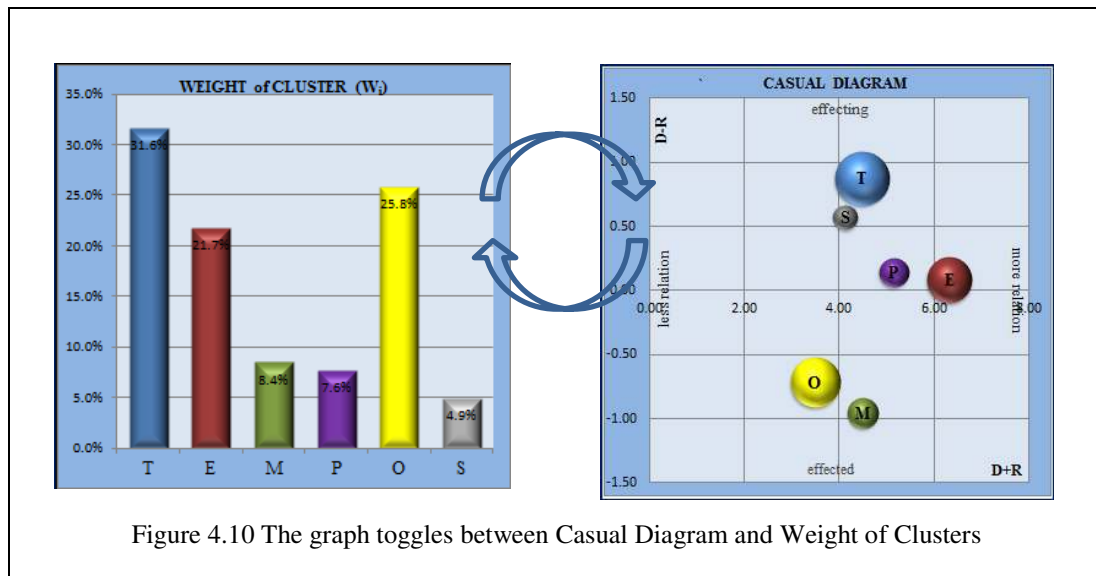
- a) The graphs of “Cluster Weights” and “Casual Diagram” are not visible to the user simultaneously. When it is clicked on the existing graph, it disappears and the other graph becomes visible.
- b) The preference of the program user about the use of arithmetic mean or geometric mean is not taken into consideration. Always geometric mean is used in the normalization process.
- c) Instead of asking the threshold value to the program user, it is defined by the program as zero.
- d) “Input-Output” sheet is not available. It is combined with “Score Calculation” sheet.

4.3.2 Other Information About TEMPOS β

- a) As long as the same data is input to TEMPOS and TEMPOS β output is also supposed to be the same. If the PCM and DRM are the same but the score of the same country is different, the reason for this situation may be

either choosing “A” for mean calculation or using a threshold value different than zero.

- b) As shown in Figure 4.10, the graph area toggles between casual diagram graph and clusters weights bar chart as soon as the visible graph is clicked.



- c) The top ½ of general layout of TEMPOSβ interaction page is as in Figure 4.8 and the bottom ½ is as in Figure 4.9.
- d) At the top of Figure 4.8 there are “CLR” and “COPY” buttons on the left side, explanations about the columns, 3 digit alpha code of country, country name and the score of the country. “CLR” and “COPY” buttons function same as in TEMPOS. Country choosing process is same as in TEMPOS. On the right hand side is the calculated score of country is given.
- e) Just below the heading the criteria belonging to technical, economical and market clusters exist which are supposed to be rated by the program user or by the program itself.
- f) On the right hand side, PCM and DRM exist. Input entrance is possible to only gray cells.

- g) CR is visible. If CR is out of the limit (0.10) then the smiling face icon changes.
- h) The check mark (✓) means that convergence is achieved during the calculation.
- i) Figures on the right side of (✓) mentions the days remaining before the expiry date of the program, and number of PDPR data obtained and number of maximum data that can be obtained.
- j) The bottom ½ of the sheet is seen in Figure 4.9. The criteria of political, operational and social clusters are shown in this figure. On the right hand side, number of criteria available for the specified country, scores and weights of each cluster are visible.
- k) Stars represent the class of the country. Possible maximum star that can be achieved for any country is five.
- l) Pressing “**CTRL+SHIFT+C**” instantaneously, copies the value of the first criterion of any cluster to the other criteria of the same cluster.
- m) Pressing “**CTRL+SHIFT+H**” instantaneously, fits all columns of “Score Calculation Sheet” to the screen,
- n) Pressing “**CTRL+SHIFT+V**” instantaneously, fits all rows of “Score Calculation Sheet” to the screen,
- o) Pressing “**CTRL+SHIFT+M**” instantaneously, fits top 2/3 of “Score Calculation Sheet” to the screen,
- p) Pressing “**CTRL+SHIFT+A**” instantaneously, clears all user criteria input,
- q) Pressing “**CTRL+SHIFT+P**” instantaneously, makes PCM a null matrix,
- r) Pressing “**CTRL+SHIFT+D**” instantaneously, makes DRM a null matrix,
- s) Pressing “**CTRL+SHIFT+S**” instantaneously, brings the Casual Diagram to the screen,
- t) Pressing “**CTRL+SHIFT+W**” instantaneously, brings the Weight of Cluster graph to the screen,

4.3 Application of TEMPOS β by an Expert

Expert-II has MS degree in mechanical engineering and working as general manager for a Turkish International Contractor, which is listed 8 times in TOP-225 since 2005. The expert has experience in international construction sector for more than 20 years and the company is experienced especially in industrial constructions such as pipe line construction, power plants and cement factories.

After giving information about TEMPOS and TEMPOS β and how to run each program expert preferred to run TEMPOS β and to score two countries, namely SERBIA and NIGERIA against TURKEY.

Firstly he scored NIGERIA. Expert-II achieved a consistent PCM in his second attempt and easily filled in DRM and scored UR criteria. The score he achieved for NIGERIA is 2.6244. His scores for UR criteria, scores of PDPR criteria, 3 digit code of the country, country name, country score, PCM, DRM, consistency information, convergence information, number of program defined for the country, number of days remaining before the expiry date of the program, graphic representation of weight of clusters, score of each cluster, the graph of the product of the score are visible in Figure 4.11 and 4.12.

Next he had chosen SERBIA from the list. PCM and DRM preference of him were the same as he had for NIGERIA. So he didn't make any modification within these two matrixes. The score (2.8883) and other information are given in Figure 4.13 and Figure 4.14.

Finally, for benchmarking, Expert-II also rated Turkey using the same PCM and DRM. The results, he achieved, are given in Figure 4.15 and Figure 4.16.



Figure 4.11 Data sheet of Nigeria (top ½)



Figure 4.12 Data sheet of Nigeria (bottom ½)

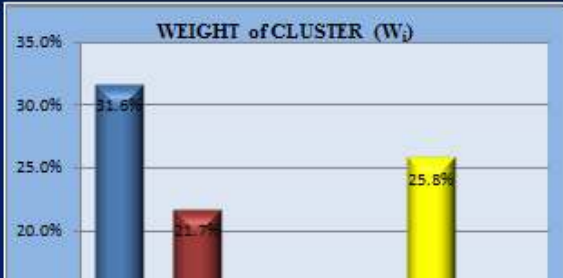
CLR		PROGRAM / USER DEFINED -		PROGRAM DEFINED -		SRB	SERBIA	2.8883			
COPY		USER RATED CRITERIA		PROGRAM RATED CRITERIA							
I	3	Availability of Construction Technologies & Skills	3.1	Number of Procedures Required to Start a Business	"PAIRWISE COMPARISION MATRIX" (Scores between 1/5 to 5) Data Entry to Gray Cells Only						
	4	Procedure For Bidding & Design approvals	1.1	Quality of Port Infrastructure							
	3	Language Barrier	1.8	Availability of Scientists & Engineers	CLR	T	E	M	P	O	S
	4	Delay In Design & Regulatory approvals	1.1	Quality of Air Transport Infrastructure	T	1	4	5	5	1	3
	3	Quality of Materials	2.5	Starting a Business	E	☺	1	2	3	1	3
	4	Import Restrictions of Material, Equipment & Spares	1.6	Quality of Management Schools	M			1	1/2	1/3	2
	2	Availability & Quality of Local Contractors	0.9	Extent of Staff Training	P	✓			1	1/4	2
	3	Ease of communication	1.6	University - Industry Collaboration in R&D	O		73	54 / 54		1	4
	3	Consulting engineers' technical background	1.9	Quality of Scientific Research Institutions	S	CR=0.0897 Consistent Matrix					1
E	5	Currency Risk	4.4	Total Tax Rate	"DIRECT RELATION MATRIX" (Scores between 0 to 4) "0" means No Influence & "4" means Very High Influence						
	4	Delay In Payments	4.0	Government Debt							
	5	Contract Currency	0.8	Intensity of Local Competition	CLR	T	E	M	P	O	S
	5	Money Transfer From Country	0.0	Oil Reserves	T	0	3	3	1	4	1
	4	Stability In Taxation Regime	3.6	Business Costs of Terrorism	E	3	0	4	4	2	1
	3	Custom Delays	2.9	Business Costs of Crime & Violence	M	0	2	0	2	1	2
	5	Currency Exchange Restrictions	2.5	Soundness of Banks	P	1	3	3	0	1	3
	3		2.8	Inflation	O	3	2	0	0	0	0
	3		1.9	Country Credit Rating	S	0	4	1	3	1	0
M	4	War	4.9	Time Required to Start a Business	WEIGHT of CLUSTER (W_i) 						
	2	Economic Crisis	0.7	Efficiency of Legal Framework In Settling Disputes							
	5	Terrorist Acts	3.9	Legal Rights Index							
	3	Bidding Volume Index	0.1	Country Risk							
	5	Enforceability of Contracts, Contract Issues & Conditions	2.1	Domestic Market Size Index							
	5	Likelihood of Project Success	2.9	Protecting Investors							
	4	Financing For Construction Projects	1.9	Resolving Insolvency							
	3	Approach to Turkish People	0.0	GDP							
			0.0	GDP As A Share of World GDP							

Figure 4.13 Data sheet of Serbia (top-1/2)



Figure 4.14 Data sheet of Serbia (bottom ½)

CLR		PROGRAM / USER DEFINED - USER RATED CRITERIA		PROGRAM DEFINED - PROGRAM RATED CRITERIA		TUR		TURKEY		3.6670																																																		
COPY																																																												
T	5	Availability of Construction Technologies & Skills	3.4	Number of Procedures Required to Start a Business	"PAIRWISE COMPARISON MATRIX" (Scores between 1/5 to 5) Data Entry to Gray Cells Only<table><tr><th>CLR</th><th>T</th><th>E</th><th>M</th><th>P</th><th>O</th><th>S</th></tr><tr><td>T</td><td>1</td><td>4</td><td>5</td><td>5</td><td>1</td><td>3</td></tr><tr><td>E</td><td>☺</td><td>1</td><td>2</td><td>3</td><td>1</td><td>3</td></tr><tr><td>M</td><td></td><td></td><td>1</td><td>1/2</td><td>1/3</td><td>2</td></tr><tr><td>P</td><td>✓</td><td></td><td></td><td>1</td><td>1/4</td><td>2</td></tr><tr><td>O</td><td></td><td>73</td><td>54 / 54</td><td></td><td>1</td><td>4</td></tr><tr><td>S</td><td colspan="5">CR=0.0897 Consistent Matrix</td><td>1</td></tr></table>							CLR	T	E	M	P	O	S	T	1	4	5	5	1	3	E	☺	1	2	3	1	3	M			1	1/2	1/3	2	P	✓			1	1/4	2	O		73	54 / 54		1	4	S	CR=0.0897 Consistent Matrix					1
	CLR	T	E	M								P	O	S																																														
	T	1	4	5								5	1	3																																														
	E	☺	1	2								3	1	3																																														
	M			1								1/2	1/3	2																																														
	P	✓										1	1/4	2																																														
	O		73	54 / 54									1	4																																														
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E	5	Currency Risk	4.3	Total Tax Rate	"DIRECT RELATION MATRIX" (Scores between 0 to 4) "0" means No Influence & "4" means Very High Influence<table><tr><th>CLR</th><th>T</th><th>E</th><th>M</th><th>P</th><th>O</th><th>S</th></tr><tr><td>T</td><td>0</td><td>3</td><td>3</td><td>1</td><td>4</td><td>1</td></tr><tr><td>E</td><td>3</td><td>0</td><td>4</td><td>4</td><td>2</td><td>1</td></tr><tr><td>M</td><td>0</td><td>2</td><td>0</td><td>2</td><td>1</td><td>2</td></tr><tr><td>P</td><td>1</td><td>3</td><td>3</td><td>0</td><td>1</td><td>3</td></tr><tr><td>O</td><td>3</td><td>2</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>S</td><td>0</td><td>4</td><td>1</td><td>3</td><td>1</td><td>0</td></tr></table>							CLR	T	E	M	P	O	S	T	0	3	3	1	4	1	E	3	0	4	4	2	1	M	0	2	0	2	1	2	P	1	3	3	0	1	3	O	3	2	0	0	0	0	S	0	4	1	3	1	0
	CLR	T	E	M								P	O	S																																														
	T	0	3	3								1	4	1																																														
	E	3	0	4								4	2	1																																														
	M	0	2	0								2	1	2																																														
	P	1	3	3								0	1	3																																														
	O	3	2	0								0	0	0																																														
	S	0	4	1								3	1	0																																														
	4	Delay In Payments	4.1	Government Debt																																																								
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		2.7	Country Credit Rating																																																									
M	3	War	5.0	Time Required to Start a Business	WEIGHT of CLUSTER (W_i)<table><tr><td>31.6%</td><td>21.7%</td><td>23.8%</td></tr></table>							31.6%	21.7%	23.8%																																														
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	4	Likelihood of Project Success	3.2	Protecting Investors																																																								
	5	Financing For Construction Projects	1.7	Resolving Insolvency																																																								
		Approach to Turkish people	0.3	GDP																																																								
			0.4	GDP As A Share of World GDP																																																								

Figure 4.15 Data sheet of Turkey (top ½)

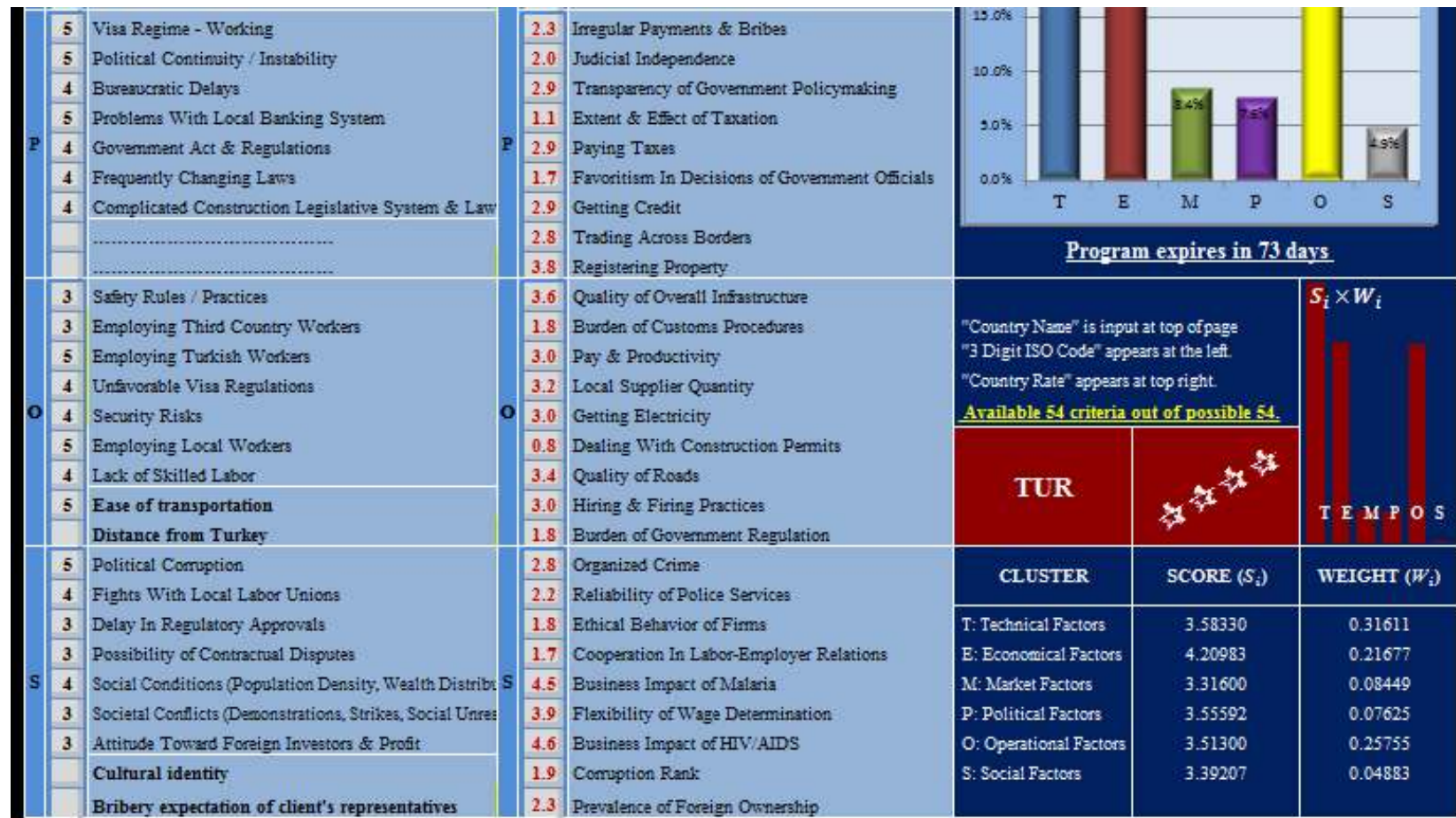


Figure 4.16 Data sheet of Turkey (bottom 1/2)

Expert-II evaluated the result as “very reasonable”. It seems that this company is more sensitive the future of the market and can be defined as “medium term international contractor”.

CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

Having an idea about the risks and the opportunities of the target countries can play a vital role in business decisions. Especially for international contractors who undertake various projects in various countries, in order to determine the appropriate country to work in, the risks and the opportunities present in the countries under evaluation should be considered. In this thesis, through the combined use of DEMATEL and ANP methods, a spreadsheet based tool is developed to guide international contractors in their new market entry decision.

After generating the idea of rating countries from the point of view of international construction, the method to be used is chosen as DEMATEL and ANP combined system and the execution is preferred to be held by MS EXCEL. After a vast investigation in the literature and using different sources of information, more than five hundred criteria are collected and these are grouped under six different clusters. By conducting surveys with several international contractors, some of the collected criteria are eliminated and the criteria which can affect the decision process of the contractors are determined and included in the model. Two types of criteria are included in the model: objective criteria and subjective criteria. The objective criteria are generally rated automatically by the program while the subjective criteria are rated by the program user

Cluster weights are obtained, according to the direct relation and pairwise comparison considerations, between the clusters of the model. Finally the country score is achieved by the product of the weight of each cluster and the average criteria scores in each cluster.

Although the combined use of DEMATEL and ANP is used for various multi criteria decision making problems, to the best of our knowledge, this is the first time it is used for country rating. In addition to that, this is the first study where an MS

Excel based tool is developed for country rating using the combined DEMATEL and ANP method.

This research can be considered as being an initial step for numerically analyzing the countries from the point of view of international contractors and the developed tools TEMPOS or TEMPOS β can easily be implemented in construction business.

5.1 Innovations of the Program

There are many reasons to conclude that this research is an innovative approach about country risk rating for international contractors. Some main points that create difference from previous studies are listed as follows;

- a. This is the first research where combined DEMATEL and ANP hybrid method is used to rate countries, specifically tailored for international construction business.
- b. MS Excel spreadsheet is used, instead of a professional software for DEMATEL and ANP calculation processes. To the best of author's knowledge this is the first time that MS Excel is used instead of the well-known softwares in the market.
- c. Both TEMPOS and TEMPOS β are interactive programs. For the same country, different scores can be obtained depending on the preferences and abilities of the contractors.
- d. Different cluster weights can be obtained according to the preferences of the program user.
- e. In case more than one country is rated, it is possible to achieve different cluster scores for each country. The opposite may also be possible. Program user may calculate a general cluster rate and can use the same cluster rates for different countries.
- f. While calculating the country score the program takes into account not only risks but also the possible benefits and opportunities of the country besides the strong and weak points of the contractor.
- g. The program is not only for Turkish international contractors but can be used by every contractor regardless of the nationality.

- h. It is possible for the program user to neglect any criterion in the fields reserved for PDUR or UDUR by leaving the related input cell as blank.
- i. Each contractor can establish her own list ranked according to her own priorities and abilities.
- j. TEMPOS and TEMPOS β are not company specific tools but rather generic tools that can be used by every international contractor.

5.2 Limitations of the Program

- a. Only six clusters are considered, neither less nor more is permitted.
- b. Program user cannot make any modification on PDPR criteria.
- c. Under each cluster, two UDUR criteria are included.
- d. Under each cluster, seven PDUR criteria are included.
- e. Under each cluster, nine PDPR criteria are included.
- f. Program goes to the end users with an expiration date so that the program user will be able to receive the latest improvements of the program.

5.3 Possible Future Improvements of the Program

- a. If a correlation can be estimated between PCM and DRM, it may be possible to rate countries only by inputting either PCM or DRM into the system.
- b. In the current version of the program, the number of clusters and the names of the clusters considered are fixed and cannot be revised by the program user. In a future research, a more flexible tool may be generated where the numbers and names of the clusters may be decided by the program user.
- c. Also the program user may choose the criteria of each cluster from a checkbox list, without any limitation, and the program may automatically assign the criteria as UR or PR.
- d. Or, TEMPOS can be modified to include four clusters, namely technical, economical, operational and social, instead of six because while practicing the program with the experts it is noticed that preferences of experts are concentrating on technical, economical and operational clusters. This new program can be named as TEOS.

- e. At the moment total number of criteria considered in TEMPOS is 108. It may be increased to 144 in TEOS.
- f. Some more information about the countries such as, map, political parties, flag, currency, parity of the currency, international exhibitions, commercial fairs, national days, visa conditions, climate, important addresses etc. can be provided to the program user.
- g. Some experts asked to improve the program to compare and graph the criteria of two countries instantly.
- h. Program can be improved to compare more than two countries simultaneously.
- i. Program calculates the score of each criterion for each country however it does not give the exact values belonging to criteria. For example, for “government dept”, “oil reserves”, “inflation” or “gross domestic product” only the comparison scores come to the related cells but the values of these criteria are not displayed to the program user. The values of each criterion can be exposed to program user.
- j. Number of program defined (PD) criteria included in the model is limited however, by modifying the program, the program user may choose any criteria from preinstalled data under each cluster, so that each program user can rate the criteria which are more important according to her/his preferences and conditions. In this case UDUR criteria may not be necessary.
- k. Future modifications of the program may contain bunch of, say a thousand, data for each country. So that program user can receive a thousand of data besides the score of the chosen country.
- l. A formulation can be derived to decide the mark-up value for any country depending on the score calculated by TEMPOS.
- m. If data is not available for any criterion under PR criteria then this criterion is not considered throughout the calculations. Another idea can be rating this criterion with the lowest score.
- n. A fuzzy version of TEMPOS β can be derived.

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APPENDICES

APPENDIX A LIST OF CRITERIA AND SOURCES

Criteria	Reference
Positive financial impact	Key Consulting (2012)
Alignment with strategic direction	Key Consulting (2012)
Positively affects a large portion of the organization	Key Consulting (2012)
Advances internal capabilities long term	Key Consulting (2012)
Increases standardization / improves quality	Key Consulting (2012)
Appropriate backup plans are in place	Key Consulting (2012)
Likelihood of project success	Key Consulting (2012)
Well understood project scope and objectives	Key Consulting (2012)
Likely willingness of organization to adopt project	Key Consulting (2012)
Understanding of project's impact on organization	Key Consulting (2012)
Use of standard well understood technologies	Key Consulting (2012)
Availability of expert resources for assistance	Key Consulting (2012)
Low time to realize benefits	Key Consulting (2012)
Low cost to completion	Key Consulting (2012)
Political continuity / instability	Akcamete (2006)
Attitude toward foreign investors and profit / foreign firms	Akcamete (2006)
Nationalization / expropriation	Akcamete (2006)
Bureaucratic delays	Akcamete (2006)
Communication and transportation	Akcamete (2006)
Professional services other than construction	Akcamete (2006)

Criteria	Reference
Hostilities with neighboring country or region	Akcamete (2006)
Fractionalization by language, ethnic, and regional groups	Akcamete (2006)
Mentality, including nationalism, corruption and dishonesty	Akcamete (2006)
Societal conflicts (demonstrations, strikes, social unrest)	Akcamete (2006)
Repatriation of capital / fund	Akcamete (2006)
Availability of construction technologies and skills	Akcamete (2006)
Availability of equipment and parts	Akcamete (2006)
Availability of construction materials	Akcamete (2006)
Material cost / fluctuation	Akcamete (2006)
Types of contracts	Akcamete (2006)
Enforceability of contracts, contract issues and conditions	Akcamete (2006)
Procedure for bidding	Akcamete (2006)
Availability of skilled and unskilled workers / labors	Akcamete (2006)
Labor cost / fluctuation	Akcamete (2006)
Financing for construction projects	Akcamete (2006)
Shortage of financial resources	Akcamete (2006)
Problems in technology transfer and implementation	Akcamete (2006)
Custom regulations	Akcamete (2006)
Problems in dispute settlement / conflicts different dispute resolution mechanisms	Akcamete (2006)
Delay in regulatory approvals	Akcamete (2006)
Delay in payments	Akcamete (2006)
Poor quality of materials	Akcamete (2006)
Unforeseen adverse ground conditions / Geography condition / poor soil qualities	Akcamete (2006)
Weather / climate conditions	Akcamete (2006)

Criteria	Reference
Terrorist acts	Akcamete (2006)
Safety	Akcamete (2006)
Inflation	Akcamete (2006)
Currency fluctuations / foreign exchange rates	Akcamete (2006)
Religion	Akcamete (2006)
Interest rate increases	Akcamete (2006)
Cultural differences / condition	Akcamete (2006)
Bribery	Akcamete (2006)
Taxation discrimination	Akcamete (2006)
Security risks	Akcamete (2006)
Legal environment of host country / legislative framework	Akcamete (2006)
Environmental issues / regulations	Akcamete (2006)
Concern about subcontractors	Akcamete (2006)
Government act and regulations	Akcamete (2006)
Communication barriers	Akcamete (2006)
Language barrier	Akcamete (2006)
Clarity of local laws	Akcamete (2006)
Interpretation of law	Akcamete (2006)
Inadequacy of technical specification	Akcamete (2006)
Change in policies	Akcamete (2006)
Political corruption	Akcamete (2006)
Economic crisis	Akcamete (2006)
Currency devaluation	Akcamete (2006)
Restrictions to scope of engineering activities for foreign entrants	Akcamete (2006)

Criteria	Reference
Protectionism / local preference	Akcamete (2006)
Lack of transparency in government procurement policies / bidding procedures	Akcamete (2006)
Complicated construction legislative system and laws	Akcamete (2006)
Lack of standardization in format of contract documents	Akcamete (2006)
Types of bidding	Akcamete (2006)
Lack of clarity of contract document	Akcamete (2006)
Lack of legality and standard dispute settlement procedure	Akcamete (2006)
Differences in design specifications	Akcamete (2006)
Differences in construction codes / building codes	Akcamete (2006)
Differences in material standards	Akcamete (2006)
Differences in management philosophy	Akcamete (2006)
Nepotism and overvalue of relationship	Akcamete (2006)
Conflicts between the private business interests and the state bureaucracy	Akcamete (2006)
Religious conflicts	Akcamete (2006)
Public resistance / non-Cooperation of public residents / plain dislike of foreigners	Akcamete (2006)
License and permit requirements	Akcamete (2006)
Importation restrictions of materials, equipment and spare parts	Akcamete (2006)
Terms of financing	Akcamete (2006)
Lack of infrastructure	Akcamete (2006)
Quality of labor / technical staff	Akcamete (2006)
Safety rules / practices	Akcamete (2006)
Frequently changing laws	Akcamete (2006)
Cost of construction equipment	Akcamete (2006)
Fights with local labor unions	Akcamete (2006)

Criteria	Reference
Racial factors	Akcamete (2006)
War	Akcamete (2006)
Government subsidy	Akcamete (2006)
Currency exchange restrictions	Akcamete (2006)
Coup d'État (coup)	Akcamete (2006)
Political arrest and expulsions	Akcamete (2006)
Confiscation or other forms of restricting foreign assets	Akcamete (2006)
Custom delays	Akcamete (2006)
Inability and reluctance to communicate	Akcamete (2006)
Lack or inaccessibility of business support mechanisms	Akcamete (2006)
Uncertainty about lines of responsibility and decision making procedures	Akcamete (2006)
Government reluctance or inability to implement favorable policies	Akcamete (2006)
Unfavorable visa regulations	Akcamete (2006)
Force majeure (in revised rbs)	Akcamete (2006)
Immature legal system	Akcamete (2006)
Delay in progress payments	Akcamete (2006)
Lack of coordination and communication with the client organizations	Akcamete (2006)
Lack of data/Delay in the necessary project information	Akcamete (2006)
Custom regulations	Akcamete (2006)
Unconformity of imported materials with host country practice	Akcamete (2006)
Unavailability of repair and maintenance services of equipment's	Akcamete (2006)
Unavailability of spare parts	Akcamete (2006)
Lack of skilled labor	Akcamete (2006)
Poor communication skills of technical staff	Akcamete (2006)

Criteria	Reference
Frequent change orders of the client	Akcamete (2006)
Difficulty in finding credits	Akcamete (2006)
High insurance premiums	Akcamete (2006)
Problems with local banking system	Akcamete (2006)
Difference in traditions	Akcamete (2006)
Changes in international relations	Akcamete (2006)
Site handover delay	Akcamete (2006)
Strict quality requirements	Akcamete (2006)
Strict health and safety requirements	Akcamete (2006)
Poor international relations	Akcamete (2006)
Corruption rank	TI (2011)
Political continuity	Hastak & Shaked (2000)
Attitude toward foreign investors and profit	Hastak & Shaked (2000)
Nationalization / expropriation	Hastak & Shaked (2000)
Enforceability of contracts	Hastak & Shaked (2000)
Government incentives	Hastak & Shaked (2000)
Monetary inflation	Hastak & Shaked (2000)
Economic growth	Hastak & Shaked (2000)
Bureaucratic delays	Hastak & Shaked (2000)
Communication and transportation	Hastak & Shaked (2000)
Professional services other than construction	Hastak & Shaked (2000)
Hostilities with neighboring country or region	Hastak & Shaked (2000)
Dependence on or importance of major power	Hastak & Shaked (2000)
Fragmented political structure	Hastak & Shaked (2000)

Criteria	Reference
Fractionalization by language, ethnic, and regional groups	Hastak & Shaked (2000)
Restraints to retaining power	Hastak & Shaked (2000)
Mentality, including nationalism, corruption, and dishonesty	Hastak & Shaked (2000)
Social conditions (population density & wealth distribution)	Hastak & Shaked (2000)
Societal conflicts (e.g., demonstrations, strikes, & street violence)	Hastak & Shaked (2000)
Instability because of nonconstitutional changes	Hastak & Shaked (2000)
Actual laws versus practices for repatriation of capital	Hastak & Shaked (2000)
Current account balance	Hastak & Shaked (2000)
Capital flow	Hastak & Shaked (2000)
Foreign exchange reserves	Hastak & Shaked (2000)
Gold and other reserves	Hastak & Shaked (2000)
Debt as GDP converted to US\$	Hastak & Shaked (2000)
Capacity service debt	Hastak & Shaked (2000)
Extent of deficit / surplus	Hastak & Shaked (2000)
Sources of revenue and major spending	Hastak & Shaked (2000)
Investor's technological advantage	Hastak & Shaked (2000)
Technology protection system	Hastak & Shaked (2000)
Market suitability for advanced technology	Hastak & Shaked (2000)
Availability of basic construction / technologies and equipment	Hastak & Shaked (2000)
Type of partnership	Hastak & Shaked (2000)
Types of contracts	Hastak & Shaked (2000)
Enforceability of construction contract	Hastak & Shaked (2000)
Procedure for bidding and design approvals	Hastak & Shaked (2000)
Availability and quality of local contractors	Hastak & Shaked (2000)

Criteria	Reference
Availability of construction materials	Hastak & Shaked (2000)
Availability of skilled and unskilled workers	Hastak & Shaked (2000)
Labor cost / productivity	Hastak & Shaked (2000)
Availability of equipment and parts	Hastak & Shaked (2000)
Medium and long term financing for construction industry	Hastak & Shaked (2000)
Special construction industry index	Hastak & Shaked (2000)
A/E/C firms client or owner relationship	Hastak & Shaked (2000)
Competitive / negotiated bidding	Hastak & Shaked (2000)
Current market volume in core competency	Hastak & Shaked (2000)
Future market volume in core competency	Hastak & Shaked (2000)
Bidding volume index	Hastak & Shaked (2000)
Problems in technology transfer and implementation	Hastak & Shaked (2000)
Retention of technological advantage	Hastak & Shaked (2000)
Possibility of contractual disputes	Hastak & Shaked (2000)
Problems in dispute settlement due to country's laws	Hastak & Shaked (2000)
Shortage of skilled and unskilled workers	Hastak & Shaked (2000)
Availability of special equipment	Hastak & Shaked (2000)
Delays in material supply	Hastak & Shaked (2000)
Delay in design and regulatory approvals	Hastak & Shaked (2000)
Defective design, error, and rework	Hastak & Shaked (2000)
Work change order	Hastak & Shaked (2000)
Difficulties to meet construction programs	Hastak & Shaked (2000)
Unforeseen adverse ground conditions	Hastak & Shaked (2000)
Bad quality of materials	Hastak & Shaked (2000)

Criteria	Reference
Bad quality of workmanship	Hastak & Shaked (2000)
Financing difficulties because of tax or capital movement restrictions	Hastak & Shaked (2000)
Financial difficulties because of currency exchange rate	Hastak & Shaked (2000)
Drop in project revenue	Hastak & Shaked (2000)
Difficulty of converting local currency to foreign exchange	Hastak & Shaked (2000)
Construction manager	Hastak & Shaked (2000)
Third party delays	Hastak & Shaked (2000)
Safety	Hastak & Shaked (2000)
Weather conditions and other natural causes of delay	Hastak & Shaked (2000)
Physical damage to project by riots, terrorist act, and so forth	Hastak & Shaked (2000)
Stability in taxation regime	Ribeiro (2001)
Macroeconomic instabilities may affect its commercial environment	Ribeiro (2001)
Chronological highlights	Ribeiro (2001)
The structure of the government	Ribeiro (2001)
Dominant conception about democracy	Ribeiro (2001)
Social aspects	Ribeiro (2001)
Geographic positioning	Ribeiro (2001)
Country risk	OECD (2013a)
Change in country risk Between 01-Jan-99 and 06-Jul-2012	OECD (2013a)
Employing workers: difficulty of hiring	IFC (2013a)
Employing workers: rigidity of hours	IFC (2013a)
Employing workers: difficulty of redundancy	IFC (2013a)
Employing workers: redundancy cost	IFC (2013a)
Starting a business	IFC (2013a)

Criteria	Reference
Dealing with construction permits	IFC (2013a)
Getting electricity	IFC (2013a)
Registering property	IFC (2013a)
Getting credit	IFC (2013a)
Protecting investors	IFC (2013a)
Paying taxes	IFC (2013a)
Trading across borders	IFC (2013a)
Enforcing contracts	IFC (2013a)
Resolving insolvency	IFC (2013a)
GDP (current US\$)	The World Bank (2013b)
Adjusted net national income per capita (current US\$)	The World Bank (2013b)
Population, total	The World Bank (2013b)
Urban population	The World Bank (2013b)
Urban population (% of total)	The World Bank (2013b)
Land area (sq. km)	The World Bank (2013b)
Adjusted savings: education expenditure (% of GNI)	The World Bank (2013b)
Adjusted savings: energy depletion (% of GNI)	The World Bank (2013b)
Adjusted savings: mineral depletion (% of GNI)	The World Bank (2013b)
Agricultural land (% of land area)	The World Bank (2013b)
Agriculture value added per worker (constant 2000 US\$)	The World Bank (2013b)
Electric power consumption (Kwh per capita)	The World Bank (2013b)
Energy use (Kg of oil equivalent per capita)	The World Bank (2013b)
Mortality rate, under-5 (Per 1,000 live births)	The World Bank (2013b)
Unemployment Rate	The World Bank (2013b)

Criteria	Reference
Exports (Billion \$)	The World Bank (2013b)
Imports (Billion \$)	The World Bank (2013b)
External Debt (Billion \$)	The World Bank (2013b)
Adjusted net savings, excluding particulate emission damage (% of GNI)	The World Bank (2013b)
Adjusted net savings, including particulate emission damage (% of GNI)	The World Bank (2013b)
Adjusted savings: carbon dioxide damage (% of GNI)	The World Bank (2013b)
Adjusted savings: consumption of fixed capital (% of GNI)	The World Bank (2013b)
Adjusted savings: net forest depletion (% of GNI)	The World Bank (2013b)
Adjusted savings: particulate emission damage (% of GNI)	The World Bank (2013b)
Annual freshwater withdrawals, agriculture (% of total freshwater withdrawal)	The World Bank (2013b)
Annual freshwater withdrawals, total (% of internal resources)	The World Bank (2013b)
Aquaculture (thousand metric tons)	The World Bank (2013b)
Bird species, threatened	The World Bank (2013b)
Capture fisheries (thousand metric tons)	The World Bank (2013b)
CO2 emissions (metric tons per capita)	The World Bank (2013b)
Combustible renewables and waste (% of total energy)	The World Bank (2013b)
Coral reef area (sq. km)	The World Bank (2013b)
Diarrhea prevalence (% of children under five)	The World Bank (2013b)
Electricity production from hydroelectric sources (% of total)	The World Bank (2013b)
Electricity production from oil, gas and coal sources (% of total)	The World Bank (2013b)
Fish species, threatened	The World Bank (2013b)
Food production index (2004-2006 = 100)	The World Bank (2013b)
Forest area (% of land area)	The World Bank (2013b)
Forest area (sq.km)	The World Bank (2013b)

Criteria	Reference
Gef benefits index for biodiversity (0 = no biodiversity potential to 100 = maximum)	The World Bank (2013b)
Gross savings (% of GNI)	The World Bank (2013b)
Improved sanitation facilities (% of population with access)	The World Bank (2013b)
Improved sanitation facilities, rural (% of rural population with access)	The World Bank (2013b)
Improved sanitation facilities, urban (% of urban population with access)	The World Bank (2013b)
Improved water source (% of population with access)	The World Bank (2013b)
Improved water source, rural (% of rural population with access)	The World Bank (2013b)
Improved water source, urban (% of urban population with access)	The World Bank (2013b)
Mammal species, threatened	The World Bank (2013b)
Mangroves area (sq. km)	The World Bank (2013b)
Marine protected areas (% of territorial waters)	The World Bank (2013b)
Plant species (higher), threatened	The World Bank (2013b)
Pm10, country level (micrograms per cubic meter)	The World Bank (2013b)
Renewable internal freshwater resources per capita (cubic meters)	The World Bank (2013b)
Terrestrial protected areas (% of total land area)	The World Bank (2013b)
Total fisheries production (thousand metric tons)	The World Bank (2013b)
Institutions	Schwab & Martin (2012)
Infrastructure	Schwab & Martin (2012)
Macroeconomic environment	Schwab & Martin (2012)
Health and primary education	Schwab & Martin (2012)
Higher education and training	Schwab & Martin (2012)
Goods market efficiency	Schwab & Martin (2012)
Financial market development	Schwab & Martin (2012)
Technological readiness	Schwab & Martin (2012)

Criteria	Reference
Market size	Schwab & Martin (2012)
Business sophistication	Schwab & Martin (2012)
Innovation	Schwab & Martin (2012)
GDP	Schwab & Martin (2012)
Population	Schwab & Martin (2012)
GDP per capita	Schwab & Martin (2012)
GDP as a share of world GDP	Schwab & Martin (2012)
Property rights	Schwab & Martin (2012)
Intellectual property protection	Schwab & Martin (2012)
Diversion of public funds	Schwab & Martin (2012)
Public trust in politicians	Schwab & Martin (2012)
Irregular payments and bribes	Schwab & Martin (2012)
Judicial independence	Schwab & Martin (2012)
Favoritism in decisions of government officials	Schwab & Martin (2012)
Wastefulness of government spending	Schwab & Martin (2012)
Burden of government regulation	Schwab & Martin (2012)
Efficiency of legal framework in settling disputes	Schwab & Martin (2012)
Efficiency of legal framework in challenging regulations	Schwab & Martin (2012)
Transparency of government policymaking	Schwab & Martin (2012)
Government provision of services for improved business perform	Schwab & Martin (2012)
Business costs of terrorism	Schwab & Martin (2012)
Business costs of crime and violence	Schwab & Martin (2012)
Organized crime	Schwab & Martin (2012)
Reliability of police services	Schwab & Martin (2012)

Criteria	Reference
Ethical behavior of firms	Schwab & Martin (2012)
Strength of auditing and reporting standards	Schwab & Martin (2012)
Efficacy of corporate boards	Schwab & Martin (2012)
Protection of minority shareholders' interests	Schwab & Martin (2012)
Strength of investor protection	Schwab & Martin (2012)
Quality of overall infrastructure	Schwab & Martin (2012)
Quality of roads	Schwab & Martin (2012)
Quality of railroad infrastructure	Schwab & Martin (2012)
Quality of port infrastructure	Schwab & Martin (2012)
Quality of air transport infrastructure	Schwab & Martin (2012)
Quality of electricity supply	Schwab & Martin (2012)
Mobile telephone subscriptions	Schwab & Martin (2012)
Fixed telephone lines	Schwab & Martin (2012)
Government budget balance	Schwab & Martin (2012)
Gross national savings	Schwab & Martin (2012)
Inflation	Schwab & Martin (2012)
Government debt	Schwab & Martin (2012)
Country credit rating	Schwab & Martin (2012)
Business impact of malaria	Schwab & Martin (2012)
Malaria incidence	Schwab & Martin (2012)
Business impact of tuberculosis	Schwab & Martin (2012)
Tuberculosis incidence	Schwab & Martin (2012)
Business impact of HIV/AIDS	Schwab & Martin (2012)
HIV prevalence	Schwab & Martin (2012)

Criteria	Reference
Infant mortality	Schwab & Martin (2012)
Life expectancy	Schwab & Martin (2012)
Quality of primary education	Schwab & Martin (2012)
Primary education enrollment rate	Schwab & Martin (2012)
Secondary education enrollment rate	Schwab & Martin (2012)
Tertiary education enrollment rate	Schwab & Martin (2012)
Quality of the educational system	Schwab & Martin (2012)
Quality of math and science education	Schwab & Martin (2012)
Quality of management schools	Schwab & Martin (2012)
Internet access in schools	Schwab & Martin (2012)
Local availability of specialized research	Schwab & Martin (2012)
Extent of staff training	Schwab & Martin (2012)
Intensity of local competition	Schwab & Martin (2012)
Extent of market dominance	Schwab & Martin (2012)
Effectiveness of anti-monopoly policy	Schwab & Martin (2012)
Extent and effect of taxation	Schwab & Martin (2012)
Total tax rate	Schwab & Martin (2012)
Number of procedures required to start a business	Schwab & Martin (2012)
Time required to start a business	Schwab & Martin (2012)
Agricultural policy costs	Schwab & Martin (2012)
Prevalence of trade barriers	Schwab & Martin (2012)
Trade tariffs	Schwab & Martin (2012)
Prevalence of foreign ownership	Schwab & Martin (2012)
Burden of customs procedures	Schwab & Martin (2012)

Criteria	Reference
Imports as a percentage of GDP	Schwab & Martin (2012)
Degree of customer orientation	Schwab & Martin (2012)
Buyer sophistication	Schwab & Martin (2012)
Cooperation in labor-employer relations	Schwab & Martin (2012)
Flexibility of wage determination	Schwab & Martin (2012)
Hiring and firing practices	Schwab & Martin (2012)
Redundancy costs	Schwab & Martin (2012)
Pay and productivity	Schwab & Martin (2012)
Reliance on professional management	Schwab & Martin (2012)
Brain drain	Schwab & Martin (2012)
Female participation in labor force	Schwab & Martin (2012)
Availability of financial services	Schwab & Martin (2012)
Affordability of financial services	Schwab & Martin (2012)
Financing through local equity market	Schwab & Martin (2012)
Ease of access to loans	Schwab & Martin (2012)
Venture capital availability	Schwab & Martin (2012)
Soundness of banks	Schwab & Martin (2012)
Regulation of securities exchanges	Schwab & Martin (2012)
Legal rights index	Schwab & Martin (2012)
Availability of latest technologies	Schwab & Martin (2012)
Firm-Level technology absorption	Schwab & Martin (2012)
FDI and technology transfer	Schwab & Martin (2012)
Internet users	Schwab & Martin (2012)
Fixed broadband internet subscriptions	Schwab & Martin (2012)

Criteria	Reference
Internet bandwidth	Schwab & Martin (2012)
Mobile broadband subscriptions	Schwab & Martin (2012)
Domestic market size index	Schwab & Martin (2012)
Foreign market size index	Schwab & Martin (2012)
GDP (PPP)	Schwab & Martin (2012)
Exports as a percentage of GDP	Schwab & Martin (2012)
Local supplier quantity	Schwab & Martin (2012)
Local supplier quality	Schwab & Martin (2012)
State of cluster development	Schwab & Martin (2012)
Nature of competitive advantage	Schwab & Martin (2012)
Value chain breadth	Schwab & Martin (2012)
Control of international distribution	Schwab & Martin (2012)
Extent of marketing	Schwab & Martin (2012)
Willingness to delegate authority	Schwab & Martin (2012)
Capacity for innovation	Schwab & Martin (2012)
Quality of scientific research institutions	Schwab & Martin (2012)
Company spending on R&D	Schwab & Martin (2012)
University- industry collaboration in R&D	Schwab & Martin (2012)
Government procurement of advanced technology products	Schwab & Martin (2012)
Availability of scientists and engineers	Schwab & Martin (2012)
Pct patent applications	Schwab & Martin (2012)
Population	CIA (2013)
Median age	CIA (2013)
Population growth rate	CIA (2013)

Criteria	Reference
Birth rate	CIA (2013)
Death rate	CIA (2013)
Net migration rate	CIA (2013)
Urban population	CIA (2013)
Rate of urbanization	CIA (2013)
Life expectancy at birth	CIA (2013)
Oil reserves	CIA (2013)
Statutory corporate tax rate	OECD (2013c)
Vat and sales tax	OECD (2013c)
Number of tax payments	OECD (2013c)
Procedures to start a business	OECD (2013c)
Average inflation (1995-2004)	OECD (2013c)
Size of informal sector 2005-07	OECD (2013c)
Attitude towards globalization	ISPAT (2013)
Financial institutions transparency	ISPAT (2013)
Flexibility and adaptability	ISPAT (2013)
Competent senior managers	ISPAT (2013)
Finance skills	ISPAT (2013)
International experience	ISPAT (2013)
Labor force	ISPAT (2013)
Skilled labor	ISPAT (2013)
Working hours	ISPAT (2013)
Registration property	ISPAT (2013)
Starting a business	ISPAT (2013)

Criteria	Reference
Population - market size	ISPAT (2013)
Population over 65 Years	ISPAT (2013)
Population under 15 Years	ISPAT (2013)
Qualified engineers	ISPAT (2013)
Information technology skills	ISPAT (2013)
Tariff barriers	ISPAT (2013)
Current composite risk	PRS group (2013)
Foreign debt as % of GDP	PRS group (2013)
International liquidity	PRS group (2013)
Exchange rate stability	PRS group (2013)
Per capita GDP	PRS group (2013)
Inflation rate	PRS group (2013)
Budget balance as % of GDP	PRS group (2013)
Current account as % of GDP	PRS group (2013)
Political risk	PRS group (2013)
Economic risk	PRS group (2013)
Financial risk	PRS group (2013)
Investment profile	PRS group (2013)
Government stability	PRS group (2013)
Socioeconomic conditions	PRS group (2013)
Internal conflict	PRS group (2013)
External conflict	PRS group (2013)
Corruption	PRS group (2013)
Military in politics	PRS group (2013)

Criteria	Reference
Religious tensions	PRS group (2013)
Law & order	PRS group (2013)
Ethnic tensions	PRS group (2013)
Democratic accountability	PRS group (2013)
Bureaucracy quality	PRS group (2013)
Employing local workers	Author
Employing Turkish workers	Author
Employing third country workers	Author
Visa regime – touristic	Author
Visa regime – working	Author
Money transfer to country	Author
Money transfer from country	Author
Inflation rate	Author
Contract currency	Author
Annual increase of GDP	Author
Currency risk	Author
Population increase	Author
Stability in customs regime	Author
Client eagerness and ability of dept payment	Author
Equipment cost	Author

APPENDIX B

**LIST OF COUNTRIES AND NUMBER OF DATA COLLECTED FOR EACH
COUNTRY OUT OF 54**

	ISO ALPHA 2 CODE	ISO ALPHA 3 CODE	COUNTRY	NUMBER OF DATA
1	AF	AFG	AFGHANISTAN	12
2	AX	ALA	ALAND ISLANDS	0
3	AL	ALB	ALBANIA	54
4	DZ	DZA	ALGERIA	53
5	AS	ASM	AMERICAN SAMOA	1
6	AD	AND	ANDORRA	0
7	AO	AGO	ANGOLA	12
8	AI	AIA	ANGUILLA	0
9	AQ	ATA	ANTARCTICA	0
10	AG	ATG	ANTIGUA & BARBUDA	11
11	AR	ARG	ARGENTINA	54
12	AM	ARM	ARMENIA	54
13	AW	ABW	ARUBA	2
14	AU	AUS	AUSTRALIA	54
15	AT	AUT	AUSTRIA	54
16	AZ	AZE	AZERBAIJAN	54
17	BS	BHS	BAHAMAS	12
18	BH	BHR	BAHRAIN	54
19	BD	BGD	BANGLADESH	54
20	BB	BRB	BARBADOS	40
21	BY	BLR	BELARUS	12
22	BE	BEL	BELGIUM	54
23	BZ	BLZ	BELIZE	11

	ISO ALPHA 2 CODE	ISO ALPHA 3 CODE	COUNTRY	NUMBER OF DATA
24	BJ	BEN	BENIN	54
25	BM	BMU	BERMUDA	1
26	BT	BTN	BHUTAN	12
27	BO	BOL	BOLIVIA	54
28	BA	BIH	BOSNIA & HERZEGOVINA	54
29	BW	BWA	BOTSWANA	54
30	BV	BVT	BOUVET ISLANDS	0
31	BR	BRA	BRAZIL	54
32	VG	VGB	BRITISH VIRGIN ISLANDS	1
33	IO	IOT	BRITISH INDIAN OCEAN TERRITORY	0
34	BN	BRN	BRUNEI DARUSSALAM	53
35	BG	BGR	BULGARIA	54
36	BF	BFA	BURKINA FASO	54
37	BI	BDI	BURUNDI	54
38	KH	KHM	CAMBODIA	54
39	CM	CMR	CAMEROON	54
40	CA	CAN	CANADA	54
41	CV	CPV	CAPE VERDE	54
42	KY	CYM	CAYMAN ISLANDS	1
43	CF	CAF	CENTRAL AFRICAN REPUBLIC	12
44	TD	TCD	CHAD	54
45	CL	CHL	CHILE	54
46	CN	CHN	CHINA	54
47	HK	HKG	HONG KONG, SPECIAL ADMINISTRATIVE REGION OF CHINA	54
48	MO	MAC	MACAO, SPECIAL ADMINISTRATIVE REGION OF CHINA	3

	ISO ALPHA 2 CODE	ISO ALPHA 3 CODE	COUNTRY	NUMBER OF DATA
49	CX	CXR	CHRISTMAS ISLAND	0
50	CC	CCK	COCOS (KEELING) ISLANDS	0
51	CO	COL	COLOMBIA	54
52	KM	COM	COMOROS	11
53	CG	COG	CONGO (BRAZZAVILLE)	12
54	CD	COD	CONGO, DEMOCRATIC REPUBLIC OF THE	12
55	CK	COK	COOK ISLANDS	1
56	CR	CRI	COSTA RICA	54
57	CI	CIV	CÔTE D'IVOIRE	54
58	HR	HRV	CROATIA	54
59	CU	CUB	CUBA	3
60	CY	CYP	CYPRUS	54
61	CZ	CZE	CZECH REPUBLIC	54
62	DK	DNK	DENMARK	54
63	DJ	DJI	DJIBOUTI	11
64	DM	DMA	DOMINICA	11
65	DO	DOM	DOMINICAN REPUBLIC	54
66	EC	ECU	ECUADOR	54
67	EG	EGY	EGYPT	54
68	SV	SLV	EL SALVADOR	54
69	GQ	GNQ	EQUATORIAL GUINEA	12
70	ER	ERI	ERITREA	12
71	EE	EST	ESTONIA	54
72	ET	ETH	ETHIOPIA	54
73	FK	FLK	FALKLAND ISLANDS (MALVINAS)	1
74	FO	FRO	FAROE ISLANDS	1

	ISO ALPHA 2 CODE	ISO ALPHA 3 CODE	COUNTRY	NUMBER OF DATA
75	FJ	FJI	FIJI	10
76	FI	FIN	FINLAND	54
77	FR	FRA	FRANCE	54
78	GF	GUF	FRENCH GUIANA	0
79	PF	PYF	FRENCH POLYNESIA	1
80	TF	ATF	FRENCH SOUTHERN TERRITORIES	0
81	GA	GAB	GABON	54
82	GM	GMB	GAMBIA	54
83	GE	GEO	GEORGIA	54
84	DE	DEU	GERMANY	54
85	GH	GHA	GHANA	54
86	GI	GIB	GIBRALTAR	1
87	GR	GRC	GREECE	54
88	GL	GRL	GREENLAND	1
89	GD	GRD	GRENADA	10
90	GP	GLP	GUADELOUPE	0
91	GU	GUM	GUAM	0
92	GT	GTM	GUATEMALA	54
93	GG	GGY	GUERNSEY	0
94	GN	GIN	GUINEA	54
95	GW	GNB	GUINEA-BISSAU	12
96	GY	GUY	GUYANA	54
97	HT	HTI	HAITI	54
98	HM	HMD	HEARD ISLAND AND MCDONALD ISLANDS	0
99	VA	VAT	HOLY SEE (VATIKAN CITY STATE)	0
100	HN	HND	HONDURAS	54

	ISO ALPHA 2 CODE	ISO ALPHA 3 CODE	COUNTRY	NUMBER OF DATA
101	HU	HUN	HUNGARY	54
102	IS	ISL	ICELAND	54
103	IN	IND	INDIA	54
104	ID	IDN	INDONESIA	54
105	IR	IRN	IRAN, ISLAMIC REPUBLIC OF	54
106	IQ	IRQ	IRAQ	12
107	IE	IRL	IRELAND	54
108	IM	IMN	ISLE OF MAN	0
109	IL	ISR	ISRAEL	54
110	IT	ITA	ITALY	54
111	JM	JAM	JAMAICA	54
112	JP	JPN	JAPAN	53
113	JE	JEY	JERSEY	0
114	JO	JOR	JORDAN	54
115	KZ	KAZ	KAZAKHSTAN	54
116	KE	KEN	KENYA	54
117	KI	KIR	KIRIBATI	11
118	KP	PRK	KOREA, DEMOCRATIC PEOPLE'S REPUBLIC OF	12
119	KT	KOR	KOREA, REPUBLIC OF	53
120	KW	KWT	KUWAIT	54
121	KG	KGZ	KYRGYZSTAN	54
122	LA	LAO	LAO PDR	11
123	LV	LVA	LATVIA	54
124	LB	LBN	LEBANON	54
125	LS	LSO	LESOTHO	54
126	LR	LBR	LIBERIA	54

	ISO ALPHA 2 CODE	ISO ALPHA 3 CODE	COUNTRY	NUMBER OF DATA
127	LY	LBY	LIBYA	41
128	LI	LIE	LIECHTENSTEIN	0
129	LT	LTU	LITHUANIA	54
130	LU	LUX	LUXEMBOURG	54
131	MK	MKD	MACEDONIA, REPUBLIC OF	54
132	MG	MDG	MADAGASCAR	54
133	MW	MWI	MALAWI	54
134	MYT	MYS	MALAYSIA	54
135	MV	MDV	MALDIVES	12
136	ML	MLI	MALI	54
137	MT	MLT	MALTA	41
138	MH	MHL	MARSHALL ISLANDS	9
139	MQ	MTQ	MARTINIQUE	0
140	MR	MRT	MAURITANIA	54
141	MU	MUS	MAURITIUS	54
142	YT	MYT	MAYOTTE	0
143	MX	MEX	MEXICO	54
144	FM	FSM	MICRONESIA, FEDERATED STATES OF	9
145	MD	MDA	MOLDOVA	54
146	MC	MCO	MONACO	0
147	MN	MNG	MONGOLIA	54
148	ME	MNE	MONTENEGRO	54
149	MS	MSR	MONTSERRAT	1
150	MA	MAR	MOROCCO	54
151	MZ	MOZ	MOZAMBIQUE	54
152	MM	MMR	MYANMAR	2

	ISO ALPHA 2 CODE	ISO ALPHA 3 CODE	COUNTRY	NUMBER OF DATA
153	NA	NAM	NAMIBIA	54
154	NR	NRU	NAURU	1
155	NP	NPL	NEPAL	54
156	NL	NLD	NETHERLANDS	54
157	AN	ANT	NETHERLANDS ANTILLES	1
158	NC	NCL	NEW CALEDONIA	1
159	NZ	NZL	NEW ZEALAND	54
160	NI	NIC	NICARAGUA	54
161	NE	NER	NIGER	12
162	NG	NGA	NIGERIA	54
163	NU	NIU	NIUE	1
164	NF	NFK	NORFOLK ISLAND	0
165	MP	MNP	NORTHERN MARIANA ISLANDS	0
166	NO	NOR	NORWAY	54
167	OM	OMN	OMAN	54
168	PK	PAK	PAKISTAN	54
169	PW	PLW	PALAU	9
170	PS	PSE	PALESTINIAN TERRITORY, OCCUPIED	0
171	PA	PAN	PANAMA	54
172	PG	PNG	PAPUA NEW GUINEA	12
173	PY	PRY	PARAGUAY	54
174	PE	PER	PERU	54
175	PH	PHL	PHILIPPINES	54
176	PN	PCN	PITCAIRN	0
177	PL	POL	POLAND	54
178	PT	PRT	PORTUGAL	54

	ISO ALPHA 2 CODE	ISO ALPHA 3 CODE	COUNTRY	NUMBER OF DATA
179	PR	PRI	PUERTO RICO	51
180	QA	QAT	QATAR	54
181	RE	REU	REUNION	0
182	RO	ROU	ROMANIA	54
183	RU	RUS	RUSSIAN FEDERATION	54
184	RW	RWA	RWANDA	54
185	BL	BLM	SAINT-BARTHELEMY	0
186	SH	SHN	SAINT HELENA	1
187	KN	KNA	SAINT KITTS AND NEVIS	11
188	LC	LCA	SAINT LUCIA	11
189	MF	MAF	SAINT-MARTIN (FRENCH PART)	0
190	PM	SPM	SAINT PIERRE AND MIQUELON	1
191	VC	VCT	SAINT VINCENT AND THE GRENADINES	12
192	WS	WSM	SAMOA	11
193	SM	SMR	SAN MARINO	0
194	ST	STP	SAO TOME AND PRINCIPE	12
195	SA	SAU	SAUDI ARABIA	54
196	SN	SEN	SENEGAL	54
197	RS	SRB	SERBIA	54
198	SC	SYC	SEYCHELLES	54
199	SL	SLE	SIERRA LEONE	54
200	SG	SGP	SINGAPORE	54
201	SK	SVK	SLOVAKIA	54
202	SI	SVN	SLOVENIA	54
203	SB	SLB	SOLOMON ISLANDS	12
204	SO	SOM	SOMALIA	3

	ISO ALPHA 2 CODE	ISO ALPHA 3 CODE	COUNTRY	NUMBER OF DATA
205	ZA	ZAF	SOUTH AFRICA	54
206	GS	SGS	SOUTH GEORGIA AND THE SOUTH SANDWICH ISLANDS	0
207	SS	SSD	SOUTH SUDAN	0
208	ES	ESP	SPAIN	54
209	LK	LKA	SRI LANKA	54
210	SD	SDN	SUDAN	12
211	SR	SUR	SURINAME	54
212	SJ	SJM	SVALBARD AND JAN MAYEN ISLANDS	0
213	SZ	SWZ	SWAZILAND	54
214	SE	SWE	SWEDEN	54
215	CH	CHE	SWITZERLAND	54
216	SY	SYR	SYRIAN ARAB REPUBLIC (SYRIA)	12
217	TW	TWN	TAIWAN, REPUBLIC OF CHINA	54
218	TJ	TJK	TAJIKISTAN	54
219	TZ	TZA	TANZANIA, UNITED REPUBLIC OF	54
220	TH	THA	THAILAND	54
221	TL	TLS	TIMOR-LESTE	53
222	TG	TGO	TOGO	12
223	TK	TKL	TOKELAU	0
224	TO	TON	TONGA	11
225	TT	TTO	TRINIDAD AND TOBAGO	54
226	TN	TUN	TUNISIA	12
227	TR	TUR	TURKEY	54
228	TM	TKM	TURKMENISTAN	3
229	TC	TCA	TURKS AND CAICOS ISLANDS	1
230	TV	TUV	TUVALU	0

	ISO ALPHA 2 CODE	ISO ALPHA 3 CODE	COUNTRY	NUMBER OF DATA
231	UG	UGA	UGANDA	54
232	UA	UKR	UKRAINE	54
233	AE	ARE	UNITED ARAB EMIRATES	54
234	GB	GBR	UNITED KINGDOM	54
235	UM	UMI	UNITED STATES MINOR OUTLYING ISLANDS	0
236	US	USA	UNITED STATES OF AMERICA	54
237	UY	URY	URUGUAY	54
238	UZ	UZB	UZBEKISTAN	12
239	VU	VUT	VANUATU	11
240	VE	VEN	VENEZUELA (BOLIVARIAN REPUBLIC OF)	54
241	VN	VNM	VIET NAM	54
242	VI	VIR	VIRGIN ISLANDS, US	1
243	WF	WLF	WALLIS AND FUTUNA ISLANDS	0
244	EH	ESH	WESTERN SAHARA	1
245	YE	YEM	YEMEN	54
246	ZM	ZMB	ZAMBIA	54
247	ZW	ZWE	ZIMBABWE	54

APPENDIX C
LIST OF CRITERIA AND NUMBER OF CHECK OFFS BY EXPERTS

Criteria	Cluster	UR	PR	Check Off
Number of Procedures Required to Start a Business	T		✓	15
Quality of Port Infrastructure	T		✓	11
Quality of Air Transport Infrastructure	T		✓	10
Availability of Scientists and Engineers in the Country	T		✓	10
Ease of Doing Business	T		✓	9
Quality of Scientific Research Institutions	T		✓	7
Extent of Staff Training	T		✓	6
University - Industry Collaboration In Research & Development	T		✓	6
Quality of Management Schools	T		✓	6
Quality of The Educational System	T		✓	5
Local Availability of Specialized Research	T		✓	5
Capacity for Innovation	T		✓	5
Quality of Math and Science Education	T		✓	4
Availability of Construction Technologies and Skills	T	✓		13
Procedure for Bidding and Design Approvals	T	✓		11
Availability and Quality of Local Contractors	T	✓		11
Poor Quality of Materials	T	✓		11
Language Barrier	T	✓		11
Restrictions on Importation of Materials, Equipment, Spare Parts and Labor	T	✓		11
Delay In Design and Regulatory Approvals	T	✓		10
Information Technology Skills	T	✓		10
Bad Quality of Materials	T	✓		9
Environmental Issues / Regulations	T	✓		9

Criteria	Cluster	UR	PR	Check Off
Strict Quality Requirements	T	✓		9
Work Change Order	T	✓		8
Difficulties to Meet Construction Programs	T	✓		8
Inadequacy of Technical Specification	T	✓		8
Lack of Clarity of Contract Document	T	✓		8
Differences In Material Standards	T	✓		8
Quality of Labor / Technical Staff	T	✓		8
Types of Contracts	T	✓		7
Problems in Technology Transfer and Implementation	T	✓		7
Lack of Standardization In format of Contract Documents	T	✓		7
Unconformity of Imported Materials With Host Country Practice	T	✓		7
Poor Communication Skills of Local Technical Staff	T	✓		7
Differences In Construction Codes / Building Codes	T	✓		6
Well Understood Project Scope and Objectives	T	✓		6
Differences In Design Specifications	T	✓		5
Uncertainty About Lines of Responsibility and Decision Making Procedures	T	✓		5
Increases Standardization / Improves Quality	T	✓		5
Total Tax Rate	E		✓	15
Government Debt	E		✓	14
Business Costs of Crime and Violence	E		✓	13
Business Costs of Terrorism	E		✓	11
Inflation	E		✓	11
Soundness of Banks	E		✓	10
VAT and Sales Tax	E		✓	9
Country Credit Rating	E		✓	9

Criteria	Cluster	UR	PR	Check Off
Intensity of Local Competition	E		✓	9
Budget Balance	E		✓	8
Ease of Access to Loans	E		✓	8
International Liquidity	E		✓	7
Statutory Corporate Tax Rate	E		✓	7
Number of Tax Payments	E		✓	7
Affordability of Financial Services	E		✓	7
Electric Power Consumption (Kwh Per Capita)	E		✓	6
GNI	E		✓	6
Efficacy of Corporate Boards	E		✓	6
Government Budget Balance	E		✓	6
Gross National Savings	E		✓	6
Venture Capital Availability	E		✓	6
Property Rights	E		✓	5
Financing Through Local Equity Market	E		✓	5
Gross Savings (% of GNI)	E		✓	3
Fixed Telephone Lines	E		✓	3
Currency Risk	E	✓		16
Money Transfer From Country	E	✓		14
Contract Currency	E	✓		13
Stability In Taxation Regime	E	✓		12
Currency Devaluation	E	✓		12
Currency Exchange Restrictions	E	✓		12
Custom Delays	E	✓		12
Economic Risk	E	✓		11
Money Transfer to Country	E	✓		11

Criteria	Cluster	UR	PR	Check Off
Stability In Customs Regime	E	✓		11
Material Cost Fluctuation	E	✓		10
Custom Regulations	E	✓		10
Enforceability of Contracts	E	✓		9
Financial Difficulties Because of Currency Exchange Rate	E	✓		9
Cost of Construction Equipment	E	✓		9
Type of Partnership	E	✓		8
Taxation Discrimination	E	✓		8
High Insurance Premiums	E	✓		8
Physical Damage to Project By Riots, Terrorist Act, and So forth	E	✓		7
Positive Financial Impact	E	✓		7
Economic Growth	E	✓		6
Gold and Other Reserves	E	✓		6
Shortage of Financial Resources	E	✓		6
Tax / Nontax Incentives In Construction Industry	E	✓		6
Terms of Financing	E	✓		6
Difficulty In Finding Credits	E	✓		6
Foreign Exchange Reserves	E	✓		5
Sources of Revenue and Major Spending	E	✓		5
Medium and Long Term Financing for Construction Industry	E	✓		5
Financing Difficulties Because of Tax or Capital Movement Restrictions	E	✓		5
Drop In Project Revenue	E	✓		5
Repatriation of Capital / Fund	E	✓		5
Finance Skills	E	✓		4
Current Account Balance	E	✓		3

Criteria	Cluster	UR	PR	Check Off
Time Required to Start a Business	M		✓	15
Investment Profile of Country	M		✓	12
Efficiency of Legal Framework In Settling Disputes	M		✓	12
Legal Rights Preservation	M		✓	12
Country Risk Classifications	M		✓	11
GDP	M		✓	11
Domestic Market Size	M		✓	11
Extent of Marketing	M		✓	9
Imports (Billion \$)	M		✓	9
GDP As A Share of World GDP	M		✓	9
Protecting Investors	M		✓	9
Resolving Insolvency	M		✓	9
Exports (Billion \$)	M		✓	8
Foreign Market Size	M		✓	8
Nature of Competitive Advantage	M		✓	8
Control of International Distribution	M		✓	8
GDP Per Capita	M		✓	7
Efficiency of Legal Framework In Challenging Regulations	M		✓	7
Regulation of Securities Exchanges	M		✓	7
GDP (Purchasing Power Parity)	M		✓	6
Energy Use (Kg of Oil Equivalent Per Capita)	M		✓	5
Intellectual Property Protection	M		✓	5
Protection of Minority Shareholders' Interests	M		✓	5
Extent of Market Dominance	M		✓	5
Size of Informal Sector	M		✓	4
Land Area	M		✓	3

Criteria	Cluster	UR	PR	Check Off
(Sq. Km)				
Economic Crisis	M	✓		16
War	M	✓		16
Terrorist Acts	M	✓		14
Bidding Volume	M	✓		13
Enforceability of Construction Contracts / Contract Issues and Conditions	M	✓		13
Foreign Debt	M	✓		12
Financial Risk	M	✓		12
Financing for Construction Projects	M	✓		12
Likelihood of Project Success	M	✓		12
Exchange Rate Stability	M	✓		10
Religious Tensions	M	✓		10
International Experience	M	✓		7
Alignment With Strategic Direction	M	✓		6
Understanding of Project's Impact on Organization	M	✓		6
Availability of Expert Resources for Assistance	M	✓		6
Low Time to Realize Benefits	M	✓		6
Hostilities With Neighboring Country or Region	M	✓		5
Inability and Reluctance to Communicate	M	✓		5
Irregular Payments and Bribes	P		✓	11
Extent and Effect of Taxation	P		✓	11
Judicial Independence	P		✓	11
Transparency of Government Policymaking	P		✓	10
Paying Taxes	P		✓	10
Favoritism In Decisions of Government officials	P		✓	10
Trading Across Borders	P		✓	10

Criteria	Cluster	UR	PR	Check Off
Registering Property	P		✓	9
Getting Credit	P		✓	9
Employing Workers: Redundancy Cost	P		✓	8
Trade Tariffs	P		✓	8
Ethnic Tensions	P		✓	7
Prevalence of Trade Barriers	P		✓	7
Military In Politics	P		✓	6
Public Trust In Politicians	P		✓	6
Strength of Investor Protection	P		✓	6
Effectiveness of Anti-Monopoly Policy	P		✓	6
Current Composite Risk	P		✓	5
Democratic Accountability	P		✓	5
Diversion of Public Funds	P		✓	5
Wastefulness of Government Spending	P		✓	5
Visa Regime – Working	P	✓		17
Political Continuity / Instability	P	✓		16
Complicated Construction Legislative System and Laws	P	✓		15
Government Act and Regulations	P	✓		14
Problems With Local Banking System	P	✓		13
Frequently Changing Laws	P	✓		13
Government Stability	P	✓		12
Bureaucratic Delays	P	✓		12
Political Risk	P	✓		12
External Conflict	P	✓		12
Bureaucracy Quality	P	✓		12
Change In Policies	P	✓		9

Criteria	Cluster	UR	PR	Check Off
Nationalization / Expropriation	P	✓		8
Clarity of Local Laws	P	✓		8
Lack of Transparency In Government Procurement Policies / Bidding Procedures	P	✓		8
Changes In International Relations	P	✓		8
Poor International Relations	P	✓		8
Law & Order	P	✓		8
Interpretation of Law	P	✓		7
Restrictions to Scope of Engineering Activities for Foreign Entrants	P	✓		7
Nationalization / Expropriation	P	✓		6
Hostilities With Neighboring Country or Region	P	✓		6
Fragmented Political Structure	P	✓		6
Mentality, Including Nationalism, Corruption and Dishonesty	P	✓		6
Financial Institutions Transparency	P	✓		6
Government Incentives	P	✓		5
Societal Conflicts (e.g. Demonstrations, Strikes, & Street Violence)	P	✓		5
Government Subsidy	P	✓		5
Political Arrest and Expulsions	P	✓		5
Attitude Towards Globalization	P	✓		4
Restraints to Retaining Power	P	✓		3
Instability Because of Nonconstitutional Changes	P	✓		3
Lack or Inaccessibility of Business Support Mechanisms	P	✓		3
Quality of Overall Infrastructure	O		✓	14
Burden of Customs Procedures	O		✓	13
Pay and Productivity	O		✓	13
Dealing With Construction Permits	O		✓	12

Criteria	Cluster	UR	PR	Check Off
Local Supplier Quantity	O		✓	12
Getting Electricity	O		✓	11
Quality of Roads	O		✓	11
Employing Workers: Difficulty of Redundancy	O		✓	8
Mobile Telephone Subscriptions	O		✓	8
Hiring and Firing Practices	O		✓	8
Reliance on Professional Management	O		✓	8
Burden of Government Regulation	O		✓	8
Quality of Railroad Infrastructure	O		✓	6
Available Airline Seat Kilometers	O		✓	6
Improved Water Source	O		✓	5
Female Participation In Labor force	O		✓	5
Internet Bandwidth	O		✓	5
Employing Third Country Workers	O	✓		17
Safety Rules / Practices	O	✓		17
Employing Turkish Workers	O	✓		16
Security Risks	O	✓		16
Employing Local Workers	O	✓		15
Unfavorable Visa Regulations	O	✓		15
Availability of Construction Materials	O	✓		14
Lack of Local Skilled Labor	O	✓		14
Communication and Transportation	O	✓		12
Availability of Equipment and Parts	O	✓		12
Labor Cost / Productivity	O	✓		11
Delays In Material Supply	O	✓		11
Unavailability of Spare Parts	O	✓		11

Criteria	Cluster	UR	PR	Check Off
Equipment Cost	O	✓		11
Quality / Technical Capability of Local Contractors	O	✓		10
License and Permit Requirements	O	✓		10
Lack of Infrastructure	O	✓		10
Lack of Coordination and Communication With The Client Organizations	O	✓		10
Unavailability of Repair and Maintenance Services of Equipment's	O	✓		10
Weather Conditions and Other Natural Causes of Delay	O	✓		9
Visa Regime – Touristic	O	✓		9
Labor Cost Fluctuation	O	✓		9
Labor Productivity	O	✓		9
Frequent Change Orders of the Client	O	✓		9
Availability of Special Equipment	O	✓		8
Third Party Delays	O	✓		8
Working Hours	O	✓		8
Climate Conditions	O	✓		7
Bad Quality of Workmanship	O	✓		6
Competent Senior Managers	O	✓		6
Registration Property	O	✓		6
Tariff Barriers	O	✓		6
Professional Services Other than Construction	O	✓		6
Concern About Local Subcontractors	O	✓		6
Differences In Management Philosophy	O	✓		3
Organized Crime	S		✓	15
Reliability of Police Services	S		✓	13
Ethical Behavior of Firms	S		✓	13

Criteria	Cluster	UR	PR	Check Off
Business Impact of Malaria	S		✓	12
Cooperation In Labor-Employer Relations	S		✓	12
Corruption Rank	S		✓	11
Business Impact of HIV / AIDS	S		✓	11
Prevalence of Foreign Ownership	S		✓	11
Flexibility of Wage Determination	S		✓	9
Buyer Sophistication	S		✓	8
Employing Workers: Rigidity of Hours	S		✓	8
Unemployment Rate (%)	S		✓	7
Business Impact of Tuberculosis	S		✓	7
Birth Rate	S		✓	5
Improved Sanitation Facilities	S		✓	5
Adjusted Net National Income Per Capita (Current Us\$)	S		✓	4
Rate of Urbanization	S		✓	3
Political Corruption	S	✓		13
Attitude Toward Foreign Investors and Profit	S	✓		11
Delay In Regulatory Approvals	S	✓		11
Societal Conflicts (e.g. Demonstrations, Strikes, and Street Violence) / Social Unrest	S	✓		11
Social Conditions (e.g. Population Density & Wealth Distribution)	S	✓		10
Fights With Local Labor Unions	S	✓		10
Possibility of Contractual Disputes	S	✓		10
Internal Conflict	S	✓		9
Corruption	S	✓		9
Socioeconomic Conditions	S	✓		9
Attitude toward Foreign Investors and Profit for Foreign Firms	S	✓		8

Criteria	Cluster	UR	PR	Check Off
Mentality, Including Nationalism, Corruption and Dishonesty	S	✓		8
Flexibility and Adaptability	S	✓		7
Racial Factors	S	✓		7
Immature Legal System	S	✓		7
Likely Willingness of Organization to Adopt Project	S	✓		7
Interaction of Foreign Management With Local Contractors	S	✓		6
Fractionalization By Language, Ethnic, and Regional Groups	S	✓		6
Bribery	S	✓		6
Protectionism / Local Preference	S	✓		6
Conflicts Between The Private Business Interests and The State Bureaucracy	S	✓		6
Religious Conflicts	S	✓		6
Public Resistance / Non-Cooperation of Public Residents / Plain Dislike of Foreigners	S	✓		6
Cultural Differences / Condition	S	✓		5
Difference In Traditions	S	✓		5
Actual Laws Versus Practices for Repatriation of Capital	S	✓		4
Religion	S	✓		4

APPENDIX D
CRITERIA IN EACH CLUSTER

Criteria under Technical Cluster considered in the program:

Cluster	Type	Criteria Name
TECHNICAL	PDP	Number of Procedures Required to Start a Business
		Quality of Port Infrastructure
		Availability of Scientists & Engineers
		Quality of Air Transport Infrastructure
		Starting a Business
		Quality of Management Schools
		Extent of Staff Training
		University - Industry Collaboration in R&D
		Quality of Scientific Research Institutions
	PDUR	Availability of Construction Technologies & Skills
		Procedure For Bidding & Design approvals
		Language Barrier
		Delay In Design & Regulatory approvals
		Quality of Materials
		Import Restrictions of Material, Equipment & Spares
		Availability & Quality of Local Contractors

Criteria under Economical Cluster considered in the program:

Cluster	Type	Criteria Name
ECONOMICAL	PDPR	Total Tax Rate
		Government Debt
		Intensity of Local Competition
		Oil Reserves
		Business Costs of Terrorism
		Business Costs of Crime & Violence
		Soundness of Banks
		Inflation
		Country Credit Rating
	PDUR	Currency Risk
		Delay In Payments
		Contract Currency
		Money Transfer From Country
		Stability In Taxation Regime
		Custom Delays
		Currency Exchange Restrictions

Criteria under Market Future Cluster considered in the program:

Cluster	Type	Criteria Name
MARKET FUTURE	PDPR	Time Required to Start a Business
		Efficiency of Legal Framework In Settling Disputes
		Legal Rights Index
		Country Risk
		Domestic Market Size Index
		Protecting Investors
		Resolving Insolvency
		GDP
		GDP As A Share of World GDP
	PDUR	War
		Economic Crisis
		Terrorist Acts
		Bidding Volume Index
		Enforceability of Contracts, Contract Issues & Conditions
		Likelihood of Project Success
		Financing For Construction Projects

Criteria under Political Cluster considered in the program:

Cluster	Type	Criteria Name
POLITICAL	PDPR	Irregular Payments & Bribes
		Judicial Independence
		Transparency of Government Policymaking
		Extent & Effect of Taxation
		Paying Taxes
		Favoritism In Decisions of Government Officials
		Getting Credit
		Trading Across Borders
		Registering Property
	PDUR	Visa Regime – Working
		Political Continuity / Instability
		Bureaucratic Delays
		Problems With Local Banking System
		Government Act & Regulations
		Frequently Changing Laws
		Complicated Construction Legislative System & Laws

Criteria under Operational Cluster considered in the program:

Cluster	Type	Criteria Name
OPERATIONAL	PDPR	Quality of Overall Infrastructure
		Burden of Customs Procedures
		Pay & Productivity
		Local Supplier Quantity
		Getting Electricity
		Dealing With Construction Permits
		Quality of Roads
		Hiring & Firing Practices
		Burden of Government Regulation
	PDUR	Safety Rules / Practices
		Employing Third Country Workers
		Employing Turkish Workers
		Unfavorable Visa Regulations
		Security Risks
		Employing Local Workers
		Lack of Skilled Labor

Criteria under Social Cluster considered in the program:

Cluster	Type	Criteria Name
SOCIAL	PDPR	Organized Crime
		Reliability of Police Services
		Ethical Behavior of Firms
		Cooperation In Labor-Employer Relations
		Business Impact of Malaria
		Flexibility of Wage Determination
		Business Impact of HIV/AIDS
		Corruption Rank
		Prevalence of Foreign Ownership
	PDUR	Political Corruption
		Fights With Local Labor Unions
		Delay In Regulatory Approvals
		Possibility of Contractual Disputes
		Social Conditions (Population Density & Wealth Distribution)
		Societal Conflicts (Demonstrations, Strikes, Social Unrest)
		Attitude Toward Foreign Investors & Profit

LIST OF ABBREVIATIONS

α	: Threshold Value
AAS	: Analitik Ağ Süreci
AHP	: Analytic Hierarchy Process
ANP	: Analytic Network Process
BLS	: United States Bureau of Labor Statistics
CIA	: Central Intelligence Agency
CICA	: Confederation of International Contractors' Associations
CR	: Consistency Ratio
DEMATEL	: Decision Making Trial and Evaluation Laboratory
DM	: Decision Maker/s, Decision Making
DRM	: Direct Relation Matrix
DSS	: Decision Support System
ENR	: Engineer's News Record Magazine
ICRAM	: International Construction Risk Assessment Model
ICRG	: International Country Risk Guide
IFC	: International Finance Corporation
FIEC	: Federation de l'Industrie Europeenne de la Construction
FIIC	: Federacion Interamericana de la Industria de la Construcccion
FST	: Fuzzy Sets Theory
GDP	: Gross Domestic Product
IC	: International Contractor/s
ICRG	: International Country Risk Guide
IJV	: International Joint Venture
IRM	: Impact Relation Matrix

KVDDL	: Karar Verme Deneme ve Değerlendirme Laboratuvarı
MCDA	: Multiple Criteria Decision Analysis
MCDM	: Multi Criteria Decision Making
OECD	: Organisation for Economic Cooperation and Development
PD	: Program Defined
PCM	: Pairwise Comparison Matrix
PDPR	: Program Defined Program Rated
PDUR	: Program Defined User Rated
PPP	: Purchasing Power Parity
PR	: Program Rated
RBS	: Risk Breakdown Structures
SEM	: Structural Equation Model
TCA	: Turkish Construction Association
TEMPOS	: Technical, Economical, Market, Political, Operational, Social
TEMPOS β	: Beta Version of TEMPOS Program
TI	: Transparency International
TIC	: Turkish International Contractors
TOP-100	: Top 100 International Contractors Listed in Engineer's News Record Magazine
TOP-225	: Top 225 International Contractors Listed in Engineer's News Record Magazine
UDUR	: User Defined and User Rated
UD	: User Defined
UR	: User Rated
UN	: United Nations
WEF	: World Economic Forum