A RISK ASSESSMENT MODEL WITH ANALYTIC NETWORK PROCESS IN COMMERCIAL REAL ESTATE DEVELOPMENT PROJECTS

by

Ayça Yetişkin Elibol

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ABSTRACT

A RISK ASSESSMENT MODEL WITH ANALYTIC NETWORK PROCESS IN COMMERCIAL REAL ESTATE DEVELOPMENT PROJECTS

Risks and uncertainties are of rapidly growing concern in commercial real estate development (CRED) projects, affect all stages of the projects from feasibility, conceptual design to handover period. All the risks and uncertainties may influence projects' objectives by leading to cost and time overruns, schedule delays and poor quality. The decision-making processes in which developers, investors, and related team leaders and members involved are affected by these risk and uncertainties. In this study, the main objective is to identify and prioritize the risk criteria and introduce an Analytic Network Process (ANP) model to assess the risk criteria in CRED projects in Turkey. It aims to provide some perspectives to increase the effectiveness of the decision-making process. Within this purpose, risk criteria related to CRED projects are defined and categorized. The criteria list is provided based on a literature review and opinions of experts. Subsequently, identified risk criteria are categorized under "PMEP" groups as Political, Monetary, Environmental and Project risks. Interrelations and relative importance rates data are gathered with the help of the expert team. Then, the priorities and importance weights are calculated using ANP. Findings of this study focus on the importance of "Exchange rate and inflation rate fluctuations" in "Monetary risks" category; "Political instability" in "Political Risks" criteria and "Location selection risk" in the "Project risks" category. Case studies are used to test the effectiveness of the proposed model. This model provided a perspective for decision - makers or stakeholders of the projects in the CRED industry to evaluate the risk criteria and they may benefit from the developed model to assess the risks of their projects and to take proper actions.

ÖZET

ANALİTİK AĞ SÜRECİ MODELİ İLE TİCARİ GAYRİMENKUL GELİŞTİRME PROJELERİNİN RİSKLERİN DEĞERLENDİRİLMESİ

Ticari gayrimenkul geliştirme (CRED) projelerinde risk ve belirsizlikler hızla artmakta ve projelerin fizibilite ve kavramsal tasarım süreçlerinden devir teslim süresine kadar olan tüm aşamalarını etkilemektedir. Tüm bu riskler ve belirsizlikler, maliyet ve zaman aşımına, gecikmelere ve düşük kaliteye yol açarak projelerin hedeflerini etkileyebilir. Geliştiricilerin, yatırımcıların ve ilgili ekip liderlerinin ve üyelerin dahil olduğu karar alma süreçleri bu risk ve belirsizliklerden etkilenir. Bu çalışmada temel amaç, Türkiye'deki ticari gayrimenkul geliştirme projelerinin yatırım kararı süreçlerinde karşılaşılan risk kriterlerini belirleyip önceliklendirmek ve geliştirilen "Analitik Ağ Süreci" modeli ile değerlendirmektir. Akabinde, karar verme sürecinin etkinliğini arttırmaya yönelik bazı perspektifler ve yorumlar sunmaktır. Bu amaçla, ticari gayrimenul projelerinin geliştirme kararları sırasında karşılaşılan risk kriterleri tanımlanmış ve kategorize edilmiştir. Literatür taraması ve uzman kişilerin görüş ve önerileri dikkate alınarak risk kriterleri listesi elde edilmiştir. Daha sonra, belirlenen risk kriterleri "Politik Riskler", "Parasal Riskler", "Çevresel Riskler" ve "Proje Riskleri" grupları altında toplanmıştır. Kriterler arası ilişkiler ve göreli önem dereceleri verileri uzman ekibin görüşleri yardımıyla değerlendirilerek ve Analitik Ağ Süreci kullanılarak öncelikler ve önem dereceleri hesaplanmıştır. Bu çalışmanın bulguları "Parasal riskler" kategorisindeki "Döviz kuru ve enflasyon dalgalanma" risklerinin; "Politik Riskler" kriterinde yer alan "Politik istikrarsızlık" riskinin ve "Proje Riskleri" kategorisindeki "Yer seçimi riski" faktörlerinin projenin geliştirme kararı üzerindeki önemlerini ortaya koymuştur. Önerilen modelin etkinliğini test etmek için vaka çalışmaları kullanılmıştır Ayrıca, ticari gayrimenkul geliştirme pazarındaki karar vericilerdir.

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LIST OF ACRONYMS/ABBREVIATIONS

AHP	Analytic Hierarchy Process
ANP	Analytic Network Process
APM	UK Association for Project Management
CRE	Commercial Real Estate
CRED	Commercial Real Estate Development
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GLA	Gross Leasable Area
JV	Joint Venture
PMBoK	Project Management Body of Knowledge Guide
PMI	Project Management Institute
PRAM	Project Risk Analysis and Management Guide
RMP	Risk Management Process
ROI	Return on Investmen
TurkStat	Turkish Statistical Institute

1. INTRODUCTION

The introduction chapter of the thesis explains the background of the research, related studies, aim and objectives of the study, methodology, scope and limitations, and organization of the thesis.

1.1. Background of the Research

The construction industry is accepted to be one of the primary sources of national economic growth and has a direct contribution to the economic development of the country. The sector has a role in the national economy in terms of the inputs it uses, because of the demand produced connected sub-sectors. This development is considered a driving force by taking into account the relation between other sectors, generation of employment for skilled/unskilled workers. Hence, it provides the most straightforward way of economic development by raising the employment rate of the economy.

As in many other economies around the world, the Turkish construction sector has been a leading indicator of the growth of the national economy in Turkey. According to KPMG Construction Report 2019 based on the Turkish Statistical Institute (TurkStat) data, throughout the years of 2003-2007 and 2010-2014, the growth of construction industry increased at a faster rate than economic growth and it was above 7-percent. Nevertheless, the construction industry has shrunk dramatically by the global financial crisis of 2008-2009. Table 1.1 shows the contribution of each sector to the gross domestic product (GDP) growth.

Table 1.1. KPMG Report Turkey GDP Growth Value Added (% of GDP).

Interval Year	Agriculture	Industry	Construction	Trade and Services	GDP Growth
2003-2007	0.1%	1.7%	0.9%	4.7%	7.0%
2008-2009	0.3%	-0.7%	-0.7%	-0.8%	-1.0%
2010-2014	0.2%	1.8%	0.9%	4.8%	7.7%
2015-2016	0.2%	0.9%	0.4%	3.1%	4.7%
2017	0.3%	1.8%	0.7%	4.6%	7.4%
2018 Q1	0.1%	1.7%	0.5%	4.9%	7.2%
2018 Q2	-0.1%	0.8%	0.1%	4.5%	5.3%
2018 Q3	0.1%	0.1%	-0.4%	1.8%	1.6%

Once the construction industry had a performance better than average growth between 2010 and 2014, it started to coincide closely with the average economic growth during 2015. Even in the fourth quarter of 2017, the industry's growth stayed below the growth of average economic growth. The relation is shown in Figure 1.1 representing the construction industry growth and GDP growth rate of Turkey (KPMG's "Sector Report - Construction 2019" Report).

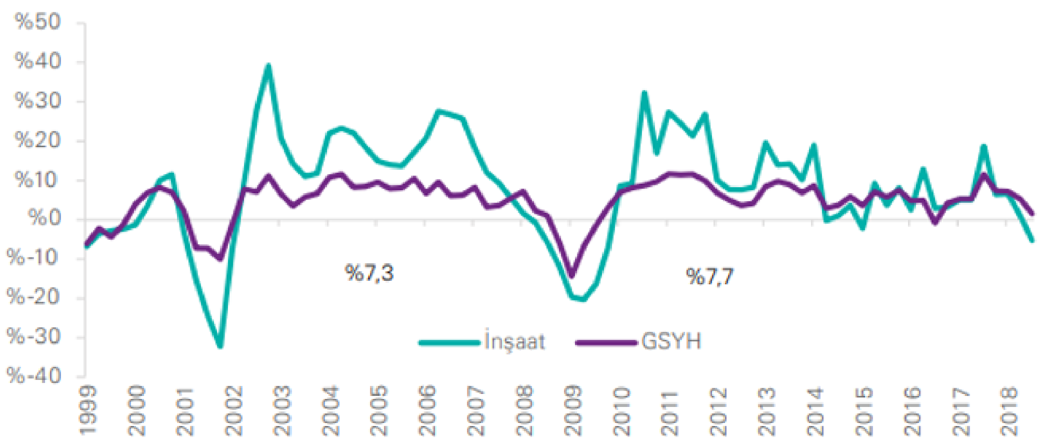

Figure 1.1. KPMG Report Growth Rates in Construction Industry and GDP Growth.

According to the latest TurkStat data published in March 2019, Turkish economy grew 2.6 percent in terms of real GDP compared to the previous year and GDP increased by 19.1 percent with the amount of 784 billion dollars. Construction industry contributed 7.23 percent shares of GDP in 2018 whereas, in the previous years; 8.1 percent share of GDP in 2013, 8.1 percent in 2014, 8.2 percent in 2015 and 8.6 percent in 2016 and 2017 respectively. When real estate and naturally construction industries' impacts on other industries are taken into account, it could be stated that the sector is one of the main driving forces in national economic growth.

Commercial Real Estate (CRE) sub-segment, which has an impact on the construction industry, is one of the main components of the national economy, society wealth and development. For instance, CRE investment had a great contribution to Foreign Direct Investment (FDI) and economic growth, particularly between 2003-2007 years. According to Çoskun (2010), "2003-2007 year period could be accepted as the boom period for Turkish economy in general and real estate sector in specific. Although there are considerable opportunities in the market, both Turkish economy and real estate sector suffer important structural problems". Besides the significance of CRED projects in terms of contribution to economic growth and development, the CRED projects are characterized by inherent risk and uncertainties as a result of their distinctive feature and competitive nature as well.

This thesis focuses on the risk assessment of commercial real estate development (CRED) projects and it aims to provide recommendations to increase the effectiveness of decision-making on the development process.

1.2. Related Studies

All real estate development projects include many risks and uncertainties which affect the decision-making process in which developers, investors, and related team leaders and members involved. Also, these risks and uncertainties influence projects' objectives by leading cost overrun, delay and poor quality. Chen and Khumpaisal (2009) stated that "Risks and uncertainties occur in all real estate development projects, particularly in the complicated real estate projects. Risks can strongly influence to each project stages from the project conceptual, project feasibility analysis, design and planning, bidding and tendering, construction and execution, and handover stage".

Related studies regarding risk assessment, decision making studies and methodologies have been covered in literature section of the thesis. For example, Mustafa and Al-Bahar (1991) studied the risk assessment of bridge construction in Bangladesh. Bing *et al.* (1999) designated the risk factors related to international construction joint ventures (JVs) by dividing into three main groups as the internal, project- specific and external. Hastak and Shaked (2000) have constructed an international construction risk assessment model (ICRAM-1) that evaluates risk criteria, including macro (country level), market and project levels.

Also, some research studies in the literature have investigated the risk assessment criteria in various countries e.g., United Kingdom (Bing *et al.* 2005), Dubai (El-Sayegh 2008), China (Shen et. al (2001) , Netherland (Gehner *et al.* 2006), etc. As an example, El-Sayegh (2008) identified and assessed the significant risks in the UAE construction industry and addressed their proper allocation. Bing *et al.* (2005) explored risk allocation in Public/private partnership construction projects in the United Kingdom. A survey questionnaire was used to canvass the opinions of people with experience in Public/private partnership projects.

Many decision-making methodologies and tools were observed in related studies and they gave the idea of using an appropriate decision-making method. For instance, Chen and Khumpaisal (2009) developed an ANP model by providing an approach to support developers in the decision-making process. The model also provides the selection of best alternatives in Liverpool City Center specific location. Mustafa and Al-Bahar (1991) reviewed the AHP model for the risks assessment of bridge construction in Bangladesh. Zeng *et al.* (2007) used the Fuzzy AHP risk assessment in complicated construction situations approach by reviewing human factors, site factors and material and equipment risk factors of projects. A modified analytical hierarchy process is used to structure and prioritize diverse risk factors. Dikmen *et al.* (2010) conducted an ANP study with the Delphi method for identifying the determinants of business failure in construction and to predict the failure likelihood of construction companies by assessing their current situation based on both company-specific and external factors.

1.3. Aim and Objectives of the Study

The aim of this research is to provide a decision-making approach to assess risk criteria in CRED projects in Turkey. In the meantime, this thesis also focuses on developing a model based on the analytic network process (ANP) theory.

To attain the aim, the following objectives of the research are identified.

- To identify the risk criteria which affect CRED projects in Turkey.
- To classify risk criteria and determine interrelations among identified risk factors through literature review and interview sessions.
- To assess the relation of interdependencies between risk factors and their important weight
- To develop proper decision-making model, which is ANP, to evaluate the risk of CRED projects in Turkey.
- To provide a tool for decision-makers in the real estate development industry to evaluate different development plans taking into account interrelations among risk criteria.
- To obtain the most and least important factors in development decision
- To represent the proposed model effectiveness by testing case studies.

1.4. Methodology

In order to be able to fulfill the previously stated aim and objectives, firstly a literature review study about the risk assessment in ANP process in both construction and real estate industry is performed. In the literature review study, encountered risk criteria are examined to determine risk factors in CRED projects and the decision making methodologies are observed to use the proper method to obtain importance rates of risk criteria.

Subsequently, a face-to-face interview with the real estate expert is performed to provide a confirmation and gain information about the risk criteria encountered in CRED projects in Turkey. After a detailed literature review and interview session, the final risk criteria are listed. When the used decision-making methods in the literature are examined, ANP, as the most proper method for the thesis, is selected considering the interrelation relation of the factor.

Then, an expert team is constructed to obtain the interrelations between factors and pairwise comparisons. In the next step, an ANP model is developed based on a review of experts, then interrelation and pairwise comparison matrices are finalized. Priorities and importance weights are calculated in the constructed ANP model using "SUPERDECISION" software program. By this way, a case study is conducted to test the validity and applicability of the model. Hence, the results of software output are evaluated and discussed and recommendations for future studies are presented.

1.5. Scope and Limitations

This thesis focuses on risk criteria in CRED projects where limited studies covered the risk factors in the literature. Risks and uncertainties are associated with all CRED projects and they can strongly influence all related progress in the entire lifecycle of properties. Specifically, those risks can occur at the initial phase of a project when developers conduct feasibility study, design and planning, construction, or even during marketing or handover period, meanwhile, risks existing in the initial stage can also influence the use of the property as well (Chen and Khumpaisal, 2009).

Although there are limited numbers of studies related to the risk factors of CRED projects, many studies examine the risk factors in any other types of construction projects in different countries. The risk factors of CRED projects in Turkey should have been determined and analyzed since other studies in the literature are country and they focus on general types of construction projects. Shortly, research studying the risk factors of CRED projects specific to the Turkish real estate market does not exist in the literature. Therefore, this research has a significant contribution by identifying and evaluating the risk criteria in CRED projects decision-making process also aims to fill the gap in the literature by conducting the ANP model in this specific field.

1.6. Organization of Thesis

In chapter 2, previous studies of the related literature about risk assessment in real estate and other construction projects, analytic hierarchy process (AHP) and ANP concept which is utilized in this research and their applications are examined. Additionally, the research question is explained in the literature review section.

In Chapter 3, the research methodology is explained in detail, including the literature review, the theoretical background of AHP and ANP. Interrelation matrix, model formation and pairwise comparison matrices and the importance of the weight of elements are given in this chapter.

In Chapter 4, risk criteria findings are listed through literature review and interview session. Data collection meetings are examined in detail. Obtained interrelation matrix, constructed ANP model based on case studies, pairwise matrices, "SUPERDECISION" software principles are stated and tried to be clarified.

In Chapter 5, the discussion of the study based on research findings is presented.

In Chapter 6, the conclusion of the study and recommendations for future studies are presented in this chapter.

2. LITERATURE REVIEW

This section explains CRE industry, the summary of the risk and risk management process (RMP) terminology, the literature review related to risk factors in the construction industry and real estate industry, categorization of risk factors and their effects on projects. Subsequently, the gap in the literature and problem statement of research are defined clearly.

Determination and classification of risk factors of this research and methodology are explained in Chapter 3.

2.1. Commercial Real Estate

Commercial real estate (CRE) is comprised of real estates which are used for a business purpose such as shopping malls, offices, hotels, logistics and etc. According to JLL Turkey CRE Market Overview Report shown in below Table 2.1, 431 shopping malls with a total gross leasable area (GLA) of 12.9 million square meters are operational in Turkey and 123 shopping mall with 4.7 million square meters GLA in Istanbul by representing approximately 37 percent of the total GLA in Turkey.

Table 2.1. JLL 2018 Report Shopping Mall Development: GLA and Unit.

Location	**Detail**	**Active**	**Under Construction**	**Total**
Istanbul	Unit	123	15	138
	GLA(sqm)	4.753.477	460.486	5.213.963
Ankara	Unit	42	6	48
	GLA(sqm)	1.641.629	207.5	1.849.129
Rest of Turkey	Unit	266	17	283
	GLA(sqm)	6.526.775	764.979	7.291.754
Total	Unit	431	38	469
	GLA(sqm)	12.921.881	1.432.965	14.354.846

Offices that can provide different services to users' demand are mainly located in the metropolitans and central regions. Due to a lack of quality office stock, especially in metropolitans in Turkey, office projects show improvement. Rent returns and sales fluctuate depending on the supply-demand balance. As a result of fluctuations, the number of stocks increases.

According to JLL Turkey CRE Market Overview Report shown in below Table 2.2, as of 2018 year-end, the Grade A office, which has the best location and the highest rent value in the city's office market, stock in Istanbul is 5.5 million square meters GLA with 254 units. After the constructions and office development are completed, the stock will reach almost 7.4 million square meters GLA with 274 office building.

Table 2.2. JLL 2018 Report Office Development: GLA and Unit.

Location	**Detail**	**Active**	**Under Construction**	**Total**
Europe	Unit	146	4	150
	GLA(sqm)	3.588.857	289,400	3.878.257
Asia	Unit	108	16	124
	GLA(sqm)	1.984.595	1.556.930	3.541.525
Total	Unit	254	20	274
	GLA(sqm)	5.573.452	1.846.330	7.419.782

Logistics market is also another important sub-segment for Turkish CRE development market. According to JLL Report, 2018, there are more than 11 million square meters logistics GLA are developed in Istanbul and Kocaeli. Domestic and foreign e-commerce companies, which has a remarkable growth trend in 2018, are envisaged to maintain their momentum in the upcoming year. The growth of e-commerce and retail companies may contribute to the mobility of leasing transactions in the logistics market.

Besides the significance of CRED projects in terms of contribution to economic growth and development, the CRED projects are characterized by inherent risk and uncertainties as a result of their distinctive feature and competitive nature as well.

From the initial stage of the projects to the sales and marketing or handover process, real estate developers face with many challenges by taking the most considerable risks. These risks have a strong effect on the whole lifecycle of the projects (Chen and Khumpaisal 2009). For instance, uncertainty in weather and climate prediction or technical risks occurred in project site are some of the most typical risks which exist in all project. As a consequence, many projects success and fail.

2.2. Risk Definition

There are numerous definitions of the terms “risk” and “uncertainty” which are the most used terminologies in literature. Whereas many authors have preferred to define them separately, some of them have preferred to combine with a broad definition. The definitions have changed for many years and all descriptions have become closer in a sense based on their particular differences. Cleden stated that “Risk is the statement of what may arise from that lack of knowledge” and also defined the “uncertainty” as “Uncertainty is the intangible measure of what we do not know. Uncertainty is what is left behind when all the risks have been identified” (Cleden 2009).

The general definition of “risk” stated in A Guide to the Project Management Body of Knowledge (PMBoK Guide) - Sixth Edition (The Project Management Institute, PMI, 2017 is “an uncertain event or condition that, if it occurs has a positive or negative effect on one or more project objectives”. PMBoK also defined “project risk” as “the effect of uncertainty on the project as a whole”.

As Raz and Hilson (2005) stated that while some authors have defined the term “risk” as opportunity and update or threat, others might have described it, as uncertainties in a negative meaning or prefer to explain broadly. As Raz and Hilson (2005) presented and summarized risk definitions based on nine significant risk management standards including PMBoK (2000) with dividing into three groups: subsequently, those which use negative meaning with “threat”, those which use neutral definitions not positive or negative and those which define the term “risk” as including meaning both threat or opportunity. All definitions are shown in Figure 2.1 below.

Negative definitions	Neutral definitions	Broad definitions
CAN/CSA-Q850-97:1997: 'the chance of *injury or loss*'	AS/NZS 4360:2004: 'the chance of something happening that will have *an impact* upon objectives'	PMBoK® 2004: 'an uncertain event or condition that, if it occurs, has *a positive or negative effect* on a project objective … includes both *threats* to the project's objectives and *opportunities* to improve on those objectives'
IEEE 1540:2001: 'the likelihood of an event, *hazard, threat* or situation occurring and its *undesirable consequences; a potential problem*'	BS6079-3:2000: 'uncertainty … that *can affect* the prospects of achieving … goals'	IRM/ALARM/AIRMIC 2002: 'combination of the probability of an event and its consequence … consequences can range *from positive to negative*'
	IEC 62198:2001: 'combination of the probability of an event occurring and its *consequences* for project objectives'	PRAM Guide 2004: 'an uncertain event or set of circumstances which, should it occur, will have *an effect* on achievement of … objectives … *either positively or negatively*'
	JIS Q2001 (E): 'a combination of the probability of an event and its *consequence*'	

Figure 2.1. Risk Definition List Based on Major Risk Management Standards Raz and Hilson, 2005.

Besides defining the term "risk" in three different groups, The Project Risk Analysis and Management (PRAM 2018) Guide (Association for Project Management APM, 2018) has defined the risk by separating between "risk event" and "project risk" to understand the risk terminology and RMP. PRAM Guide explicitly stated the risk event as:

- A risk event is an uncertain event or set of circumstances which, should it occur, will affect the achievement of one or more of the project's objective Subsequently, Guide has defined the "project risk" as follows:
- A project risk is the exposure of stakeholders to the consequences of variations in outcome.

Based on the definitions, it can be said that a key element of defining the risk that recognition of the uncertainties which affect project objectives achievement in a positive, negative or neutral way (PRAM Guide 2004). At that point, the RMP tool is designed to recognize risk, avoid or minimize threats and maximize opportunities.

2.3. Risk Management Process

Risk Management includes the processes of conducting risk management planning, identification, analysis, response planning, response implementation, and monitoring risk on a project. The objectives of project risk management are to increase the probability and/or impact of positive risks and to decrease the probability and/or impact of negative risks, in order to optimize the chances of project success (PMBoK, Guide 2017).

RMP (Risk Management Process) is the process of identifying, analysing and responding of the risk groups, factors or criteria to achieve the goal or objectives of the project (PMBoK, Guide 2000). Cooper *et al.* 2005 stated that "The RMP involves the systematic application of management policies, processes and procedures to the tasks of establishing the context, identifying, analyzing, assessing, treating, monitoring and communicating risks (Cooper *et al.*, 2005).

As abovementioned before, risk recognition is a crucial element for achieving objectives of projects. At that point, the RPM provides a systematic approach related to identifying, analyzing and responding to the risk. It provides maximizing the consequence of positive events or opportunities and minimizing threats. Figure 2.2 gives a risk management overview of the following processes;

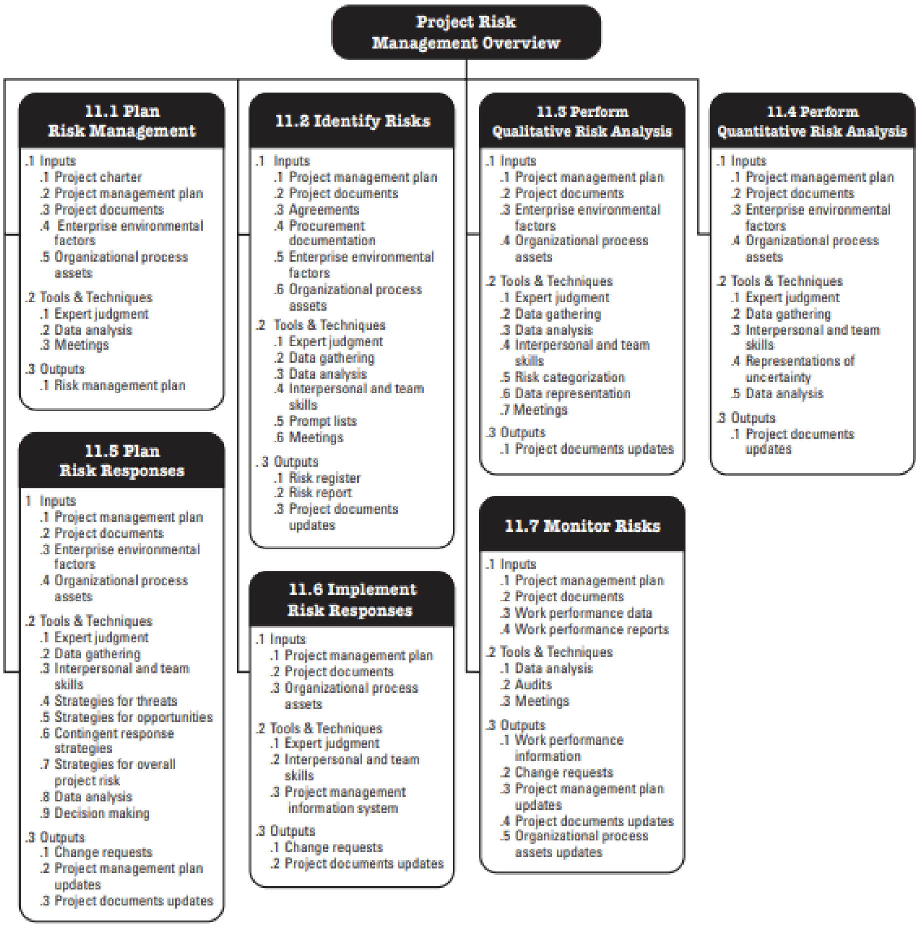

Figure 2.2. PMBoK 2017 Risk Management Overview.

2.3.1. Risk Identification

Risk identification is the first step, and one of the most crucial phases for RPM since the result of this process might affect the following phases. This first step also provides a link to combine all RMP. Effective and well-defined risk criteria provide detail information and clarification by decreasing the level of uncertainty (Merna and Al-Thani, 2008).

Risk identification is of considerable importance since the processes of risk analysis, and response management can only be performed on identified potential risks (Al-Bahar and Crandall, 1990). Thus, it becomes more possible to analyze the identified risk in the following stages. Therefore, effective risk identification stage is the crucial point for precise RMP. (Kıral *et al.*, 2014).

According to PMI (2004), "Risks and other threats can be hard to eliminate, but when they have been identified, it is easier to take actions and have control over them. If the causes of the risks have been identified and allocated before any problems occur, the risk management will be more effective". With all these things come together, it can be said the purpose of risk identification is for providing a list including potential risks managed in projects.

In order to obtain all potential risks which might affect projects, many techniques might be observed. In literature, there are many risk identification methods to define risk criteria. However, the most important thing is to find the best technique which fits with project objectives and project team.

Brainstorming is the most common and preferred technique since it is a time and cost saving process and its easiness for setting up. According to Smith *et al.* (2009), Brainstorming technique consists of project stakeholders' idea for identifying and prioritizing the risk criteria of projects. British standards (2000) defines this technique as "stimulating and encouraging free-flowing conversation amongst a group of knowledgeable people to identify potential failure modes and associated hazards, risks criteria for decisions or options". Besides these techniques' advantages, Chapman (1998) stated that due to its unstructured nature, some risks could be possibly overlooked, and group members with dominant personalities could reduce the other members' participation.

Another method to identify the risks is checklist technique which is commonly used in construction projects. According to British Standards (2000), the checklist can be thought of as a complete list of contained potential risks or failures from previous projects. It also has an advantage like easiness to set up, and this technique is much faster than other techniques. However, it only focuses on previous project experience and construction or real estate development projects have a project-specific and unique nature. For this reason, this method might neglect the characteristics of risks (Kıral *et al.* 2014).

Besides, the Delphi method, well-designed, technical and more systematic technique, is also utilized in construction projects in literature. It is firstly applied in the mid-1950s for military services. The method consists of four main parts. These are problem definition, participant selection, questionnaire preparation, and sent to an expert, and lastly receiving feedback and analysis of the data. Subsequently, statistical analysis is done by taking into account terms of standard deviation and mean, etc. The second round is performed and continued until a consensus is provided (Linstone and Turoff, 2002).

In literature, risk identification methods generally are divided into three main groups and many subgroups: (i) information gathering methods - workshops, brainstorming, interview, questionnaires, expert consultancy, learning from past experience, Delphi technique, risk breakdown structure, site visit observations (ii) documentation - database, checklists, project documentation, literature review studies, (iii) research - stakeholder analysis, research assumptions, and interfaces (PMI 2004, British Standards 2000, Smith *et al.* (2006), Kıral *et al.* (2014), Linstone and Turoff (2002)).

2.3.2. Risk Analysis

Risk analysis is the next step of RMP and according to PMI (2004), it is defined as "Risk analysis involves examining how project outcomes and objectives might change due to the impact of the risk event".

There are two types of risk analysis; (i) qualitative and (ii) quantitative risk analysis. Qualitative risk analysis provides prioritization of risks with the assessment and combination of the probability of occurrence and impact. The benefit of this analysis type is to reduce the level of uncertainty and focus on high-priority risks. These methods are probability and assessment, risk rating matrix, risk categorization and risk assessment. Quantitative risk analysis provides a numerically analyze for identified risk effect on overall project objectives. The main advantage of this analysis is to support the decision to reduce project uncertainty. Their methods are a Monte-Carlo simulation, sensitivity analysis, diagramming, event tree analysis and fault tree analysis.

2.3.3. Risk Response

The third part of RMP is the risk response, which is the action taken toward defined risks. PMI (2017) described as “the process of developing options and actions to enhance opportunities and to reduce threats to project objective”. According to PMBOK (2017), there are five types of risk response shown in Figure 2.3 below. Risk avoidance is a strategy whereby the project members act to eliminate the threat or protect from its potential impacts. Risk exploit is where the level of overall project risk is significantly positive and outside the agreed-upon risk thresholds for the projects. Risk transfer is another type whereby project members shift the effects of a threat to a third party. On the other hand, in the risk mitigation strategy, project members act to reduce the probability of occurrence or risk impact. Lastly, risk acceptance is a risk response strategy whereby the project members decide to acknowledge the risk and not take any action unless the risk occurs.

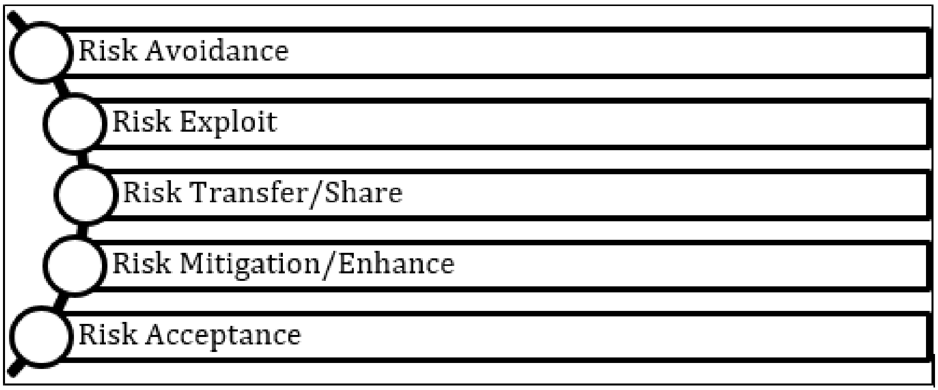

Figure 2.3. PMBOK, 2017 Risk Response Types.

2.4. Previous Studies

The construction industry is complex and characterized by many risks and uncertainties as an example of uncertainty about weather conditions, different site condition risks, etc. These risks and uncertainties affect the whole projects’ cost, time and naturally quality, so risk assessment plays a crucial role. In the literature, there are many risk assessment studies in construction industry. However, it is observed that there is a limited number of study performed in real estate development and CRED projects, especially for Turkey. Mainly, related academic studies are generally covered under general types of the construction projects. For instance, Al-Mustafa and Al-Bahar (1991) studied the risks assessment in construction projects. The study provides an approach for risk assessment through AHP as a multi-criteria decision analysis. The model is used in the study to assist a contractor in the evaluation of the riskiness applied to assess the risks of the bridge construction project in Bangladesh. The authors developed a basic model by including the risk factor as; physical risks, financial and economic risks, political and environmental risks, design risks and job-site related risks. Akintoye and MacLeod (1997) conducted a survey of project management practices to understand the construction industry's perception of risk and presented to contractors and project managers. Also they stated that "Construction risk is generally perceived as events that influence project objectives of cost, time and quality. Risk analysis and management in construction depend mainly on intuition, judgement and experience. The study focused on environmental, political, social and economic, construction, market related, IT and risk factors and at the end of the study, the authors concluded that the risk management is crucial for construction activities such as minimizing the loss, increasing the probability.

Similarly, Hastak and Shaked (2000) have constructed an international construction risk assessment model (ICRAM-1) that evaluates risk criteria including macro (country level), market and project levels. The model provides an approach to quantify and evaluate the risks involved in international investment. It concluded that four main results are obtained from the model as follows: high-risk indicators; the impact of the country environment on a specific project; the impact of the market environment on a specific project; and overall project risk. El-Sayegh (2008) identified and assessed the risk in the UAE construction industry and addressed proper allocation. The questionnaire is conducted and distributed to experts. Economic risks such as inflation and changes in prices, shortage in material and labor supply are found as significant. Other significant risks include owner risks such as unrealistic construction schedule, improper intervention and changes in design.

Bing *et al.* (1999) designated the risk factors related to international construction joint ventures (JVs) by dividing into three main groups as the internal, project- specific and external. The internal risks mean that are related to JV and developed from operation nature conflict within in JVs. The project-specific risks refer to unexpected developments in the construction period that lead to time, cost overruns or to shortfalls. The external risks lastly represent the risks that derive from the competitive macro environment that the JV operates. Authors examined the effective mitigating measures adopted by professionals in managing divided risk for construction projects in East Asia. Based on the conducted survey, it is found that the most critical risk factors exist within financial aspects, government policies, economic conditions and project relationships (Bing *et al.*, 1999).

As another study, Bing *et al.* (2005) conducted a survey to focus on risk allocated for Public-Private Partnership (PPP) or Private Finance Initiative (PFI) in the UK. The author identified the risk factors associated with PPP/PFI projects and categorized them into three levels as micro, macro and meso-level risk groups. Whereas macro-level risks include political and government policy, macroeconomic, legal, social and natural risks, meso-level risks consist of project selection, project finance, residual risk, design, construction and operation. Besides, micro level risks include relationship and third-party risk factors.

Shen *et al.* (2001) have identified six critical risk categories with 58 factors the Joint Ventures (JVs) in China. The critical risk categories obtained are (i) financial risks, (ii) legal risks, (iii) management risk, (iv) market risks, (v) policy and political risks and (vi) technical risks. They subsequently have conducted surveys to understand the risks in the market and determine their significance index. Thus, they proposed three risk management strategies to cope with: cooperation with government offices, proper risk allocation in contract, and technical risk control.

On the other hand, it is observed that risk criteria for construction or real estate-based projects have similar categorization. At that point, Khumpaisal (2012) highlighted the im-portance, consequences and impacts of risks in the real estate development projects by classifying of risks in Real Estate Development Business. The study mainly supported the assumption that risk in real estate development is mostly caused by the effect of STEEP factors. In this regard, STEEP is an acronym for Social, Technological, Economic, Environmental and Political implemented by Morrison (2007). As other examples, Chapman (2009), Chen and Khumpaisal (2009), categorized their risk factors in their research studies as STEE factors (Social, Technological, Environmental, and Economic). Khumpaisal and Chen (2010) also have used the Political factor as well.

Another group divided risk groups as Internal, External and Project Specific or Micro and Macro levels. Also, some risk factors differ from other real estate development from other developed countries, especially country, legal and regulatory risks, which are due to the regulation of the local market and the economic and political situations of the countries of origin.

In decision-making methods selection, AHP application has been the most preferred method in the construction industry because this application is easy to apply compared to ANP. Many decision problems cannot be structured hierarchically because they involve the interaction and dependence of higher level elements in a hierarchy on lower level elements (Saaty and Özdemir, 2005). While the AHP represents a framework with a uni-directional hierarchical AHP relationship, the ANP allows for complex interrelationships among decision levels and attributes (Yüksel and Dağdeviren, 2010). The ANP is a general form of AHP and allows interdependencies, outer dependencies among decision elements in the hierarchical or non-hierarchical structures.

For instance, Dikmen and Birgonul (2006) have presented a methodology of risk and opportunity assessment for international construction projects. Authors have used AHP method for the risk calculation and opportunity rating. The research focused on two main factors; project and country factors. According to Sipahi and Timör (2010), there are only twelve studies conducted in the construction industry between 2005 and 2008 and eight of them have used AHP application. After 2009, ANP application is examined especially in the construction industry. For example, Dikmen *et al.* (2010) have performed to determine relative priorities of risk factors for decision support tool, which can be utilized during bidding decisions in the construction industry.

As another study conducted after the year 2009, Erdem and Ozorhon (2015), developed a comprehensive success ANP model for real estate projects considering performance. Data gathering is provided by eight experienced civil engineers. The findings of the study focused on the importance of the attractiveness of project location, level of contribution to business value, the accuracy of cost estimation, level of innovativeness, and effectiveness of cost control for a successful real estate project. The applicability of the proposed model is tested on nine projects.

Dikmen *et al.* (2010) conducted a study for identifying the determinants of business failure in construction and predicting the failure likelihood of construction companies by assessing their current situation based on both company-specific and external factors. ANP and Delphi methods are applied to obtain the importance weights of variables on business failure through interviews and discussions with experts. The applicability of the proposed model is tested on five companies to estimate their failure likelihood by using the findings derived from the analysis.

Gehner *et al.* (2006) studied the results of an explorative survey of the top representatives of the Dutch real estate development sector on the usage of risk management. The survey is conducted based on in-depth interviews to gain insight of the real estate development process, the risks involved, and the risk analysis and control methods used. With regard to risk analysis, it was found that real estate developers do not make use of probabilistic techniques; scenario analyses are thought of as most applicable because of the complexity of real estate development; several methods to assess the total risk exposure are used; and intuition and experience are necessary for decision-making. The risks in the real estate development projects are listed and shown in Table 2.3.

Table 2.3. Risk in Real Estate Development (Gehner *et al.* 2006).

No	**Risks in RE development**	**No**	**Risks in RE development**
1	Risks of planning procedure	15	Delay in construction time
2	Delay of development process	16	Risks of making ready for building
3	Marketing risks	17	Archaeological excavation
4	Technical/construction risks	18	Land pollution
5	Legal/judicial risks	19	Protected flora and fauna
6	Risks of abandonment	20	Liability risks
7	Objection against building plans	21	Financing risks
8	Tendering: construction costs	22	Fiscal risks
9	Changes in politics	23	Risks of monumental building
10	Changes in legislation	24	Vacancy
11	Design errors	25	Longer time to rent/sell
12	Risks of site acquisition	26	Risks in rental/sale price
13	Interest risks	27	Bankruptcy of advisors/contractor
14	Opposition of administrative mach.	28	Construction defects

They concluded that the three most important risk categories, namely the risk concerning the planning procedure, marketing risks and construction risks. The importance depends on the extent to which the risks can be objectively evaluated, and can be influenced and thus controlled. Also they stated that risk activities in the real estate development process, the risks involved and the usage of risk analysis techniques are joined together at the gates in the decision-making process.

Khumpaisal *et al.* (2010) developed an Analytic Network Process (ANP) model to support the decision makers or project managers to deal with the potential risks of mega construction projects. Risks assessment criteria used to accomplish the ANP calculation based on both a review of the literature and related experience against Social, Technological, Economic, Ecological and Political (STEEP) requirements.

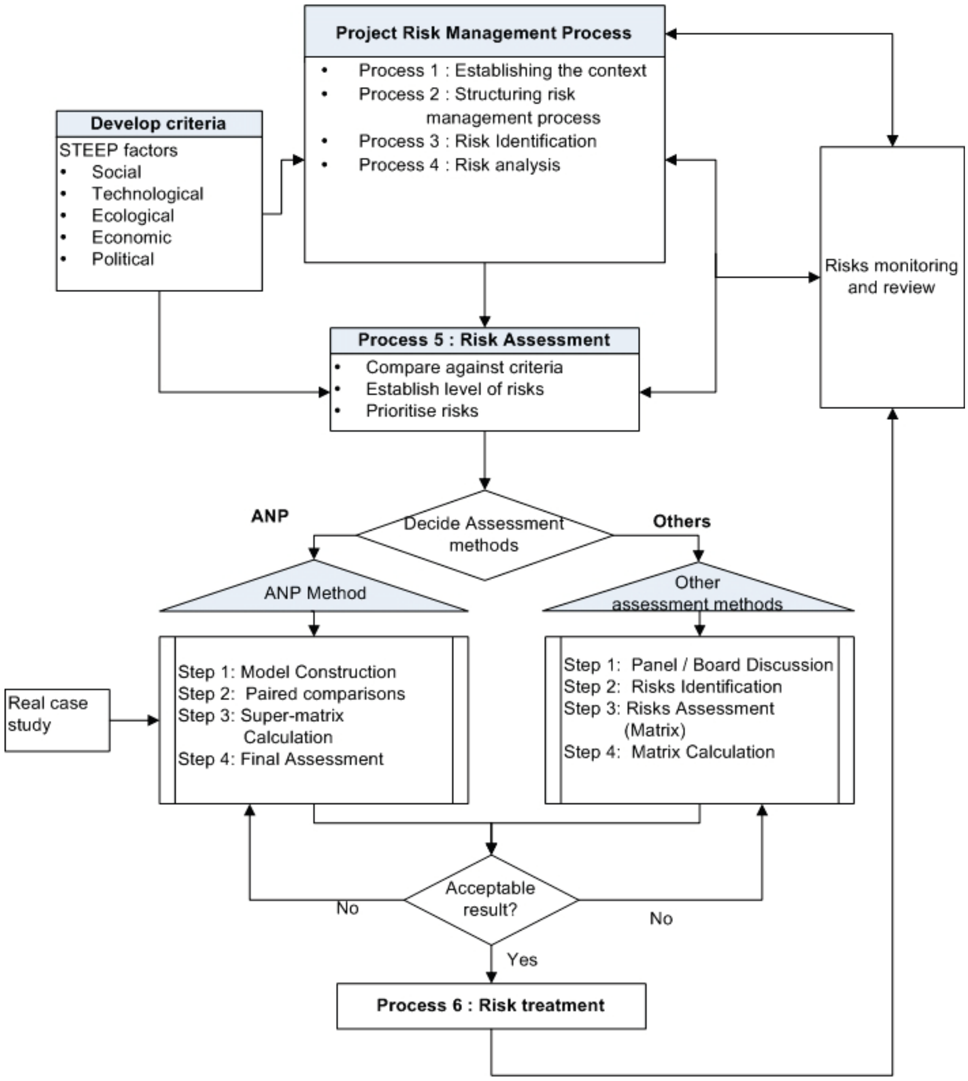

Figure 2.4. ANP Risk Assessment Model (Khumpaisal *et al.* 2010).

Khumpaisal *et al.* (2010) stated that methodology adopted in this research consists of literature review, and interview with a practitioner to gather information of the current risks assessment approaches used in mega-projects, following by data analysis to support ANP model. As a result, a case study of mega-project has been used to test ANP model effectiveness. The research methodology structure could be seen in Figure 2.4.

In addition to these studies on construction and real estate that use ANP, there are studies which focus on selecting the best development alternatives, location, property type and strategy by using multi-criteria decision-making methods. The main goal in these types of research is the selection of best alternatives rather than the calculation of importance weights of criteria or factors. For instance, Khumpaisal and Chen (2010) focused on the risks assessment criteria, emphasizing on risks and their consequences in real estate development. Risk assessment criteria are set up based on Social, Technological, Economic, Environmental and Political factors (STEEP), which are necessary when the developers conducting a project feasibility analysis. A large airport terminal, London Heathrow Terminal 5, was chosen as a case study to demonstrate the effectiveness of the ANP model.

As another example, Chen and Khumpaisal (2009) developed an ANP model in order to support developers in the decision-making process. The article introduces a novel decision-making approach to risks assessment in commercial real estate development against social, economic, environmental, and technological (SEET) criteria shown in Table 2.4. Therefore, it aims to describe a multiple criteria decision-making model based on ANP theory. The model also provides the selection of best alternatives in Liverpool City Center specific location. Chen and Khumpaisal (2009) concluded that ANP could be used as an effective tool to support developers in decision-making based on risks assessment. The ANP model therefore can be adopted by real estate developers in the case of business needs to assess risks in a real estate development.

Table 2.4. Risk Criteria in CRED Projects (Chen and Khumpaisal, 2009).

No	**Risks in CRE development**	**Sub Criteria**
1	Environmental Risk	Adverse environment impacts
		Climate change
2	Social Risks	Workforce availability
		Cultural compatibility
		Community acceptability
		Public Hygiene

Table 2.4. Risk Criteria in CRED Projects (Chen and Khumpaisal, 2009) (cont.).

No	**Risks in CRE development**	**Sub Criteria**
3	Economic Risks	Interest Rate
		Property Type
		Market Liquidity
		Confidence to the market
		Demand and Supply
		Purchesability
		Brand visibility
		Capital Exposure
		Lifecycle value
		Area accessibility
		Currency conversion
		Buyers
		Tenants
		Investment Return
4	Technological Risks	Site conditions
		Designer and constructors
		Multiple functionality
		Constructability
		Duration
		Amendments
		Facilities Management Accessibility and evacuation
		Durability

2.5. Statement of Research Question and Gap in Literature

In the literature, it is observed that real estate and CRED market-related studies, were insufficient, especially for Turkey. Related studies covered the risk criteria in many types of construction projects such as infrastructure, joint ventures, Studies generally remain limited with general construction industry perspective. For instance, Bing *et al.* (1999) designated the risk factors for international construction JV projects. Hastak, and Shaked (2000) developed an AHP model, including international construction projects. Shen *et al.* (2001) focused on JV project risk in China. Gehner *et al.* (2006) performed a study for Netherland real estate development industry and Thyet *et al.* (2007) focused on oil and gas construction projects in Vietnam an etc.

Thereby, this study focuses on the risk factors encountered in CRED projects and their effects on development decision in Turkish market where limited number of studies in the literature have covered the risks especially in the real estate field. This study aims to provide recommendation in decision making in real estate development projects by defining risk criteria and assessing their priorities and importance weights. On the other hand, it aims to fill this gap in the literature by providing a tool or model structure for decision makers in the industry to evaluate development plan taking into account interrelations among them. CRE has its uniqueness and features and this study helps to fill the gap in the literature by studying risk criteria with a detailed literature review.

The research question of this study summarized as follows: What are the risk factors and classification criteria of CRED projects in Turkey and what is the relationship of interdependencies among risk factors?

3. RESEARCH METHODOLOGY

In this thesis study, the aim is to identify and evaluate the risk criteria in CRED projects and to obtain their importance weight effects on the development decision process in Turkey. In order to provide this aim, the following steps will be explained:

- To define the risk factors in CRED projects through extensive literature review study.
- To list defined risk factors based on their frequencies used in literature and to combine under related categories.
- To explain the AHP and ANP theoretical background in detail.
- To gather data form expert, a team which is formed by experienced professionals via face to face interview and meeting.
- To construct a model and give information about "Super Decision" decision-making software.
- To obtain interrelation matrix and importance weight matrices.

In this chapter, firstly the methods used in previous studies are explained. After that, the theoretical background for multiple criteria decision is discussed. Data gathering methods and model construction are explained, respectively. Subsequently, "Super Decision" decision-making software and matrices examples are clarified. To summarize, the general framework of the research study is shown below.

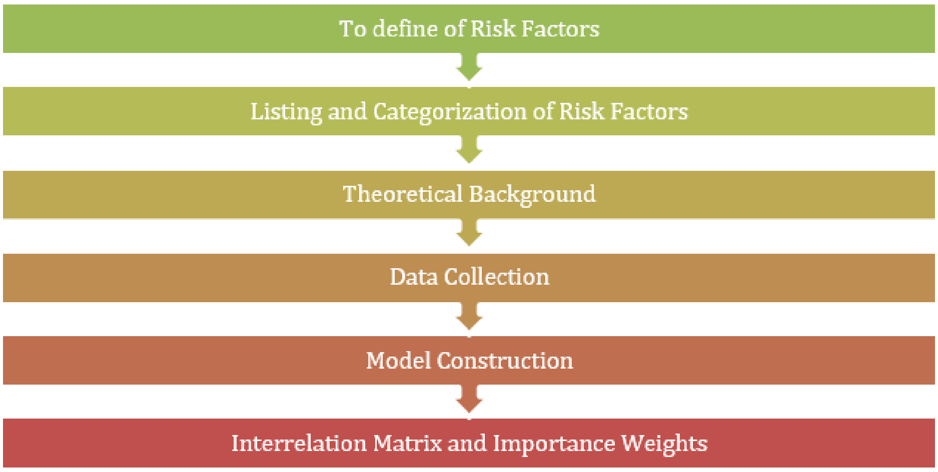

Figure 3.1. General Framework of the Study.

3.1. Risk Identification and Classification

The risk identification step is performed depending on the literature review. In the literature review process, previously designated keywords, "risk factors/criteria", "risk assessment", "risk management" "decision making", and "development" are searched. These keywords are tried to be found in the studies that are specifically about the construction industry and real estate based development projects. However, it is observed that there is a limited number of studies performed in real estate development projects. Therefore all studies published after 1990 were included and peer reviewed journal papers, including International Journal of Project Management, Journal of Construction Engineering and Management, Journal of the Architectural Planning and Research, Journal of Corporate Real Estate, are examined. Also, conference papers, including top conferences such as European Real Estate Society Conference and International Postgraduate Research are included.

Although there are limited studies concerning the risk factors in real estate development projects, other related studies (e.g. Akintöye and Macload, 1997, Bing *et al.*, 2005, Dikmen *et al.*, 2007 etc.) explained the risk criteria in other types of construction projects such as infrastructure, joint ventures, etc. in different countries. However, an article or any other study related to risk factors in CRED projects in Turkey does not exist in the literature.

In the literature review, 22 articles are examined and all list is shown in the Table C below. Consequently, it is realized that the selected research studies do not focus on a particular country. The studies remain conversely limited to many countries in general perspective. Among these studies, only 6 of them are focusing on a specific market such as United Kingdom (Bing *et al.* 2005), Dubai (El-Sayegh 2008), China (Shen et. al (2001), Netherland (Gehner *et al.* 2006) On the other hand, the real estate market-based studies in the literature remain somewhat limited. For instance, 5 of 22 articles are related to the real estate market. Due to the lack of CRED specific studies for the Turkish market, risk factors and their classification in CRED projects unique to Turkey should have evaluated again. In this manner all possible risk factors listed by analyzing previous studies (E.g. Akintöye and Macload, 1997, Bing *et al.*, 2005, Dikmen *et al.*, 2007, Chen and Khumpaisal 2009, and etc.). As a consequence, 108 risk factors with 34 categories in literature are obtained and listed by reviewing 22 articles.

Since many studies in the literature have been examined, it was realized that the contents of the studies are quite similar. Also, related studies have used the similar references. Therefore, some of the risk factors, which have close meaning, are combined by merging their definitions and also eliminated. In other words, these studies performed the same risk factor framework using similar references and many repetitions are examined in these studies. The risk criteria list combining related risk factors has been prepared based on the literature and presented in the Appendix B, C and D section. Final list table is prepared based on literature, combining similar risk factors. Literature review article list and merging list of categories are presented below in Table C and Table 3.2, respectively.

The risk factors are gathered based on a literature study and merged into determined classification with the expert opinion in the interview session. A final 21 risk factors are gathered and classified into four sub-criteria. The final risk factors and categories could be seen in Chapter 4.

Table 3.1. Literature Review Lists for Risk Identification.

No	**Reference Author**	**Article Name**	**Categories**
1	Akintoye MacLeod -1997	Risk analysis and management in construction	Environmental (e.g weather), Political social and economic, Contractual agreement, Financial, Construction, Market/industry, Company, Development in IT, Project
2	Chapman (2009)	PEST analysis method and examples with free PEST template	Political, Environmental, Social, Technological
3	Baum and Crosby (2008)	Property investment appraisal	Unsystematic Risks, Systematic Risks
4	Bing *et al.* (2005)	The Allocation of Risk in PPP PFI Construction Projects in the UK.	Macro Level Risk, Micro Level Risks, Meso Level Risks
5	Chen and Khumpaisl(2009)	An analytic network process for assessment in CRED	Social, Techological, Economic, Environmental
6	Khumpaisal and Chen (2010)	Risks Assessment in RE Development: ANP	Social, Techological, Economic, Environmental, Pol.
7	Dikmen Birgonul (2006)	AHP Based model for risk and opportunity assessment of ICP	Project and Country Risks
8	Dikmen *et al.* (2007)	Using Fuzzy Risk Assessment to Rate Cost Overrun Risk in ICP	Project, Construction and Country Risks
9	Forrest E. Huffman (2002)	Corporate real estate risk management and assessment.	Financial, Physical, Regulatory Risks
10	Gehner *et al.* (2006)	Risk management in the Dutch Real Estate Development Sector	Planning procedure risks, Delay of development, Marketing Risks, Technical Risks, Legal Risks, Building plans objection risks
11	Hargitay Yu (1993)	Decision criteria - return and risk, property investment decisions: A quantitative approach.	Business Risks, financial risks, liquidity risks, other risks
12	Hastak Shaked (2000)	ICRAM-1:Model for Interrn Construction Risk Assessment	Macro(country), market and project levels
13	He Zhi (1995)	Risk management for overseas construction projects	Nation / Region (Political, Economic, Financial, Social), Construction Industry, Company, Project
14	James L. Morrison (2007)	STEEP Factors	Political, Environmental, Social, Technological, Economic
15	Bing *et al.* (1999)	Risk Management in International Construction JV	Intermal, Project Specific Risk Factors, External Risk Factors
16	Mustafa Al-Bahar (1991)	Project Risk Assessment Using The AHP	Acts of God,, Financial, Political and Environmental, Design, Job Site
17	Nezhad Kathawala (1990)	Risk Assessment for International Investment	Socio-cultural factors, economic factors, political, legal factors, technological, physical factors, availability of resources, market
18	Perera *et al.* (2009)	Risk management in road construction: the case of Sri Lanka	Technical and contractual risks, Economic-financial-political risks, Managerial risks, External and site conditions risks
19	Sameh Monir El-Sayegh (2008)	Risk assesment and allocation in the UAE construction industry	Internal (Owner, designer, contractors, subcontractors, suppliers), External (Political, Social , Natural, Economic)
20	Shen *et al.* (2001)	Risk Assessment for Construction JV in China	Financial, Legal, Management, Market, Policy and Political , Technical
21	Thuyet *et al.* (2007)	Risk management in oil and gas construction projects in Vietnam	Bureaucratic government system and long project approval, poor design, incompetence of project team, inadequate tendering
22	Zhang and Zou (2007)	Fuzzy AHP Risk Assessment Approach	Intermal, Project Specific Risk Factors, External Risk Factors

To determine the categories of the model, minor related groups merged into the major groups. In 34 categories, similar groups are combined and gathered the same related major group. For instance, political risks, regulatory/policy risks, country risks and legal/contractual risk groups are combined into "Political Risk". On the other hand, financial risks, investment risks, market-related risks, and economic risks are merged into "Monetary Risks".

Since real estate market-related studies in Turkey were insufficient and were not included in the literature, the prepared list, including criteria and factors are analyzed by interviewing with an experienced person in the industry, and academician. The confirmation was provided by academia and experienced professionals. The final version of the risk criteria list was created by doing brainstorming. The final list was presented in Chapter 4.

Table 3.2. Literature Review Risks Categories.

Risks Categories	
Groups	**Risks**
Political Risks	Political Risks
	Regulatory/Policy Risks
	Country Risks
	Legal Risks, Contractual
Monetary Risks	Financial Risks
	Investment Risks
	Market Related Risks
	Economic Risks
Environmental Risks	Environmental Risks
	Acts of Gods
	Physical Risks
	Natural Risks
Project Risks	Technical Risks, Technological Risk
	Construction Related Risks
	Social Risks - Workforce market and labor etc.

3.2. Theoretical Background

In the thesis study model, the primary purpose is to define risk criteria in CRED projects and their important effects on the decision-making process. In order to succeed in this aim, all risk criteria are listed and categorized. The next step is to present the Multiple-Criteria Decision method in literature and to give information about AHP and ANP in detail.

In the literature, there are many methods in order to obtain reliable output in the decision-making process and the most appropriate Multiple-Criteria Decision method should be utilized. Among these methods, AHP and ANP methods have been considered as more practical rather than the rest of the methods because of several reasons which are explained in the further sections. When these two methods are compared, Saaty (1996) states that ANP allows the practitioners to build the interdependencies between the criteria in each cluster and criteria in different clusters whereas AHP does not allow to take into account of effects of the interdependencies on the quantitative and qualitative calculations. In the following subsections, the theoretical backgrounds of AHP and ANP are going to be presented and the reason for choosing ANP for this study is going to be reviewed.

3.2.1. Analytic Hierarchy Process and Analytic Network Process

AHP is one of the multi-criteria decision methods, and it is defined as "a decision-making model that aids us in making decisions in our complex world" by its founder, Thomas Saaty, in 1988. In this model, a hierarchical model with linking alternatives is presented, and in order to evaluate alternatives on decision priorities of criteria is established. The model involves many decision makers who evaluate all processes. Pairwise comparisons and judgements of expert people have formed the foundation of this theory. These comparisons are used to find the relative importance between the defined criteria and factor. According to Baker *et al.* 2001, AHP is suitable for decisions with both quantitative and qualitative criteria. It puts them in the same decision context by relying on relative comparisons instead of attempting to define absolutes. For the implementation of AHP, a linear structure is built by neglecting the interrelations between the nodes. This is the main difference from ANP, which is used in this study. While the ANP analyzes the dependencies both in a cluster which is the main criteria and between clusters, AHP ignores the interdependencies between clusters and nodes. AHP is a general and more empirical form of ANP. The general framework of both models is shown in Figure 3.2 below.

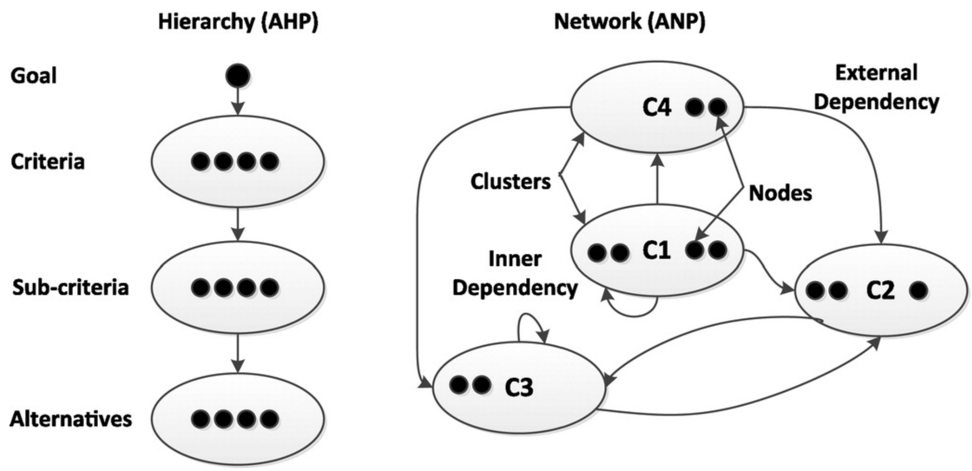

Figure 3.2. AHP and ANP General Framework (Gkountis and Zayed, 2015).

According to Lee *et al.* (2008), to be able to implement AHP properly, there are several steps to be taken as follows (i) definition of problem, (ii) building hierarchical structure with decision elements, (iii) conducting pairwise comparisons and forming comparison matrices, (iv) obtaining importance weights utilizing eigenvalue method, (v) calculating overall ratings of alternatives. In order to conduct pairwise comparisons, Saaty (2008) proposes a nine-point scale that enables the users to form comparison matrices, as shown in Table 3.3. A point of one declares that two elements contribute equally to the objective; on the other hand, nine-point shows the much higher importance of a component to the other.

Table 3.3. Nine Point Scale (Saaty, 2008).

Intensity of Importance	Definition	Explanation
1	Equal	Two activities contribute equally to the objective
2	Weak or Slight	
3	Moderate	Experience and judgement slightly favour one activity over another
4	Moderate Plus	
5	Strong	Experience and judgement strongly favour one activity over another
6	Strong Plus	
7	Very Strong	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very Very Strong	
9	Extreme	The evidence favouring one activity over another is of the highest possible order of affirmation

According to Oguztimur (2011), the primary goal of the AHP is to select an alternative that best satisfies a given set of criteria out of a set of other options or to determine the weights of criteria in any application. AHP scales the weights of attributes at each level of the hierarchy concerning a goal using the decision maker's experience and knowledge in a matrix of pair-wise comparison of characteristics. The general application of AHP is to select the best alternative from a discrete set of alternatives. Table 3.4 shows and summarized the advantages and disadvantages of AHP structure.

Table 3.4. Advantages and Disadvantages of AHP (Oguztimur, 2011).

Advantages	**Disadvantages**
· AHP can take into consideration the relative priorities of factors or alternatives and represents the best alternative.	· There is not always a solution to the linear equations.
· AHP provides a simple and very flexible model for a given problem.	· The computational requirement is tremendous even for a small problem.
· AHP provides an easily applicable decision making methodology that assists the decision maker to precisely decide.	· AHP allows only triangular fuzzy numbers to be used.
· Either objective or subjective considerations or either quantitative or qualitative information play an important role during the decision process.	· AHP is based on both probability and possibility measures.
· Any level of details about the main focus can be listed or structured in this method. By this way the overview of the main focus or the problem can be represented easily.	· Rank reversal fact should be considered carefully during the application. It defines the changes of the order of the judgment alternatives when a new judgment alternative is added to the problem. Validity of the rank reversal is still discussed in literature.
· AHP has a very wide range of usage like; planning, effectiveness, benefit and risk analysis, choosing any kind of decision a	· AHP has a subjective nature of the modeling process is a constraint of AHP. That means that methodology cannot guarantee the decisions as definitely true.
· AHP relies on the judgments of experts from different backgrounds; so the main focus or the problem can be evaluated easily from different aspects.	· When the number of the levels in the hierarchy increase, the number of pair comparisons also increase, so that to build the AHP model takes much more time and effort.
· Decision maker can analyze the elasticity of the final decision by applying the sensitivity analysis.	
· It is possible to measure the consistency of decision maker's judgments.	
· Computer software helps decision makers to apply AHP fast and precisely.	

On the other hand, ANP is a different form of AHP. Dikmen *et al.* (2010) define the ANP's area of use as the way of computing the importance weights of elements through expert's opinions. ANP is exercised with the participation of three or more experts (Dikmen *et al.* 2010). The main difference between these methods is that ANP considers the interdependencies between the elements, whereas AHP does not (Saaty, 2008). For this reason, a network model between clusters and nodes are built instead of the hierarchical model. The dependencies between the nodes can be classified as inner and outer dependencies. The inner dependency covers the dependencies between the elements held in the same cluster, whereas outer dependency is used for dependencies between the elements from different clusters.

The implementation of ANP is proposed in four steps by Coulter and Sarkis (2009). First of all, the decision problem is broken down into a network model, including goal, criteria, and sub-criteria with various levels relying on the complexity of the problem and number of factors included. Secondly, once the clusters are formed, the network model is completed by allowing the interactions between elements and clusters as inner and outer dependencies. Then, the pairwise comparisons are utilized to compute the priorities and relative importance weights of the elements via the nine-point scale as mentioned about AHP's implementation. As the last step, the block matrices are incorporated into a super matrix which has three different types called "unweighted matrix" formed by priorities of the elements obtained from pairwise comparisons, "weighted matrix" obtained by multiplication of priority of each element with its cluster's priority and lastly "limit matrix" computed by modifying weighted matrix to its powers.

When taking the merits of ANP over AHP into account, the following advantages are listed by Schenkarman (1994):

- ANP is structured on the widely used AHP method,
- ANP allows for interdependency,
- ANP deals with dependency within a group of elements as inner and outer dependencies. The interdependency among elements and their levels is defined as a systems-with-feedback approach. Unlike ANP, AHP does not consider the feedback loops through the elements that allow to arrange the weightings and decrease the probability of the reverse ranking in the network model,

- ANP enables users to build more complex interrelationship structures. The looser network structure of the ANP enables the higher possibility for the representation of a decision problem regardless of what comes first and what comes next in a network model.

In this study, it was decided on being taken the interrelations between the elements into account to be able to reflect the nature of the real case studies. For this purpose, ANP has been utilized to obtain more exact and realistic consequences from the network model to be evaluated later.

3.2.2. Areas of Applications of AHP and ANP

According to Sipahi and Timor (2010), AHP has been serving for various areas such as engineering, food, business, ecology, health, and government since 1970 when Thomas L. Saaty developed AHP whereas ANP is mainly used for risk and uncertainty decisions. According to their research, the studies conducted between 2005 and 2009, the method utilized and industry breakdown are shown in Table 3.5.

Table 3.5. Details of Studies Utilized AHP and/or ANP between 2005 and 2009.

Area	**AHP**	**ANP**	**AHP and ANP**	**Total**
Manufacturing	45	2	4	76
Environment	24	-	1	26
General Decision Problem	12	2	1	19
Power & Energy	14	-	-	15
Transportation	12	1	-	15
Construction	8	1	1	11
Health	10	-	-	10
Others	44	3	2	60
Total	**169**	**9**	**9**	**232**

According to the information given above, AHP has been dominant in manufacturing, followed by the environmental management and agriculture field, power and energy industry, transportation industry, construction industry, and healthcare. In these industries, AHP serves for strategy evaluation, performance assessment, product, and process design, risk evaluation, system selection, cost/benefit analysis, quality evaluation, and measurement of objectives. The construction industry benefits AHP while conducting analyses in technical assessment, construction safety, project evaluation, project risk analysis, and intelligent building design evaluation (Sipahi and Timor, 2010).

Yurdakul (2003) expresses that more data and computation requirement makes ANP more difficult when compared with AHP. Although the AHP is still a powerful decision tool for assisting decision makers in many decision situations, it does not pay attention to the dependencies and interrelations among the factors. However, real cases usually consist of dependence or feedback between elements. At this point, the ANP will gain more popularity shortly since it provides more flexible models to overcome real cases. The ANP method was implemented for several cases in construction industry such as contractor qualification, evaluation of the environmental impact of various project alternatives, selection of project locations (Cheng *et al.*, 2005).

3.3. Super Decision Software

For the sake of implementation of ANP, the software called "Super Decision" is being widely used. That software was developed by Thomas L. Saaty and his research team in 1996 and has been improved since that year for serving to advanced methods of decision making involving ANP. With its common user interface, Super Decision allows the decision makers to enter all data as an input, to calculate and to obtain the assessment values in a few steps.

Super Decision enables the users to define interrelations and make the pairwise comparisons between the nodes and clusters. For this purpose, "Decision" cluster, "criteria" cluster and "sub-criteria" clusters are identified with relevant nodes. Once the interrelations between the nodes are determined, the assessment values are entered into the software as the user's input. With the data identified, the software calculates the unweighted, weighted super matrices, and limit matrix. Besides, priorities and importance weights are obtained as the output of the software.

Finally, the consistency of pairwise comparisons is required to be checked for a healthy ANP exercise. With the help of Super Decision, consistency values of the experts' judgments can be calculated easily. According to Saaty (1994), the levels of consistencies are 0.05 for a 3x3 matrix, 0.08 for a 4x4 matrix and 0.10 for larger matrices.

3.4. Interrelation Matrix

After the list of the risk factors is constructed and the theoretical background is explained, the next step is data gathering to perform interrelations between factors and order the relation matrix to obtain pairwise comparisons. For this step, an expert team is constructed. According to Dikmen (2010), there is no minimum number for panel size in this model. However, it is common to conduct ANP exercise with the participation of three or more experts. Therefore, five team members came together and for this study. The expert team is selected among experienced in CRED projects engineers, architectures, etc. Table 3.6 shows the expert team members' positions and experience details. Among the experts are directors, asset manager, and leasing manager. They have experience in CRED project, especially for shopping centers and office buildings. The expert team assessed pairwise matrices among clusters and nodes and their collected sheets are compared between each other in order to provide a consensus. In order to provide a consensus, two meetings are organized and interrelations, and pairwise relation matrices are evaluated and finalized based on the expert's background and literature study.

Table 3.6. CRED Expert Team.

No	Position Detail	Experience (Years)	Expertise
1	Business Development Director	15	Shopping Center, Outlet Center, Office and Hotel
2	Operations Director	10	Shopping Center, Outlet Center, Office and Hotel
3	Architectural Director	16	Shopping Center, Outlet Center, Office and Hotel
4	Asset Manager	8	Shopping Center, Outlet Center, Office
5	Leasing Manager	6	Shopping Center, Office

After an expert team is constructed, the next step is to perform interrelations between factors and order the relation matrix to obtain pairwise comparisons. For this model, the relative importance rates are some of the most objectives of this study. To obtain dependencies, each risk factor should be taken into account in more detail.

According to Tang and Li (2009), in the ANP model, nodes or elements and affect the structure by feeding back the network. Because of this reason, it should be needed to compare elements. Interrelation matrix, including risk factors, is prepared based on the literature review study and explained the experts. The pairwise relation decision matrix is prepared in detail for the relation between all risks criteria affecting investment decision in CRED projects. Each factor has been reviewed one by one to determine the interrelation between factors. At that point, the critical point is that only direct relation should be considered; indirect connections should be neglected.

This matrix is constructed depending on node connections and filled by the expert based on their experience and background in CRED projects. The matrix is formed by risk factor node in both the column and row. For each row, it is asked to expert whether there is an effect on the column or not. If the row has an impact on the column, the matrix is filled with plus "+" sign. For example, according to the table below, 1st risk criterion affects and has a direct effect on 2nd risk criterion but has no impact on 3rd risk criterion. Whereas 2nd risk criterion affects both 1st and 3rd risk criteria, 3rd risk criterion has no impact on criteria 1st and 2nd ones. Diagional cells mean that a risk factor is not influenced by itself. Erdem and Ozorhon (2015).

Table 3.7. Interrelation Matrix Example.

Interrelation Matrix	**1st Risk**	**2nd Risk**	**3rd Risks**
1st Risk		+	
2nd Risk	+		+
3rd Risk			

All details about the model and the matrix, including risk criteria, are given to the experts and filling of interrelation matrix are explained and requested to fill. The expert team filled the interrelation matrix by reviewing risk criteria one by one and applied the procedure presented above. Some incompatibilities are observed, and then it is requested that all results are evaluated together. Filled matrices are given to the experts, and they assessed and discussed between each other based on their backgrounds. A consensus is provided by making minor arrangements.

3.5. Model Formation

After obtaining the interdependences, the next step is to form a pairwise comparison among the clusters and nodes. For this step, it is required to establish a model in SUPER DECISION software by entering the interdependencies inputs and connecting interrelated variables and then obtained the matrices with the help of the software output. In the second session meeting, all given matrices are given to the experts and requested to evaluate them.

In order to form a model, the network structure based on the literature survey is formed in a software program, and all clusters, node, and connections are shown in Figure 3.3. Subsequently, all pairwise matrices data are entered into the program by taking into account their consistency ratio. According to Saaty (1994), there are three acceptable levels for consistency; 0.05 for a 3 x 3 matrix, 0.08 for a 4 x 4 matrix, and 0.10 for other matrices. Consistency ratios for all matrices were found to be less than the recommended level of 0.10.

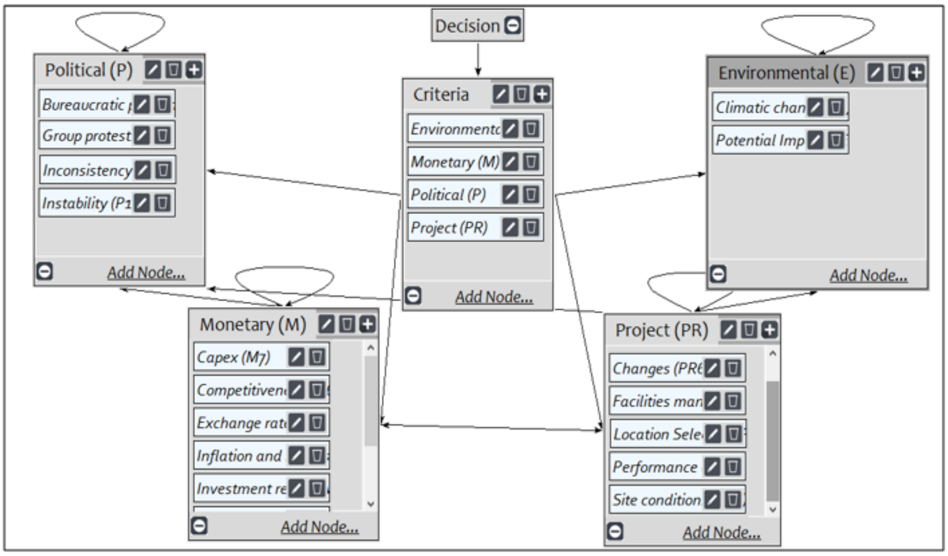

Figure 3.3. Software Snapshot and Model Construction.

3.6. Pairwise Comparison Matrices

As mentioned chapter before, ANP is the broader version of AHP and focuses on the interdependences between elements and to make comparisons between clusters a scale of numbers that indicates how many times more important or dominant one element is over another element concerning criterion or property concerning they are compared (Saaty 2008) Above the Table 3.3 has explained a nine- scale format, and it is used for pairwise comparison, which is formed by row and column element and parent element.

In Table 3.8 below the sample for how to fill the matrix could be seen. A is given as parent element of matrix and B, C and D are relative importance rates elements while evaluating the "A" as the parent element. These empty cells are filled using a nine-point scale, which is to assess the previous section. Expert or person who filled the empty cells answered the question "What is the influence of B relative to C and D for parent element A". According to Saaty's nine-point scales, a point of 1 "equal importance" means that two activities contribute equally to the objective, 5 as strong importance means that experience and judgment strongly favour one activity over another and lastly where 9 means that extremely important with the evidence favouring one activity over another is of the highest possible order of affirmation.

Table 3.8. Pairwise Comparison Example Matrix.

A	**B**	**C**	**D**
B		5	3
C	1/5		1/5
D	1/3	5	

Pairwise comparison matrices should be evaluated row by row, and each risk factors or nodes should be compared against others. Based on the above example, when B factor row is evaluated concerning "A" parent element, B factor has 5 points with strong importance on C, and 3 points with moderate importance on D respectively. When C row is examined, the question "how much C is more/less important than D for "A" parent element is answered by filling 1/5 point scale. The 1/5 point scale means that C factor strongly less importance than D factor with respect to "A" parent element. In other words, the D factor has strong importance "5 points" on the C factor. This the opposite relationships (i.e., D factor on C or C factor on D with respect to A), does not need to be filled because expert always enters the whole number in its appropriate position and automatically enters its reciprocal in the transpose position with the help of the software. (Saaty, 2008). Also, the relative importance rate for comparing each element on themselves (i.e., C factor on C factor comparison) is given as "1", and these cells are not filled as well. All unfilled cells could be seen in the above Table 3.8.

According to (Baker *et al.*, 2001) the "priority vector" (i.e., the normalized weight) is calculated for each criterion, and relative importance for each criterion is determined by comparing them one to another. The calculations are easily set up in a spreadsheet, and commercial software packages are available. To understand the concept of theory, some sample matrices are given below.

Table 3.9. Pairwise Comparison with respect to the Site Condition.

Site Conditions	**E2**	**E1**
E2		1/2
E1		

Table 3.10. Pairwise Comparison with respect to the Market Liquidity.

Market Liquidity	**P3**	**P2**	**P1**
P3		1/3	1/4
P2			1/2
P1			

Table 3.11. Pairwise Comparison with respect to the Bureaucratic Problems.

Bureaucratic Problems	**P3**	**P2**
P3		1/4
P2		

Table 3.12. Political Cluster Pairwise Comparison Matrix.

POLITICAL	**P4**	**P3**	**P2**	**P1**
P4		4	1/2	1/3
P3			1/2	1/4
P2				1/2
P1				

Table 3.13. Decision Cluster Pairwise Comparison Matrix.

DECISION	**ENVIRON.**	**MONETARY**	**POLITICAL**	**PROJECT**
ENVIRON.		1/7	1/5	1/4
MONETARY			3	4
POLITICAL				2
PROJECT				

4. FINDINGS

4.1. Risk Identification and Classification in CRED Projects

In this thesis, the primary purpose is obtaining the most important risk factors which are crucial for CRED projects and determine the importance weights of elements. Firstly, an extensive literature review has been performed, and the main categories are observed in detail. As aforementioned in "Research Methodology", all risk factors in 22 articles are listed by obtaining 108 risk factors with 34 groups in literature. Although many studies in the literature have been examined, it was realized that the contents of the studies are quite similar. Therefore, some of the risk factors, which have close meaning, are combined by merging their definitions. The risk criteria list combining related risk factors has been prepared based on the literature and presented. All factor list and combined risk factors are listed in Appendix B, C, and D section.

In the classification part, minor risk groups are merged into significant groups. For instance; "Political Risks" groups are covered into political risks, regulatory and policy risks, country risks and legal risks. Financial risks, investment risks, market-related risks, and economic risks are combined with the factor of "Monetary Risks". Environmental hazards, acts of gods, physical risks and natural risks are merged to "Environmental Risks". The final categories were combined under four main groups; political, monetary, environmental and project related risk groups respectively.

The risk factors are gathered based on a literature study and combined and merged into determined classification with the expert opinion in the interview session. A final 21 risk factors are gathered and classified into four sub-criteria. The final risk factors and categories could be seen below Table 4.1.

Table 4.1. Final Risk Factor List.

Risks / Clusters	No.	Sub-Criteria
Political Risks	**1**	Political instability
	2	Inconsistency in policies, laws and regulations
	3	Civil disorder, terrorist attack, group protests
	4	Bureaucratic problems
Monetary Risks	**5**	Inflation and interest rate fluctuation
	6	Exchange rate fluctuation
	7	Selling or leasing rate
	8	Investment return
	9	Market liquidity or exit options
	10	Competitiveness
	11	Capital expenditure per sqm
	12	Developer or local partner (if any) reputation
Environ. Risks	**13**	Potential negative impacts (acts of good an etc.)
	14	Climatic change
Project Risks	**15**	Site conditions
	16	Designers and constructors' performance
	17	Technical difficulties
	18	Location selection
	19	Infrastructures usability
	20	Design and construction changes
	21	Facilities management

4.2. Interrelation and Pairwise Comparison Matrices

After the list of the risk factors is constructed, the next step is data gathering to perform interrelations between factors. The data from the expert teams are gathered with a prepared matrices structure by focusing on CRED projects in Turkey. Interrelation matrices elements are reviewed one by one. The elements are filled in detail by an expert team and decided whether there is a direct relation or not. Incompatibilities between filled sheets are ordered and evaluated by reaching a reasonable consensus. The interrelation matrix, filled by an expert team, is given below Figure 4.1.

		Political Risks				Monetary Risks								Envirn. Risks		Project Risks						
		P1	P2	P3	P4	M1	M2	M3	M4	M5	M6	M7	M8	E1	E2	PR1	PR2	PR3	PR4	PR5	PR6	PR7
Political Risks	P1			+		+	+	+	+	+												
	P2			+	+			+	+	+												
	P3				+			+	+	+			+									
	P4							+	+								+					
Monetary Risks	M1			+				+	+	+		+					+					+
	M2			+		+		+	+	+		+					+					+
	M3								+			+										
	M4																					
	M5							+	+		+											
	M6							+	+										+			
	M7								+													
	M8							+														
Envr Risk	E1															+	+					
	E2													+		+	+					
Project Risks	PR1																+					
	PR2																					
	PR3																+				+	
	PR4							+	+													
	PR5																+		+			
	PR6																					
	PR7											+										

Figure 4.1. Interrelation Matrix.

Subsequently, relative importance is determined based on given matrices and the expert team scored the prepared matrices using a nine-point scale of Saaty. Pairwise comparison matrices are completed and filled based on each node or clusters in terms of importance through the parent element. After that comparison process is continued until all given matrices and their importance are evaluated and the consensus is provided. After gathering all data, the network structure is formed using the "Super Decisions" software program. All nodes, clusters, hierarchical system and interrelations are defined clearly in the program and all data given by expert team are entered into it. Some snapshots on the software are shown in the Figure 4.2, Figure 4.3 and Figure 4.4 respectively.

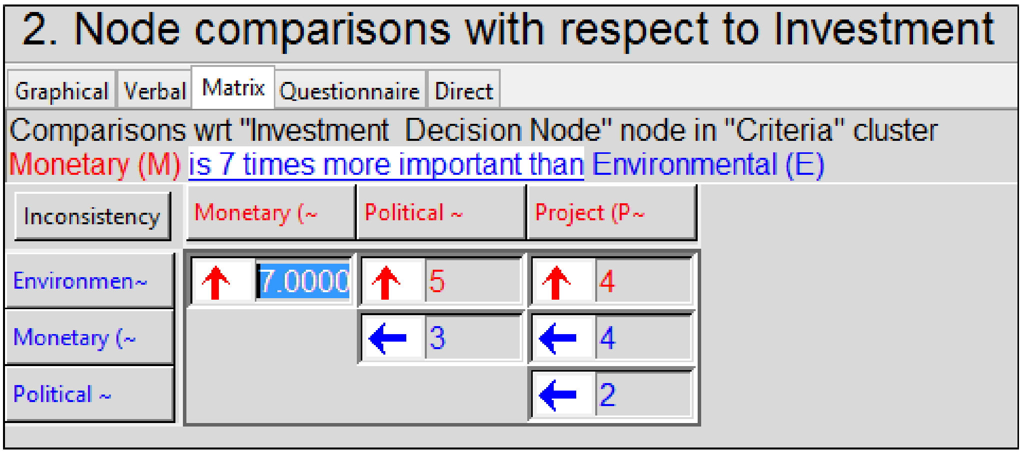

Figure 4.2. Super Decision Pairwise Comparison Matrix in Decision Cluster.

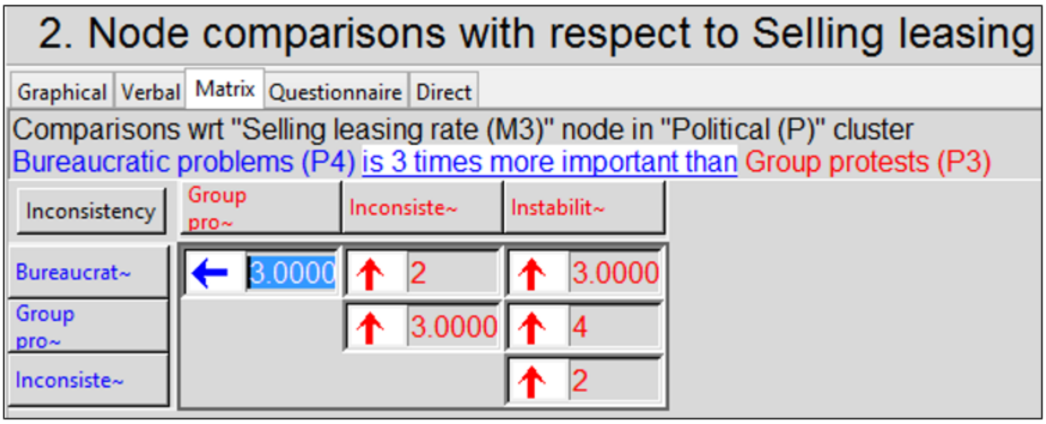

Figure 4.3. Pairwise Comparison with respect to Selling Leasing.

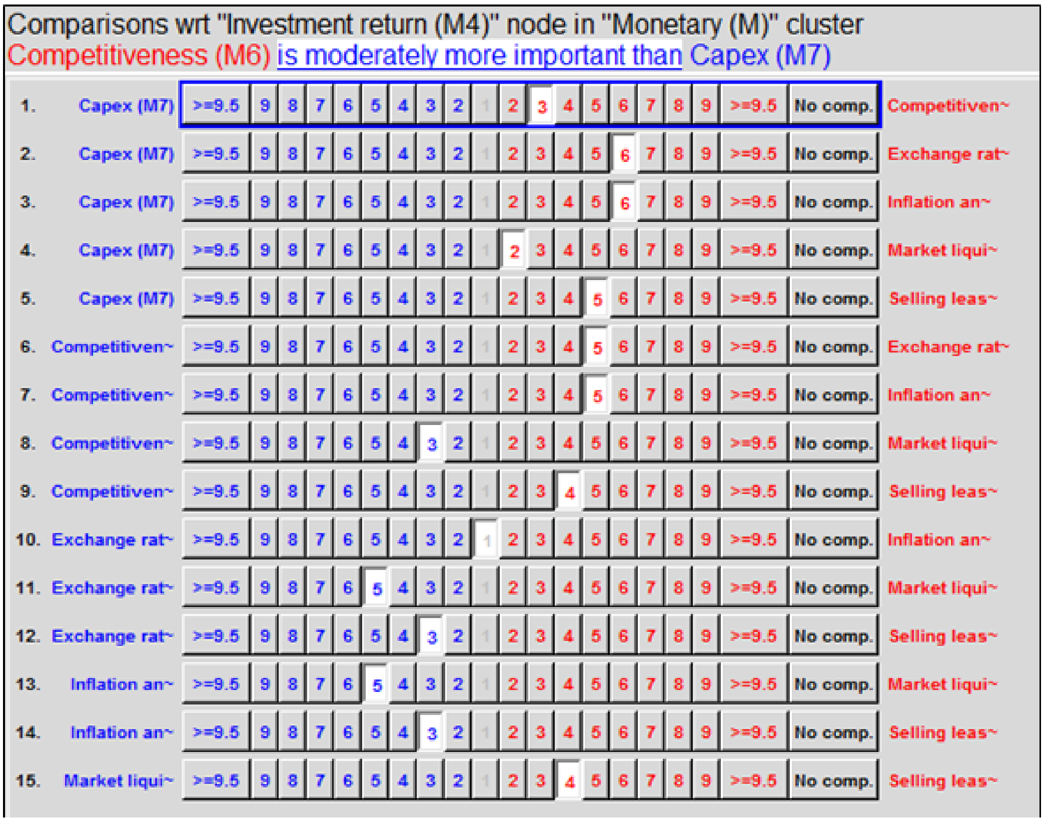

Figure 4.4. Pairwise Comparison with respect to Investment Return.

After all comparison matrices are incorporated in the software, the program gives three matrices which are called as supermatrices. These matrices are formed to analyze nodes and clusters relationships in the model. Unweighted supermatrices, weighted and limiting matrix are the forms of these matrices. This supermatrix is formed of prepared matrices by calculating in three steps via Super Decision software. Firstly, the unweighted supermatrix is calculated based on the given nine-point scale of pairwise comparison matrices. Secondly, the software provides the weighted supermatrix by calculating the multiplication of unweighted matrix values with the weight of clusters on nodes. Thirdly, the limiting matrix is obtained by multiplying priorities of elements with the cluster's priority. Shortly, Erdem and Ozorhon (2015) stated that "A supermatrix is computed in a three-step calculation: (1) the unweighted supermatrix is formed based on the scores of the pairwise comparison matrices among interacting elements; (2) next, the program calculates the weighted supermatrix by multiplying the values of the unweighted supermatrix with cluster weights on which nodes connect; and (3) as last step, a limiting supermatrix is achieved by raising the weighted supermatrix to powers until all of the columns corresponding to any node concentration the same values. In the program, limiting super matrix explains the priorities of each node of cluster and network. All calculated priorities of clusters and nodes are given in the Table 4.2.

Table 4.2. Cluster and Element Priorities.

No.	**Risks/Clusters - Nodes**	**Priorities**
POLITICAL RISKS		**0.24314**
P1	Political instability	0.73703
P2	Inconsistency in policies	0.14204
P3	Group protest	0.06244
P4	Bureaucratic problems	0.05848
MONETARY RISKS		**0.55133**
M1	Inflation and interest rate fluctuation	0.21613
M2	Exchange rate fluctuation	0.37348
M3	Selling or leasing rate	0.05738
M4	Investment return	0.07992
M5	Market liquidity	0.14459
M6	Competitiveness	0.09681
M7	Capex per sqm	0.01784
M8	Developer reputation	0.01385
ENVIRONMENTAL RISKS		**0.0533**
E1	Potential negative impacts	0.42361
E2	Climatic change	0.57639
PROJECT RISKS		**0.15224**
PR1	Site conditions	0.1002
PR2	Performance	0.18763
PR3	Technical difficulties	0.09353
PR4	Location selection	0.37635
PR5	Accessibility	0.12622
PR6	Changes in design and cons.	0.029
PR7	Facilities management	0.08707

4.3. Importance Weights

After the priorities are obtained, the last step is explaining the importance of weights. The multiplication of node priorities and related cluster priorities is performed to obtain the importance weights of nodes. By way of illustration, the priority of node M2 “Exchange rate fluctuation” which is shown in the table above, is 0.37348. Then, the importance weight of “Monetary” cluster is shown as “0.55133”. As a result, the importance of weight, shown in the table below, is obtained as “0.205911” by multiplying priority in node and cluster. In this manner, all results, importance weights of clusters, and results corresponding to the influence of decision are shown in Table 4.4 by calculating with multiplication.

Table 4.3. Clusters of Importance Weights.

No.	**Clusters**	**Importance Weight**
1	Political Risks (P)	0.24314
2	Monetary Risks (M)	0.55133
3	Environmental Risks (E)	0.0533
4	Project Risks (PR)	0.15224

Based on “Clusters of Importance Weights” results coming from software, the most important factor for decision is Monetary Risks with “0.55133” then respectively, “Political Risks” with 0.24314, “Project Risks” with 0.15224 and the last and least important factor is “Environmental Risks” with 0.05330.

According to Importance Weights in node shown in the table below, the first important risk factors on development decision are Exchange rate fluctuation (0.205911), Political instability (0.179201), Inflation and interest rate (0.119159), Market liquidity (0.79717) and Location selection (0.057296).

Table 4.4. Importance Weights of Risk Factors.

No.	**Code**	**Nodes in Clusters**	**Importance Weight**
1	M2	Exchange rate fluctuation	0.205911
2	P1	Political instability	0.179201
3	M1	Inflation and interest rate fluctuation	0.119159
4	M5	Market liquidity	0.079717
5	PR4	Location selection	0.057296
6	M6	Competitiveness	0.053374
7	M4	Investment return	0.044062
8	P2	Inconsistency in policies	0.034536
9	M3	Selling or leasing rate	0.031635
10	E2	Climatic change	0.030722
11	PR2	Performance	0.028565
12	E1	Potential negative impacts	0.022578
13	PR5	Accessibility	0.019216
14	PR1	Site conditions	0.015254
15	P3	Group protests	0.015182
16	PR3	Technical difficulties	0.014239
17	P4	Bureaucratic problems	0.014219
18	PR7	Facilities management	0.013256
19	M7	Capex per sqm	0.009836
20	M8	Developer reputation	0.007636
21	PR6	Changes	0.004415

4.4. Testing the Model

In the previous section, all results are obtained based on ANP methodology and terminology using the "Super Decision" software. In this section, to test the proposed model, the constructed steps will be explained clearly. Firstly, the unfilled Table 4.8 shown below is prepared and send to the newly formed expert team which are different than the first group. Then, the new expert team was requested to fill the table. Before the table is filled and scored through 100, they were asked to consider one of their previous CRED projects participation and share the details of the projects. All expert profiles and case study project details are given below Table 4.6 and Table 4.7.

Table 4.5. Expert Profiles.

No	**Interviewee Position**	**Experience (Years)**	**Expertise**
Case 1	Development Manager	11	Shopping Center, Outlet Center, Office and Hotel
Case 2	Business Development Asst. Manager	10	Shopping Center, Outlet Center, Office and Hotel
Case 3	Business Development Executive	8	Shopping Center, Outlet Center, Office and Hotel
Case 4	Business Development Manager	18	Shopping Center, Outlet Center, Office
Case 5	Sr. Development Executive	9	Office

All interviewee assessed a project in which they are involved and they were requested to evaluate the scores for their projects. Khumpaisal and Chen (2010) stated that the main concern is to evaluate the developers' opinions regarding the consequential degree of risks affected by their projects.

Table 4.6. Case Studies Details.

No	**Project Type**	**Size**	**Location**
Case 1	Outlet Center, Theme Park Center, Marine	255 million USD	İstanbul
Case 2	Shopping Mall - Outlet	870 million TL	İstanbul
Case 3	—M—i—x—e—d Used Development (Shopping Mall, Hotel, Residence, Office)	2,5 Billion USD	İstanbul
Case 4	Mixed Used Development (Theme Park, Hotel, Shopping Mall)	1,2 Billion USD	Antalya
Case 5	Office Building	125 million USD	İstanbul

In Table 4.8, all scores, which are related to a considerable degree of risks affected to selected projects, are shown below. The aim is to determine the effects of potential risks in the development decision-making process in CRED projects. The study information is provided with a face-to-face interview with the experts who are involved in the above-selected project. In Table 4.8, all calculated and actual scoring data, which refers to the overall score in terms of feasibility stages for CRED projects, are shown. The calculated rating is obtained by the experts scoring values with importance weights from ANP software program. Error rates are calculated by the evaluation of the estimated and actual score values. These case studies seem sufficient with error rates between "1.49 % - 4.76 %.

However, it should be noted that all scoring values are subjective, and it might change from developer to developer and their risk perception. Therefore, this rate is considered; it is said that these items should be regarded as sufficient for obtaining a feasible development decision. To receive more reliable data, the expert team can be diversified. Engineers, architects, finance team, site team, and management team members can be involved in the expert team to provide any point of view options. Also, more case studies may be added to the study to validate the model.

Table 4.7. Case Study Scoring and Testing the Model.

No	Sub-Criteria	CASE 1	CASE 1	CASE 3	CASE 4	CASE 5
P1	Political instability	90	80	85	90	85
P2	Inconsistency in policies	60	60	90	85	80
P3	Group protest	50	75	70	75	60
P4	Bureaucratic problems	85	70	85	80	75
M1	Inflation and interest rate	95	95	95	90	95
M2	Exchange rate fluctuation	95	95	95	90	95
M3	Selling or leasing	90	95	95	90	90
M4	Investment return	95	90	85	90	90
M5	Market liquidity	80	80	85	85	85
M6	Competitiveness	80	85	85	80	75
M7	Capex per sqm	85	80	70	60	70
M8	Reputation	85	90	65	60	70
E1	Potential negate. impacts	70	60	70	70	60
E2	Climatic change	60	60	40	30	50
PR1	Site conditions	85	80	90	60	80
PR2	Performance	80	85	70	70	80
PR3	Technical difficulties	85	75	60	70	75
PR4	Location selection	95	95	90	90	90
PR5	Accessibility	85	80	70	80	80
PR6	Changes in design and cons.	75	80	85	80	80
PR7	Facilities management	80	85	70	60	65

Table 4.8. Calculated, Actual Score and Error Rate.

Explanation	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
Calculated Score	81	81	79	73	74
Actual Score	80	78	75	70	72
Error (%)	1.49%	3.48%	4.76%	4.42%	2.84%

5. DISCUSSION

Real estate development industry, which has an impact on the construction industry as a whole, is one of the main components of the national economy, society wealth and social development. CRED projects, as one of the most common types of real estate development, have an impact on economic growth by creating jobs for subsectors, improving infrastructure and creating places for working, shopping, etc. Especially the years between 2003-2008 CRE investments had a significant contribution to Foreign Direct Investment (FDI) in Turkey and economic growth. The determination of related risk factors in CRED industry, which has a contribution to the national economy, and their effects on decision-making process have great importance. In this regard, this thesis focuses on the identification and categorization of risk factors in CRED projects, the interrelation between them, their priorities and the importance of weights.

Firstly, this study focuses on to determine and categorize the risk factors encountered in Turkey CRED projects. Within this purpose, an extensive literature review with 22 articles have performed, all possible risk factors in all types of construction projects, including limited real estate based studies are observed and listed. The risk criteria and similar risk factor are merged into the same group and irrelevant risk factors are excluded based on confirmation of both academicians and experienced professionals worked on CRED projects. Final 21 risk factors list, including four risk categories, is prepared and presented.

The first risk assessment criteria group is related to risks associated with political topics. These factors have included not only government-level risks but also local-level risks. The political risks consist of four risk factors explained below. These include political instability, inconsistency or change in policies, laws or regulations, thirdly civil disorder or group protests and bureaucratic problems such as late approval long-permit process, etc. Political instability defines as frequent changes in government, agitation for change of government or disputes between political parties or different organs of the state (Wang *et al.* 2015). Since political instability factor affects the whole projects' cost overrun, delay in time and naturally quality, it plays a crucial role in taking into account. Changes in policies, law, and regulations are another critical sub-criteria for CRED projects. For example, land or tax policies, changes in law like labor salaries or acts might affect projects' cost overrun. Civil disorder, terrorist attack, or group protest might also influence the project time delay. For instance, Khumpaisal and Chen (2010) and Arthurson (2001) specifically focus on political groups/activist's protest by urban communities. The bureaucratic problems are clarified as delay or refusal of project approval and permit by local government (Wang *et al.* 2015) or local city council Khumpaisal and Chen (2010). The risk caused by these type of delay in the approval process have great importance and effect on all project management steps in terms of cost, return on investment and time.

According to the extensive literature review, some subcategory risk groups (financial risks, investment related risks, economic risk, and market-related risks) have been merged into a significant risk group with a broad definition as "Monetary risks" to provide an efficient way in a more comprehensive perspective. In all real estate development project, profit, return on investment (ROI) and economic and financial factors have great importance because of its income generated characteristics. With all these concerns, there are eight risk criteria contained in monetary risk cluster. These include inflation and interest rate, exchange rate fluctuation, expected selling and leasing rate, investment return or expected capitalization rate, market liquidity, regional competitiveness, capital expenditure, and reputation.

Inflation and interest rate fluctuation might affect the construction cost and cash flow of the project. For instance, the contractor working for a real estate project might incur an additional fee due to price escalations in construction items and at the end of this, a price increase will affect the budget of project and ROI. On the other hand, interest rate fluctuation due to immature local economic and banking system might put forward delay payment or sufficient cash flow, all of which affect the cost overrun (Wang *et al.* 2015). The exchange rate fluctuation risk might create difficulties in convertibility that brings out cost overrun on the project budget.

In case of unexpected selling and leasing rate and low-return investment, project ROI might be affected and the cash flow of the project will remain insufficient. Naturally, this insufficient capital drastically will affect daily business operations, long term plans, as well as loan eligibility.

Real estate transactions are grouped into illiquid assets compared to funds, stocks, and bonds, etc. Especially during the financial crisis period, liquidity has become more crucial due to sales price has been fallen and investors were not able to sell assets. For developers or investors, in case of lower liquidity situation, the balance of the investor's portfolio might be damaged. For this reason, market liquidity risk should be taken into account.

The developer's reputation risk is the consequences of the adverse effects such as safety, security issues, ethical issues and a lack of sustainability, etc. This risk group was challenging to define and analyzed financially due to the subjectivity of the reputation term.

The third risk category is "Environmental Risk" factors. In this category, there are only two risk factors. These are potential negative impacts and climatic change Potential negative impacts explained and analyzed quantitatively in Khumpaisal and Chen (2010), article subsequently; soil and ground contamination, ground and underground water pollution, waste, noise and vibration, dust, hazardous emissions and odors, wildlife and natural features impact and archaeology impacts. Mustafa and Al-Bahar (1991) stated environmental risk under acts of god risks and political and environmental risks and these risk factors are merged into potential negative impacts. The other environmental risk is the climatic change, which is stated in Khumpaisal and Chen (2010), Deviprasadh (2007) and Chen and Khumpaisal (2009) articles.

The final risk category is "Project Risk". There are eight risks concerning project risks. These are: site conditions, designer and constructors' performance, technical difficulties, workforce availability, location selection, accessibility, changes is design and construction and finally, facility management. As a construction project's complexity nature, especially site conditions, it has many difficulties for every level of the development plan. The site condition and constraints create so many risks and any accidents stemming from these risks lead to delay in time and cost overrun. For instance, Bing *et al.* 2005 focused on site condition difficulties in macro level risk factors and gave an example "ground conditions are natural risks significant at the construction stage and are typically borne by the contractor. Also, Khalafallah *et al.* (2002) have focused on different site condition factors under construction risks.

Another project risk factor is the performance of designer and constructors that are explained as developers' satisfaction about their experience or any other services. Also, change risk in design and construction of the real estate development defines as amendments at the related phases and Khumpaisal and Chen (2010) stated that these amendments are highly related to cost and time change of the all project. Technical difficulties are generally associated with constructability or any problems in construction or design phases for all level of development. In both Khumpaisal and Chen (2010) and Chen and Khumpaisal (2009) articles, workforce availability in the market is analyzed under social risk group. However, interview expert suggests that this risk group should be observed under project related risks due to their results directly affect the project's objectives.

Location selection is a critical part, especially in feasibility studies (Khumpaisal and Chen (2010). Adair and Hutchison (2005) also stated the location selection (prime and secondary, etc.) is one of the principal factors considered to affect the investment quality and naturally investment return. Furthermore, Khumpaisal and Chen (2010) stated that a retail-led property as a one of CRE is strongly affected location selection risk. Infrastructure usability risk in the area of real estate development projects is explained in economic risk as area accessibility and expert who make interview also suggests that this risk should be observed under project-specific risk groups. The last risk factor is facility management, which refers to difficulties and complexities in facility management and possible scenario situations.

In the first step, the interrelations between the factors were determined by the expert team with meeting session providing a consensus. Then, the interrelations were entered to the software and the pairwise comparison matrices are taken from the software. Subsequently, taken pairwise comparison were simplified and presented to the expert team and it was requested them to fill these matrices. Finally, all filled matrices were entered into the software to obtain the priorities and the limiting matrix. In the last step, the importance weights of the risk factors were calculated based on the software output.

In the literature, similar academic studies have been performed for all types of the construction sector (Akıntöye and Macleof (1997), Alan and Chapman (2005), Bing *et al.* (2005) Dikmen and Birgönül (2006) Hastak and Shaked (2000), etc.) Although there are similarities in the main ideas and methods of research in principle, there are important points where this study is different from the others. Differences and theoretical contribution are explained as follows.

This research focuses on the risk factors encountered in CRED projects and their effects on development decision in Turkey where limited literature have covered the risks in the especially for the real estate field. In literature, real estate market-related studies, especially for Turkey, were insufficient. Research studies are generally not focused on a particular country like Turkey. Studies generally remain limited with many countries in types of construction industry perspective. For instance, Bing *et al.* (1999) designated the risk factors for international construction JV projects, Hastak, and Shaked (2000) developed an AHP model, including international construction projects. Shen *et al.* (2001) have focused on JV project risk in China. Gehner *et al.* (2006) have performed a study for Netherland real estate development industry and Thyet *et al.* (2007) focused on oil and gas construction projects in Vietnam an etc.

On the other hand, in literature, there are studies which are focused on selecting the best development alternatives, location, property type, and strategy by using multi-criteria decision-making methods. In these types of researches, the main goal is the selection of best alternatives rather than the calculation of importance weights of criteria or factors. For instance, Khumpaisal and Chen (2010) have applied in ANP model by giving an approach to support developers in the decision-making process. The model also provides the selection of best alternatives in Liverpool City Center specific location. The main focus of authors is a selection of best development alternative, not an evaluation of the importance weights. However, one of the main goals in the study is to assess factor priorities and importance weights of criteria. Thereby, it aims to fill this gap literature by providing a tool for decision makers in the industry to evaluate and quantify the risk factors of a development plan, taking into account interrelations among them. Also, CRED project has its uniqueness and features and this study helps fill the knowledge gap in the studies of risk criteria with a specific market in a particular location.

In previous studies, risk criteria for construction or real estate-based projects have similar categorization. For instance; Alan and Chapman (2009), Chen and Khumpaisal (2009), Khumpaisal and Chen (2010), James L. Morrison (2007) categorized their risk factors in their research studies as STEE factors (Social, Technological, Environmental, and Economic). Some of them also have used the Political factor as well. Another group divided risk groups as Internal, External and Project Specific or Micro and Macro levels. All criteria list table is shown in Table 4.1. In this study, the difference from other is merging all similar categories under "PEMP" factors including Monetary and Project Related Risk criteria. Financial, Market Related Risk and Economic risks are examined in detail and merged under the "Monetary" roof. Also, some risk factors differ from other real estate development from other developed countries, especially country, legal and regulatory risks, which are due to the regulation of the local market and the economic and political situations of the countries of origin. In this study, political risks, regulatory/policy risks, country risks and legal/contractual risk groups are covered and combined into "Political Risk".

In decision-making methods selection, AHP application has been dominant in the construction industry because this application is easy to apply compared to ANP. According to Sipahi and Timör (2010), there are only 12 studies conducted between "2005-2008" and 8 of them have used AHP application. After 2009, ANP application is examined in especially in the construction industry. For example, Dikmen *et al.* (2009) have performed to determine relative priorities of risk factors for decision support tool, which can be utilized during bidding decisions in the construction industry. In this research, ANP, which allow consideration of the interdependence of factors, is selected for decision-making methods for evaluation of the risk factors in CRED projects.

Similar to all types of construction projects, CRED projects includes many risk and uncertainties. This research contributes to the literature by defining and classifying the risk factors encountered in Turkish CRED projects from the decision- makers point of view. Numbers of risk factors and classification names may differ in each study because the project types, project location, and project attitudes may change in different studies of the literature. In terms of practical contributions, this study presents a way to understand risk factors. Decision-makers having experience in CRED projects could also benefit from listed risk criteria and priorities before deciding their development, feasibility or conceptual design phases. This enables them to understand the origin of risk factors and to take preventive precautions before the development phase. Although the results are valid for the Turkish CRED projects, similar models with minor changes may be developed for other types of projects in other countries.

As a recommendation, the decision makers in the CRE market should consider all risks and uncertainties. In this manner, before making a development decision, explained risk criteria should be taken into account and their possible outcomes should be evaluated. According to the results, it is observed that “Monetary” and “Political” risk factors are great importance on development projects. In the monetary cluster, “Exchange rate fluctuation”, “Inflation and interest rate fluctuation”, “Market liquidity” “Competitiveness” and “Investment Return” risk factors have around 50% importance weights on the development decision. When this rate is considered, it is said that these items should be considered as top items for obtaining satisfied and feasible development decisions.

On the other hand, in “Political” cluster, “Political instability” and “Inconsistency in policies”, risk factors have more than 20% importance on the development decision. As a result, it is indicated that Monetary and Political Risk clusters are crucial risk categories affecting the development decision. At that point, the developers, the stakeholders or the other decision makers should prepare their contingency plan to mitigate the consequence of risks and respond to these risk groups. Furthermore, "Environmental Risk" cluster and also "Project Related Risk" clusters should also be taken into account. For example; "Project Location" in the Project Risk cluster is in top-5 most important risk factors and also a critical factor in profitability in development projects. In order to obtain a satisfying development project with good quality, high profitability, the decision makers should be conscious of risks criteria considering their importance weights.

In testing the model part, all scoring values are subjective, and it might change from developer to developer and their risk perception. As an improvement, the expert team may be diversified. Engineers, architects, finance team, site team, and management team members can be included in the expert team to provide different perspectives. Also, more case studies may be conducted to validate the model. In addition, this study is presented based on the current economic, political, and environmental conditions of Turkey in 2019. It should be noted, however, the CRE industry is highly dynamic and open to change. Therefore, risk factors and results may vary in different markets and in different time periods.

Moreover, there are some complexities regarding impractical outputs in ANP application, especially in model construction and entering the interdependencies. ANP is also more sophisticated in its application and not user-friendly due to the amount of pairwise comparison that would be necessary. Other software programs, "Expert choice" or "Decision lens", may be used.

6. CONCLUSION

In all the real estate development and specifically CRED projects, risk and uncertainties occurred and affected all stages of the projects. The decision-making process in which developers, investors, and related team leaders and members involved are affected by this risk and uncertainties. Also, these risks and uncertainties influence projects' objectives by leading to cost overrun, delay in time and poor quality. This thesis focuses on the risk assessment of CRED projects and it aims to provide some perspectives to increase the effectiveness of decision-making on the development process. Although there are many studies for assessing risk criteria in any other type of projects in the construction industry or in general, the real estate development based projects, even CRED projects have remained limited. Because of the real estate market nature, inadequate studies and their possible outcomes, findings of this study fill the gap with the knowledge within the extensive literature review.

In order to evaluate the risk factors for CRED projects, the ANP application tool has been applied. The hierarchical structure has been set up and the interdependencies between the elements have been determined. ANP calculation has been performed based on the literature review study and expert confirmation and experiences in CRED projects. In this manner, the risk factors have been determined based on the detailed literature review. One hundred eight risks criteria under 34 categories have been listed as a result of an extensive literature review. Even though many studies in the literature have been examined, it was realized that the contents of the studies are quite similar. The risk criteria list table combining related risk factors has been prepared based on the literature. Since real estate market-related studies in Turkey were insufficient and were not included in the literature, the prepared list including criteria and factors has been analyzed by interviewing with an experienced person in the industry and an academician. The confirmation was provided by an academician and experienced professional. The final version of the risk criteria list has been created. A total of 21 risk factors were analyzed under PEMP factors, which were divided as "Political", "Environmental", "Monetary" and "Project Related" risk factors.

Through the study, ANP technique has been selected for analyzing and ranking the risk factors encountered in CRED projects. This technique has been applied, considering the interrelations between risk factors. The model has been created by utilizing SUPERDECISION decision-making software in order to evaluate the priorities and the importance of weights. The validity of the proposed model is tested with the gathered data from the expert team with the case studies.

After obtaining the importance of weights, it is seen that "Monetary" cluster has great importance among the other clusters. Political, Project and Environmental risks are the other risk clusters, respectively. According to the calculated data in the clusters, "exchange rate fluctuation", "political instability", "inflation and interest rate fluctuation", "market liquidity" and "location selection" are the most important risk factors for CRED projects in conducting feasibility stages. Three of 5-top most important factors are under the "Monetary" cluster, one of them is under the "Political" cluster and the last one is under the "Project" cluster. Environmental cluster is not as important as the other clusters. The least important risk factors are ordered as follows respectively; "facilities management", "capital expenditure", "reputation", "changes in design and construction". In this manner, before making a development decision, explained risk criteria should be taken into account and their possible outcomes should be evaluated. According to the results, it is observed that "Monetary" and "Political" risk factors are great importance on development projects. It is said that these items should be considered as top items for obtaining satisfied and feasible development decision.

On the other hand, in "Political" cluster, "Political instability" and "Inconsistency in policies" risk factors significant importance on the development decision. As a result, it is indicated that Monetary and Political Risk clusters are crucial risk categories affecting the development decision. At that point, the developers, the stakeholders or the other decision makers should prepare their contingency plan to mitigate the consequence of risks and respond to these risk groups.

For further studies, the ANP model can be applied more for future real estate development projects to provide support to the developers or the other stakeholders during the decision-making process and risk evaluation. Also, new ANP Model application models should be developed and compared to many case studies especially in Turkish Real Estate Market because there is an important gap in the literature about this topic to explain needs for evaluating risks. As an alternative, in order to define risk criteria, the Delphi method with an extensive literature review can be applied. To improve consistency and obtain more reliable data, researchers can collect data from the more expert team by verifying the model in more cases. As another option, researches can compare two or more specific case studies and continue to assess risk factors in specific development projects or alternatives. This research could give an idea to assess CRED projects' risk and could provide a focusing point to decision makers and developers. The proposed model could be utilized in not only Turkish Real estate market, specifically CRED projects but also in any other foreign market as well.

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APPENDIX A: PAIRWISE COMPARISON MATRICES

Table A.1. Pairwise Comparison Matrices 1.

Decision	Environmental (E)	Monetary (M)	Political (P)	Project (PR)
Environmental (E)		1/7	1/5	1/4
Monetary (M)			3	4
Political (P)				2
Project (PR)				

Table A.2. Pairwise Comparison Matrices 2.

Monetary	Monetary (M)	Political (P)	Project (PR)
Monetary (M)		3	4
Political (P)			2
Project (PR)			

Table A.3. Pairwise Comparison Matrices 3.

Political	Monetary (M)	Political (P)
Monetary (M)		3
Political (P)		

Table A.4. Pairwise Comparison Matrices 4.

Project	Environmental (E)	Monetary (M)	Project (PR)
Environmental (E)		1/7	1/4
Monetary (M)			4
Project (PR)			

Table A.5. Pairwise Comparison Matrices 5.

Environmental	E2	E1
E2		1/3
E1		

Table A.6. Pairwise Comparison Matrices 6.

Monetary	**M7**	**M6**	**M2**	**M1**	**M4**	**M5**	**M8**	**M3**
M7		1/2	1/6	1/6	1/5	1/2	2	1/4
M6			1/5	1/5	1/4	3	4	1/2
M2				1	2	5	6	3
M1					2	5	6	3
M4						5	5	2
M5							3	1/3
M8								1/4
M3								

Table A.7. Pairwise Comparison Matrices 7.

Political	**P4**	**P3**	**P2**	**P1**
P4		4	1/2	1/3
P3			1/2	1/2
P2				1/2
P1				

Table A.8. Pairwise Comparison Matrices 8.

Project	**PR5**	**PR6**	**PR7**	**PR4**	**PR2**	**PR1**	**PR3**
PR5		2	1/4	1/6	1/5	1/3	1/4
PR6			1/4	1/6	1/5	1/3	1/2
PR7				1/4	1/3	1/2	2
PR4					2	3	4
PR2						3	3
PR1							2
PR3							

Table A.9. Pairwise Comparison Matrices 9.

Investment Return	M7	M6	M2	M1	M5	M3
M7		1/3	1/6	1/6	1/2	1/5
M6			1/5	1/5	3	1/4
M2				1	5	3
M1					5	3
M5						1/4
M3						

Table A.10. Pairwise Comparison Matrices 10.

Investment Return	P4	P3	P2	P1
P4		4	1/2	1/3
P3			1/2	1/5
P2				1/2
P1				

Table A.11. Pairwise Comparison Matrices 11.

Market Liquidity	M2	M1
M2		1
M1		

Table A.12. Pairwise Comparison Matrices 12.

Market Liquidity	P3	P2	P1
P3		1/3	1/4
P2			1/2
P1			

Table A.13. Pairwise Comparison Matrices 13.

Site Conditions	E2	E1
E2		1/2
E1		

Table A.14. Pairwise Comparison Matrices 14.

Selling Leasing Rate	M6	M2	M1	M5	M8
M6		1/5	1/4	3	4
M2			1	5	6
M1				5	6
M5					2
M8					

Table A.15. Pairwise Comparison Matrices 15.

Selling Leasing Rate	P4	P3	P2	P1
P4		3	1/2	1/3
P3			1/3	1/4
P2				1/2
P1				

Table A.16. Pairwise Comparison Matrices 16.

Bureaucratic Problems	P3	P2
P3		1/4
P2		

Table A.17. Pairwise Comparison Matrices 17.

Group Protests	**M2**	**M1**
M2		1
M1		
Group Protests	**P2**	**P1**
P2		1/3
P1		

Table A.18. Pairwise Comparison Matrices 18.

Bureaucratic Problems	**P3**	**P2**
P3		1/4
P2		

Table A.19. Pairwise Comparison Matrices 19.

Performance (PR2)	**E2**	**E1**
E2		1/3
E1		

APPENDIX B: LITERATURE REVIEW LISTS FOR RISK IDENTIFICATION

Table B.1. Literature Review Lists for Risk Identification.

Lit. No	Reference Author	Article Name
P1	Akintoye MacLeod -1997	Risk analysis and management in construction
P2	Chapman (2009)	PEST analysis method and examples with free PEST template
P3	Baum and Crosby (2008)	Property investment appraisal
P4	Bing *et al.* (2005)	The Allocation of Risk in PPP PFI Construction Projects in the UK.
P5	Chen and Khumpaisal -2009	An analytic network process for assessment in CRED
P6	Khumpaisal and Chen -2010	Risks Assessment in RE Development: ANP
P7	Dikmen Birgonul -2006	AHP Based model for risk and opportunity assessment of ICP
P8	Dikmen *et al.* -2007	Using Fuzzy Risk Assessment to Rate Cost Overrun Risk in ICP
P9	Forrest E. Huffman -2002	Corporate real estate risk management and assessment.
P10	Gehner *et al.* *-2006*	Risk management in the Dutch Real Estate Development Sector
P11	Hargitay Yu -1993	Decision criteria - return and risk, property investment decisions: A quantitative approach.
P12	Hastak Shaked -2000	ICRAM-1:Model for Intern Construction Risk Assessment
P13	He Zhi (1995)	Risk management for overseas construction projects
P14	James L. Morrison -2007	STEEP Factors
P15	Bing *et al.* -1999	Risk Management in International Construction JV
P16	Mustafa Al-Bahar -1991	Project Risk Assessment Using The AHP
P17	Nezhad Kathawala -1990	Risk Assessment for International Investment
P18	Perera *et al.* -2009	Risk management in road construction: the case of Sri Lanka
P19	Sameh Monir El-Sayegh -2008	Risk assessment and allocation in the UAE construction industry
P20	Shen *et al.* -2001	Risk Assessment for Construction JV in China
P21	Thuyet *et al.* -2007	Risk management in oil and gas construction projects in Vietnam
P22	Zhang and Zou -2007	Fuzzy AHP Risk Assessment Approach

APPENDIX C: ALL RISK FACTORS LIST

Table C.1. All Risk Factors List.

Original Factor No.	Risk Criteria	Lit. Review No
1	Environmental (e.g. weather)	P1, P9, P13, P14, P15, P16, P18, P19, P20, P21
2	Political, Social and Economic (e.g. inflation)	P1, P5, P6, P11, P12, P13, P14, P15, P16, P18, P19, P20, P21, P22
3	Contractual (e.g. responsibilities)	P1, P6, P12, P13, P18, P19, P20, P21, P22
4	Financial	P1, P9, P11, P12, P13, P14, P15, P16, P20, P21, P22
5	Construction	P1, P6, P9, P10, P13, P14, P15, P18, P19, P20, P21, P22
6	Market/Industry	P1, P5, P6, P11, P20
7	Company/Corporate	P1, P13, P20, P22
8	Development in IT	P1
9	Project (design information)	P1, P6, P7, P8, P9, P12, P13, P18, P20, P22
10	Unstable government	P1,P4, P15, P16, P20
11	Expropriation or nationalization of assets	P4,P12, P16, P22
12	Poor public decision-making process	P1, P4, P20, P21,P22
13	Strong political opposition/hostility	P1,P4, P12, P16, P18, P20,P22
14	Poor financial market	P1,P4, P12, P13, P21, P22
15	Inflation rate volatility	P1, P4, P5, P6, P11, P12, P13, P14, P15, P16, P18, P19, P20, P21, P22
16	Interest rate volatility	P1, P4, P5, P6, P11, P12, P13, P14, P15, P16, P18, P19, P20, P21, P22
17	Influential economic events	P1, P4, P9, P11, P12, P13, P15, P19, P21
18	Change in tax regulation	P4, P9, P11, P12, P13, P16, P18, P21
19	Industrial regulatory change	P4, P6, P12, P16, P18, P21
20	Legislation change	P4, P6, P12, P16, P18, P22
21	Force majeure	P4, P16, P21, P22
22	Geotechnical conditions	P4
23	Weather	P1, P4, P6, P9, P13, P16, P18, P19, P21
24	Environment negative impacts	P1, P4, P6, P9, P13, P14, P16, P18, P19, P21
25	Project selection	P1, P4, P20
26	Land acquisition	P4
27	Delay in project approvals and permits	P4, P6, P7, P8, P12, P13, P16, P18, P19, P21, P22
28	Construction cost overrun	P4, P6, P10, P20, P21, P22
29	Construction time delay	P4, P6, P7, P8, P10, P20, P21, P22
30	Material/labor availability	P4, P6, P19, P21, P22
31	Late design changes	P4, P7, P8, P9, P18, P19
32	Poor quality workmanship	P4, P20,P22
33	Excessive contract variation	P1, P4, P19, P22
34	Insolvency/default of sub -contractors or suppliers	P1, P4, P6, P7, P8, P10, P20, P22
35	Design deficiency	P4, P6, P7, P8, P9, P18, P19

Table c.1. All Risk Factors List (cont.).

Original Factor No.	Risk Criteria	Lit. Review No
36	Maintenance costs higher than expected	P4, P21
37	Adverse environment impacts	P1, P5, P6, P9, P13, P16, P18, P19, P20, P21
38	Climate change	P1, P5, P6, P13, P20
39	Workforce availability	P1, P5, P6, P20, P22
40	Cultural compatibility	P5, P6, P19, P20, P22
41	Community acceptability	P5, P6, P13, P20
42	Public Hygiene	P5, P6
43	Interest Rate	P1, P5, P6 P9, P11, P12, P13, P16, P19, P20, P21, P22
44	Property Type	P5, P6, P9, P11
45	Market Liquidity	P1, P5, P6, P9, P11, P20
46	Confidence to the market	P1, P5, P6, P9, P11, P12, P16
47	Demand and Supply	P5, P6, P9, P11, P20
48	Purchesability	P5, P6
49	Brand visibility	P1, P5, P6, P20
50	Capital Exposure	P5, P6
51	Lifecycle value	P5, P6
52	Area accessibility	P5, P6
53	Currency conversion	P5, P6, P11, P13, P16, P19, P21, P22
54	Buyers	P5, P6, P9, P11
55	Tenants	P5, P6, P9, P11
56	Investment Return	P1, P5, P6, P9, P11, P21, P22
57	Site conditions	P5, P6, P9, P13, P16, P20
58	Designer and constructors	P1, P5, P6, P7, P8, P12, P13, P19, P20, P21,P22
59	Multiple functionality	P5, P6
60	Constructability	P1, P5, P6, P9, P13, P18, P19, P20, P21, P22
61	Duration	P5, P6, P20
62	Amendments	P5, P6, P13, P19, P20
63	Facilities Management	P5, P6, P9
64	Accessibility and evacuation	P5, P6
65	Durability	P5, P6
66	Political Groups/Activist	P6, P20
67	Commercial Tax Policy	P6
68	Tax Policy	P6, P11, P12, P21
69	Council Approval	P6
70	License Approving	P6, P13, P18, P19, P22
71	Risks of planning procedure	P10
72	Delay of development process	P6, P7, P8, P10, P20
73	Marketing risks	P9, P10, P20
74	Technical/construction risks	P1, P6, P7, P8, P9, P10, P12, P13, P14, P15, P18, P19, P20, P21, P22
75	Legal/judicial risks	P6, P10, P18, P19, P20, P21
76	Risks of abandonment	P10
77	Objection against building plans	P10
78	Tendering: construction costs	P1, P10, P12, P19, P20
79	Changes in politics	P1, P9, P10, P12, P13, P14, P15, P16, P20
80	Changes in legislation	P9, P10, P16, P18, P20
81	Design errors	P7, P8, P10, P16, P18, P20
82	Risks of site conditions	P5, P6, P10, P16, P20
83	Interest risks	P1, P9, P10, P11, P13, P15, P16, P20, P21, PP22
84	Civil disorder	P10, P13, P16, P20, P22
85	Delay in construction time	P4, P6, P7, P8, P10, P20, P21, P22
86	Risks of making ready for building	P10
87	Archaeological excavation	P5, P6, P10
88	Pollution	P1, P5, P6, P10, P15, P16, P22
89	Protected flora and fauna	P10
90	Liability risks	P10

Table c.1. All Risk Factors List (cont.).

Original Factor No.	**Risk Criteria**	**Lit. Review No**
91	Financing risks	P1, P5, P6, P9, P10, P15, P16, P21, P22
92	Fiscal risks	P10
93	Risks of monumental building	P5, P6, P10
94	Vacancy	P5, P6, P10, P11
95	Longer time to rent/ sell	P5, P6, P9, P10, P11
96	Risks in rental/sale price	P5, P6, P9, P10, P11
97	Bankruptcy of advisors/contractor	P1, P4, P7, P8, P10, P12, P15, P19, P20, P21, P22
98	Construction defects	P6, P9, P10, P20
99	Bureaucratic government system and long project approval	P1, P4, P9, P12, P13, P15, P16, P20, P21, P22
100	Poor design	P5, P6, P7, P8, P9, P13, P15, P16, P18, P19, P20, P21
101	Incompetence of project team	P6, P15, P19, P20, P21, P22
102	Inadequate tendering	P1, P6, P12, P20, P21, P22
103	Improper selection of project location	P1, P4, P20, P21
104	Loss incurred due to corruption and bribery	P12, P13, P16, P19, P20, P21, P22
105	Competition from other similar projects	P5, P6, P20, P21
106	Inadequate forecast about market demand	P1, P5, P6, P11, P20, P21
107	Increase of accessory facilities price	P5, P6, P20, P21
108	Design changes	P4, P7, P8, P9, P18, P19

APPENDIX D: COMBINED FACTORS LIST

Table D.1. Combined Factors List.

Combined Factor No	Original Factor No	Risk Factors
1	2,10,11,13,104	Political instability
2	12,18,19,20,67,68, 79,80	Inconsistency in policies
3	66,84	Civil disorder, terrorist attack, group protests
4	27,69,70,75,77,99	Bureaucratic problems (late council approval, long permit process, etc.)
5	2,15,16,43,	Inflation and interest rate fluctuation
6	53	Exchange rate fluctuation
7	54,55,94,95,96	Selling or leasing rate
8	2,4,56,91	Investment return (capitalization rate)
9	6,14,17,45,46,48,106	Market liquidity
10	47,105	Regional Competitiveness
11	50	Capital Expenditure (Capex)
12	7,34,49,97	Developer or local partner (if any) reputation
13	21,22,24,37,87,88,89	Potential adverse impacts
14	1,23,38	Climatic change
15	39,40,41,42,57,64,82,93	Site conditions
16	32,34,58,101	Designers and constructors' performance
17	5,8,60,74,78,102	Technical difficulties
18	25,103	Location Selection
19	52,103	Accessibility
20	9,28,29,30,31,35,62,71,81,100,108	Design and Construction Changes
21	36,63,107	Facilities management