DEVELOPING ROBUST PROJECT SUCCESS MODELS FOR TRANSPORTATION PROJECTS IN TURKEY: INTEGRATING CSFS AND CONTRACT SIGNING PARAMETERS

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ABSTRACT

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In Turkey, the transportation sector attracts a significant share of public investments, primarily directed towards transportation projects to ensure their success. However, not all projects within this sector achieve success, and a comprehensive analysis of the factors impacting project success in Turkey is lacking. This thesis aims to develop project success models for transportation projects in Turkey, focusing on overall success, budget success, and schedule success. Through data collection and linear regression analysis, the study identifies critical success factors (CSFs) specific to the Turkish transportation context. Real project data from 118 selected projects is utilized to develop and evaluate the accuracy of the models, employing metrics such as adjusted R^2 values, Mean Squared Error (MSE), and Mean Absolute Percent Error (MAPE). The study discusses the significance and influence of selected variables on project success and provides insights into the dynamics and complexities of transportation projects in Turkey. By incorporating parameters obtained during the contract signing phase, the research enhances the practical relevance of its findings, bridging the gap between theory and application in transportation project management. Moreover, the study highlights the negative impact of negotiation

method as tender procedure on project success, recommending improvements in public procurement practices. These findings have important implications for policy and decision-making, encouraging competitive procurement processes for better project outcomes. Implementing the suggested changes based on the study's findings can lead to improved project success rates, reduced risks, and more effective utilization of public investments in the Turkish transportation sector.

Keywords: Critical success factors, PPP, Infrastructure, Procurement strategies, Regression analysis

ÖZ

TÜRKİYE'DEKİ ULAŞTIRMA PROJELERİ İÇİN PROJE BAŞARI MODELLERİ GELİŞTİRME: KRİTİK BAŞARI FAKTÖRLERİNİN VE SÖZLEŞME İMZALAMA PARAMETRELERİNİN ENTEGRASYONU

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Türkiye’deki kamu yatırımlarının önemli bir kısmı ulaştırma sektörüne ayrılır. Bu yatırımların büyük bir kısmı ulaşım projelerine yönlendirilmekte ve bu projelerin başarılı bir şekilde tamamlanması hedeflenmektedir. Ancak, sektördeki tüm projelerin başarıyla sonuçlandırılamadığı görülmektedir ve Türkiye'deki ulaşım projelerinin başarısını etkileyen faktörler yeterince araştırılmamıştır. Bu tez, Türkiye'deki ulaştırma projelerinin genel başarı, bütçe başarısı ve iş programı başarısı üzerine odaklanarak proje başarı modelleri geliştirmeyi amaçlamaktadır. Bu araştırma, veri toplama ve doğrusal regresyon analizleri aracılığıyla, Türkiye'nin ulaştırma bağlamına özgü kritik başarı faktörlerini (CSF'ler) belirlemektedir. Seçilen 118 projenin gerçek proje verileri kullanılarak, modellerin geliştirilmesi ve doğruluğunun değerlendirilmesi sağlanmıştır. Düzeltilmiş R^2 değerleri, Ortalama Hata Karesi (MSE) ve Ortalama Mutlak Yüzde Hata (MAPE) gibi metrikler kullanılarak modellerin doğruluğu değerlendirilmiştir. Çalışma, seçilen değişkenlerin proje başarısı üzerindeki önemini ve etkisini tartışmakta ve Türkiye'deki ulaştırma projelerinin dinamiklerine ve karmaşıklıklarına dair içgörüler sunmaktadır. Sözleşme imzalama aşamasında elde edilen parametreleri dahil etmek suretiyle, araştırma bulgularının pratik uygulanabilirliği artırılmış ve ulaştırma proje yönetiminde teori ile uygulama arasındaki boşluk doldurulmuştur. Ayrıca, çalışma, ihale sürecindeki pazarlık usulünün proje başarısı üzerindeki olumsuz etkisini vurgulamakta ve kamu ihale uygulamalarında iyileştirmeleri önermektedir. Bu bulgular, politika yapma ve karar alma süreçleri için önemli sonuçlar taşımakta ve daha iyi proje sonuçları için rekabetçi ihale süreçlerinin teşvik edilmesini önermektedir. Araştırmanın bulgularına dayanarak önerilen değişikliklerin uygulanması, Türkiye'nin ulaştırma sektöründe proje başarılarının artırılmasını, risklerin azaltılmasını ve kamu yatırımlarının daha etkili kullanılmasını sağlayabilir.

Anahtar Kelimeler: Kritik başarı faktörleri, KÖİ, Altyapı, Satın alma stratejileri, Regresyon analizi

Dedicated to my beloved family

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LIST OF ABBREVIATIONS

ABBREVIATIONS

AYGM: Altyapı Yatırımları Genel Müdürlüğü

BOT: Build-Operate-Transfer

CSFs: Critical Success Factors

DHMİ: Devlet Hava Meydanları İşletmesi

DPPI: Domestic Producer Price Index

EKAP: Elektronik Kamu Alımları Platformu

EUR: Euro

IJV: International Joint Venture

JV: Joint Venture

KGM: Karayolları Genel Müdürlüğü

KİK: Kamu İhale Kanunu

KPI: Key Performance Indıcator

MAPE: Mean Absolute Percent Error

MSE: Mean Squared Error

PMBOK: Project Management Body of Knowledge

PMI: Project Management Institute

PPP: Public Private Partnership

SEM: Structural Equation Modeling

SSR: Sum of Squared Residual

SST: Sum of Squares for Treatment

TCDD: Türkiye Cumhuriyeti Devlet Demiryolları

TUİK: Türkiye İstatistik Kurumu

U.K.: The United Kingdom

U.S.: The United States

UYS: Ulaştırma Yönetim Sistemi

TL: Turkish Lira

USD: The United States Dollar

LIST OF SYMBOLS

SYMBOLS

$\in$: Residual

CHAPTER 1

INTRODUCTION

1.1 Motivation

In Turkey, the transportation sector receives a significant portion of public investments. As outlined in the 2023 Investment Program of the Presidency of Strategy and Budget - Presidency of the Republic of Turkey, over a quarter of public investments in 2023 will be allocated to the transportation sector which is surpassing the total investments in education and healthcare (Türkiye Cumhuriyeti Cumhurbaşkanlığı Strateji ve Bütçe Başkanlığı, 2023). These investments are primarily channeled into transportation projects, with the goal of achieving project success. However, not all projects in the sector are successfully completed, and the factors influencing project success in Turkey have not been extensively studied.

One of the main reasons for the limited research on project success factors in Turkey is the difficulty in accessing project data, which is typically challenging to obtain. The availability of project data has been a driving force behind the initiation of this study, as it provides an opportunity to delve into critical success factors specific to transportation projects in Turkey. The research aims to identify the factors that significantly impact the overall success, budgetary success, and program success of such projects.

Critical success factors can emerge at various stages of a project, and they originate from diverse sources, often beyond the control of project stakeholders. However, the existing literature lacks comprehensive research on how factors at different project stages influence project success. There is not any research investigated focusing on critical success factors emerging pre-contract stage. This knowledge gap, along with the presence of a dataset containing pre-contract information, has motivated the current study to explore the relationship between project stages and project success.

Furthermore, in the context of public tenders, while technical qualifications and price validity criteria are disclosed, there is currently no decision support mechanism to assist in contract signing, termination, or repetition of tenders. The potential development of project success prediction models through this research presents an opportunity to establish a decision support mechanism. Such models would estimate the overall success, budgetary success, and program success of a project before contract signing, aiding decision-makers in determining whether to proceed with the contract or not.

Moreover, existing literature on critical success factors in transportation projects in Turkey relies on survey-based approaches rather than utilizing authentic project data. Additionally, these studies primarily focus on factors that manifest during the execution phase of the project, aiming to support decision-making during the construction phase. In contrast, the present research takes real project data and identifying critical success factors at the pre-contract stage. This approach presents a unique opportunity to support decision-makers in determining whether to proceed with contract signing under existing conditions.

Furthermore, the previous research in the international context is also limited in addressing the specific gap this study seeks to fill. While studies on critical success factors in transportation projects do exist, they often lack an emphasis on pre-contract stages. The lack of studies targeting the critical success factors emerging before contract signing leaves a significant knowledge gap in the literature.

Given this background, the current study aims to fill both the domestic and international gaps in the literature by using actual project data and focusing on pre-contract stages. By examining the factors that are crucial for project success during the tendering and contract signing stages, this research aims to develop project success prediction models that can effectively assess overall success, budgetary success, and program success. Consequently, these prediction models can serve as decision support mechanisms for stakeholders involved in public tenders. With the capability to estimate project success even before the contract is signed, decision-makers will be empowered to make more informed choices regarding contract signing, termination, or repetition of tenders, thereby enhancing the efficiency and effectiveness of transportation projects.

In conclusion, the inadequacy of research on pre-contract critical success factors in transportation projects, the reliance on real project data, the focus on decision support mechanisms at tender and contract signing stages, and the potential to fill significant knowledge gaps both nationally and internationally serve as the motivations behind this research. Researching the critical success factors that emerge during the pre-contract stage and their impact on project success, this study aims to make a valuable contribution to the field of construction management and project planning.

1.2 The Objective of the Thesis

The main objective of this research is to develop regression models to predict the overall success, budget success, and schedule success of transportation projects in Turkey at the stage of contract signing. Other objectives that revolve around this main goal are as follows:

- To determine the critical success factors that influence the success of transportation projects in the specified three areas at the stage of contract signing and pre-contract.
- To identify project characteristics that do not sufficiently impact the success of transportation projects in the specified three areas at the stage of contract signing and pre-contract.

- To develop a decision support mechanism for contract signing or non-signing based on the generated success prediction models, contributing to an increase in the success rate of transportation projects.
- To identify the areas that decision-makers should pay attention to for future projects to be more successful.
- To identify if there is gap in regulations that negatively affect project success and provide recommendations to lawmakers.

1.3 Scope

This study focuses on investigating the factors that influence the overall project success, budget success, and schedule success of transportation projects in Turkey. The data utilized in this study is derived from a collection of 118 completed transportation projects in Turkey. These projects were selected based on their contract value, which exceeds 50 Million TL (Turkish Lira) when escalated to the value of December 2022.

The project data was obtained from two main sources: the Web-based Project Management System of the Strategy Development Department of the Ministry and the Electronic Public Procurement Platform (Elektronik Kamu Alımları Platformu - EKAP) of the Public Procurement Institution (Kamu İhale Kurumu - KİK) of Turkey. These sources provide comprehensive information about the projects, including various parameters and characteristics.

To assess the overall success, budget success, and schedule success of the projects, a survey was conducted. The survey was administered to professionals working for the Strategy Development Department of the Ministry and consultants responsible for investment planning, monitoring, and program management. The participants assigned scores to each project on a scale of 1 to 10, reflecting the success level in each category.

The dataset was created and managed using Microsoft Office Excel 2013. To analyze the data and explore the relationship between the factors and project success, multiple linear regression analysis were conducted using IBM SPSS Statistics. This statistical software enables the examination of various independent variables and their impact on the dependent variables, providing insights into the factors that significantly influence project success.

By employing this methodology and utilizing the collected data, the study aims to identify the critical factors that contribute to the overall success, budget success, and schedule success of transportation projects in Turkey.

1.4 Organization

Given the information in previous sections, the rest of the study is organized as follows:

Chapter 1: Introduction

- Provides an overview of the thesis and its contents
- Introduces the research motivation and objectives
- Outlines the organization of the research

Chapter 2: Literature Review

- Focuses on the background of the research
- Discusses the changing perspectives on project success
- Summarizes previous studies on project success and factors influencing it

Chapter 3: Methodology

- Provides a detailed explanation of the methodology used in the thesis

- Describes the data acquisition and processing methods
- Explains the analysis technique used in the research
- Presents the performance tests conducted on the developed models

Chapter 4: Data Analysis

- Describes the process of data analysis
- Presents the developments and determination of prediction performances of the estimation models

Chapter 5: Comparison of Accuracy and Factors Affecting Project Success

- Compares the accuracy of the models developed
- Discusses the factors that influence project overall success, budget success, and schedule success
- Provides detailed explanations for the observed factors and their impact on project success

Chapter 6: Conclusion

- Summarizes the critical findings of the study
- Highlights the contributions made by the research
- Discusses potential future research directions

Overall, this structure allows for a systematic exploration of the research topic, starting with the introduction and literature review, followed by the methodology, data analysis and results, discussion of results, and conclusion.

CHAPTER 2

LITERATURE REVIEW

The issue of performance is of utmost importance, and the success of the construction projects will encounter various obstacles throughout project implementation. Performance evaluation involves both subjective and objective assessments, and its interpretation varies among individuals. Moreover, it is significantly influenced by the project's context (Jugdev & Moller, 2006). The concept of project success and the metrics used to measure performance remain unclear (Pinto & Prescott, 1988), primarily due to the differences in expectations of stakeholders across various projects within a project portfolio (Gunduz & Almuajebh, 2020). Moreover, in spite of the numerous of research in the area, scholars have yet to arrive at a consensus regarding the essential elements that contribute to project success (Brown & Adams, 2000).

2.1 Modifications on the Success Point of View

Jugdev and Moller (2005) propose that the literature on project management has undergone a gradual transformation, as evidenced by their retrospective analysis of how our comprehension of success has progressed over time. They divided the literature into three periods, drew conclusions based on their analysis, and offered additional recommendations for a fourth period. Figure 2.1, illustrates the evolution of project success literature:

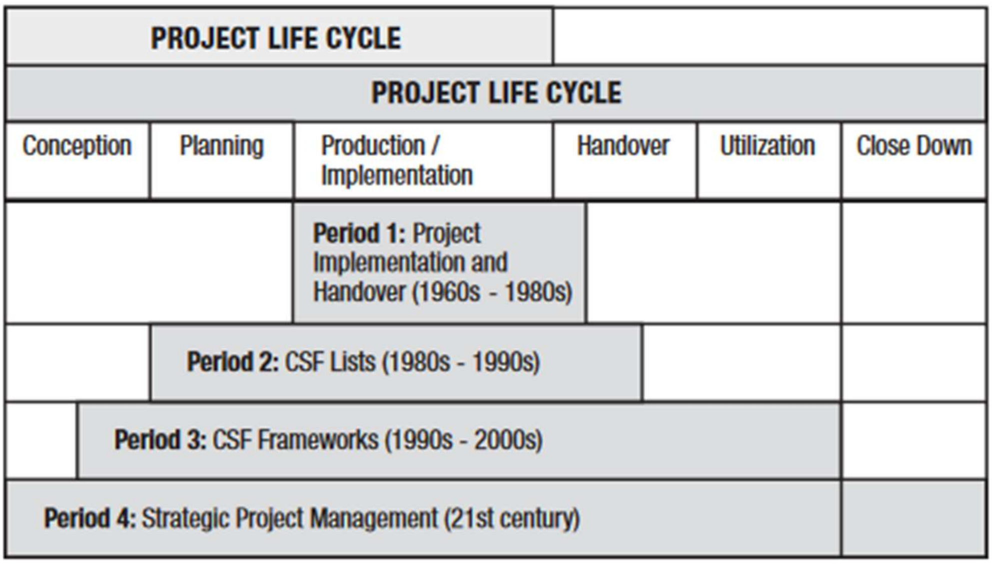

Figure 2.1. Measuring Success Across the Project and Product Lifecycles (Jugdev & Muller, 2005)

2.1.1 The First Period: Project Implementation and Handover (1960s-1980s)

In this period, the very early studies seek why the projects failed or succeeded in term of schedule. After these studies, the primary focus of project success was on the iron-triangle, which encompassed time, cost, and specifications - all of which were essential factors within the project organization (Lim & Mohamed, 1999). The concentrated project phase was execution or implementation, which is a reasonable approach since the implementation phase was usually the most extensive and resource-intensive (Project Management Institude 2000). The primary goal of the project team was to complete the project within a fixed budget, meet target dates, and deliver the end product. Time and cost estimates are approximations that are usually made when there is a limited understanding of the project during the planning stages, and quality is an attitude that evolves throughout the project life cycle. Customer interaction and long-term follow-up were minimized during this period. The literature mainly comprised theoretical works that focused on the implementation phase and supported the iron-triangle, while empirical studies were scarce. The prevalent research of this period primarily examined project schedules to comprehend project failures. There was minimal attention given to interpersonal or behavioral issues, with a more mechanistic approach emphasizing efficiency measures or technical systems, which prioritized hard skills (Jugdev & Muller, 2005).

2.1.2 The Second Period: Lists of Critical Success Factors (1980s-1990s)

In this period, the iron-triangle continued to be relevant, however, there was a notable shift towards identifying critical success factors (CSFs). These factors were considered essential for project success, primarily based on narrative evidence and single case studies. Project success was achieved when excellence was attained in terms of time, cost, and performance/quality levels. However, these metrics could be misleading if they did not align with stakeholders' expectations. Typically, success was determined based on a single measure for the project rather than multiple measures over the project lifecycle. In other words, a project was considered either successful or a failure, without considering the nuances of its performance across different stages. Although some of these factors were helpful, they were still in an early stage, lacking coherence, and presented in the form of unordered lists without any categorization or framework. The term "success" remained ambiguous, and there was no consensus on what it truly meant. However, stakeholders' satisfaction was widely recognized as a fundamental element of project success, and clients became increasingly aware of this, leading to a shift in their focus from completion criteria to satisfaction criteria. Consequently, the competitive landscape also transformed, but the traditional binary view of project success or failure still prevailed, rather than a holistic view incorporating multiple measures throughout the project lifecycle. During this period, some concepts from organizational effectiveness and strategic management emerged in the project management context.

The evaluation of project success has also been examined from different perspectives. Micro and macro viewpoints were distinguished, where the former pertains to success upon completion of the project, and the latter concerns far-reaching implications related to product use and stakeholder satisfaction. The analogy of "trees and forest" was used in order to illustrate that success at a macro level is the sum of micro achievements (Lim & Mohamed, 1999). They suggested that defining expectations from the outset would enable the project to be guided accordingly and ensure alignment between deliverables and expectations. Additionally, they recommended that assessments should be made after handover, during the operational stage, to ensure that the original project concept is achieved. Their study was significant in linking the planning stage with stakeholder satisfaction at the end of the project.

In summary, during Period 2, several critical success factors (CSFs) were identified, but they were not presented in a cohesive manner. Some sources mentioned organizational effectiveness, change management, and the importance of aligning project management with strategic management, but these concepts were not fully developed. As we transitioned to Period 3, we observed the emergence of CSF frameworks (Jugdev & Muller, 2005).

2.1.3 The Third Period: CSF Frameworks (1990s-2000s)

In this period, the emergence of integrated CSF frameworks marked a significant milestone in the project management literature, as they provided comprehensive and organized categorization of the factors under different groups such as functionality, management, commercial performance, and project termination. A hierarchical model has been proposed which considers budget, schedule, and quality as inputs that contribute to the success of a construction project (Chua et al., 1999). These frameworks also broadened the span of CSFs by including "soft" elements such as attitudes, communication, leadership, teamwork, human qualities, commitment, external factors, organization, and contract strategy, alongside the "hard" elements such as resources management and finance. Furthermore, CSFs were applied to senior management, resulting in the development of a corporate understanding of projects and a more strategic viewpoint. The importance of top management became more concrete, and the concept of "preparing for the future" gained significance in addition to immediate success. The notion of "value," although narrowly defined, started to have coverage in the literature, focusing more on business-value, such as improved organizational effectiveness and merit. Environmental, political, legal, and social concerns were also highlighted. For the first time, stakeholder satisfaction was addressed as the primary gauge of success, leaving the iron-triangle as a secondary measure. However, early CSF literature was criticized for lacking information on how to apply them in practice (Jugdev & Muller, 2005).

The concept of project success is now widely acknowledged as a construct that is dependent on the stakeholders involved, with interactions occurring between the recipient and internal organizations. It has been recognized that success may not be constant throughout the lifecycle of a project and that it can be evaluated from both objective and subjective perspectives. In Scandinavian literature, projects are viewed as having numerous side effects, which contrasts with the conventional approach of project management that stresses planning and control. As a result, even if a project aimed at reducing drug abuse fails to achieve its predetermined goals, it may still be regarded as successful because the learning and interaction with other institutions that the project initiates can be more significant than the predetermined objectives. The use of ambiguous objectives has also been suggested to promote learning. Additionally, the interaction between the project and its external environment is crucial because it generates emergent opportunities that cannot be realized in projects that are conducted in isolation

In the 2000s, there were several two-fold gauges of project success that were similar in nature. One such gauge was presented by (Cleland & Ireland, 2006), which differentiated between technical project performance and the project's strategic contribution to the firm. Another approach was proposed by (Cooke-Davies, 2002), who identified "project management success" as a measure of the project's traditional performance, and "project success" as a measure of its overall objectives. Zwikael and Smyrk (2012) expanded on this approach by introducing a three-fold gauge of success, including "project management success" in terms of the project manager's performance compared to the project plan, "project ownership success" in terms of the owner's ability to realize the business case, and "project investment success" in terms of the actual value generated by the project.

The conception of project success has evolved from being purely technical in nature, as viewed by providing organizations, to a more complex interaction between stakeholders and internal/external factors. Nevertheless, there still exists considerable ambiguity in defining project success, which has led to problems with project objectives due to divergent perspectives. For example, while project managers may focus on achieving specific targets, line managers may view projects as strategic building blocks for accomplishing broader business objectives through the productive use of project outcomes. Though it may be desirable to assign this broader responsibility to project managers, the temporary nature of project teams and the time lag between project delivery and business outcomes renders it difficult to hold project managers accountable for business results. Such issues point to a disconnection between line managers and project managers and suggest that strategic aspects of project management remain inadequate. This issue leads us to the fourth period, which is Strategic Project Management.

2.1.4 The Fourth Period: Strategic Project Management (21st Century)

Over the past four decades, significant advancements have been made in the field of projects and project success:

- The attainment of project success requires more than having a shared vision, support from top management for the allocation of resources, and the necessary authority and power to execute the project.

- Senior management commitment is a crucial factor for project success, encompassing the provision of vision, strategy, and sponsorship. This commitment sets the tone for the project and establishes a clear direction and purpose for the team to follow. Without this, the project may lack direction and may not align with overall goals and objectives of the organization. Therefore, it is essential that senior management plays an active role in supporting the project to ensure its success.
- CSFs for projects can be related to both the organization itself, such as top management support, as well as to the external environment in which the project operates. External factors could include political, economic, social, technological, and natural factors, as well as the characteristics of the client, competition, and subcontractors involved in the project. It is important to consider all of these factors when planning and executing a project in order to increase the likelihood of success.
- It is the responsibility of senior management within the organization that initiates the project to ensure the alignment between organizational plans and the goals and purposes of the selected projects, as well as to promote creative processes for identifying potential project ideas. Effective project management necessitates comprehensive planning and a commitment to completing the project, with executives demonstrating commitment throughout the project's duration rather than just at the outset (Jugdev & Muller, 2005).

Recent literature on project success has synthesized the findings of numerous empirical studies to identify four essential but insufficient factors for achieving success in projects. These factors are necessary but not individually capable of guaranteeing project success (Jugdev & Muller, 2005; Rodney Turner, 2004; Wateridge, 1998). The first factor is that success criteria must be agreed upon with stakeholders before the project's initiation and periodically reviewed at different stages of the project. The second factor is maintaining a collaborative working relationship between the project owner or sponsor and project manager, where both parties see the project as a partnership. The third factor involves empowering the project manager with the flexibility to handle unforeseen events as they arise, with the owner providing guidance on the best course of action to take. The final factor entails the owner taking an active interest in the project's progress and performance. The evolution of our understanding of project success has been gradual over the years, moving towards a more comprehensive view. While some authors have previously presented project management success in a holistic manner, with links to organizational success, most literature has discussed project success in a narrow context limited to the project life cycle (Jugdev & Muller, 2005). The PMBOK’s table below illustrates the conventional understanding of the project lifecycles (Figure 2.2).

	PHASES		CONSTRUCTION	PHARMACEUTICAL	DEFENSE ACQUISITION	SOFTWARE DEVELOPMENT
Product Life Cycle	**Initial Phase:** Conceptualization, Planning	Project Life Cycle	Feasibility	Discovery & Screening	Concept Exploration & Definition	Proof of Concept Cycle
	Intermediate Phase: Production / Implementation		Planning and Design	Pre-Clinical Development	Demonstration & Validation	First Build Cycle
			Production	Registration(s) Workup	Engineering & Manufacturing Development	Second Build Cycle
	Final Phase: Handover		Turnover and Start Up	Post-Submission Activity	Production & Deployment	Final Cycle Including Testing, Final Build
	Operations: Utilization				Operations & support	Deployment
	Decommissioning: Closedown					

Figure 2.2. Overview of The Project and Product Lifecycles (Project Management Institute, 2004)

The concept of success became more holistic, viewing project success as a multidimensional concept that is obtained through interaction with the external environment and stakeholders. The implications of a project that go beyond its immediate deliverables were acknowledged, such as benefits to the organization, developing core competencies, preparing for the future, and innovation. A corporate understanding of projects emerged, where project managers were no longer solely responsible for the success of a project, but senior management also played a crucial role. However, there were still deficiencies in the strategic aspect of project management, and links between project management and corporate management were lacking. This approach places a significant amount of responsibility for project success on the project owner, highlighting the importance of empowering the project manager and revisiting success criteria throughout the project's life cycle. Furthermore, it introduces a new perspective that considers the owner's underlying attitude and level of interest in the project (Jugdev & Muller, 2005).

2.2 Client Satisfaction as a Performance Criteria

In a construction project, it is common to have multiple participants involved, including owners, consultants, and contractors. Each of these stakeholders brings their own perspectives, interests, and objectives to the project. While their opinions and interests may differ, they share a common goal of achieving project success (Lindhard & Larsen, 2016). Several case studies indicate that one of the barriers to establishing effective working relationships between clients and contractors is the inability to reach consensus on measures of success (Bryde & Robinson, 2005). In the 2000 edition of the ISO 9000 quality management system, client satisfaction has been recognized as a significant component of total quality management philosophy. This highlights the growing emphasis on meeting and exceeding client expectations to achieve high-quality outcomes. By incorporating client satisfaction into the ISO 9000 standard, organizations are encouraged to prioritize customer-centric approaches and continually improve their processes to enhance client satisfaction levels. This recognition underscores the importance of customer satisfaction as a key driver for overall quality management.

According to Pheng and Chuan (2006), Project success cannot be evaluated solely based on traditional indicators such as time, cost, and quality. The incorporation of non-financial measures such as client satisfaction, business performance, and health and safety environment has expanded the scope of research in project success criteria beyond the project level to the company and stakeholder levels (Rashvand & Zaimi Abd Majid, 2014). However, there is a lack of consideration for stakeholders in the classification of success criteria in previous studies.

Chan et al. (2004) classified key performance indicators (KPIs) for successful construction projects into two main categories. The first category included objective measures such as time, cost, safety, and environment. The second category encompassed subjective measures such as quality, functionality, and satisfaction of various project participants.

In the construction industry, the relationship between different contracting parties can be complex due to the involvement of various stakeholders such as owners, consultants, and contractors. To measure the overall project performance and monitor progress, stakeholders' individual performances are measured using performance measurement at the stakeholder level (Rashvand & Zaimi Abd Majid, 2014). Figure 2.3, which is taken from the study, presents a compilation of studies carried out from 1981 to 2011 that highlights the significance of stakeholder satisfaction criteria in achieving project success.

References	Category of stakeholder satisfaction
Essex et al. (1981), De Wit (1988), Ahmed and Kangari (1995), Kumaraswamy and Thorpe (1996), Alarcon and Ashley (1996), Lim and Mohamed (1999), Tang et al. (2003), Cheng et al. (2006), Takim and Adnan (2008), Elattar (2009), Chen et al. (2010), Ling et al. (2009), Papke-Shields et al. (2010), Isik et al. (2010)	Client satisfaction
Kaplan and Norton (1992), Belassi and Tukel (1996), Hennig-Thurau and Klee (1997), Landin (2000), Torbica and Stroh (2001), Raz and Michael (2001), Shenhar et al. (2001), Tukel and Rom (2001), Zwikael and Globerson (2004), Bryde and Robinson (2005), Milosevic and Patanakul (2005), Forsythe (2007), Yu et al. (2007), Ahadzie et al. (2008a, b), Takim and Adnan (2008), Thomas and Fernandez (2008), Karna et al. (2009), Al-Tmeemy et al. (2011)	Customer satisfaction

Figure 2.3. Importance of Stakeholder Satisfaction Criteria for Project Success (Rashvand & Zaimi Abd Majid, 2014)

A survey was conducted in the construction industry to analyze the client-satisfaction factors, identifying six key factors: time, cost, quality, client orientation, communication skills, and response to complaints. These factors were deemed significant in assessing the level of client satisfaction within the industry (Ahmed & Kangari, 1995).

In their study, Tang et al. (2003) identified eight key factors, comprising a total of 29 indicators, to assess the overall client satisfaction in engineering consulting firms in Hong Kong via two stages survey with 47 participants from 47 projects. These factors encompass various aspects of service delivery and performance. The factors identified are timeliness of service, professionalism of service, competitiveness of service, degree of innovation, quality of design, completeness of other considerations, availability of support for client, and supervision at implementation. The summary of this study is that adopting a proactive approach towards achieving professionalism of service and delivering flawless services from the outset is a crucial strategy for attaining client satisfaction in the engineering consulting industry. Clients place greater value on the prevention of issues rather than reactive measures taken to rectify defects after they have occurred. Another study shows that client satisfaction in projects is primarily influenced by management mechanisms such as effective communication, meaningful participation, and strong commitment, rather than specific project goals such as time, cost, and quality. It is the quality of interactions, engagement, and commitment demonstrated by project managers and team members that directly impact the satisfaction levels of project participants (Leung et al., 2004).

Takim and Adnan (2009) worked on specific requirements and priorities of different clients like the Government and private clients in Malaysia. They proposed that the effectiveness measures of project success in Malaysia highlight the importance placed on client satisfaction, high profit margin, and fitness for purpose by both contractor and private client organizations. The level of importance attached to these measures is higher for contractor and private client organizations compared to the government and their consultants. This suggests that meeting client expectations, achieving profitability, and delivering projects that meet their intended purpose are key priorities for contractors and private clients in Malaysia. Understanding these preferences and aligning project objectives accordingly can contribute to the overall success of construction projects in the country.

Some researchers suggest that a comprehensive definition of project success cannot be captured in a single list due to the diverse perspectives and priorities of project participants (Elattar, 2009). However, the criteria presented in Table 2.1, which is taken from his study, provide a broad understanding of success criteria from the viewpoints of different participants.

Table 2.1 Success Criteria from different participant's viewpoints (Elattar, 2009)

Participant	Success criteria
Owner	On schedule On budget Function for intended use (satisfy users and customers) End result as envisioned Quality (workmanship, products) Aesthetically pleasing Return on investment Building must be marketable (image and financial) Minimize aggravation in producing a building
Designer	Satisfied client Quality architectural product Met design fee and profit goal Professional staff fulfillment Met project budget and schedule Marketable product / process Minimal construction problems No liability, claims Socially accepted(community response) Client pays (reliability) Well defined scope of work (contract and scope and compensation match)
Contractor	Meet schedule Profit Under budget Quality specification met or exceeded No claims Expectations of all parties clearly defined Client satisfaction (Expectations of all parties clearly defined) Good direct communication Minimal or no surprises during the project

A study examined how interorganizational trust and control are related and how they influence project success, specifically from the viewpoint of project owners (Jiang et al., 2017). The direct and indirect effects of calculative trust, relational trust, and distrust on project success was studied by using structural equation modeling (SEM). Distrust has a directly negative influence on project success according to model. While both calculative trust and relational trust have a positive impact on project success, the direct influence of calculative trust is relatively weaker compared to the direct influence of relational trust (Jiang et al., 2016, 2017). Mistry and Davis (2009) also mentioned trust, together with provision of adequate resources, as the key determinants that significantly contribute to the development of relationships among project stakeholders.

2.3 Public Projects vs. PPP Projects

In the conventional sense, public works projects that are funded by the government typically encompass various community-oriented structures, such as dams, highways, bridges, schools, and government buildings. However, starting from the 1980s, larger infrastructure initiatives have gradually embraced the integration of private sector involvement. The emergence of Public-Private Partnerships (PPP) has proven to be an invaluable resource for communities seeking to enhance their economic attractiveness and contribute to essential social welfare, housing, infrastructure, and employment programs.

The notion of partnership has gained considerable recognition as an exemplary framework for shaping inter-organizational relationships within the realm of public sector management (Friend, 2006). This concept stems from the traditional expectation that government agencies should engage in collaborative efforts with other governmental entities, non-profit organizations, or even businesses to enhance the provision of services and goods while optimizing resource utilization. Despite the recognition of the significance of collaborative working approaches, scholars have noted that partnerships were frequently not effectively implemented in practice, despite their acknowledged importance. The ongoing debate suggests that both practitioners and researchers involved in partnerships should exercise caution, as the partnership approach does not automatically guarantee superior success or efficiency compared to traditional approaches (Jacobson & Ok, 2008).

Over the course of the development of the partnership perspective, the widespread use of the term "public-private partnership" has implied a significant proposition that a collaborative approach spanning sectors has been discovered to enhance service efficiency, transfer risk to the private sector, reform the public sector (Flinders, 2005), introduce new forms of accountability, and possess democratic potential, thereby becoming a prevalent governance tool. However, it is not surprising that several conditions must be fulfilled for public-private partnerships to be successful, such as establishing horizontal relationships between parties, engaging in consensual decision-making, and fostering respect and trust as key elements of social capital reform (Jacobson & Ok, 2008). Furthermore, there is a growing call for greater clarity in the application of the term "public-private partnership" to describe the relationships between the government and the private sector.

Two contrasting viewpoints exist regarding the differentiation between the public and private sectors. The initial standpoint highlights the distinct characteristics inherent in each sector. The public sector possesses ambiguous objectives and operates under the influence of authoritative control and management. In contrast, the private sector has clearly defined goals, such as profit maximization, and operates based on market mechanisms. Williamson (1979), drawing from transaction cost economics, further highlights the disparity between public and private bureaucracies concerning exchange and authority systems, particularly in the context of "sovereign transactions." Private bureaucracy exhibits a higher degree of incentive and lower management control, as individual profits are directly tied to the private sector. Conversely, public bureaucracy demonstrates lower incentive levels and higher management control due to the absence of direct individual profit links in the public sector. The second perspective challenges the notion of significant inherent distinctions among the sectors, emphasizing instead the artificial nature of these distinctions. Bozeman and Bretschneider (1994), for instance, argue that all organizations possess a public dimension, with the degree of "publicness" being the differentiating factor. Even private firms undertake public functions, such as contributing to social welfare, while public organizations often engage in simple market contracts.

Contemporary literature suggests that traditional public works projects are plagued by several challenges that can give rise to issues related to conflicts, quality control, project delays, and budget overruns (Chan et al., 2004; L. Tang et al., 2010). Within the framework of traditional public works projects, the client typically engages the services of an architect before selecting a contractor. Once the architect's plans are approved, the contractor proposal is then circulated for bidding purposes. This design-bid-build approach restricts direct initial communication between the design team and the construction team, potentially leading to an adversarial relationship. On the other hand, in design-build projects, the design-build team usually employs a general contractor who is responsible for providing both the design (including architecture and engineering) and construction services (Jacobson & Ok, 2008).

2.4 Project Success in PPP Projects

Six Critical Success Factors (CSFs) that contribute to securing Build-Operate-Transfer (BOT) type PPP contracts has been outlined (Tiong, 1996). These factors include entrepreneurship and leadership, accurate project identification, strength of the consortium, technical solution advantage, differentiation in the financial package, and differentiation in guarantees. Tiong and Alum (1997) have further delved into the distinctive elements of winning proposals in competitive BOT tendering, focusing on sub factors derived from the CSFs of technical solution advantage, financial package differentiation, and differentiation in guarantees. Gupta and Narasimham (1998) add to the CSFs required for promoters to secure BOT contracts, highlighting the importance of being able to provide a suitable transfer package, incorporating built-in flexibility for future growth and changes, garnering support from the local community, and ensuring a short construction period (Zhang, 2005b).

According to the World Bank, several factors have contributed to delays and challenges in partnered infrastructure projects (Gurgun & Touran, 2014). These include significant disparities between the expectations of the public and private sectors, intricate decision-making processes, insufficient legal or regulatory frameworks, ambiguously defined sector policies, a lack of clear government objectives and commitment, ineffective risk management, inadequate domestic capital markets, limited credibility of government policies, absence of mechanisms to attract affordable long-term financing from private sources, inadequate transparency, and a dearth of competition. These factors collectively contribute to the obstacles faced by partnered infrastructure projects.

Another example of problems sourced by differences in public and private sector is in between Malaysia government and Indah Water Konsortium (IWK) (Zhang, 2005). Despite the Malaysian government's assertion that the reverse divestment of the sewerage systems to the public sector does not indicate a failure, it is evident that the original objective of reducing costs and modernizing the infrastructure was not achieved. Instead, a significant amount of public funds was used to support the privatized sewerage project over a seven-year period. Certain industrialists and their management team profited undisclosed amounts from their involvement in the privatization venture. This situation led to non-monetary costs, such as damaging the public perception of the nation's privatization program. The unpopularity of the privatized sewerage entity, IWK, was evident among consumers, opposition parties, media outlets, state governments, and even politicians within the ruling coalition parties. Some members of parliament expressed their opposition to the recurrence of privatized schemes returning to government control. This episode highlights important lessons for future privatization endeavors. Transparency in the selection process of concession companies is crucial, and the concerns of consumers must be taken into account. The public should be informed about the potential concession holders before awarding the project, and there should be full disclosure of the charge structure. The divested infrastructure should be entrusted to entities capable of fulfilling their obligations efficiently, rather than seeking quick profits through the outright sale of controlling stakes. Re-involvement of the public sector, especially through injecting new funds, should be minimized if possible. The privatization scheme must be carefully structured to ensure commercial and operational viability for all parties involved (Abdul-Aziz, 2001). He concluded several problems arose in this project, encompassing the following issues:

- Lack of competition and transparency during the concessionaire selection process.
- Insufficient equity-debt ratio, leading to imbalanced financial arrangements.
- Overly generous "safety nets" provided to the concessionaire by the government.
- Inefficiencies and mismanagement by the concessionaire.
- Frequent changes in ownership of the concession company within a short timeframe.
- Significant public opposition to the project.

These problems collectively contributed to the challenges and shortcomings experienced in the project. All of these are the examples of lessons learned from unsuccessful PPP projects in the world.

PPPs should not be viewed as a mechanism for governments to transfer all risks to the private sector and absolve themselves of responsibilities. Instead, they necessitate the proper allocation and management of risks. It should be recognized that private finance initiatives do not guarantee the automatic success of infrastructure projects. To ensure effective outcomes, PPP schemes need to be well-structured to prevent wastage and depletion of resources. A PPP project procurement protocol should be guided by a win-win principle between the public and private sectors. This protocol should establish a favorable environment, offer necessary support for private sector participation, and implement effective measures to ensure that privatized projects and services meet public standards and acceptable levels of quality. Achieving a balance between governmental support and private sector inputs is essential. Through a systematic research approach, the author can identify several CSFs that are further analyzed, distilled, coded, and categorized into five primary CSFs, each comprising several SSFs (Zhang, 2005a). These five main CSFs include:

- a favorable investment environment
- economic viability
- a reliable consortium of concessionaires with strong technical expertise
- a sound financial package
- appropriate risk allocation through reliable contractual arrangements

These five CSFs includes 47 sub factors with altered significance. Another study focused on CSFs for PPP projects in the UK construction industry (Li et al., 2005). He argued that while certain PPP/PFI projects have encountered setbacks, it is important to acknowledge that there have also been instances of successful implementation. However, the specific reasons behind this success remain somewhat ambiguous. A questionnaire survey research was conducted to assess the relative significance of 18 potential critical CSFs for PPP/PFI construction projects in the UK. The findings of the survey revealed that among these factors, the three most crucial ones were identified as follows: 'a strong and good private consortium', 'appropriate risk allocation', and 'available financial market'. These factors emerged as the most important contributors to the success of PPP/PFI construction projects in the UK, according to the survey results.

Babatunde et al. (2012) focused on CSFs in PPP on infrastructure delivery in Nigeria. The paper highlights nine CSFs in the context of PPPs. These factors include: competitive procurement process, thorough and realistic assessment of the cost and benefits, favorable framework, appropriate risk allocation and risk sharing, government involvement by providing a guarantee, political support, stable macroeconomic condition, sound economic policy and availability of suitable financial market. The paper emphasizes that these CSFs should be given utmost consideration by both the public and private parties involved in order to ensure the successful implementation of infrastructure projects using PPPs. By adhering to these factors, the partnership arrangement can achieve its optimum objectives. The results of the work indicate that transportation projects, which encompass roads, rails, and airports construction, as well as projects related to the provision of electricity, water, and environmental and natural resources, are considered highly suitable for implementation using PPPs. That means PPP projects in these two sectors are prone to be more successful compared to educational projects, real estate construction, and the provision of leisure, tourism, and cultural facilities in Nigeria.

The CSFs for PPP projects from 1990 to 2013 systematically reviewed in 2015 (Osei-Kyei & Chan, 2015). The study was undertaken with the four objectives: to analyze the annual publication trends of CSFs, to identify the origin/country of the authors and active contributors in researching CSFs, to determine the countries with the highest number of published papers on CSFs, to summarize, compare, and contrast the findings of studies on CSFs for PPP projects conducted between 1990 and 2013.

According to the systematic review, Hong Kong, the United Kingdom, and Australia have the highest number of researchers contributing to the exploration of CSFs for PPP projects over the past 23 years. This indicates that these countries have been actively involved in studying and researching the CSFs for PPP projects, suggesting a strong interest and commitment to understanding the factors that contribute to successful PPP initiatives in their respective contexts. These countries followed by the Singapore, China and the USA. As a result, the identified success factors derived from research studies conducted in these countries have significantly enhanced the implementation practices of PPP projects. The findings have played a crucial role in informing government guidelines, thereby providing valuable insights for local practitioners on effective strategies for managing and delivering successful PPP initiatives (Osei-Kyei & Chan, 2015).

Publications focusing on CSFs for PPP projects in developing countries have exhibited a notable scarcity. This dearth of literature may stem from the relatively limited exploration of the PPP concept within these regions or could be attributed to the inclusion of a restricted number of journals in the present study. There was only PPP CSFs publication with Turkey focus in the selected journals.

The identification of CSFs for PPP schemes is crucial, not only at the implementation stage but also during the initial feasibility evaluation (Ng et al., 2012). The evaluation of CSFs during the initial feasibility stage plays a significant role in determining the overall success of a PPP project. Therefore, it is crucial to thoroughly examine the CSFs for evaluation at this early stage to ensure the feasibility and success of the PPP initiative. The study aims to investigate the key factors that contribute to the success of PPP projects, as perceived by the public sector, private consortium, and general community. A questionnaire survey and expert interviews were conducted in Hong Kong to gather insights. The survey results indicate that the most critical factor for evaluating the feasibility of PPP projects, particularly from the perspective of the general community, is an acceptable level of tariff. Cost effectiveness and financial attractiveness are ranked as the most important factors by the public sector and private consortium, respectively. Furthermore, the presence of long-term demand for the proposed services, the availability of a strong private consortium, alignment with the government's strategic objectives, and reliable service delivery are also highlighted as highly important factors for the success of PPP schemes.

The study conducted by Pinto and Prescott (1988) provides valuable insights into the changing significance of CSFs throughout the project life cycle. Their field study aimed to investigate how the importance of these factors evolves over time, specifically focusing on four stages: conceptualization, planning, execution, and termination. The findings of the study highlight the critical role of the "Project Mission" CSF across all phases of the project life cycle. It was observed that maintaining a clear and well-defined project objective is crucial for project success, underscoring the ongoing significance of the project's mission. Project managers are advised to continuously emphasize and reinforce this mission as a unifying focal point for the project team.

Moreover, the study reveals that the relative importance of CSFs can vary across different phases of the project implementation process. This suggests that the significance of these factors is influenced by the specific stage of the project or the overall organizational context. Therefore, future critical success factor analyses should take into account the project or organizational life cycle to better understand the relevance and prioritization of these factors.

These findings emphasize the need for a dynamic and context-specific approach to implementing and managing critical success factors. By considering the evolving nature of CSFs and their varying importance throughout different project stages, practitioners can enhance project success and better align their strategies with the project or organizational context.

2.5 Project Success Prediction Models

Having an early understanding of project conditions is of paramount importance in order to effectively respond to the dynamic and unpredictable nature of a project. That is why there are a lot of researches in the literature which seeks the factors effecting the project success. Various methods have been used to predict projects success including: evolutionary Gaussian process inference model (Cheng et al., 2013), regression analysis (Kuprenas, 2005), Bayesian betaS-curve method (B.-C. Kim & Reinschmidt, 2009), structural equation model (Beng et al., 2017; Deep et al., 2022; D. Y. Kim et al., 2009), artificial neural network (Emadi & Emadi, 2022), analytic hierarchy process (Ansari et al., 2022), and hybrid approaches (Ko & Cheng, 2007; Bang et al., 2022).

Rockart (1982) is credited with introducing the term "critical success factors" within the field of project management, specifically in reference to the management of projects. The origin of the factors that determine project success can be traced back to the Integrated Building Process Model developed by Sanvido 1990. These factors were later tested on sixteen projects, and the findings indicated a strong correlation between the attainment of the factors and project success. Ultimately, the four most essential factors for achieving success in a project are highlighted (Sanvido et al., 1992).

2.6 Project Success in Turkey

Although there is a significant body of literature on critical success factors in the construction sector, number of the researches focused on CSFs influencing project performance in Turkey is very limited. The success rate of projects which are not in the construction sector but banking and finance, information technologies, public services, telecommunication, manufacturing, etc. in Turkey is evaluated, and the key factors contributing to both successful and unsuccessful outcomes are ranked (Bilir & Yafez, 2021). According to the researchers, to the best of their knowledge, this study represents the first comprehensive attempt to measure the success rate of projects in Turkey on a wide scale.

Based on the literature review conducted, a limited number of studies were found regarding the factors influencing the success of construction and infrastructure projects in Turkey. These studies primarily focused on public-private partnership projects rather than the ones with traditional public procurement.

An innovative six-factor framework has been developed to identify the key factors that influence the successful construction or failure of pipeline projects in Europe and Turkey (de Jong & Haesebrouck, 2023). However, out of the 21 projects examined in the study, only one of them was a pipeline project passing through Turkey. Furthermore, that project can be characterized as more of an international project rather than a project specific to Turkey.

The CSFs for the PPP projects performed in Turkey was identified by using triangulation of literature review, semi-structured interviews and empirical questionnaire survey (Budayan, 2018). In addition to 44 CSFs establish via literature review, 10 more CSFs specific to the Turkish market are added and the list of CSFs finalized. Subsequently, a questionnaire is developed based on the final CSF list to collect data on the perceived importance of these factors in the Turkish market. A total of 89 valid responses are obtained from the questionnaire survey. The collected data is then subjected to factor analyses to analyze and identify underlying factors within the dataset.

A comprehensive review of the literature on PPP initiatives has been conducted, focusing on Europe, the U.K., China, the U.S., and Turkey (Gurgun & Touran, 2014). Their aim was to identify the common success factors, risks, limitations, and challenges across these regions and understand the variations in their implementation approaches. While certain challenges, risks, limitations, and success factors are found to be common, it is emphasized that the adoption of the PPP framework is influenced by country-specific factors. Therefore, Turkey, which has a significant history of employing various PPP models for almost three decades, is examined more extensively as a representative case for developing countries, alongside the prominent PPP practices observed in Europe, the U.K., the U.S., and China. Key factors for successful PPP projects are highlighted, including a conducive economic environment, well-defined contractual arrangements ensuring appropriate risk allocation, a robust legal framework, public support and acceptance, transparency in processes, and the establishment of a central unit to standardize procedures. These factors are crucial for the effective implementation of PPP projects, both in Turkey and in other regions/countries with extensive PPP experience (Gurgun & Touran, 2014).

Overall, the literature review revealed a limited number of studies focusing on the critical success factors influencing projects in Turkey. Furthermore, the few studies conducted primarily employed survey-based research methods. This can be attributed to the challenging nature of accessing project data in the Turkish context, given the prevailing circumstances.

2.7 Studies Focusing on Specific CSF

In the literature, there are various studies that focus on a single critical success factor and its subcategories. Specifically, detailed information about some of the studied critical success factors is provided in this section.

Project complexity

Despite being widely acknowledged in both literature and practice, the impact of project complexity on project success has lacked empirical evidence (Luo et al., 2017). To address this gap, (Luo et al., 2017) conducted an analysis to explore the relationship between project complexity and success specifically in complex construction projects. It examined how various dimensions of complexity, including information, task, technological, organizational, environmental, and goal complexities, influence project success. Through correlation and factor analyses, the study found support for the proposed negative relationship between complexity and success in complex construction projects. Specifically, information complexity and goal complexity were identified as significant factors negatively impacting project success.

Nguyen et al. (2019) conducted a research study that adds to the existing literature on construction project complexity. Their study empirically demonstrates that the influence of project complexity on schedule performance is contingent upon the level of resource allocation. Specifically, they focused on the effect of project complexity on cost and schedule performance in transportation projects. The findings of their study align with the outcomes of a previous study conducted by (Luo et al., 2017).

International Joint Ventures

The assessment of performance in International Joint Ventures (IJVs) has been a subject of considerable research interest, particularly in the construction industry (Ozorhon et al., 2010). Their study proposes a model to evaluate the performance of

IJVs in construction and investigates the validity of the proposed drivers and performance measures, as well as the relationships between them. The study examines the effects of interpartner fit/relations, structural characteristics of the IJV, host country factors, and project-related factors on IJV performance through a questionnaire survey. IJV performance is defined as a four-dimensional construct that encompasses the performance of the project, the IJV partners, the IJV organization itself, and the perceptions of the IJV partners. The results highlight the importance of interpartner fit and the quality of partner relations for achieving successful IJV operations. Additionally, the study finds that project-related factors have a moderate influence on IJV performance. It is observed that a well-designed IJV structure, with partners possessing compatible skills, resources, and cultures, tends to foster positive relations and is associated with greater IJV success. These findings underscore the significance of effective partnership dynamics and appropriate project-related factors in enhancing the performance of IJVs in the construction sector.

Another paper is aimed to evaluate the factors that influence the performance of partners involved in joint venture construction projects in Nigeria (Famakin et al., 2012). The findings of the study indicate that all the identified factors have a significant impact on the performance of partners in such projects. Specifically, effective communication, compatibility of objectives, and mutual understanding among partners are identified as the most crucial factors contributing to partner performance in joint venture projects. The research outcomes can provide valuable insights to potential investors in determining the key factors that significantly contribute to the performance of partners in joint venture construction projects.

Bid Characteristics

A crucial factor influencing the success of capital construction projects is the presence of a responsive and competitive bid process. Construction professionals believe that when too many projects are bid within a short timeframe, the quality of bids received may be compromised, and the pricing of bids may not be competitive, falling outside the estimate or budget range. Conversely, it is commonly perceived in the construction industry that if a project is awarded to a low bidder significantly below the budget or if there is a substantial gap between the first and second lowest bids, the low bid contractor may attempt to compensate for the difference through change orders (Kuprenas, 2005). In terms of bid decisions from a contractor's standpoint, Chua and Li (2000) conducted research and identified four factors influencing the decision to bid: competition, risk, the need for work, and the company's position in the bidding process.

Contractor

Within the literature on construction project success and causes of time and cost overruns, there is recognition of the significant role contractors play in project outcomes (Alzahrani & Emsley, 2013). Their study aims to examine the impact of contractors' attributes on project success through a post-construction evaluation perspective, with the objective of identifying CSFs that greatly influence project success. Factor analysis is employed to uncover nine underlying clusters of attributes. The analysis reveals that factors such as turnover history, quality policy, adequacy of labor and plant resources, waste disposal practices, size of completed past projects, and company image hold significant influence over project success. Assuming that project success is replicable, these findings contribute to a better understanding of contractors' performance and have the potential to enhance existing knowledge on construction project success.

Another study about project success and contractor relationship in the literature focused on pre-qualification criteria in contractor selection and their impacts on project success (Doloi, 2009). The research findings highlight the significance of two critical factors that impact contractors' ability to achieve success in terms of time, cost, and quality in construction projects. The first factor is the soundness of the contractor's business and the strength of their workforce. Within this factor, five key attributes were identified as crucial: technical expertise, attitudes towards defects liability, site safety records, successful completion of past projects, and yearly turnover. These attributes collectively determine the contractor's capability to achieve success in project delivery. The second factor that greatly influences contractors' effective project management capability is realistic planning and the implementation of appropriate control measures. This factor emphasizes the importance of careful planning and the establishment of control mechanisms to ensure project success.

Furthermore, the researches in the literature examined the quantitative impacts of contractor selection criteria on project success measures. The findings demonstrate a clear relationship between the attributes used for contractor selection and the achievement of successful project outcomes. This highlights the importance of considering specific contractor attributes in the selection process to enhance the likelihood of project success.

Constraints

The first study which measure and articulate the impact of project governance constraint, project constraint and stakeholder induced constraints on project success is revealed in 2022 (Deep et al., 2022). The study aimed to measure the extent of influence of various constraints on the overall success of highway projects (e.g. National highway project, state highway projects and major district roads). Based on the literature, various factors were grouped under three categories: Project Constraints, Project Governance Constraints and Stakeholder Induced Constraints. It was identified that the impact of project constraints on project success is more than that of project governance constraints and stakeholder induced constraints. Additionally, it was found that project governance constraints have a strong impact on project constraints and stakeholder induced constraints.

CSFs interaction

Williams (2016) claimed that there is limited research exploring the causal relationships that lead to project success. He aims to shed light on this aspect by examining the multifaceted nature of success and how various success factors interact with each other. Specifically, the study investigates the interplay of success factors within a company engaged in two significant construction programs. By mapping and analyzing the pathways from underlying causes to success criteria, the research highlights the complex interactions that contribute to project performance. The findings reveal a combination of specific factors, some of which are generic and others context-dependent. Although individually these factors may not be uncommon, their synergistic convergence is noteworthy and contributes to overall success.

2.8 Analysis

The reviewed literature on critical success factors in construction and transportation projects has contributed valuable insights to the field. However, there are significant gaps. Firstly, the lack of comprehensive research on critical success factors emerging during the pre-contract stage is striking. Most studies tend to concentrate on factors take place during project execution, with relatively few research addressing the crucial decision-making phase of contract signing. This knowledge gap leaves project stakeholders with limited guidance in understanding and managing the risks and determinants of success associated with contract signing and its implications for the project's overall outcome.

Secondly, while some research exists on critical success factors in transportation projects in Turkey, it predominantly relies on survey-based methodologies. While survey studies provide valuable perceptions from various stakeholders, their effectiveness in capturing real-world project data and accurately predicting project outcomes may be limited. Consequently, the lack of research that incorporates authentic project data and explores the relationship between pre-contract factors and project success poses a significant constraint in advancing project management practices in the transportation sector.

Moreover, the international literature on this subject also suffers from similar limitations. Although there are studies on critical success factors in transportation projects, few delve into the pre-contract stages and the impact of decision-making during this crucial phase.

Considering these gaps in the literature, this thesis aims to address these limitations and make substantial contributions to the field of construction management and project planning. By utilizing actual project data, the research efforts to identify and assess the critical success factors that emerge during the pre-contract stage in transportation projects. The goal is to develop robust prediction models that can effectively estimate project success, budgetary success, and program success before the contract signing decision is made. In doing so, the study seeks to provide a reliable decision support mechanism for stakeholders involved in public tenders, empowering them to make well-informed choices and ultimately enhancing the efficiency and success rates of transportation projects.

Overall, by critically analyzing the gaps in the existing literature and identifying the specific areas of focus, this study aims to enrich the academic understanding of critical success factors in construction and transportation projects while offering practical implications for decision-makers in the transportation sector in Turkey.

CHAPTER 3

METHODOLOGY

Prior to delving into the specifics of the methodological approach employed in this study, it is crucial to address one of the initial steps in any research endeavor. This step involves the selection of the research method and scientific research type, which is conducted independently of the subsequent methodological approaches. Various methods of scientific research exist, including quantitative, qualitative, mixed, and exploratory approaches. The choice of research method is based on two key factors: (1) the study's purpose and (2) the characteristics of the data obtained. In this regard, the following criteria are considered when determining the research method:

- Characteristics of the acquired data: This criterion examines whether the data obtained are measurable or inferential in nature, distinguishing between quantitative and qualitative approaches.
- Suitability of the obtained data for systematic analysis: This criterion evaluates the appropriateness of the data for conducting a methodical investigation utilizing statistical, mathematical, and computational techniques.

Among the research methods available, quantitative research methods can be classified as descriptive or experimental. Descriptive methods involve measuring the subject of interest only once, providing a snapshot of the current state. On the other hand, experimental methods allow researchers to investigate causal relationships between variables by making deliberate modifications to the subject of interest.

In the present study, the focus is on examining the effects of independent variables on a dependent variable, aiming to establish causal relationships. Therefore, the causal-comparative research method was deemed appropriate. This method enables the researcher to compare different groups or conditions to determine the causal impact of the independent variables on the dependent variable.

3.1 Description of the Data

To create a project success prediction model using regression analysis, a substantial amount of data is required, incorporating as many critical success factors as possible. To comprehensively understand the factors that contribute to project success, it is crucial to collect and analyze data on project characteristics. This process involves gathering relevant information about various aspects of the project, such as scope, budget, schedule, stakeholders, resources, and risks. The historical project data used in this study consists of 296 infrastructure projects constructed under the ownership of institutions affiliated with the Republic of Turkiye Ministry of Transportation and Infrastructure (T.C. Ulaştırma ve Altyapı Bakanlığı). The project data is collected from a Web-based Project Management System which belongs to Strategy Development Department of the Ministry and Electronic Public Procurement Platform (Elektronik Kamu Alımları Platformu - EKAP) of Public Procurement Institution (Kamu İhale Kurumu - KİK) of Turkey.

Because this study focusing on the stage between tender and contract signing, the available parameters are limited. Based on the literature review and the available datasets, the following parameters have been identified as potential critical success factors that may affect the overall success, schedule success, or budget success of the project for use in regression analysis:

Responsible Institution (İlgili İdare)

It is the institution which is affiliated with the Ministry. This institution is the owner of the project in behalf of the Ministry. There are 4 different responsible institutions in the dataset which are:

- General Directorate of Infrastructure Investments (AYGM – Altyapı Yatırımları Genel Müdürlüğü)
- General Directorate of Highways (KGM – Karayolları Genel Müdürlüğü)
- General Directorate of State Airports Authority (DHMİ – Devlet Hava Meydanları İşletmesi Genel Müdürlüğü)
- Turkish State Railways (TCDD – Türkiye Cumhuriyeti Devlet Demiryolları

Procurement Method (Satınalma Yöntemi)

This data represents whether the project is handled with PPP or traditional procurement.

Joint Venture presence for the contractor (Ortaklık varlığı)

This data represents whether the contractor is a Joint Venture (JV) or a single company.

Contractor Experience (Yüklenici Tecrübesi)

This data represents the experience of the contractor at the bid date.

Consultant Presence

This data represents whether there is a consultant in the project or not.

Tender Procedure

The procedures and principles to be applied in tenders conducted by public institutions and organizations in Turkey that are subject to public law, under the supervision of the government, or utilizing public resources are determined by the Public Procurement Law No. 4734. In other words, all infrastructure projects except PPP projects belongs to the Ministry are tendered according to the Law No. 4734. The method alternatives for the tendering are:

- Open Tender Procedure: A procedure in which all bidders can submit their proposals.
- Restricted Tender Procedure: A procedure in which bidders invited by the administration following a pre-qualification evaluation can submit their proposals.
- Negotiated procedure: A procedure that can be used in specified cases under this Law, where the tender process is conducted in two stages, and the administration negotiates the technical details, implementation methods, and, in certain cases, prices with the bidders.
- Direct procurement: A procedure in which needs can be directly procured by the administration by discussing technical specifications and prices with invited bidders, in the cases specified under this Law.

According to this Law, open tender procedure and restricted tender procedure are the fundamental methods for conducting procurement. Other procurement methods can be utilized in specific cases specified in the Law.

According to Article 21, paragraphs b and c of this Law:

- In cases determined by the administration where there are sudden and unexpected events or specific technical characteristics such as natural disasters, epidemic diseases, threats to life or property, or the necessity of ensuring the safety of structures, life, and property, or in cases where the procurement needs to be carried out urgently due to unforeseen events anticipated by the administration,

- In cases where there are special circumstances related to defense and security that necessitate urgent procurement, Negotiated procedure can be used for the procurement. The projects which have negotiated procedure of the Ministry make use of these two case for the negotiated procedure.

On the other hand, the procedures and principles to be applied in tenders of PPP projects are subject to the Law No. 3996 instead of the Law No. 4734 according to the Public Private Partnership Legislation.

In conclusion, there are 4 different Tender Procedure in the dataset which are:

- Law No. 4734 Open Tender Procedure
- Law No. 4734 Restricted Tender Procedure
- Law No. 4734 Negotiated Tender Procedure
- Law No. 3996

Awarded Bid / Estimated Cost Ratio (Kazanan Teklif / Yaklaşık Maliyet Oranı)

According to the Law No. 4734, before the procurement of goods, services, or construction works, the responsible institution determines the estimated cost by conducting all necessary price research, excluding value-added tax, and presents it in a cost estimate table along with its supporting documentation. While calculating the estimated cost, the institutions uses the unit price tables which are published and updated (annually till 2021 and twice per year after 2021) by ministries and other relevant institutions. The estimated cost is not included in the tender and prequalification announcements and is not disclosed to bidders or other individuals who are not involved in the tender process. After the tender, participants are informed about the bid prices and the estimated cost amount.

Estimated Cost and Awarded Bid values for the projects conducted through traditional public procurement method are taken from the EKAP system in this study. Values for the PPP projects are taken from UYS. This parameter calculated by dividing Awarded Bid Value by Estimated Cost Value.

Duration (Projenin Süresi)

This data represents the duration of the projects.

Contract Currency (Sözleşme Para Birimi)

This data represents the currency of the projects. The values are TL (Turkish Lira), EUR (Euro) and USD (U.S. Dollar).

Awarded Bid Amount – December 2022 (Kazanan Teklif Bedeli – Aralık 2022)

This data represents the financial size of the projects. Awarded Bid Amounts is collected from EKAP system. Since the date and the currency of the tenders are different, all awarded bid amounts are converted to TL and to date of December 2022.

Domestic Producer Price Index (DPPI)(Yurt İçi Üretici Fiyat Endeksi - Yİ ÜFE) is used to escalate the amounts. DPPI is released by Turkish Statistical Institute (Türkiye İstatistik Kurumu – TUİK) and it is a measure of the change in the prices of goods and services sold as output by domestic producers in a given reference period. The reference of this index is 100 for year 2003 and the index is updated monthly. The formula for the projects with TL currency is

$$(Awarded\ Bid\ Amount)_{t_1} = (Awarded\ Bid\ Amount)_{t_2} \times \frac{DPPI_{t_1}}{DPPI_{t_2}} \qquad [3.1]$$

where;

$(Awarded\ Bid\ Amount)_{t_1}$: Awarded bid amount escalated to 2022 December

$(Awarded\ Bid\ Amount)_{t_2}$: Awarded bid amount which is not escalated

$DPPI_{t_1}$: Index for 2022 December

$DPPI_{t_2}$: Index for bid date

For projects conducted in currencies other than the TL, the bid amounts are first converted into TL. Subsequently, the TL amounts are escalated using the formula mentioned above. For the exchange rates forex buying rate is taken from the Indicative Exchange Rates Announced by the Central Bank of Turkey webpage (Gösterge Niteliğindeki Türkiye Cumhuriyet Merkez Bankası Kurları sayfasındaki Döviz Alış Kuru).

Project Sector

This data represents the sector of the projects. The sectors in the dataset are Air, Rail, Road and Water.

Project Success

This data represents the success of the projects which is the dependent variable. Professionals working for the Strategy Development Department of the Ministry and the consultant of the Ministry for investment planning, monitoring and program management scored the projects in the dataset on a scale of 1 to 10. Statistical information regarding participants will not be disclosed, except for the organizations they work for, in accordance with their request for confidentiality. Participants were instructed to assess the success of the project, taking into account not only the contractor's performance but also all stakeholders involved. Each participant score each project in three success category which are overall success, budget success and schedule success according to their expertise. Average of the scores given by the participant are taken with 1 decimal rounding and accepted as the project success points for each category.

3.2 Description of the Analysis Technique

In this study, the regression analysis technique is used to develop success prediction models. Regression analysis is selected as the modeling method, as this method provides models that can be easy to understand and implement. The dataset is created and modified in Microsoft Office Excel 2013 and the regression analysis are performed in IBM SPSS Statistics.

Regression analysis serves the purpose of fitting a curve to available data by minimizing the sum of squared errors, and it employs regression models to express a dependent variable in relation to independent variables (Halinski & Feldt, 1970). This statistical technique is employed to examine and understand the relationships among various parameters. Regression models can be categorized into two main types: univariate regression, which involves a single explanatory variable, and multivariate regression, which incorporates multiple independent variables.

In the context of simple regression analysis, the model consists of a dependent variable (y), an independent variable (x), and regression coefficients (B_0 and B_1). The formulation of the simple regression model can be represented as follows:

$$y = B_0 + B_1 \times x + \in \quad [3.2]$$

Where;

B_0 : y-intercept (constant term)

B_1 : regression coefficient for x

$\in$: the error term of the model (residual)

In the majority of research problems involving regression analysis, it is common to include multiple independent variables in the regression model. When the coefficients in the model are assumed to be linear, it is referred to as a multivariate linear regression model. Multivariate linear regression enables researchers to simultaneously explore the correlation between a dependent variable and multiple independent variables, thereby facilitating a more extensive comprehension of the fundamental elements that impact the concerned dependent variable.

In order to decide what variables will use in the final model, backward elimination is a widely used method in multivariate linear regression analysis. It involves systematically removing independent variables from the model to determine the most influential and significant predictors for the dependent variable. This method starts with a full model that includes all potential independent variables and then eliminates one variable at a time, usually based on a predetermined criterion, such as p-values, to assess their significance in explaining the variation in the dependent variable. Variables with the highest p-values are removed first until a final, more refined model is obtained, consisting only of statistically significant predictors.

For a regression model with n independent variables, denoted as x_1, x_2, ..., x_n the estimated response can be obtained from the sample regression equation as follows:

$$y = B_0 + B_1 \times x_1 + B_2 \times x_2 + \cdots + B_n \times x_n + \in \qquad [3.3]$$

Each regression coefficient in the equation is estimated from the sample data using the method of least squares. The error term, denoted as e, captures all the unknown factors that are not accounted for in the model.

The coefficient of determination (R^2) is a commonly used criterion to assess the goodness-of-fit of a regression model. It is calculated as the ratio of the Sum of Squared Residuals (SSR) to the Sum of Squares for Treatment (SST).

$$R^2 = 1 - \frac{SSR}{SST} = 1 - \frac{\sum_{i=1}^{k}(\hat{y}_i - \bar{y})^2}{\sum_{i=1}^{k}(y_i - \bar{y})^2} \qquad [3.4]$$

Where;

k : sample size

$\hat{y}_i$: the estimation of the linear regression model for the dependent variable.

$\bar{y}$: mean of y_i values

y_i : the actual value of the dependent variable

An interesting characteristic of R^2 is that it tends to increase with the inclusion of additional variables. Consequently, when another variable is added to the model, R^2 is not likely to decrease and might even increase by chance. However, this does not necessarily indicate an improvement in the model. To address this issue, an adjusted version of the coefficient of determination was employed.

3.3 Preparation of the Data

11 types of data of 296 projects are collected in order to develop success prediction models as stated before. Before the model development, this data is needed to be adjusted. Dataset includes some projects with a very small scope. That is why the projects with Awarded Bid Amount – December 2022 less than 50 Million TL is dropped. Then number of projects decrease to 121.

Number of the some of the categorical variables are limited. It is decided to drop the projects with the variables which total number of them are less than 8 because developing a good fitted model with so limited variable is not possible.

Under the Responsible Institution data, there were 4 types of Institution. Because there were only 3 DHMI projects, they dropped. After this stage the total number of the projects was 118.

Since the categorical data is not suitable to use in regression analysis, they were converted to dummy variables. After DHMI projects were dropped, there are 3 variable types under Responsible Institution which are AYGM, KGM and TCDD. This variable split into three variables with names “is AYGM”, “is KGM” and “is TCDD”. If a project is an AYGM project, its variables are

is AYGM = 1

is KGM = 0

is TCDD = 0

However in this situation, one of these variables is dependent the other two because each project has one Responsible Institution only. Then, “is TCDD” variable was dropped.

AYGM projects get variables as

is AYGM = 1

is KGM = 0

KGM projects get variables as

is AYGM = 0

is KGM = 1

TCDD project gets variables as

is AYGM = 0

is KGM = 0

Procurement Method variable was dropped because it totally dependent on Tender Procedure variable. If Tender Procedure of a project is Law No. 3966, Procurement Method of it is traditional procurement. If Tender Procedure of a project is not Law No. 3966, Procurement Method of it is PPP.

Another categorical variable Tender Procedure which have 4 variable types split into 3 variables: “is Open”, “is Negotiated” and “is 3996”.

Projects with Law No. 4734 Open Tender Procedure get variables as

is Open = 1

is Negotiated = 0

is 3996 = 0

Projects with Law No. 4734 Restricted Tender Procedure get variables as

is Open = 0

is Negotiated = 0

is 3996 = 0

Projects with Law No. 4734 Negotiated Tender Procedure get variables as

is Open = 1

is Negotiated = 0

is 3996 = 0

Projects with Law No. 3996 Tender Procedure get variables as

is Open = 0

is Negotiated = 0

is 3996 = 1

Categorical variable Project Sector which have 4 variable types split into 3 variables: "is Road", "is Rail" and "is Air".

Projects in Road Sector get variables as

is Road = 1

is Rail = 0

is Air = 0

Projects in Rail Sector get variables as

is Road = 0

is Rail = 1

is Air = 0

Projects in Air Sector get variables as

is Road = 0

is Rail = 0

is Air = 1

Projects in Water Sector get variables as

is Road = 0

is Rail = 0

is Air = 0

Contract Currency variable was changed as “is TL” variable and gets value of 1 for projects with TL currency and value of 0 for the projects with EUR or USD currency.

JV Presence and Consultant Presence variables gets values 1 for the presence and 0 for the not presences as well.

After the modification stage of the variables, the final list of the 15 variables used in the models, their abbreviations and their units are shown in Table 3.1.

Table 3.1 Variables and their abbreviations

Variables	Abbreviation	Unit
Is AYGM	AYGM	- (dummy)
Is KGM	KGM	- (dummy)
JV Presence	JV	- (dummy)
Contractor Experience	Exp	years
Consultant Presence	Cons	- (dummy)
Is Open	Open	- (dummy)
Is Negotiated	Neg	- (dummy)
Is 3996	PPP	- (dummy)
Awarded Bid / Estimated Cost Ratio	Ratio	-
Duration	Dur	days
Is TL	TL	- (dummy)
Awarded Bid – Dec 2022 (millions)	Bid	TL
Is Road	Road	- (dummy)
Is Rail	Rail	- (dummy)
Is Air	Air	- (dummy)

3.4 Development of the Models

Multiple linear regression models were constructed for each of the three success categories. Initially, comprehensive models were developed incorporating all available variables. Subsequently, variables with low significance were eliminated using the backward elimination technique. During the backward elimination process, the significance level (P-value) and judgment of the researcher were taken into account to determine which variables will be eliminated.

To assess the accuracy of the models, hold-out cross-validation technique was used. The dataset was split into training sample and testing sample. A testing sample consisting of 37 projects, approximately one third of the dataset, was selected, while the remaining 81 projects were utilized to develop the models. The list of the projects which are randomly selected as training data is shown in the Table 3.2. The selection method used for determining the testing sample will be elaborated upon in the upcoming section.

Table 3.2 List of projects selected as training sample

Projects Selected as Training Sample		
Project 1	Project 50	Project 83
Project 2	Project 52	Project 84
Project 3	Project 53	Project 85
Project 4	Project 55	Project 87
Project 6	Project 57	Project 88
Project 7	Project 58	Project 89
Project 8	Project 59	Project 90
Project 9	Project 60	Project 91
Project 11	Project 61	Project 94
Project 12	Project 62	Project 95
Project 16	Project 64	Project 96
Project 17	Project 65	Project 97
Project 18	Project 67	Project 98
Project 19	Project 68	Project 99
Project 20	Project 69	Project 100
Project 22	Project 71	Project 102
Project 23	Project 72	Project 103
Project 24	Project 73	Project 104
Project 26	Project 74	Project 106
Project 28	Project 75	Project 109
Project 31	Project 76	Project 110
Project 33	Project 77	Project 111
Project 36	Project 78	Project 113
Project 38	Project 79	Project 114

Table 3.2 *Continued*

Projects Selected as Training Sample		
Project 41	Project 80	Project 115
Project 44	Project 81	Project 116
Project 49	Project 82	Project 117

3.5 Performance Test of the Models

Performance of the prediction models The Adjusted R2 value in a regression model serves as an important metric for evaluating the goodness of fit between the model and the data. It indicates the proportion of the dependent variable's variance that can be explained by the independent variables. A higher Adjusted R2 value indicates a stronger fit of the model to the data. However, it is crucial to recognize that a high Adjusted R2 value alone does not guarantee accurate predictions (Sonmez, 2008). The validity of the prediction models is assessed in terms of predictive accuracy. To assess the predictive performance of the model, cross-validation techniques are commonly employed. These techniques involve dividing the data into training and testing sets. The model is trained on the training set and then evaluated on the testing set to assess its ability to generalize to new, unseen data. By employing cross-validation, the model's predictive capability can be more robustly evaluated, providing a more reliable assessment of its performance. The data was split into training and testing data. The projects listed in Table 3.2 used to develop success models. Remaining projects were used to test the models. Predicted values were compared with the actual values to evaluate the prediction performance.

To assess the prediction performance and the closeness of fit of the final cost models, two error measures were utilized: Mean Absolute Percent Error (MAPE) and Mean Squared Error (MSE). They are calculated as follows:

$$MAPE = \frac{100}{N}\sum_{i=1}^{N}\frac{|actual_i - predicted_i|}{actual_i} \quad [3.5]$$

$$MSE = \frac{1}{N}\sum_{i=1}^{N}(actual_i - predicted_i)^2 \quad [3.6]$$

Where;

N : Number of test sample

$predicted_i$: Prediction of the model

$actual_i$: Actual success score of the project

A random number between 0 and 1 is assigned to the each project by using =RAND() command in the excel. Then, the first 38 projects with the lowest value were selected as testing sample. The same 38 projects were used for testing of the success models. After deciding the ultimate models for overall success, budget success and schedule success, MAPE and MSE values were calculated for each of them. These measures provide quantitative indicators for the accuracy of the models.

CHAPTER 4

DATA ANALYSIS AND RESULTS

4.1 Overall Success Model

As stated previously, there are many various success factors which effecting overall project success. Because this research is focusing on pre-construction stage, multiple linear regression analysis was done by using all variables which considered as potential critical project success parameter. The results of the overall success models will be presented in this chapter.

4.1.1 Data Analysis

As previously mentioned, the initial model for overall success was constructed, including all parameters. Data of 81 selected projects are used for the model construction.

The data for the first linear regression model which included all the variables is shown in the Table 4.1.

Table 4.1 Descriptive Statistics of Variables of the Overall Success Model-1

Parameter	B	Std. Error	Beta	t	P-Value (Significance)
(Constant)	1.466	2.519		0.582	0.563
AYGM	0.202	0.637	0.046	0.317	0.752
KGM	-1.159	1.800	-0.272	-0.644	0.522
JV	0.150	0.458	0.033	0.327	0.745
Exp	0.020	0.009	0.237	2.203	0.031
Cons	0.852	0.462	0.196	1.844	0.070
Open	0.028	0.542	0.007	0.052	0.959
Neg	-0.920	0.588	-0.205	-1.566	0.122

Table 4.1 *Continued*

Parameter	B	Std. Error	Beta	t	P-Value (Significance)
PPP	1.143	1.222	0.163	0.935	0.353
Ratio	6.445	1.663	0.448	3.876	2.5E-04
Dur	0.000	0.000	-0.074	-0.576	0.567
TL	-0.152	1.082	-0.024	-0.141	0.888
Bid	1.627E-05	0.000	0.130	1.065	0.291
Road	-0.301	1.741	-0.071	-0.173	0.863
Rail	-1.625	0.740	-0.372	-2.196	0.032
Air	0.019	0.745	0.003	0.026	0.979

"Is Air" is the variable with the highest P-Value in the Model-1. That is "Is Air" variable has the lowest significance on the dependent variable "Overall Success". Therefore, following the backward elimination method, the "Is Air" variable was eliminated, and Model-2 was constructed using the remaining variables.

After creating each model, a decision was made whether to eliminate the variable with the highest P-value, resulting in a total of 9 models. The statistical data consisting P-Values of the variables, R^2 values and Adjusted-R^2 values of the models, for these 9 models is displayed in Table 4.2.

Table 4.2 P-Values of Variables and Adj-R^2 Values for the Overall Success Models

Variable	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7	Model-8	Model-9
(Constant)	0.563	0.553	0.516	0.409	0.412	0.249	0.210	0.232	0.293
AYGM	0.752	0.751	0.750	0.731	0.724	-	-	-	-
KGM	0.522	0.519	0.512	0.512	0.114	0.006	0.004	0.004	0.007
JV	0.745	0.742	0.734	0.697	0.713	0.697	-	-	-
Exp	0.031	0.027	0.026	0.025	0.020	0.020	0.013	0.012	0.015
Cons	0.070	0.068	0.066	0.064	0.063	0.058	0.055	0.062	0.085
Open	0.959	0.962	-	-	-	-	-	-	-
Neg	0.122	0.112	0.035	0.031	0.030	0.029	0.027	0.029	0.028
PPP	0.353	0.345	0.311	0.195	0.180	0.166	0.168	0.167	0.029
Ratio	2.5E-04	2.1E-04	1.8E-04	5.4E-05	4.6E-05	4.1E-05	3.8E-05	3.0E-05	1.5E-05
Dur	0.567	0.564	0.549	0.546	0.529	0.570	0.572	-	-
TL	0.888	0.887	0.876	-	-	-	-	-	-
Bid	0.291	0.287	0.282	0.281	0.257	0.262	0.220	0.272	-
Road	0.863	0.856	0.857	0.868	-	-	-	-	-
Rail	0.032	0.014	0.013	0.012	0.011	3.4E-04	3.3E-04	3.2E-04	4.9E-04
Air	0.979	-	-	-	-	-	-	-	-
Adj. R-squared	0.506	0.514	0.521	0.528	0.534	0.540	0.546	0.550	0.549

In each of the first 7 models, variables with the lowest significance levels, having P-values of 0.5 or higher, were eliminated straightforwardly. Throughout this process, each subsequent model had a higher Adjusted R-squared value than the previous one. In Model-8, the "Awarded Bid" variable, which had the lowest significance level, had a relatively high P-value of 0.272. Therefore, the "Awarded Bid" variable was also eliminated, leading to the formation of Model-9. In Model-9, the significance of the "is 3996" variable increased, and no variable remained above the commonly used threshold value of 0.1, which is employed in the literature. Moreover, the R-squared value did not decrease significantly. Additionally, Model-9 was a more simplified version compared to Model-8. Considering these factors, Model-9 was determined as the ultimate Overall Success Model. Descriptive statistics of the model is displayed in Table 4.3.

Table 4.3 Descriptive Statistics of Variables of Overall Success Model-9

Parameter	**B**	**Std. Error**	**Beta**	**t**	**P-Value (Significance)**
(Constant)	1.283	1.212		1.058	0.293
KGM	-1.529	0.549	-0.359	-2.785	0.007
Exp	0.018	0.007	0.215	2.502	0.015
Cons	0.746	0.428	0.172	1.743	0.085
Neg	-0.898	0.400	-0.200	-2.246	0.028
PPP	1.611	0.721	0.229	2.233	0.029
Ratio	6.638	1.428	0.461	4.648	1.5E-05
Rail	-1.645	0.451	-0.377	-3.650	4.9E-04

The final regression equation from which the overall success of a project can be estimated is written as follows:

$$Overall\ Success = 1.283 - 1.529\ x\ KGM + 0.018\ x\ Exp + 0.746\ x\ Cons - 0.898\ x\ Neg + 1.611\ x\ PPP + 6.638\ x\ Ratio - 1.645\ x\ Rail \quad [4.1]$$

The results obtained from the final overall success model reveal the importance of various variables in determining the overall success of the project. Among these variables, the most significant one is the Awarded Bid / Estimated Cost Ratio, indicating that the ratio between the awarded bid and the estimated cost plays a crucial role in project success.

The second significant variable is the Is Rail variable, suggesting that whether a project is in rail sector or not significantly influences its success.

Additionally, several other important success parameters were identified. These include Is KGM, Contractor Experience, Is Negotiated, is 3996, and Consultant Presence, listed in descending order of their impact on project success.

4.1.2 Validation of Overall Success Model

Adjusted R^2 value of the final overall success model is 0.55 which means that 55% of the variance in the training sample is explained by the model. MAPE and MSE which are calculated with the formulas 3.5 and 3.6 respectively, are used to assess the forecasting performance of the model. Projects used for testing, actual and predicted success scores using the formula 4.1 and errors are shown in Table 4.4.

Table 4.4 Actual Overall Success - Predicted Overall Success Comparison

Project ID	Overall Success	Model Prediction	Percentage Error	Squared Error
Project 5	4.0	7.7	92.0	13.5
Project 10	10.0	8.5	14.6	2.1
Project 13	8.4	8.2	3.0	0.1
Project 14	4.8	4.9	2.5	0.0
Project 15	5.6	5.6	0.2	0.0
Project 21	5.8	6.3	9.3	0.3
Project 25	3.2	5.8	82.0	6.9
Project 27	8.5	7.3	14.3	1.5
Project 29	6.2	6.6	6.5	0.2
Project 30	2.6	4.1	56.7	2.2

Table 4.5 *Continued*

Project ID	Overall Success	Model Prediction	Percentage Error	Squared Error
Project 32	7.2	6.9	4.8	0.1
Project 34	6.4	5.6	12.7	0.7
Project 35	9.0	10.2	12.9	1.4
Project 37	5.4	5.9	9.1	0.2
Project 39	4.2	6.6	56.7	5.7
Project 40	7.6	7.0	8.2	0.4
Project 42	6.2	7.0	13.6	0.7
Project 43	2.0	4.9	147.4	8.7
Project 45	6.4	7.3	14.6	0.9
Project 46	7.2	7.0	3.5	0.1
Project 47	8.6	7.8	9.3	0.6
Project 48	6.0	5.6	7.5	0.2
Project 51	10.0	8.9	10.7	1.1
Project 54	2.2	4.1	84.9	3.5
Project 56	5.8	5.9	0.9	0.0
Project 63	2.5	4.4	75.7	3.6
Project 66	4.4	6.1	38.3	2.8
Project 70	8.8	9.5	8.3	0.5
Project 86	8.4	5.9	29.9	6.3
Project 92	4.4	6.4	44.4	3.8
Project 93	6.6	8.0	21.9	2.1
Project 101	7.4	7.4	0.1	0.0
Project 105	3.4	4.8	41.1	1.9
Project 107	5.0	5.2	4.3	0.0
Project 108	8.4	8.1	3.2	0.1
Project 112	7.4	6.5	12.0	0.8
Project 118	2.3	6.0	162.2	13.9

Calculated MAPE and MSE values are 30.25 and 2.35 respectively. Overall success predictions done by the overall success regression model within ±30% in average. The projects with low overall success like Project 25, 30, 43, 54, 63 and 118 has higher percentage errors because of their scores closed to 0.

MSE of the model on testing data is 2.35. That is the average of the squared errors of the predictions.

4.2 Budget Success Model

Multiple linear regression analysis was done by using all variables which considered as potential critical project budget success parameters. The results of the budget success models will be presented in this chapter.

4.2.1 Data Analysis

Like the overall success model, the initial model for budget success was constructed, including all parameters. Data of 81 selected projects are used for the model construction. The data for the first linear regression model is shown in the Table 4.5.

Table 4.6 Descriptive Statistics of Variables of the Budget Success Model-1

Parameter	B	Std. Error	Beta	t	P-Value (Significance)
(Constant)	-0.236	2.941		-0.080	0.936
AYGM	0.031	0.744	0.006	0.042	0.966
KGM	-1.682	2.103	-0.321	-0.800	0.427
JV	-0.373	0.535	-0.068	-0.697	0.488
Exp	0.016	0.011	0.159	1.555	0.125
Cons	2.097	0.540	0.394	3.886	0.000
Open	-0.151	0.633	-0.029	-0.239	0.812
Neg	-1.018	0.686	-0.185	-1.482	0.143
PPP	-0.140	1.427	-0.016	-0.098	0.922
Ratio	10.143	1.942	0.574	5.224	2.0E-06
Dur	0.000	0.001	-0.050	-0.413	0.681
TL	-1.048	1.264	-0.134	-0.829	0.410
Bid	1.287E-05	0.000	0.083	0.721	0.473
Road	-0.148	2.033	-0.028	-0.073	0.942
Rail	-2.047	0.864	-0.382	-2.369	0.021
Air	-0.334	0.871	-0.039	-0.383	0.703

“Is AYGM” is the variable with the highest P-Value in the Model-1. That is “Is AYGM” variable has the lowest significance on the dependent variable “Budget Success”. Therefore, following the backward elimination method, the “Is AYGM” variable was eliminated, and Model-2 was constructed using the remaining variables.

After creating each model, a decision was made whether to eliminate the variable with the highest P-value, resulting in a total of 10 models. The statistical data consisting P-Values of the variables, R^2 values and Adjusted-R^2 values of the models, for these 10 models is displayed in Table 4.6.

Table 4.7 P-Values of Variables and R^2 Values for the Budget Success Models

Variable	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7	Model-8	Model-9	Model-10
(Constant)	0.936	0.945	0.936	0.887	0.841	0.836	0.651	0.497	0.531	0.015
AYGM	0.966	-	-	-	-	-	-	-	-	-
KGM	0.427	0.385	0.020	0.019	0.018	0.015	0.016	0.021	0.025	0.054
JV	0.488	0.485	0.468	0.465	0.482	0.452	0.468	-	-	-
Exp	0.125	0.122	0.108	0.105	0.090	0.074	0.080	0.097	0.105	0.027
Cons	2.4E-04	2.1E-04	1.9E-04	1.5E-04	1.3E-04	1.2E-04	1.1E-04	1.2E-04	1.3E-04	1.9E-04
Open	0.812	0.809	0.807	0.829	-	-	-	-	-	-
Neg	0.143	0.134	0.131	0.104	0.058	0.058	0.055	0.051	0.045	0.014
PPP	0.922	0.922	0.905	-	-	-	-	-	-	-
Ratio	2.0E-06	1.1E-06	8.8E-07	7.2E-07	5.3E-07	4.5E-07	1.1E-07	2.8E-08	1.1E-08	7.3E-12
Dur	0.681	0.680	0.674	0.685	0.687	0.638	-	-	-	-
TL	0.410	0.399	0.397	0.332	0.320	0.292	0.342	0.402	0.211	-
Bid	0.473	0.471	0.452	0.441	0.416	0.401	0.462	0.518	-	-
Road	0.942	0.940	-	-	-	-	-	-	-	-
Rail	0.021	0.004	0.003	0.002	0.002	0.001	0.001	3.3E-04	3.3E-04	3.8E-04
Air	0.703	0.700	0.703	0.714	0.734	-	-	-	-	-
Adj. R-squared	0.553	0.560	0.567	0.573	0.579	0.584	0.589	0.591	0.595	0.591

In each of the first 8 models, variables with the lowest significance levels, having P-values of 0.5 or higher, were eliminated straightforwardly. Throughout this process, each subsequent model had a higher Adjusted R-squared value than the previous one. In Model-9, the "is TL" variable, which had the lowest significance level, had a relatively high P-value of 0.211. Therefore, the "is TL" variable was also eliminated, leading to the formation of Model-10. In Model 10, the significance of the "Contractor Experience" variable increased, and no variable remained above the commonly used threshold value of 0.1, which is employed in the literature. Moreover, the R-squared value did not decrease significantly. Additionally, Model-

10 was a more simplified version compared to Model-9. Considering these factors, Model-10 was determined as the final Budget Success Model. Descriptive statistics of the model is displayed in Table 4.7.

Table 4.8 Descriptive Statistics of Variables of Budget Success Model-10

Parameter	**B**	**Std. Error**	**Beta**	**t**	**P-Value (Significance)**
(Constant)	-3.121	1.251		-2.496	0.015
KGM	-1.169	0.598	-0.223	-1.957	0.054
Exp	0.018	0.008	0.176	2.252	0.027
Cons	1.914	0.487	0.359	3.934	1.9E-04
Neg	-1.105	0.438	-0.201	-2.523	0.014
Ratio	11.790	1.450	0.667	8.131	7.3E-12
Rail	-1.930	0.518	-0.360	-3.724	3.8E-04

The final regression equation from which the budget success of a project can be estimated is written as follows:

$$Budget\ Success = -3.121 - 1.169\ x\ KGM + 0.018\ x\ Exp + 1.914\ x\ Cons - 1.105\ x\ Neg + 11.790\ x\ Ratio - 1.930\ x\ Rail \qquad [4.2]$$

The findings from the final budget success model highlight the significance of various variables in determining the overall success of the project. The variable with the highest level of significance is the Awarded Bid / Estimated Cost Ratio, indicating that the ratio between the awarded bid and the estimated cost is a critical factor in project success.

The second and third variables that demonstrate significant influence on project success are the presence of a Consultant and the Is Rail variable, respectively.

Furthermore, several other important parameters for project success were identified. These include Is Negotiated, Contractor Experience, and Is KGM, listed in descending order of their impact on project success.

4.2.2 Validation of Budget Success Model

Adjusted R^2 value of the final budget success model is 0.59 which means that 59% of the variance in the training sample is explained by the model. MAPE and MSE which are calculated with the formulas 3.5 and 3.6 respectively, are used to assess the forecasting performance of the model. Projects used for testing, actual and predicted success scores calculated by using formula 4.2 and errors are shown in Table 4.8.

Table 4.9 Actual Budget Success - Predicted Budget Success Comparison

Project ID	Budget Success	Model Prediction	Percentage Error	Squared Error
Project 5	6.8	7.9	16.2	1.2
Project 10	9.8	9.4	3.6	0.1
Project 13	8.2	8.5	4.1	0.1
Project 14	6.0	5.3	11.0	0.4
Project 15	8.4	6.2	26.7	5.0
Project 21	8.0	6.6	17.8	2.0
Project 25	3.0	6.6	118.7	12.7
Project 27	7.8	7.5	4.5	0.1
Project 29	3.4	5.7	68.9	5.5
Project 30	2.0	2.7	36.7	0.5
Project 32	7.5	7.1	5.8	0.2
Project 34	8.5	6.3	25.4	4.7
Project 35	9.6	10.8	12.9	1.5
Project 37	6.6	6.9	4.7	0.1
Project 39	6.4	6.4	0.5	0.0
Project 40	7.6	7.2	5.6	0.2
Project 42	6.0	6.9	14.8	0.8
Project 43	1.6	4.3	169.9	7.4
Project 45	7.0	7.4	5.2	0.1
Project 46	7.6	7.3	4.5	0.1
Project 47	9.0	8.3	8.1	0.5
Project 48	8.5	6.2	27.0	5.3
Project 51	10.0	8.4	15.7	2.5
Project 54	1.4	2.3	64.4	0.8

Table 4.8 *Continued*

Project ID	Budget Success	Model Prediction	Percentage Error	Squared Error
Project 56	5.8	6.4	11.2	0.4
Project 63	3.0	4.1	38.2	1.3
Project 66	5.6	6.7	19.0	1.1
Project 70	9.4	10.2	8.5	0.6
Project 86	9.2	6.1	33.3	9.4
Project 92	6.6	6.3	3.8	0.1
Project 93	7.8	8.4	7.3	0.3
Project 101	7.4	7.8	5.4	0.2
Project 105	2.4	4.4	83.9	4.1
Project 107	2.4	4.5	87.6	4.4
Project 108	8.0	8.6	7.7	0.4
Project 112	9.6	6.8	29.1	7.8
Project 118	2.0	7.4	269.7	29.1

Calculated MAPE and MSE values are 34.52 and 3.00 respectively. Budget success predictions done by the budget success regression model within ±35% in average. The projects with low overall success like Project 25, 43, 54 and 118 has higher percentage errors because of their scores closed to 0.

MSE of the model on testing data is 3.00. That is the average of the squared errors of the predictions.

4.3 Schedule Success Model

Multiple linear regression analysis was done by using all variables which considered as potential critical project schedule success parameters. The results of the schedule success models will be presented in this chapter

4.3.1 Data Analysis

Like the other two models, the initial model for schedule success was constructed, including all parameters. Data of 81 selected projects are used for the model construction.

The data for the first linear regression model is shown in the Table 4.9.

Table 4.10 Descriptive Statistics of Variables of the Schedule Success Model-1

Parameter	B	Std. Error	Beta	t	P-Value (Significance)
(Constant)	3.655	3.027		1.207	0.232
AYGM	0.261	0.765	0.057	0.341	0.734
KGM	-1.767	2.164	-0.397	-0.817	0.417
JV	-0.578	0.550	-0.124	-1.051	0.297
Exp	0.021	0.011	0.240	1.939	0.057
Cons	0.256	0.555	0.057	0.461	0.646
Open	-0.218	0.651	-0.049	-0.335	0.739
Neg	-0.719	0.706	-0.154	-1.018	0.312
PPP	0.941	1.469	0.128	0.641	0.524
Ratio	3.081	1.998	0.205	1.542	1.3E-01
Dur	2.8E-06	0.001	0.001	0.005	0.996
TL	-0.531	1.301	-0.080	-0.408	0.684
Bid	1.7E-05	1.8E-05	0.126	0.899	0.372
Road	1.109	2.093	0.250	0.530	0.598
Rail	-1.855	0.889	-0.407	-2.086	0.041
Air	0.117	0.896	0.016	0.130	0.897

"Duration" is the variable with the highest P-Value in the Model-1. That is "Duration" variable has the lowest significance on the dependent variable "Schedule Success". Therefore, following the backward elimination method, the "Duration" variable was eliminated, and Model-2 was constructed using the remaining variables.

After creating each model, a decision was made whether to eliminate the variable with the highest P-value, resulting in a total of 12 models. The statistical data consisting P-Values of the variables, R2 values and Adjusted-R2 values of the models, for these 12 models is displayed in Table 4.10.

Table 4.11 P-Values of Variables and R^2 Values for the Schedule Success Models

Variable	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7	Model-8	Model-9	Model-10	Model-11	Model-12
(Constant)	0.232	0.193	0.173	0.075	0.080	0.062	0.067	0.051	0.065	0.077	0.031	0.083
AYGM	0.734	0.729	0.728	-	-	-	-	-	-	-	-	-
KGM	0.417	0.413	0.409	0.308	0.313	0.128	0.139	0.175	0.220	0.263	0.187	-
JV	0.297	0.285	0.282	0.277	0.310	0.340	0.344	0.416	-	-	-	-
Exp	0.057	0.037	0.035	0.033	0.026	0.029	0.026	0.015	0.021	0.024	0.022	0.017
Cons	0.646	0.640	0.640	0.618	0.603	0.575	-	-	-	-	-	-
Open	0.739	0.733	0.700	0.680	-	-	-	-	-	-	-	-
Neg	0.312	0.303	0.277	0.296	0.300	0.303	0.347	0.317	0.318	0.295	-	-
PPP	0.524	0.500	0.505	0.513	0.387	0.300	0.332	0.121	0.111	0.019	0.003	0.006
Ratio	0.128	0.118	0.112	0.118	0.114	0.119	0.093	0.053	0.039	0.030	0.055	0.016
Dur	0.996	-	-	-	-	-	-	-	-	-	-	-
TL	0.684	0.634	0.621	0.552	0.581	0.528	0.493	-	-	-	-	-
Bid	0.372	0.327	0.322	0.320	0.314	0.346	0.387	0.332	0.414	-	-	-
Road	0.598	0.594	0.602	0.611	0.621	-	-	-	-	-	-	-
Rail	0.041	0.039	0.016	0.001	4.9E-04	3.0E-04	3.1E-04	3.6E-04	2.2E-04	2.7E-04	4.1E-04	0.001
Air	0.897	0.895	-	-	-	-	-	-	-	-	-	-
Adj. R-squared	0.345	0.355	0.364	0.372	0.380	0.387	0.393	0.397	0.400	0.402	0.401	0.395

In each of the first 9 models, variables with the lowest significance levels, having P-values of 0.4 or higher, were eliminated straightforwardly. Throughout this process, each subsequent model had a higher Adjusted R-squared value than the previous one. In Model-10, the "is Negotiated" variable, which had the lowest significance level, had a relatively high P-value of 0.295. Therefore, the "is Negotiated" variable was also eliminated, leading to the formation of Model-11. In Model 11, the significance of the "Is KGM" variable increased, but its P-Value 0.187 is still above the value of 0.1. That is why “Is KGM” variable was eliminated and Model-12 was constructed. Adjusted R-squared value of the model was not decreased considerably. Nevertheless, despite the simplicity of Model-12, Model-11 was deemed the final Schedule Success Model due to the aim of maximizing the R2 value, even though it is lower compared to the other two success models. Descriptive statistics of the model is displayed in Table 4.11.

Table 4.12 Descriptive Statistics of Variables of Schedule Success Model-11

Parameter	B	Std. Error	Beta	t	P-Value (Significance)
(Constant)	3.001	1.361		2.204	0.031
KGM	-0.697	0.523	-0.157	-1.333	0.187
Exp	0.020	0.009	0.230	2.334	0.022
PPP	2.391	0.769	0.326	3.110	2.6E-03
Ratio	2.974	1.527	0.198	1.948	0.055
Rail	-1.920	0.519	-0.421	-3.700	4.1E-04

The final regression equation from which the schedule success of a project can be estimated is written as follows:

$$Schedule\ Success = 3.001 - 0.697\ x\ KGM + 0.020\ x\ Exp + 2.391\ x\ PPP + 2.974\ x\ Ratio - 1.920\ x\ Rail \quad [4.3]$$

4.3.2 Validation of Schedule Success Model

Adjusted R2 value of the final schedule success model is 0.40 which means that 40% of the variance in the training sample is explained by the model. MAPE and MSE which are calculated with the formulas 3.5 and 3.6 respectively, are used to assess the forecasting performance of the model. Projects used for testing, actual and predicted success scores calculated by using formula 4.3 and errors are shown in Table 4.12.

Table 4.13 Actual Schedule Success - Predicted Schedule Success Comparison

Project ID	Schedule Success	Model Prediction	Percentage Error	Squared Error
Project 5	3.0	7.9	163.5	24.1
Project 10	9.0	9.4	5.0	0.2
Project 13	5.8	8.5	47.1	7.5
Project 14	3.6	5.3	48.3	3.0
Project 15	4.2	6.2	46.6	3.8

Table 4.14 *Continued*

Project ID	Schedule Success	Model Prediction	Percentage Error	Squared Error
Project 21	1.8	6.6	265.2	22.8
Project 25	3.8	6.6	72.7	7.6
Project 27	7.5	7.5	0.6	0.0
Project 29	8.0	5.7	28.2	5.1
Project 30	2.2	2.7	24.3	0.3
Project 32	4.0	7.1	76.6	9.4
Project 34	5.2	6.3	21.9	1.3
Project 35	8.2	10.8	32.2	7.0
Project 37	4.6	6.9	50.2	5.3
Project 39	3.2	6.4	100.9	10.4
Project 40	5.8	7.2	23.7	1.9
Project 42	6.2	6.9	11.1	0.5
Project 43	2.8	4.3	54.2	2.3
Project 45	3.6	7.4	104.6	14.2
Project 46	5.4	7.3	34.4	3.4
Project 47	6.8	8.3	21.6	2.2
Project 48	4.6	6.2	34.9	2.6
Project 51	9.8	8.4	14.0	1.9
Project 54	2.5	2.3	7.9	0.0
Project 56	5.0	6.4	28.9	2.1
Project 63	2.3	4.1	80.3	3.4
Project 66	3.0	6.7	122.1	13.4
Project 70	6.6	10.2	54.5	12.9
Project 86	6.4	6.1	4.1	0.1
Project 92	3.8	6.3	67.1	6.5
Project 93	4.2	8.4	99.4	17.4
Project 101	6.8	7.8	14.7	1.0
Project 105	1.0	4.4	341.4	11.7
Project 107	7.4	4.5	39.1	8.4
Project 108	7.8	8.6	10.4	0.7
Project 112	5.8	6.8	17.3	1.0
Project 118	2.7	7.4	173.8	22.0

Calculated MAPE and MSE values are 63.32 and 6.41 respectively. Budget success predictions done by the budget success regression model within ±63% in average. The projects with low overall success like Project 21, 63, 66, 105 and 118 has higher percentage errors because of their scores closed to 0.

MSE of the model on testing data is 6.41. That is the average of the squared errors of the predictions.

CHAPTER 5

DISCUSSION OF RESULTS

This chapter provides a detailed discussion for the results of the data analyses conducted for overall success, budget success, and schedule success, accompanied by the presentation of the results. Furthermore, this section includes a comparison of the predictive accuracy of the models and a comprehensive discussion of the obtained outcomes.

The predictive accuracy of the models is evaluated by assessing how well they can anticipate and forecast project success, budget performance, and schedule adherence. By comparing the predictive accuracy of the models, their effectiveness in capturing and predicting the respective success criteria can be assessed.

The results obtained from the data analyses are critically examined and discussed in this section. The discussion entails an in-depth analysis of the findings, highlighting the key patterns, relationships, and trends observed in the data. It also involves a comparison of the obtained results with previous research and theoretical expectations.

By inspecting the predictive accuracy of the models and engaging in a thorough discussion of the results, this chapter aims to provide a comprehensive evaluation of the effectiveness of the developed models in predicting overall success, budget success, and schedule success in construction projects.

5.1 Accuracy of the Models

Although all models aim to predict the project's success, there are differences in prediction consistency due to various factors. These factors encompass the utilization of data extracted from the project's contract signing stage, thereby representing a limited scope within the project's life cycle. The impact of the factors available during the preconstruction stage on the three categories of success exhibits distinct variations. The predictive accuracy of the models is compared in Table 5.1.

Table 5.1 Performance Comparison of the Success Models

Performance Indicator	Overall Success Model	Budget Success Model	Schedule Success Model
Adj. R-squared	0.55	0.59	0.40
MAPE	30.25	34.52	63.32
MSE	2.35	3.00	6.41

5.1.1 Overall Success Model

The regression analysis conducted using data from 81 projects demonstrated that 55% of the fluctuations in the project overall success can be explained by this model. The success of testing sample predicted by the model with an accuracy range of ± 30.25%. Although the Overall Success Model ranks as the second most consistent model based on the Adjusted R-squared value, it is considered the most accurate model according to the MAPE and MSE values calculated from the test sample.

While budget and schedule performance are evaluated using strong quantitative parameters such as cost overruns and schedule delays, a more qualitative assessment is made for overall success. One of the criteria for overall success is the public reaction or response. The perception of the public is shaped not only by these quantitative parameters but also by criteria such as the size of the project, the procurement method, and the industry. Furthermore, the ultimate evaluation of a project's success is influenced by whether it is ultimately completed or not.

Therefore, despite potential budget and schedule failures due to various external factors, the mere completion of a large project can lead to its successful evaluation.

One of the most prominent examples illustrating this phenomenon is the Sydney Opera House project. Despite experiencing a significant delay of 10 years and a substantial cost overrun of 1400%, the project is still widely regarded as an architectural and engineering masterpiece. It has generated immense value for both Sydney and the entire Australian nation, and is considered a remarkable success (Cheng et al., 2013). Another notable example is the Suez Canal, which exceeded its budget by a staggering 19 times (Flyvbjerg, 2017).

Information about the project which is eligible in the contract signing stage is enough to understand how the public will react to this project if it will completed. This is the main reason of the difference between the accuracy of this model and other two success models.

It is important to note that while the model provides a reasonable level of predictive accuracy, there is still a margin of error of ± 30.3% in the predictions. This indicates that there may be additional factors that come into play after the project has started and are not accounted for in the existing model. These unaccounted factors could potentially have an impact on the overall success of projects.

5.1.2 Budget Success Model

The regression analysis conducted on a dataset revealed that the proposed model explains 59% of the variations in the overall success of the projects. The model's accuracy was further evaluated by predicting the success of a testing sample, which resulted in a prediction accuracy range of ± 34.5%.

While the Budget Success Model showed the highest level of consistency based on the Adjusted R-squared value, it ranked as the second most accurate model when considering the MAPE and MSE values calculated from the test sample. This suggests that although the model performs well in terms of explaining the variations in project success, overall success model provide more accurate predictions in terms of absolute errors. In contrast, the budget performance model exhibited higher accuracy compared to the schedule performance model across all metrics. This difference in accuracy suggests that the factors influencing budget performance are more apparent and established prior to the commencement of projects, in comparison to the factors affecting schedule performance.

5.1.3 Schedule Success Model

Based on the regression analysis conducted on the dataset, the proposed model was able to explain 40% of the variations observed in the overall success of the projects. To assess the accuracy of the model, a testing sample was used to predict the success of projects, resulting in a prediction accuracy range of ± 63.3%. This indicates that the model's predictions can deviate by up to 63.3% from the actual outcomes.

Furthermore, when comparing the accuracy levels of the success prediction models, it is evident that the schedule performance model exhibited the lowest accuracy across all metrics. This suggests that the factors influencing schedule performance are more complex and less predictable compared to other aspects of project success.

Upon reviewing the approval letters for time extension requests in Turkish projects, it has been observed that the most prevalent reason for delays is insufficient funding. This financial constraint often hampers the contractors' ability to make satisfactory progress within the designated timeframe. Insufficient funding can have cascading effects on various aspects of the project, leading to delays and potential disruptions in the overall project schedule.

Table 5.2 Year 2023 Transportation and Communication Investment Plan of Turkey

	Project Value	Invested Amount (end of 2022)	Amount to be invested	2023 Budget
Total Investment	₺ 2,060,564,283,982	₺ 732,679,386,463	₺ 1,327,884,897,519	₺ 121,664,619,000
Foreign Credit	₺ 502,458,771,713	₺ 133,470,569,866	₺ 368,988,201,847	₺ 22,075,620,847
Public Investment	₺ 1,558,105,512,269	₺ 599,208,816,597	₺ 958,896,695,672	₺ 99,588,998,153

According to the 2023 Investment Program of the Presidency of Strategy and Budget - Presidency of the Republic of Turkey (Türkiye Cumhuriyeti Cumhurbaşkanlığı - Strateji ve Bütçe Başkanlığı), the transportation and communication sectors consist of a total of 778 projects with a combined value exceeding 2 trillion TL. As of the end of 2022, an amount of 732.6 billion TL has been invested. When excluding foreign credits and the already invested amount, the remaining total to be invested after the end of 2022 amounts to 958.9 billion TL. However, considering the budget allocated to the Ministry, which stands at 99.6 billion TL, it would take approximately 10 years to complete these projects if the budget does not experience a significant increase in the coming years. Out of the 119 projects in our dataset, 98 of them have a construction duration of 3 years or less, and 115 of them have a construction duration of 5 years or less. These statistics further support the notion that budget allocation is indeed a crucial factor influencing the schedule performance of a project. The total budget available is not adequate to complete all the projects within the specified contract durations.

5.2 Critical Success Factors

The statistical data of the models reveals that the same variables are influencing the overall, budget, and schedule performances of a project, albeit with varying degrees of significance. Table 5.3 provides the critical success factors (CSFs) of the models and their respective order of significance.

Table 5.3 The Significance Orders of Variables in the Success Models

	Overall Success Model	Budget Success Model	Schedule Success Model
KGM	3	6	5
Exp	4	5	3
Cons	7	2	-
Neg	5	4	-
PPP	6	-	2
Ratio	1	1	4
Rail	2	3	1

These CSFs, as identified in the models, highlight the significant factors influencing the performance of the projects in Turkey which are eligible in contract signing stage.

5.2.1 Awarded Bid / Estimated Cost Ratio

The Awarded Bid / Estimated Cost Ratio has been identified as a variable with the lowest P-value in the overall success and budget success models, and the second lowest P-value in the schedule success model. This indicates that it is one of the most critical factors influencing the success of projects in Turkey. The ratio between the awarded bid and the estimated cost holds significant importance in determining project outcomes and can be considered a crucial metric for project success assessment.

Estimated Cost of a project is calculated by the responsible institution as described in the Methodology section before. The Estimated Cost of a project includes a 25% cap for indirect costs, overhead expenses, and the contractor's profit. When the ratio of the Awarded Bid to Estimated Cost decreases, it indicates that the bid is becoming more competitive. There are two possible reasons for such a low bid. Firstly, the contractor may have implemented innovative solutions to reduce costs in certain work aspects. Secondly, the contractor may have lowered the profit ratio and assumed higher risks.

However, it is important to note that extremely low bids can raise concerns and are subject to scrutiny under Article 38 of the Public Procurement Law No. 4734. This article allows the tender commission of the responsible institution to identify bids that are significantly below the estimated cost or other bids. The commission may request an explanation from the bidder regarding the components that are deemed important by the commission. This highlights that excessively low bids are not always desirable.

The results of the model support this proposition, as the prediction of budget success increases when the ratio of the Awarded Bid to Estimated Cost increases. When a bid is too low, to the point where the contractor incurs losses, it can lead to various drawbacks. For instance, the contractor may slow down the progress of the work, face financial difficulties or even bankruptcy, or seek opportunities to increase the project scope (keşif artışı) to compensate for the low bid. These factors emphasize the potential negative implications of extremely low bids in construction projects.

5.2.2 Presence of a Consultant

Presence of a consultant is the second most significant variable in the budget success model and the seventh in overall success model. The consultant is an institution appointed and authorized by the responsible institution to ensure that a consulting project is carried out in accordance with the contract and its annexes, both technically, financially, and legally, within the construction period.

The output of the models reveals that the inclusion of a consultant plays a significant role in fostering the prospective success of a project. The absence of a dedicated consultant places an additional burden on the engineers and technicians, as they are compelled to manage projects without the specialized expertise and support typically provided by a consultant. Consequently, the control and oversight of projects may not exhibit the same level of efficiency and comprehensiveness as when a consultant is involved.

The engagement of a dedicated consultant offers several advantages. These consultants bring a wealth of experience, knowledge, and specialized skills to the project. They offer impartial supervision, provide expert guidance, and ensure adherence to industry standards and best practices. With a consultant actively engaged, the project can benefit from their focused attention and dedicated efforts, resulting in improved control and management. This control minimizes the potential scope change. That is why the presence of a consultant variable has more significance in budget success model.

Hence, the presence of a consultant in a project amplifies the control mechanism, enabling more effective monitoring and coordination, thereby contributing to the potential success of the project.

5.2.3 Is Rail

Is Rail variable represents whether a project is in rail sector or not. It has been observed that this variable holds significant influence in all the models. Notably, the negative coefficient indicates that being in the rail sector tends to decrease the performance of a project across all areas.

One possible reason for this negative influence is the inherent complexity of rail projects compared to projects in other sectors. Rail projects typically involve a combination of infrastructure and superstructure works that are often distributed among different contractors. Any decrease in the performance of one contractor can have a negative ripple effect on the overall project.

Additionally, rail projects often involve extensive tunnel works, which can pose challenges and complexities not typically encountered in other types of projects. These tunnel works have been found to have a particularly significant impact on the schedule performance, as indicated by the highest level of significance for this variable in the model outputs.

Considering the unique characteristics and complexities of rail projects, it becomes apparent why being in the rail sector can have a detrimental effect on project performance. The interdependencies among contractors, combined with the challenges posed by tunnel works, contribute to decreased performance across various project success areas.

5.2.4 Is Negotiated

This particular variable represents one of the dummy variables related to the tender procedure. Is Negotiated variable is a CSF for overall success and budget success. Because this variable has negative coefficient in both models, having a negotiated tender procedure affects success if a project in Turkey negatively.

As explained in the methodology section, this type of tender can be employed in specific situations that require urgent procurement. In these cases, the tender procedure may commence before the completion of design drawings. The incomplete design aspect can lead to scope changes during the project's construction phase. Consequently, projects that undergo a negotiated tender procedure are at an increased risk of scope changes, which often result in cost overruns and negatively impact the budget performance of the project.

Furthermore, as previously discussed, there is a correlation between public reactions and the overall success of a project. When a project utilizes a negotiated tender procedure, public perception tends to shift toward the negative side. There is a prevalent belief among the public that contractors involved in such procedures enjoy high profit rates, leading to a perception that public resources are being wasted.

Therefore, the presence of a negotiated tender procedure not only elevates the risk of scope changes and subsequent cost overruns but also influences public sentiment by creating a perception of inefficient resource allocation. These factors contribute to the budget success, the overall success and public perception of the project. That is why the requirements of negotiated tender procedure mentioned in Article 21 of Law No. 4734 should be tightened.

5.2.5 Contractor Experience

Contractor experience is indeed identified as a CSF in all three success models. Numerous studies in the literature, such as (Doloi, 2009) and (Alzahrani & Emsley, 2013), support the significant role of contractors in project success.

While other stakeholders, such as the owner and consultant, play important roles, it is the contractor who executes the work on the field. Their experience and expertise are crucial in ensuring project success. Therefore, in this study, the experience of the contractor is selected as a variable, as it provides clear and relevant data.

The findings from the three success models demonstrate that the potential for project success in all three areas increases as the experience of the contractor increases. Several possible reasons contribute to this relationship. Firstly, as the contractor's experience grows, there is a higher probability that they have completed similar projects or work packages in the past. This familiarity enhances their ability to handle project challenges effectively.

Furthermore, an experienced contractor is more likely to have qualified and highly skilled personnel within their team. These experienced individuals contribute to the successful execution of the project.

Overall, the increasing potential for project success across all three success areas is attributed to the contractor's experience. Their prior project experience and access to qualified personnel significantly impact the outcomes of the project.

5.2.6 Is KGM

Is KGM variable represents whether responsible institution of a project is KGM or not. It has been observed that this variable holds significant influence in all the models. Notably, the negative coefficient indicates that being under responsibility of KGM tends to decrease the performance of a project across all areas.

One possible reason for the decreased performance of projects under the administration of KGM (General Directorate of Highways) is related to the role of consultants. In the KGM system, there are 17 zones in Turkey and each project belong to one them. The consultancy services for all projects within a specific zone in Turkey are tendered as a single contract. This means that the same personnel are often assigned to multiple projects within the same zone simultaneously.

This arrangement can present challenges in terms of specialization and detailed project control. When consultants are responsible for overseeing multiple projects simultaneously, it becomes more difficult to allocate sufficient time and resources to each project. This can lead to a weaker level of control and oversight, ultimately impacting the performance of the projects.

The lack of specialized focus and detailed control due to the workload of consultants may result in delays, quality issues, or other project-related problems. Consequently, the decreased performance of projects within the KGM system can be attributed, at least in part, to this aspect of the consultancy arrangement.

Addressing this issue may involve considering alternative approaches to consultant assignments, such as allocating consultants to specific projects or implementing measures to enhance project monitoring and control within the existing system. By improving the specialization and control aspects of project consultancy, the performance of KGM projects could potentially be improved.

Indeed, it has been observed that being a KGM project has a negative effect on project performance, and a similar negative effect is observed for projects in the rail sector. Considering most of the KGM projects are in road sector, this suggests that projects in the air and water sectors have generally performed better compared to projects in other sectors.

One possible reason is the nature of the working area. Projects in the air and water sectors have typically a more limited working area, such as airports or ports. In contrast, road and rail projects often span across kilometers, which increases the risk of encountering unexpected difficulties and challenges. The larger working area introduces complexities related to land acquisition, right-of-way issues, utility relocations, and environmental considerations.

Moreover, projects in the air and water sectors generally exhibit lower complexity compared to road and rail projects. Complexity and project success relationship is shown in the literature (Luo et al., 2017; Nguyen et al., 2019). Airports and ports typically involve the construction of terminals, runways, berths, and associated facilities. These projects tend to have more standardized designs and construction processes, leading to greater predictability and reduced complexity.

In contrast, road and rail projects encompass various elements such as interchanges, bridges, tunnels, track systems, signaling, and infrastructure works. The coordination and integration of these diverse components can introduce higher complexity and increase the potential for project performance issues.

Considering the limited working area and lower complexity of projects in the air and water sectors, it is plausible that they have demonstrated relatively better performance compared to road and rail projects. However, it is important to note that project success can still be influenced by various other factors, including project management, stakeholder involvement, and contractual arrangements.

5.2.7 Is PPP

Is PPP variable is representing both the tender procedure of a project and whether it is a PPP project or public procurement project. This variable has significant effect on schedule performance and moderate effect on overall performance. Is PPP variable has a positive coefficient in both models. That means the effect of being PPP project is positive in overall success and schedule success.

PPP projects in Turkey has BOT method generally. In BOT contracts, contractor has a duration, 25 years for example, for both build and operate phase in total. That means the earlier the contractor completes the construction phase, the longer the operation period will be, which implies that the contractor will earn more money. This idea encourages contractors to strive for faster completion. Moreover, as the financing of these projects is sourced from private initiatives rather than the public budget, they do not face the same funding constraints as other projects. All these factors contribute to higher schedule performance in PPP projects compared to other projects.

The PPP method is predominantly favored for projects of significant scope, particularly for mega projects, as it allows for the allocation and transfer of certain risks. As previously discussed, the perception of a size of the project serves as a determining factor in shaping public opinion. In this regard, the perception of a project being extensive in scale and successfully completed is often sufficient to elicit a positive appraisal of the overall success of the project.

CHAPTER 6

CONCLUSION

In Turkey, the majority of public investments are allocated to transportation projects. Although all transportation projects are initiated with the aim of being successful, not all projects can be successfully completed (Flyvbjerg, 2017). This research is conducted based on the hypothesis that project success models, which can support decision-making using these resources during the tender process and contract signing, can be developed to enhance the overall success, budgetary success, and program success of projects. The objective is to develop robust project success models through linear regression analysis.

The study collected data from 296 transportation projects in Turkey and underwent a data preparation stage. After the preparation stage, a subset of 118 projects was selected for further analysis. These projects were then divided into training and testing samples.

Multiple linear regression analysis was conducted using the selected variables to develop models for overall success, budget success, and schedule success. The outputs of these models were thoroughly discussed, analyzing the significance and influence of the selected variables on project success.

To assess the accuracy of the models, several evaluation metrics were utilized, including adjusted R^2 values, MSE, and MAPE. These metrics provided insights into the predictive power and performance of the developed models.

The study compared the accuracy levels of the three success models, considering the aforementioned evaluation metrics. This comparison allowed for a comprehensive assessment of the models and their ability to predict project success from different perspectives.

Furthermore, the study identified and discussed the CSFs that emerged from the models for each success perspective (overall, budget, and schedule). The reasons behind the effects of these CSFs on project success were detailed in the discussion of the results chapter, providing valuable insights into the key factors influencing project performance.

The study makes several practical and theoretical contributions to the literature on transportation projects, specifically in Turkey. One of the significant theoretical contributions is the identification and determination of CSFs specific to transportation projects in Turkey. Unlike previous studies that relied solely on literature reviews and surveys, this study utilized real project data, providing a more robust and data-driven analysis of CSFs.

Moreover, this study highlights the importance of considering parameters that can only be obtained during the contract signing phase in assessing the success of projects. By incorporating data from this critical phase, the study provides valuable insights into the factors that influence project success, offering a more comprehensive understanding of the dynamics and complexities involved in transportation projects in Turkey.

The inclusion of real project data and the analysis of parameters obtained during the contract signing phase enhance the practical relevance of the study's findings. This research approach contributes to bridging the gap between theoretical considerations and practical applications in the field of transportation project management.

Furthermore, the study fills a research gap by focusing specifically on transportation projects in Turkey. By providing insights into the unique characteristics and challenges of this context, the study contributes to the understanding of project success factors in the Turkish transportation sector.

In the international context, this research study makes significant contributions to the literature on critical success factors in construction and transportation projects. By focusing specifically on the pre-contract stage, the study addresses a prominent gap in the existing research. While the majority of studies have primarily concentrated on factors occur during project execution, this research delves into the crucial phase of contract signing, providing valuable insights into the determinants of project success before project initiation. This emphasis on the pre-contract stage offers a novel perspective and enhances the overall understanding of project management practices in transportation projects globally.

From a practical perspective, the developed models for overall success, budget success, and schedule success can indeed serve as valuable decision support tools for project stakeholders. These models can provide quantitative estimates and insights into the factors that influence project success, allowing decision-makers to make more informed choices during the tender process and contract signing phase.

The findings of the study regarding the negative impact of negotiation procedures in the tender process on project success have important practical implications. The recommendation to avoid the use of negotiation procedures, except in exceptional cases, highlights the need for improvements in the public procurement process. This finding can inform policy and decision-making at the institutional level, leading to potential changes in the Public Procurement Law to mitigate the negative effects and enhance project success rates.

By emphasizing the potential risks associated with negotiation procedures, this study provides valuable guidance to project stakeholders, including government agencies, project owners, and contractors. It encourages the adoption of transparent and competitive procurement practices, promoting fairness, efficiency, and project success.

Implementing the suggested changes in the public procurement process based on the findings of this study can lead to improved project outcomes, reduced risks, and better allocation of public resources. It underscores the importance of continuous evaluation and refinement of procurement regulations and practices to enhance the success of projects in Turkey's transportation sector.

Overall, the practical implications of the study extend beyond the development of project success models. The recommendation to revise the Public Procurement Law based on the findings underscores the potential for policy and procedural improvements that can positively impact project success rates and contribute to more effective utilization of public investments in the transportation sector.

However, it's important to note that there are limitations to the study. The sample size of 118 projects may not represent the entire population of transportation projects in Turkey, which could impact the generalizability of the findings. Additionally, the study focused on transportation projects in Turkey and may not be directly applicable to projects in other sectors or countries. Indeed, the difficulty in accessing data posed a limitation in this study, leading to the inclusion of experience of contractors only on a yearly basis in the models. Incorporating additional data such as completed project volume and budgets or key personnel experience could have enhanced the consistency of the models. Another limitation of the study is the use multiple linear regression analysis models only.

For future studies, there are several avenues for further research and improvement based on the findings and limitations of this study:

- Sample Size and Sector Representation: Expanding the sample size and including projects from diverse sectors can enhance the generalizability of the findings. A larger sample size can provide a more comprehensive understanding of the critical success factors and their impact on project success. Including projects from different sectors can also reveal sector-specific factors that influence project performance.
- Comparative Analyses: Conducting comparative analyses between different developing countries or regions can provide valuable insights into the factors influencing project success in different contexts. Comparing the findings from Turkey with those from other countries can help identify common trends or unique factors that contribute to project success or failure.
- Advanced Analytical Techniques: Employing advanced analytical techniques, such as neural networks or nonlinear regression analysis, can

improve the consistency and predictive power of the models. These techniques can capture complex relationships and non-linear patterns that may exist between the independent variables and project success criteria.

- Multiple Phases and Dynamic Models: Collecting data from multiple phases of projects and developing dynamic models can support decision-making throughout the entire project lifecycle. By considering data from various stages, such as the pre-contract stage, construction phase, and post-construction phase, a more comprehensive understanding of the critical success factors and their influence at each stage can be obtained.

By addressing these suggestions in future studies, researchers can further enhance the understanding of critical success factors in transportation projects, refine the predictive models, and contribute to the development of more robust decision support mechanisms for project stakeholders in Turkey.

REFERENCES

Abdul-Aziz, A.-R. (2001). Unraveling of BOT Scheme: Malaysia's Indah Water Konsortium. *Journal of Construction Engineering and Management*, *127*(6), 457–460. https://doi.org/10.1061/(ASCE)0733-9364(2001)127:6(457)

Ahmed, S. M., & Kangari, R. (1995). Analysis of Client-Satisfaction Factors in Construction Industry. *Journal of Management in Engineering*, *11*(2), 36–44. https://doi.org/10.1061/(ASCE)0742-597X(1995)11:2(36)

Alzahrani, J. I., & Emsley, M. W. (2013). The impact of contractors' attributes on construction project success: A post construction evaluation. *International Journal of Project Management*, *31*(2), 313–322. Scopus. https://doi.org/10.1016/j.ijproman.2012.06.006

Ansari, R., Khalilzadeh, M., Taherkhani, R., Antucheviciene, J., Migilinskas, D., & Moradi, S. (2022). Performance Prediction of Construction Projects Based on the Causes of Claims: A System Dynamics Approach. *Sustainability (Switzerland)*, *14*(7). Scopus. https://doi.org/10.3390/su14074138

Bang, S., Aarvold, M. O., Hartvig, W. J., Olsson, N. O. E., & Rauzy, A. (2022). Application of Machine Learning tzo Limited Datasets: Prediction of Project Success. *Journal of Information Technology in Construction*, *27*, 732–755. Scopus. https://doi.org/10.36680/j.itcon.2022.036

Beng, C. H., Tammy, N. J. B., Ramlee, N. B., Nasir, S. R. B. M., Husna, R. N., Noor, B. R. M., Musir, A. B. A., & Karim, N. B. A. (2017). Determining success factors influencing construction project in northern Malaysia. *Journal of Engineering and Applied Sciences*, *12*(Specialissue3), 6456–6461. Scopus. https://doi.org/10.3923/jeasci.2017.6456.6461

Bilir, C., & Yafez, E. (2021). Project success/failure rates in Turkey. *International Journal of Information Systems and Project Management*, *9*(4), 24–40. Scopus. https://doi.org/10.12821/ijispm090402

Bozeman, B., & Bretschneider, S. (1994). The "Publicness Puzzle" in Organization Theory: A Test of Alternative Explanations of Differences between Public and Private Organizations. *Journal of Public Administration Research and Theory*, *4*(2), 197–224. https://doi.org/10.1093/oxfordjournals.jpart.a037204

Brown, A., & Adams, J. (2000). Measuring the effect of project management on construction outputs: A new approach. *International Journal of Project Management*, *18*(5), 327–335. https://doi.org/10.1016/S0263-7863(99)00026-5

Bryde, D. J., & Robinson, L. (2005). Client versus contractor perspectives on project success criteria. *International Journal of Project Management*, *23*(8), 622–629. Scopus. https://doi.org/10.1016/j.ijproman.2005.05.003

Budayan, C. (2018). Analysis of critical success factors in public private partnership projects by triangulation method: Turkey perspective. *Journal of the Faculty of Engineering and Architecture of Gazi University*, *33*(3), 1029–1044. Scopus. https://doi.org/10.17341/gazimmfd.416404

Chan, A. P. C., Scott, D., & Chan, A. P. L. (2004). Factors affecting the success of a construction project. *Journal of Construction Engineering and Management*, *130*(1), 153–155. Scopus. https://doi.org/10.1061/(ASCE)0733-9364(2004)130:1(153)

Cheng, M.-Y., Huang, C.-C., & Roy, A. F. V. (2013). Predicting project success in construction using an evolutionary gaussian process inference model. *Journal of Civil Engineering and Management*, *19*(SUPPL.1), S202–S211. Scopus. https://doi.org/10.3846/13923730.2013.801919

Chua, D. K. H., Kog, Y. C., & Loh, P. K. (1999). Critical success factors for different project objectives. *Journal of Construction Engineering and Management*, *125*(3), 142–150. Scopus. https://doi.org/10.1061/(ASCE)0733-9364(1999)125:3(142)

Chua, D. K. H., & Li, D. (2000). Key Factors in Bid Reasoning Model. *Journal of Construction Engineering and Management*, *126*(5), 349–357. https://doi.org/10.1061/(ASCE)0733-9364(2000)126:5(349)

Cleland, D. I., & Ireland, L. R. (2006). *Project management: Strategic design and implementation* (5th ed.). New York: McGraw-Hill.

Cooke-Davies, T. (2002). The “real” success factors on projects. *International Journal of Project Management*, *20*(3), 185–190. https://doi.org/10.1016/S0263-7863(01)00067-9

de Jong, M., & Haesebrouck, T. (2023). Under pressure: A qualitative comparative analysis on the factors contributing to the success and failure of cross-border gas pipeline construction in Europe and Turkey. *Energy Strategy Reviews*, *45*. Scopus. https://doi.org/10.1016/j.esr.2022.101033

Deep, S., Bhoola, V., Vidhani, J., & Hampannaver, P. R. (2022). Evaluating the impact of constraints on project success: Empirical study of highway projects. *Built Environment Project and Asset Management*, *12*(4), 684–700. Scopus. https://doi.org/10.1108/BEPAM-05-2021-0074

Doloi, H. (2009). Analysis of pre-qualification criteria in contractor selection and their impacts on project success. *Construction Management and Economics*, *27*(12), 1245–1263. Scopus. https://doi.org/10.1080/01446190903394541

Elattar, S. M. S. (2009). Towards developing an improved methodology for evaluating performance and achieving success in construction projects. *Scientific Research and Essays*, *4*(6), 549–554. Scopus.

Emadi, S., & Emadi, S. (2022). Analyzing Cost and Time Objectives in the Construction Projects Using Artificial Neural Network. *International Review of Civil Engineering*, *13*(2), 91–98. Scopus. https://doi.org/10.15866/irece.v13i2.21124

Famakin, I. O., Aje, I. O., & Ogunsemi, D. R. (2012). Assessment of success factors for joint venture construction projects in Nigeria. *Journal of Financial Management* *of Property and Construction*, *17*(2), 153–165. Scopus. https://doi.org/10.1108/13664381211246606

Flinders, M. (2005). The Politics of Public-Private Partnerships. *British Journal of Politics & International Relations*, *7*(2), 215–239. https://doi.org/10.1111/j.1467-856X.2004.00161.x

Flyvbjerg, B. (2017). *Introduction: The Iron Law of Megaproject Management*. United Kingdom: Oxford University Press. https://doi.org/10.1093/oxfordhb/9780198732242.013.1

Friend, J. (2006). Partnership meets politics: Managing within the maze. *The International Journal of Public Sector Management*, *19*(3), 261–277. https://doi.org/10.1108/09513550610658222

Gunduz, M., & Almuajebh, M. (2020). Critical success factors for sustainable construction project management. *Sustainability (Switzerland)*, *12*(5). Scopus. https://doi.org/10.3390/su12051990

Gupta, M. C., & Narasimham, S. V. (1998). Discussion: CSFs in Competitive Tendering and Negotiation Model for BOT Projects. *Journal of Construction Engineering and Management*, *124*(5), 430–430. https://doi.org/10.1061/(ASCE)0733-9364(1998)124:5(430)

Gurgun, A. P., & Touran, A. (2014). Public-private partnership experience in the international arena: Case of Turkey. *Journal of Management in Engineering*, *30*(6). Scopus. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000213

Halinski, R. S., & Feldt, L. S. (1970). THE SELECTION OF VARIABLES IN MULTIPLE REGRESSION ANALYSIS. *Journal of Educational Measurement*, *7*(3), 151–157. https://doi.org/10.1111/j.1745-3984.1970.tb00709.x

Jacobson, C., & Ok, S. O. (2008). Success factors: Public works and public-private partnerships. *International Journal of Public Sector Management*, *21*(6), 637–657. Scopus. https://doi.org/10.1108/09513550810896514

Jiang, W., Lu, Y., & Le, Y. (2016). Trust and Project Success: A Twofold Perspective between Owners and Contractors. *Journal of Management in Engineering*, *32*(6), 4016022. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000469

Jiang, W., Zhao, X., & Zuo, J. (2017). (Dis)trust, control, and project success: From a Chinese project owner's perspective. *Sustainability (Switzerland)*, *9*(11). Scopus. https://doi.org/10.3390/su9111936

Jugdev, K., & Moller, R. (2006). A retrospective look at our evolving understanding of project success. *IEEE Engineering Management Review*, *34*(3), 110–127. Scopus. https://doi.org/10.1109/EMR.2006.261387

Jugdev, K., & Muller, R. (2005). A Retrospective look at our Evolving Understanding of Project Success. *Project Management Journal*, *36*(4), 19–31. https://doi.org/10.1177/875697280503600403

Kim, B.-C., & Reinschmidt, K. F. (2009). Probabilistic forecasting of project duration using bayesian inference and the beta distribution. *Journal of Construction Engineering and Management*, *135*(3), 178–186. Scopus. https://doi.org/10.1061/(ASCE)0733-9364(2009)135:3(178)

Kim, D. Y., Han, S. H., Kim, H., & Park, H. (2009). Structuring the prediction model of project performance for international construction projects: A comparative analysis. *Expert Systems with Applications*, *36*(2 PART 1), 1961–1971. Scopus. https://doi.org/10.1016/j.eswa.2007.12.048

Ko, C.-H., & Cheng, M.-Y. (2007). Dynamic prediction of project success using artificial intelligence. *Journal of Construction Engineering and Management*, *133*(4), 316–324. Scopus. https://doi.org/10.1061/(ASCE)0733-9364(2007)133:4(316)

Kuprenas, J. A. (2005). *Construction project cost performance prediction based on project bid characteristics*. 957–965. Scopus.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-27644583629&partnerID=40&md5=8b14fd0f785adfea640f85c6c518b4b1

Leung, M.-Y., Chong, A., Ng, S. T., & Cheung, M. C. K. (2004). Demystifying stakeholders' commitment and its impacts on construction projects. *Construction Management and Economics*, *22*(7), 701–715. https://doi.org/10.1080/0144619042000300736

Li, B., Akintoye, A., Edwards, P. J., & Hardcastle, C. (2005). Critical success factors for PPP/PFI projects in the UK construction industry. *Construction Management and Economics*, *23*(5), 459–471. Scopus. https://doi.org/10.1080/01446190500041537

Lim, C. S., & Mohamed, M. Z. (1999). Criteria of project success: An exploratory re-examination. *International Journal of Project Management*, *17*(4), 243–248. Scopus. https://doi.org/10.1016/S0263-7863(98)00040-4

Lindhard, S., & Larsen, J. K. (2016). Identifying the key process factors affecting project performance. *Engineering, Construction and Architectural Management*, *23*(5), 657–673. Scopus. https://doi.org/10.1108/ECAM-08-2015-0123

Luo, L., He, Q., Xie, J., Yang, D., & Wu, G. (2017). Investigating the Relationship between Project Complexity and Success in Complex Construction Projects. *Journal of Management in Engineering*, *33*(2). Scopus. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000471

Mistry, D., & Davis, P. R. (2009). *A client's perspective of critical success factors in project alliances*. 217–226. Scopus. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84861048473&partnerID=40&md5=2b6903e47cea5dfd22f0c5e22d7c4431

Ng, S. T., Wong, Y. M. W., & Wong, J. M. W. (2012). Factors influencing the success of PPP at feasibility stage—A tripartite comparison study in Hong Kong. *Habitat International*, *36*(4), 423–432. Scopus. https://doi.org/10.1016/j.habitatint.2012.02.002

Nguyen, L. D., Le-Hoai, L., Tran, D. Q., Dang, C. N., & Nguyen, C. V. (2019). Effect of project complexity on cost and schedule performance in transportation projects. *Construction Management and Economics*, *37*(7), 384–399. Scopus. https://doi.org/10.1080/01446193.2018.1532592

Olusola Babatunde, S., Opawole, A., & Emmanuel Akinsiku, O. (2012). Critical success factors in public-private partnership (PPP) on infrastructure delivery in Nigeria. *Journal of Facilities Management*, *10*(3), 212–225. Scopus. https://doi.org/10.1108/14725961211246018

Osei-Kyei, R., & Chan, A. P. C. (2015). Review of studies on the critical success factors for public-private partnership (PPP) projects from 1990 to 2013. *International Journal of Project Management*, *33*(6), 1335–1346. Scopus. https://doi.org/10.1016/j.ijproman.2015.02.008

Ozorhon, B., Arditi, D., Dikmen, I., & Birgonul, M. T. (2010). Performance of international joint ventures in construction. *Journal of Management in Engineering*, *26*(4), 209–222. Scopus. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000022

Pheng, L. S., & Chuan, Q. T. (2006). Environmental factors and work performance of project managers in the construction industry. *International Journal of Project Management*, *24*(1), 24–37. https://doi.org/10.1016/j.ijproman.2005.06.001

Pinto, J. K., & Prescott, J. E. (1988). Variations in Critical Success Factors Over the Stages in the Project Life Cycle. *Journal of Management*, *14*(1), 5–18. Scopus. https://doi.org/10.1177/014920638801400102

Project Management Institute. (2004). *A Guide to the Project Management Body of Knowledge*. Project Management Institute.

Rashvand, P., & Zaimi Abd Majid, M. (2014). Critical criteria on client and customer satisfaction for the issue of performance measurement. *Journal of Management in Engineering*, *30*(1), 10–18. Scopus. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000183

Rockart, J. F. (1982). The Changing Role of the Information Systems Executive: A Critical Success Factors Perspective. *Sloan Management Review*, *24*(1), 3–13.

Rodney Turner, J. (2004). Five necessary conditions for project success. *International Journal of Project Management*, *22*(5), 349–350. https://doi.org/10.1016/j.ijproman.2004.02.001

Sanvido, V., Grobler, F., Parfitt, K., Guvenis, M., & Coyle, M. (1992). Critical success factors for construction projects. *Journal of Construction Engineering and Management*, *118*(1), 94–111. Scopus. https://doi.org/10.1061/(ASCE)0733-9364(1992)118:1(94)

Sonmez, R. (2008). Parametric Range Estimating of Building Costs Using Regression Models and Bootstrap. *Journal of Construction Engineering and Management*, *134*(12), 1011–1016. https://doi.org/10.1061/(ASCE)0733-9364(2008)134:12(1011)

Takim, R., & Adnan, H. (2009). Analysis of Effectiveness Measures of Construction Project Success in Malaysia. *Asian Social Science*, *4*(7). https://doi.org/10.5539/ass.v4n7p74

Tang, L., Shen, Q., & Cheng, E. W. L. (2010). A review of studies on Public-Private Partnership projects in the construction industry. *International Journal of Project Management*, *28*(7), 683–694. Scopus. https://doi.org/10.1016/j.ijproman.2009.11.009

Tang, S. L., Lu, M., & Chan, Y. L. (2003). Achieving Client Satisfaction for Engineering Consulting Firms. *Journal of Management in Engineering*, *19*(4), 166–172. https://doi.org/10.1061/(ASCE)0742-597X(2003)19:4(166)

Tiong, R. L. K. (1996). CSFs in Competitive Tendering and Negotiation Model for BOT Projects. *Journal of Construction Engineering and Management*, *122*(3), 205–211. https://doi.org/10.1061/(ASCE)0733-9364(1996)122:3(205)

Tiong, R. L. K., & Alum, J. (1997). Evaluation of proposals for BOT projects. *International Journal of Project Management*, *15*(2), 67–72. https://doi.org/10.1016/S0263-7863(96)00003-8

Türkiye Cumhuriyeti Cumhurbaşkanlığı Strateji ve Bütçe Başkanlığı. (2023). *2023 Yılı Yatırım Programı*. https://www.sbb.gov.tr/wp-content/uploads/2023/01/2023_Yili_Yatirim_Programi-19012023.pdf

Wateridge, J. (1998). How can IS/IT projects be measured for success? *International Journal of Project Management*, *16*(1), 59–63. https://doi.org/10.1016/S0263-7863(97)00022-7

Williams, T. (2016). Identifying Success Factors in Construction Projects: A Case Study. *Project Management Journal*, *47*(1), 97–112. Scopus. https://doi.org/10.1002/pmj.21558

Williamson, O. E. (1979). Transaction-Cost Economics: The Governance of Contractual Relations. *The Journal of Law & Economics*, *22*(2), 233–261. https://doi.org/10.1086/466942

Zhang, X. (2005a). Criteria for selecting the private-sector partner in public-private partnerships. *Journal of Construction Engineering and Management*, *131*(6), 631–644. Scopus. https://doi.org/10.1061/(ASCE)0733-9364(2005)131:6(631)

Zhang, X. (2005b). Critical success factors for public-private partnerships in infrastructure development. *Journal of Construction Engineering and Management*, *131*(1), 3–14. Scopus. https://doi.org/10.1061/(ASCE)0733-9364(2005)131:1(3)

Zwikael, O., & Smyrk, J. (2012). A General Framework for Gauging the Performance of Initiatives to Enhance Organizational Value. *British Journal of Management*, *23*(SUPPL. 1), S6–S22. Scopus. https://doi.org/10.1111/j.1467-8551.2012.00823.x