A Structural Equation Model on Critical Risk and Success in Public–Private Partnership: Exploratory Study

Medya Fathi

Department of Civil and Environmental Engineering, Manhattan College, Riverdale, GA 10471, USA; mfathi01@manhattan.edu

Abstract: In construction, risk is inherent in each project, and success involves meeting defined objectives beyond budget and schedule. Factors vary for infrastructure projects, and their correlation with performance must be studied. In the case of public–private partnership (PPP) transportation, the level of complexity is higher due to more involved parties. Risks and success factors in PPP projects affect each other, which may lead to project failure. Recognizing the critical risk factors (CRFs) and critical success factors (CSFs) is indispensable to ensure the success of PPP infrastructure project implementation. However, the existing research on the PPP risk and success relationship has not gone into sufficient detail, and more support to address the existing gaps in the body of knowledge and literature is necessary. Therefore, in response to the missing area in the public–private partnership transportation industry, this paper analyzed the correlation between PPP risks and success factors. It identified, explored, and categorized various risk and success factors by combining a literature review, expert panel interviews, and a questionnaire survey among both the public and private sectors, a win–win principle. The data collected were analyzed using the structural equation modeling (SEM) approach and relative significance. Results show the relationship between risk and success factors, their influence on PPPs, and the most important factors, known as CRFs and CSFs, with high loading factors (LF > 0.5) and high relative importance (NMS > 0.5). The top five CRFs include “Contract quality (incomplete, conflicting)”, “Staff expertise and experience”, “Financial market risk”, “Conflicting objectives and expectations”, and “Inefficient feasibility study”. The top five CSFs were found as “Appropriate risk allocation and risk-sharing”, “Strong financial capacity and capability of the private sector”, “Government providing guarantees”, “Employment of professional advisors”, and “Realistic assessment of the cost and benefits”. This study advances the understanding of risk and success factors in PPPs and contributes to the theoretical foundations, which will benefit not only public management, policy consultants, and investors but also academics interested in studying PPP transportation projects.

Keywords: risk; finance; success; transportation; public-private partnership; critical factors; structural equation modeling

1. Introduction

The construction sector is vital to any country’s development, life quality, tourism, sustainable environment, money circulation, and employment (Alaloul and Musarat 2020), accounting for USD 1.7 trillion worldwide and impacting 5 to 7 percent of the total GDP (gross domestic product) in most countries (Alaloul et al. 2021; Gade 2022). The transportation industry, as a primary element of this sector, contributes to economic development by connecting people, businesses, and resources and increasing employment, incomes, productivity, property values, and tax revenues (Prus and Sikora 2021; Alotaibi et al. 2022). Therefore, effective management and efficient performance of transportation projects is crucial.

Taking the US into account, while construction industry expenditure has increased only after a massive decline during the last recession around 2008, the transportation percentage
of overall construction industry expenditure has increased since 2004, spending over USD 40 billion annually (US Census Bureau 2023). Meanwhile, public–private partnership (PPP) transportation projects have gained popularity as an alternative procurement model for infrastructure projects.

It is worth mentioning that joint public–private projects have existed for centuries in various disguises; however, their modern form, PPP, emerged in the 1990s in the UK (Välilä 2020), which lies midway between traditional public procurement and full privatization (Cruz and Sarmento 2021). In these long-term contracts, depending on how risks are shared, the private partner is responsible for delivering the service linked to the asset and is granted ownership or at least significant control rights (Cotula 2019).

Some countries need private players’ active involvement in public services due to operational efficiency, innovative technologies, management skills, and expertise (Cotula 2019; Meissner 2019). Other countries have adopted PPP for the fiscal deficit and budgetary pressure (Anago 2022), demand–supply gap, and inefficient public services to infrastructure. In America, the high infrastructure deficit, the growth in population, and public demand, as well as an increase in old poor transportation projects, highlight today’s deteriorating infrastructure industry (Fathi and Shrestha 2023a), where PPP could pave the way for new services and make less demand for life-cycle maintenance (Cruz and Sarmento 2021).

Unfortunately, despite the fact that the PPP scheme will improve project efficiencies and attract capital investments from private investors, the success of PPP implementation is not guaranteed (Nguyen et al. 2020). Since the 2008 global financial crisis, governments in both developed and developing countries have increased interest in adopting the PPP policy (Cheng et al. 2020). With such growing interest in PPP, researchers worldwide have attempted to investigate different areas of PPP infrastructure, such as contract frameworks (Darko et al. 2023; Fathi and Shrestha 2023b), disputes (Gunduz et al. 2024; Abdul Nabi et al. 2024), conflict management (Osei-Kyei et al. 2019; Sinha and Jha 2020), risk management (Burke and Demirag 2019; Heydari et al. 2020), relationship management (Panda 2016; Hu et al. 2021), financial viabilities (Hang 2019; Queiroz and Mladenovic 2020), funding and finance analysis (Fathi and Shrestha 2020, 2021), procurement (Välilä 2020; Ross and Yan 2020), success factors (Nguyen et al. 2020; Debela 2022), failure (Ruiz Díaz 2020; Wang et al. 2021), project selection factors (Zhao and Ying 2019; Fathi and Shrestha 2023c), sustainable development (Cheng et al. 2021; De Matteis et al. 2024), and cost and schedule project performance (Zhang et al. 2020; Fathi and Shrestha 2022). The construction itself is a complex and dynamic industry involving significant risk; however, complexity, challenges, and risks are intensified in the case of PPPs with long-term agreements (Lember et al. 2019; Scott et al. 2019). This necessitates studying PPP’s risk and success factors.

In the past two decades, there has been considerable focus in academic, institutional, and political realms on the concept of PPP for developing and managing infrastructure (Rasheed et al. 2022). This interest was largely sparked by initial trials of PPP-like agreements in Australia, Canada, and the United States, as well as the United Kingdom’s Private Finance Initiative policy. Furthermore, experiences from regions like Asia, continental Europe, and South America played a role. While PPP policies and methods have progressed in various parts of the world, the United States has been somewhat sluggish in embracing this approach (Bonvillian 2021; Fathi and Shrestha 2023a). The downside of PPPs is the challenge of performing and managing a long-term contract between the government and its private partner (Välilä 2020). To shed some light on this issue, several researchers have investigated risk and success factors in their local construction industry that are vital to be considered in PPP implementation. This work updates prior literature reviews, which is an important contribution because papers addressing risks and success factors in PPPs have increased in the last several years. This research aims to investigate the PPP transportation industry in the US with the help of both the public and private sectors to analyze the correlation between PPP risks and success factors. It first identifies risk and success factors through a literature review and expert panel’s viewpoints. Then, a questionnaire survey is conducted among the public and
private sectors. Then, the study finds critical risk and success factors with confirmatory factor analysis (influence measure) and mean value analysis (significance measure) to be considered in PPP transportation projects. Findings reveal the relationship between risk and success factors, their influence on PPPs, and the most important factors, known as critical risk factors (CRFs) and critical success factors (CSFs).

2. Literature Review

In general, only a limited number of studies have investigated the relationships between PPP and risks as well as PPP and success. The main focus has been on risk identification, risk allocation, risk assessment, risk factors, or success factors. Some researchers have identified the risk factors associated with PPPs in specific types of projects or specific countries and have categorized them by mostly allocated either to the public or private partners and not both (Liu et al. 2018; Jayasuriya et al. 2019; Fathi and Shrestha 2023a).

2.1. Risk Factors

Risk identification and allocation are among key topics in PPPs in which several research studies have been conducted. Under long-term PPP agreements between the public and private sectors, inappropriate risk-sharing may fail a PPP project (Chou and Pramudawardhani 2015), and poor risk management may lead to disputes and litigation (Wang et al. 2020).

PPP risks of infrastructure facilities in different countries have been explored. Here are some of the research studies: different sectors of infrastructure in China (Ke et al. 2010; Cheung and Chan 2011); Iran (Ghorbani et al. 2014); Taiwan, Singapore, China, the United Kingdom, and Indonesia (Chou and Pramudawardhani 2015); Spain (Carpintero and Helby Petersen 2016); Vietnam (Likhitruangsilp et al. 2017); Ghana and Hong Kong (Osei-Kyey and Chan 2017); Nigeria (Babatunde et al. 2019); and The Netherlands (Koppenjan et al. 2022).

Kumar et al. (2018) examined the financial risks linked to highway infrastructure ventures by pinpointing factors like traffic volume and project expenses. They assessed these risks by scrutinizing actual PPP highway projects in India. The study employed the net present value (NPV)-at-risk model, which leverages Monte Carlo simulation to consider the likelihood distributions of various input variables, revealing uncertainties related to NPV. Results highlighted the importance of arriving at an accurate discount rate while conducting financial feasibility studies for a PPP project by private investors. Also, it was found that to minimize the project risk, uncertainty associated with project cost needs to be reduced.

Babatunde et al. (2019) identified risk factors associated with different PPP infrastructure project phases in Nigeria. Using descriptive statistics, the mean score, the Kruskal–Wallis test, and the risk significance index in terms of severity and the likelihood of occurrence conducted, 51 risk factors were located in the yellow zone as moderate risks, and 19 risk factors were located in the red zone as critical risks. Nguyen et al. (2018) identified significant challenges in PPP toll road projects in Vietnam that impact their financial sustainability. Empirical data from both quantitative and qualitative studies unveiled 22 risks that have a critical impact on the financial viability of toll road projects in Vietnam. These risks either increase project expenses or decrease revenue when assessed through the widely used NPV analysis model. The study found the crucial role of government support and guarantees in mitigating risks in developing countries and highlighted the need for governments to actively engage in risk management and planning for associated government support measures.

Koppenjan et al. (2022) evaluated the performance of Dutch Design-Build-Finance-Maintain (DBFM) infrastructure projects and Design and Construct (D&C) contracts. While the study could find the cost and schedule performance, it was unsuccessful regarding private profits and return on investment, mentioning the difficulty in clearly determining the performance of the projects because of the complexity of arrangements between the various private parties involved.
Some researchers identified risks through a literature review and assessed them using a fuzzy method for railroad projects or a case study (Jiang et al. 2019). A variety of risk factors of PPP infrastructure have been explored, including risk factors for sustainable delivery (Wang et al. 2020), low-carbon risk factors for road projects (Sun et al. 2020), social risk factors of transportation (Yuan et al. 2018), stakeholder-associated risks for an airport case study (Aladağ and İşık 2018), and traffic revenue risk (Babatunde and Perera 2017). Besides data collection and analysis, there has been considerable effort in the form of review studies as well (Fathi and Shrestha 2019a, 2019b; Rybnicek et al. 2020; Akomea-Frimpong et al. 2021; Le et al. 2022; Osei-Kyei et al. 2023; Rejeb et al. 2024).

While PPPs/PFIs (private finance initiatives) have garnered growing interest, the remaining need for additional research in areas such as operational and post-operational risk analysis, risk management and oversight, and the role of trust became the motivation for a study by (Tallaki and Bracci 2021). The authors’ analysis underscored the challenges associated with how risk is perceived and the determination of value for money (VFM). Furthermore, the authors revealed how the rising frequency of contract renegotiation is altering risk allocation provisions, leading to market distortions.

Kukah et al. (2023) assessed the primary risk elements inherent in PPP power projects in Ghana and further identified the critical risk factors affecting both the public and private sectors involved in these PPP power projects. To establish a comprehensive list of these critical risk factors, a two-round Delphi survey with a ranking-type approach was conducted. The selection of experts for the Delphi survey was facilitated through purposive and snowball sampling techniques. The analysis employed mean score ranking, factor analysis, Cronbach α coefficients, and Kendall’s concordance. More than half of the risks were found to be critical, among which the five most significant risk factors were delayed payment on contracts, changes in private investors, political risks, fluctuations in power demand, and public opposition. Principal component analysis was employed to categorize these risk factors into seven major themes.

2.2. Success Factors

Project success and efficient resource management rely heavily on identifying success factors (Kwak et al. 2009). Some scholars hold the view that a consensus on how to evaluate PPP success has not been achieved and that success indicators and critical success factors (CSFs) for PPPs are different (Liang and Jia 2018). Developing a list of required success factors for PPP projects has been among the main PPP topics. However, a vast number of studies have been conducted in the UK, and undivided attention has been paid to BOT-type PPPs (Fathi and Shrestha 2023a).

There are several studies on PPP success factors of infrastructure projects in different countries, such as mixed infrastructure sectors in Nigeria (Babatunde et al. 2012); Ethiopia (Debela 2022); Vietnam (Nguyen et al. 2020); UAE and UK (Almarri and Abu-Hijleh 2017; Al-Saadi and Abdou 2016); China (Deng et al. 2021); Taiwan (Hsueh and Chang 2017); Indonesia (Surachman et al. 2020); and India (Sehgal and Dubey 2019; Sarkar et al. 2021).

Nguyen et al. (2020) delved into the crucial elements of the success of PPP infrastructure projects in Vietnam. To gather pertinent information, they conducted interviews with six PPP experts, distributed questionnaires to 150 respondents, and then analyzed the data using word cloud analysis and the one-way analysis of variance (ANOVA) test. The identified success factors were ranked based on the perspectives of the public sector, the private sector, and PPP consultants. The results indicate that there were no significant differences in how these three parties perceive the factors contributing to the success of PPP infrastructure projects in Vietnam. The top five critical success factors include (1) prompt land acquisition and fair compensation, (2) financial strength of the private sector, (3) efficient project management, (4) a supportive and comprehensive legal framework and regulations, and (5) financial viability and attractiveness.

Almarri and Abu-Hijleh (2017) identified the critical success factors for PPPs in both the UK and the UAE. The questionnaire gathered responses from 30 participants in the
UAE and 62 participants in the UK that showed a high degree of similarity in the critical success factors between the two countries. The same nine factors as the most significant among the eighteen critical success factors for PPP implementation include the commitment of both public and private parties, appropriate risk allocation, a dedicated and capable public agency, a transparent procurement process, a robust private consortium, a competitive procurement process, political support, thorough cost/benefit assessments, and good governance. The differences were three factors, namely the local financial market, macroeconomic conditions, and the presence of a favorable legal framework.

Adiyanti and Fathurrahman (2021) investigated factors that led to the financial close of six national water supply projects and one successful project in Indonesia. With data collection from national and local stakeholders, five critical success factors were found, including a strong commitment from the contracting agency, as well as local and national government, experienced project partners, long-term capital, tangible political support, and the existence of the Indonesia PPP Joint Office. Some researchers have worked on reviewing the existing literature. Among recent ones, Hai et al. (2022) identified CSFs for different PPP infrastructure project types by reviewing prior studies and seeking input from numerous construction practitioners. Ahmed and Garvin (2022) presented six categories of CSFs and four categories of key performance indicators (KPIs) to update the literature and clarify a distinction.

2.3. Research Gap

While PPPs have been utilized in US procurement for some time, the adoption and implementation of this model has been gradual, causing the US to lag behind the global PPP transportation market (PWF 2016). Despite extensive research efforts in various aspects of PPP project delivery, significant questions remain unanswered regarding the performance of US transportation projects under the PPP delivery method (Fathi and Shrestha 2022). One of the key unresolved issues is the identification of critical risk and success factors that should be prioritized in PPP implementation. Therefore, this study addresses the lack of research on critical risk and success factors in US PPP transportation projects by combining insights from a literature review, an expert panel, and a survey of industry experts of public and private entities involved in PPP projects to incorporate practical knowledge and experience. Using SEM analysis and input from practitioners, the research reveals critical factors influencing PPP performance and sheds light on prioritized considerations for managing risks and enhancing project success in the US transportation industry. This work fills a crucial gap in the existing literature and contributes valuable insights for both academia and industry professionals.

3. Methodology

The methodology comprises three main approaches: literature review, expert opinion survey, and structural equation modeling (SEM). These approaches are conducted through the following stages, which are presented in Figure 1.

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**Figure 1.** The flow chart of the research method.
• Factor identification: identifying risk and success factors for PPP transportation projects;
• Data collection: collecting data through a questionnaire survey in the public and private sectors of transportation;
• Data analysis: analyzing data statistically using structural equation modeling.

3.1. Factor Identification

First, a comprehensive literature review was conducted. Then, to better understand and verify the indicators extracted from the literature, experts’ opinions were collected through a pilot survey in the public and private sectors of the transportation industry. The selected experts for phone interviews represent the key responsible stakeholders at all main stages of PPP and experienced practitioners of transportation projects in the US, with at least 10 years overall experience in their positions: (1) a project director with 19 years of work experience (public sector), (2) a senior program and project manager with 21 years of work experience (public sector), (3) two PPP consultants/advisors (financial and legal) with over 15 years of work experience (private sector), (4) a risk management professional (responsible for the overall risk management process) with 14 years of work experience (private sector), (5) a financial manager with 20 years of work experience (private sector), and (6) a project engineer with 15 years of work experience (public sector).

Initially, a literature review was conducted to identify the focus of this study and reveal any existing gaps. A preliminary list was compiled based on the findings from the literature review. Input from an expert panel led to adjustments being made to this initial list by incorporating overlooked factors or combining/splitting them. The final list can be found in Tables 1 and 2. For example, while the literature review initially included the “Inflation” risk factor, the expert panel recommended adding “Interest rate fluctuations” in addition to “Inflation”. Consequently, in Table 1, research studies were categorized under both factors as they were commonly amalgamated as “inflation”, regardless of the distinctions made in this study’s list. Furthermore, factors such as “Political risk” and “Inadequate supervision system”, though not significant concerns for US practitioners, were included based on the literature review. Considering success factors, the initial list included a factor called “Economic analysis and feasibility”, which was later refined into two separate factors, “Financial feasibility and attraction” and “Realistic assessment of costs and benefits”, based on the expert panel’s input. Also, “Appropriate risk allocation” was updated to “Appropriate risk allocation and risk-sharing”; however, not all studies marked in Table 2 encompassed both terms, with the marking indicating the presence of at least one. Lastly, the term “Stable political-economic environment” was initially referred to as “Stable economic”, with studies that specified political, economic, or both aspects being noted in the table. Overall, the expert panel played a crucial role in enhancing the accuracy and conciseness of the list due to their practical knowledge of US PPP transportation projects.
### Table 1. Selected literature on PPP risk factors.

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Table 2. Selected literature on PPP success factors.

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<td>S-1 Appropriate risk allocation and risk-sharing</td>
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<td>S-2 Available financial market</td>
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<td>S-3 Clear project identification</td>
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<td>S-4 Effective project management</td>
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<td>S-5 Employment of professional advisors</td>
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<td>S-6 Environmental impact</td>
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<td>S-7 Experience and compatibility skills of parties</td>
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<td>S-8 Favorable and completed legal framework and regulations</td>
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<td>S-9 Financial feasibility and attraction</td>
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<td>S-10 Government providing guarantees</td>
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<td>S-11 Open and constant communication</td>
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<td>S-12 Realistic assessment of the cost and benefits</td>
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<td>S-13 Select suitable subcontractor</td>
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<td>S-14 Social and community support</td>
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<td>S-15 Solid commitment and responsibility of parties</td>
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<td>S-16 Stable political-economic environment</td>
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<td>S-17 Strong financial capacity and capability of the private sector</td>
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<td>S-18 Technical (innovation) capacity and transfer</td>
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<td>S-19 Timely land acquisition and appropriate compensation</td>
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<td>S-20 Transparent procurement and competitive tendering process</td>
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Note: "**+**" shows that a particular factor was referenced in the associated source, and a blank cell indicates that the factor was not referenced in the source.
Therefore, referring to the previous literature and with the expert panel’s validation, risk and success factors were summarized into 21 and 20 factors, respectively. The identified factors and their citations are represented in Tables 1 and 2.

3.2. Data Collection

To find CRFs and CSFs of PPP performance in the transportation industry, the questionnaire approach was adopted, and experienced experts were asked to give relative importance weights. For the relative significance of indicators, an asymmetric six-point Likert scale ranging from negligible (0), very low (1), to very high (5) importance was adopted.

A total of 160 professionals were selected, representing both actors from the public and private sectors in the transportation industry. The respondents were experts with at least 7 years of working experience in PPP projects. The questionnaires were distributed via email to the respondents. A total of 57 complete questionnaires were received from different states, namely Alabama, California, Colorado, Florida, Georgia, Indiana, Kentucky, Louisiana, New York, North Carolina, Ohio, Pennsylvania, Texas, and Virginia. It is worth mentioning that this sample size had the measure of sampling adequacy, KMO (Kaiser–Meyer–Olkin), as 0.62, which is in the acceptable range for sample sizes less than 100 (Shrestha 2021; Tabachnick et al. 2013). The sample of respondents had a variety of roles and positions in the transportation industry, including program manager, senior project manager, senior transportation planner, project director, transportation funding manager, project engineer, mega project engineer, project delivery manager, project advisors, or consultants (financial, legal, and technical), director of corporate affairs, bond counsel, P3 (PPP) counsel, and director of operations. Table 3 briefly summarizes respondents’ average years of work experience and the number of distributed and completed questionnaires.

Table 3. Survey information.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Questionnaire Distributed</th>
<th>Questionnaire Completed</th>
<th>Response Rate</th>
<th>Average Years of Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>80</td>
<td>31</td>
<td>39%</td>
<td>16</td>
</tr>
<tr>
<td>Private</td>
<td>80</td>
<td>26</td>
<td>33%</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>160</td>
<td>57</td>
<td>36%</td>
<td>15</td>
</tr>
</tbody>
</table>

3.3. Data Analysis

Structural Equation Modeling (SEM)

SEM is a statistical method that has been extensively used by many researchers to study the relationship among variables in various fields, such as ecological studies (Fan et al. 2016; Lefcheck 2016), risk perception (Wang et al. 2016; Bae and Chang 2021), agriculture (Scalco et al. 2017), project management (e.g., de Carvalho et al. 2015), COVID-19 (Mukherjee et al. 2022), and sustainability (Abbas and Sağsan 2019; Khan et al. 2020). SEM has been applied to research in construction management as well. For instance, disputes between owners and contractors (e.g., Molenaar et al. 2000), factors influencing construction waste reduction (Liu et al. 2020), the effectiveness of project planning (e.g., Mainul Islam and Faniran 2005), level of partners’ trust and partnering success (e.g., Wong and Cheung 2005), analyzing safety behaviors of temporary construction workers (Seo et al. 2015), causes of contractor’s claims (Shen et al. 2017), soft skills of construction project management professionals and project success factors (Zuo et al. 2018), construction project performance based on coordination factors (Alaloul et al. 2020), and adoption of cyber technology in sustainable construction (Kineber et al. 2023).

Although the SEM method is similar to linear regression analysis, it has superior features: (1) It reveals the relationship among hidden structures that are not directly measured. (2) Possible mistakes in the measurements of the observed variables are considered, unlike the classic regression approach that assumes no measurement error. (3) It is a
useful method for analyzing highly complex multi-variable models and revealing direct and indirect relationships between variables (Civelek 2018). For the current study, SEM’s primary advantage is having a latent variable as a dependent variable in one set of relationships and an observed variable as an independent variable in another set of relationships simultaneously (Hou et al. 2014; Kline 2023).

In other words, SEM represents the relationship between latent and observed variables. Observed variables are those that can be directly measured through questionnaires. Latent variables are not directly measured, but they are influenced by the observed variables (Iacobucci 2009; Hair et al. 2021). Having a latent variable is beneficial as it enables researchers to model complex constructs such as success, risk, and satisfaction, which are not directly measurable but can be inferred from multiple observed variables (Loehlin 2004; Mueller and Hancock 2018). Also, by combining multiple observed variables into a latent variable, SEM helps minimize measurement error inherent in individual observed variables, which means higher reliability and validity of the measurement (Loehlin 2004; Iacobucci 2009; Hair et al. 2021).

The equations that express the structural equation model are similar to standard linear regression models (Hoyle 2012), and the basic ones are the following Equations (1)–(3) (Wang and Wang 2012):

\[
\begin{align*}
\eta &= B\eta + \Gamma \xi + \zeta \\
y &= \Lambda_y \eta + \epsilon \\
x &= \Lambda_x \xi + \delta
\end{align*}
\]

where \(\eta\) is the latent endogenous variable, \(\xi\) is the latent exogenous latent variable, \(B\) represents the effect of endogenous latent variables on endogenous variables, \(\Gamma\) is the effect of exogenous latent variables on endogenous latent variables, \(y\) and \(x\) are observed variables, \(\Lambda_x\) and \(\Lambda_y\) describe how the observed and latent variables are related, and \(\epsilon\) and \(\delta\) are measurement error terms.

These three equations are represented in matrices. Equation (1) is a structural model that describes the causal relationship between latent variables. Equations (2) and (3) are measurement models, which describe the latent variables based on observed variables. These equations express how latent endogenous and exogenous indicators (\(h\) and \(x\)) are linked to observed variables (\(y\) and \(x\)) (Civelek 2018; Kline 2023). With the capability to determine how the observed variables measure latent variables and model the relations among variables (Hoyle 2012), SEM is a suitable method to analyze the data collected from questionnaires and find the impact of the identified factors on PPP performance.

The initial model was established according to the identified indicators. First-order analyses were conducted to study the pair-wise relationships between risk and success and their factor. However, second-order analyses were performed to investigate the relationships between the risk and success factors with the PPP project performance. The survey data were analyzed using EQS 6 as the SEM tool (Bentler and Wu 2005; Byrne 2013). Based on the initial model, several attempts were made to enhance the fit indices of the model. In this regard, the variables that did not have statistically important loadings and had low correlations to the latent variables are removed from the model.

Table 4 shows the relative importance of the risk and success factors by mean score (MS) and their normalized mean scores (NMS). The NMSs are calculated as follows:

\[
NMS_i = \frac{MS_i - MS_{\text{min}}}{MS_{\text{max}} - MS_{\text{min}}}
\]

where \(NMS_i\) = the value for MS of indicator \(i\), \(MS_{\text{min}}\) = the minimum value for MS in all phases, and \(MS_{\text{max}}\) = the maximum value for MS in all phases.
Table 4. The relative importance.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Risk (R)</th>
<th>Success (S)</th>
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<tbody>
<tr>
<td></td>
<td>MS</td>
<td>NMS</td>
</tr>
<tr>
<td>R-1</td>
<td>4.16</td>
<td>0.76</td>
</tr>
<tr>
<td>R-2</td>
<td>4.41</td>
<td>0.88</td>
</tr>
<tr>
<td>R-3</td>
<td>4.56</td>
<td>0.95</td>
</tr>
<tr>
<td>R-4</td>
<td>4.22</td>
<td>0.78</td>
</tr>
<tr>
<td>R-5</td>
<td>4.3</td>
<td>0.82</td>
</tr>
<tr>
<td>R-6</td>
<td>3.8</td>
<td>0.58</td>
</tr>
<tr>
<td>R-7</td>
<td>4.53</td>
<td>0.93</td>
</tr>
<tr>
<td>R-8</td>
<td>3.38</td>
<td>0.38</td>
</tr>
<tr>
<td>R-9</td>
<td>3.56</td>
<td>0.47</td>
</tr>
<tr>
<td>R-10</td>
<td>4.27</td>
<td>0.81</td>
</tr>
<tr>
<td>R-11</td>
<td>4.38</td>
<td>0.86</td>
</tr>
<tr>
<td>R-12</td>
<td>3.89</td>
<td>0.63</td>
</tr>
<tr>
<td>R-13</td>
<td>3.72</td>
<td>0.55</td>
</tr>
<tr>
<td>R-14</td>
<td>4.19</td>
<td>0.77</td>
</tr>
<tr>
<td>R-15</td>
<td>4.2</td>
<td>0.78</td>
</tr>
<tr>
<td>R-16</td>
<td>3.45</td>
<td>0.42</td>
</tr>
<tr>
<td>R-17</td>
<td>4</td>
<td>0.68</td>
</tr>
<tr>
<td>R-18</td>
<td>4.11</td>
<td>0.73</td>
</tr>
<tr>
<td>R-19</td>
<td>4.55</td>
<td>0.94</td>
</tr>
<tr>
<td>R-20</td>
<td>3.58</td>
<td>0.48</td>
</tr>
<tr>
<td>R-21</td>
<td>3.84</td>
<td>0.60</td>
</tr>
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</table>

The value of Cronbach’s alpha for the initial structure was 0.76, which is higher than 0.7 as the acceptable threshold (Nunnally and Bernstein 2010). To improve the initial structure of the model and achieve the recommended values for the comparative fit index (CFI), non-normed fit index (NNFI) (Wang and Wang 2012), and root mean square error of approximation (RMSEA) (Kline 2023), the R-6, R-10, S-3, and S-6 factors were removed.

Both first-order and second-order analyses of the final structure are depicted in Figure 2. The results of the model fittings of the proposed structure are exhibited in Table 5. Also, acceptable ranges of fit indices are listed, including Cronbach’s alpha (Nunnally 1978), $\chi^2$/degree of freedom (Hayduk 1987), CFI (Bagozzi and Yi 1988; Kline 2023), NNFI (Bentler and Bonett 1980; Kline 2023), and RMSEA (Kline 2023; Browne and Cudeck 1992).

Table 5. Fit indices for the SEM model.

<table>
<thead>
<tr>
<th>Fit Indices</th>
<th>Recommended Value</th>
<th>First-Order Analysis</th>
<th>Second-Order Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2$/degree of freedom</td>
<td>1~2</td>
<td>1.42</td>
<td>1.42</td>
</tr>
<tr>
<td>Cronbach’s $\alpha$</td>
<td>&gt;0.7</td>
<td>0.86</td>
<td>0.86</td>
</tr>
<tr>
<td>CFI</td>
<td>0 (worse fit) to 1 (perfect fit)</td>
<td>0.67</td>
<td>0.96</td>
</tr>
<tr>
<td>NNFI</td>
<td>0 (worse fit) to 1 (perfect fit)</td>
<td>0.64</td>
<td>0.96</td>
</tr>
<tr>
<td>RMSEA</td>
<td>&lt;0.1</td>
<td>0.02</td>
<td>0.02</td>
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As can be found in Table 5, the model fitness indices have greatly improved compared to the initial structure. Although the goodness-of-fit indices for the improved structure are still slightly lower than 0.9, these negligible differences do not cause major changes in the results, similar to Tsai et al. (2011).
4. Results and Discussion

As shown in Figure 2, the relationship between risk and success may be interpreted as follows: With the risk-success relationship and its correlation coefficient, it can be inferred that their direct relationship is strong, whereby addressing one leads to the other. While the path coefficient for success and PPP is considerable (0.45), the correlation between the PPP performance of transportation projects and risk is 1. This indicates that the PPP performance is sufficiently measurable by measuring risk that also relates to the project’s success, which highlights the PPP’s definition of sharing risks, resources, responsibilities, and rewards. Therefore, an appropriate response to the contributing risks, particularly the CRFs, plays a leading role in the performance of PPP, including its completion, output, and success. Likhitruangsilp et al. (2017) also believed that risk plays a leading role in the success of PPP infrastructure projects, especially PPP transportation projects.

Out of 21 identified risk factors and 20 success factors, 19 risk and 18 success factors remained in the modified SEM model, revealing their correlation with their dimension. To find which source of risk better measures the project’s overall risk and, similarly, which success factor has the most influence on the project’s overall success, critical influencing factors were determined.

In the SEM, loading factors (LFs) greater than 0.5 are statistically significant (Hair 2009). Risk and success are strongly measurable by their factors with high LFs (>0.5), which means 17 risk and 16 success factors (Figure 2). Among these effective factors, by considering those with high relative importance rates, i.e., an NMS greater than 0.5 (Table 4), critical risk and success factors in PPP transportation projects were determined and summarized in 12 CRFs and 13 CSFs. Figure 3 presents CRFs and CSFs associated with the US transportation PPP in a scatter chart with NMS as the vertical and LFs as the horizontal axis.
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Figure 3. Scatter chart with loading factors (LFs) and normalized mean score (NMS).

4.1. Critical Risk Factors (CRFs)

The top 12 risk factors are critical with a high level of importance and significant impact. For any project, contracts are essential as binding agreements between cooperating partners (Soliño and de Santos 2010). Regarding PPP as a long-term partnership, respondents believe “Contract quality; R-3” is first, which means contract incompleteness, ambiguities, conflicts, and lack of transparency. The quality of contracts in PPP transportation projects is of paramount importance. Contracts should be clear and comprehensive to ensure project success, allocate risks effectively, prevent cost overruns and delays, maintain transparency and accountability, attract investor confidence, and ensure long-term viability. Ambiguities, conflicts, and lack of transparency in contracts can lead to disputes, financial strain, and public opposition, posing significant challenges to the success of these projects. To overcome these challenges, stakeholders must prioritize well-structured contracts, legal expertise, stakeholder engagement, and effective dispute-resolution mechanisms. Ultimately, contract quality is vital for the sustainable and successful execution of P3 transportation projects.
The second critical risk is “Staff expertise and experience; R-19”. While staff without experience in a certain work can harm a project (Waring et al. 2013), the availability of experienced and knowledgeable staff is an essential resource in PPPs. Staff expertise and experience are vital in PPP transportation projects. They contribute to effective planning, risk management, contract oversight, quality assurance, innovation, public trust, long-term sustainability, regulatory compliance, financial management, and problem solving. A knowledgeable project team is crucial for optimizing P3 project outcomes and ensuring they serve the public interest efficiently.

The third critical risk is “Financial market risk; R-7”, highlighting the financial complexity of PPPs, poor initial cost estimates, and the availability of financial resources. Financial market risk in PPP transportation projects is highly significant. It affects the cost of capital, project viability, and funding availability. The implications include increased costs passed on to users, project delays, contract renegotiations, impacts on investor confidence, potential government commitments, and the need for effective risk allocation in PPP contracts. Careful consideration and risk management are essential to ensure the success and sustainability of these partnerships.

The fourth critical risk is “Conflicting objectives and expectations; R-2”, which was also found among the main PPP risks in some studies (Paez-Perez and Sanchez-Silva 2016; Rangel and Manuel Vassallo 2015). Such risk lies in the two sectors’ different perspectives, where the public sector’s long-term goal is job creation and growth in the public services, whereas the private sector aims to maximize profit, create short-term revenues, and cut costs for firms and individual shareholders (Ruuska and Teigland 2009). The risk of conflicting objectives and expectations in PPP transportation projects arises from the differing goals of the public and private sectors involved. This risk is significant as it can lead to project delays, compromises in service quality, and disputes and erode public trust. Managing this risk requires effective communication, alignment of interests, and well-structured contracts to balance the public sector’s long-term objectives with the private sector’s profit-driven goals.

The fifth critical risk is “Inefficient feasibility study; R-11”. An inefficient feasibility study lacks a thorough, accurate analysis of the parties’ risks, rights and obligations, costs, and benefits. Inefficient studies can lead to financial risks, project delays, reduced investor confidence, contract disputes, public dissatisfaction, and resource wastage. A well-executed feasibility study is crucial to mitigate these risks and ensure project success.

After the five top risks, “Demand and revenue risk; R-5” is ranked next, covering low ridership, a decreasing number of students attending schools or universities, or the unsatisfying actual use of a certain infrastructure project (Leruth 2012; Siemiatycki and Friedman 2012). Demand and revenue risk in PPP transportation projects are significant because they affect financial viability and private-sector investment. Shortfalls in revenue can lead to financial losses, renegotiations, public subsidies, operational challenges, reduced investor confidence, and increased user costs. Effective risk management and accurate demand forecasting are essential to address these challenges and ensure project success.

“Delay in project approvals and permits; R-4” was the next ranked risk factor. In general, a delay or refusal of project approval or permit by the government may lead to a lack of cash flow to pay for the operating costs and subsequent debts, increased loan interest, and, eventually, completion risk. The risk of delays in project approvals and permits in PPP transportation projects is significant because it can disrupt project timelines, strain finances, increase loan interest costs, heighten completion risk, lead to contractual issues, and impact public perception. Efficient approval processes and effective coordination between partners are crucial to mitigate these challenges and ensure project success.

The next high-ranked risk is “Partners’ commitment and attitude; R-15”. A negative attitude, pessimistic behavior, and lack of commitment cause major challenges. The risk of partners’ commitment and attitude is significant in PPP transportation projects because it impacts collaboration, risk mitigation, investor confidence, and project progress. Negative attitudes and a lack of commitment can lead to delays, increased costs, contractual...
disputes, investor reluctance, public dissatisfaction, and risk allocation challenges. Effective communication and a shared commitment to project success are crucial to mitigate these risks.

“Unfair selection process of the private sector; R-14” is the other critical risk, which emphasizes a transparent and competitive bidding process. The risk of an unfair selection process in PPP transportation projects is significant because it impacts transparency, investor confidence, and project outcomes. Unfair selections can lead to legal challenges, reduced investor interest, loss of public trust, inefficiency, reputation damage, and economic consequences. A commitment to fairness and transparency is essential to mitigate these risks and ensure project success.

Unanticipated changes form the last three CRFs, namely “Change in laws and regulations; R-1”, “Scope change of projects; R-18”, and “Inflation; R-12”. The risk of changes in laws and regulations in PPP transportation projects is significant as it affects project planning, financial stability, and investor confidence. Implications include financial impacts, contractual adjustments, project delays, investor uncertainty, financing challenges, operational efficiency concerns, legal disputes, and public perception issues. Proactive risk management and clear regulatory frameworks are crucial to mitigate these risks and ensure project success. The risk of a “change in project scope” is significant in PPP transportation projects because it can disrupt planning, lead to cost overruns, project delays, financial challenges, contractual adjustments, operational complexities, and impact public perception and investor confidence. Effective scope management and risk mitigation strategies are crucial to address this risk and ensure project success. The risk of inflation is significant in PPP transportation projects as it can lead to budget overruns, financing challenges, delays, contractual disputes, reduced investor confidence, public dissatisfaction, and operational complexities. Effective risk management strategies, including inflation-indexed contracts, are crucial to mitigate these risks and ensure project success.

4.2. Critical Success Factors (CSFs)

The top 13 success factors that define CSFs with a high importance level and great influence were revealed. The first CSF was “Appropriate risk allocation and risk-sharing; S-1”, crucial for promoting negotiations between partners. Appropriate risk allocation for a successful PPP project should be carried out at the early stage (Chan et al. 2010). Appropriate risk allocation and risk-sharing are vital for the success of PPP transportation projects. They ensure efficient risk management, boost investor confidence, and contribute to project feasibility. Improper risk allocation can lead to financial instability, deter investors, trigger contract disputes, affect operational efficiency, and influence public perception. Balancing and fairly distributing risks among stakeholders is crucial for achieving successful outcomes in PPP transportation projects.

“Strong financial capacity and capability of the private sector; S-17” ranked second, helping increase the competence and capability of the private sector in performing PPP projects. The strong financial capacity and capability of the private sector are vital for the success of PPP transportation projects. They ensure project viability, mitigate risks, foster innovation, and attract investor confidence. Weak financial capacity can lead to feasibility issues, contractual challenges, reduced quality, and operational difficulties, potentially jeopardizing project success. A financially robust private sector enhances the competence and capability of private partners in delivering PPP projects effectively.

The third CSF was “Government providing guarantees; S-10”, which aims to distribute risk. However, the extent needs to be appropriate, on the one hand, to prevent the government’s financial burden from an excessive guarantee and, on the other hand, to avoid investors’ reluctance to participate due to an insufficient guarantee. Government guarantees are crucial in PPP transportation projects, as they mitigate risks, boost investor confidence, and lower financing costs. They strike a balance between preventing excessive government financial burdens and ensuring private sector participation. An effective guarantee enhances project attractiveness, stability, and public trust, while an insufficient
one can deter investors, and an excessive one can strain public resources. Therefore, a well-calibrated government guarantee is essential for project success.

The next CSF is concerned with skills and expertise: “Employment of professional advisors; S-5”. The employment of professional advisors is crucial in PPP transportation projects due to their expertise, which contributes to effective risk management, project viability, quality assurance, and efficiency. Advisors attract investors, ensure compliance, and foster public confidence. Without them, projects may face inadequate risk assessment, inefficiencies, investor reluctance, legal challenges, and budget issues. Hence, professional advisors with the right skills are essential for project success.

Ranked fifth was “Realistic assessment of the cost and benefits; S-12”, which is a part of the feasibility study where all of the potential options’ pros and cons with respect to the government, investors, and end-users must be considered. A realistic assessment of costs and benefits is critical in PPP transportation projects as it informs decision making, identifies risks, boosts investor confidence, and ensures efficient resource allocation. Accurate assessments prevent budget overruns, attract investors, gain public acceptance, and promote long-term financial sustainability. Failing to conduct realistic assessments can lead to poor decisions, budget problems, investor reluctance, public dissatisfaction, and financial instability, making thorough cost–benefit analysis essential for project success.

After the top five CSFs, “Financial feasibility and attraction; S-9” ranked sixth, which still highlights effective feasibility studies’ impact on project success. Different procurement approaches must be evaluated so that PPP is selected when there is financial viability and attractiveness to offer good value for money through the early planning stages since investors will not be interested in committing to a project without a strong business case (Ho and Liu 2002). Effective feasibility studies determine project viability, attract investors, optimize resource allocation, and mitigate financial risks. They influence project continuation, investor participation, budget control, risk management, public funding allocation, contractual terms, and public perception. Thorough and accurate financial assessments are essential for project success.

The seventh CSF is “Effective project management; S-4”, since it is directly related to the successful accomplishment of cost, time, and quality objectives. “Effective project management; S-4” is crucial in PPP transportation projects as it aligns activities with objectives, controls costs, ensures timely delivery, and guarantees quality. It also mitigates risks, enhances stakeholder satisfaction, promotes financial sustainability, and ensures legal compliance. Poor project management can lead to objective misalignment, cost overruns, delays, quality issues, risk escalation, stakeholder dissatisfaction, and legal challenges. Diligent and efficient project management is essential for project success.

The next CSF, “Solid commitment and responsibility of parties; S-15”, stressed that all parties should take their agreed responsibility efficiently and commit their best resources (financial, human, time, etc.) to the partnership project. They foster collaboration, mitigate risks, ensure resource availability, promote accountability, enhance public perception, support financial sustainability, and ensure legal compliance. Failure to uphold these commitments can lead to inefficiencies, disputes, resource shortages, budget issues, and negative project outcomes. A shared commitment and clear responsibilities are essential for project success.

“Stable political environment; S-16” was the next CSF. In general, political instability creates a tougher business climate, while a stable environment can reduce inflation, financing, and payment risks (Zhang and Wei 2012), enabling private sponsors to access relatively cheaper financing packages (Cheung et al. 2012) and, subsequently, be more willing to invest. A stable political environment fosters investor confidence, reduces political risks, ensures project continuity, optimizes resource allocation, attracts investor participation, simplifies risk management, promotes project progress, and enhances public trust. Conversely, political instability can deter investors, lead to project delays, trigger resource allocation issues, result in budget problems, erode public trust, and increase the likelihood of legal challenges. Therefore, political stability is essential for project success.
“Transparent procurement and competitive tendering process; S-20” was the next CSF. In general, lack of transparency and competition, lengthy duration, and high transaction costs can cause failure (Carbonara et al. 2012). Transparent procurement and a competitive tendering process promote fairness, efficiency, investor confidence, risk mitigation, quality, innovation, public trust, legal compliance, and project viability. Non-transparent or non-competitive processes can lead to inefficiencies, reduced quality, investor reluctance, legal challenges, and a lack of public trust. Ensuring transparency and competitiveness is essential for project success.

The last three CSFs are “Open and constant communication; S-11”, “Favorable and completed legal framework and regulations; S-8”, and “Experience and compatibility skills parties; S-7”. Open and constant communication is crucial in PPP transportation projects as it fosters stakeholder alignment, issue resolution, risk mitigation, efficient resource allocation, collaboration, stakeholder engagement, risk reduction, project progress, resource availability, public trust, legal compliance, and adaptability. Inadequate communication can lead to misunderstandings, project delays, resource shortages, stakeholder dissatisfaction, legal challenges, and project failure. Effective communication throughout the project lifecycle is essential for success. A favorable and completed legal framework and regulations are crucial for the success of PPP transportation projects. They instill investor confidence, reduce legal risks, enhance project feasibility, streamline resource allocation, promote project efficiency, ensure legal compliance, and build public trust.

Conversely, a lack of legal clarity or an unfavorable legal environment can deter investors, lead to project delays, increase legal risks, and erode public trust. Establishing and maintaining a robust legal framework is essential for project success. The experience and compatibility of parties are critical for PPP transportation project success. They enhance project efficiency, risk management, collaboration, and quality. Experienced and compatible partners streamline processes, reduce risks, promote teamwork, optimize resources, build stakeholder confidence, and ensure legal compliance. Inexperienced or incompatible parties can lead to project delays, conflicts, lower quality, and legal issues. Therefore, selecting and fostering experienced and compatible partners is essential for success.

5. Conclusions

Transportation projects play a key role in any society’s development. In recent years, a specific type of procurement of transportation projects has gained increasing attention, in which the government and private entities share resources, responsibilities, rights, and rewards. Such a long-term PPP comes with risks and obstacles to a successful performance. What risk factors need to be considered in implementing PPPs and what success factors enable a successful project completion to have motivated researchers to investigate different sectors in different countries? Reviewing the literature and finding the research gap led the author to conduct this study. First, risk and success factors from the previous studies were reviewed thoroughly, resulting in a list later validated by an expert panel. Then, PPP professionals from the public and private sectors shared their opinions in a questionnaire survey on the factors’ relative importance. These factors’ power in measuring PPP risk and success and their influence were analyzed through SEM. Factors’ significantly high criticality was defined by high LFs > 0.5 and high relative importance weights (NMS > 0.5). As a result, 13 CRFs were determined, such as “Contract’s quality (incomplete, conflicting); R-3”, “Staff expertise and experience; R-19”, “Financial market risk; R-7”, “Conflicting Objectives and expectations; R-2”, and “Inefficient feasibility study; R-11”. Similarly, 12 CSFs were found, where the top five included “Appropriate risk allocation and risk-sharing; S-1”, “Strong financial capacity and capability of the private sector; S-17”, “Government providing guarantees; S-10”, “Employment of professional advisors; S-5”, and “Realistic assessment of the cost and benefits; S-12”. Last but not least, this research identified which source of risk has the most influence on the project’s overall risk and which factor has the largest impact on the project’s success. It is expected to help practitioners and new researchers consider appropriate strategies and measures to adopt when engaging in
future transportation PPP projects. This research can be seen as a step up to have a holistic viewpoint in investigating the risk and success of PPPs focused on transportation projects. The adopted approach and the results can be a stimulus for further studies to investigate where the public and private sectors have conflicts or consensus on the importance of risk and success factors by applying appropriate statistical tests.

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