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**Taxonomy of risks in PPP transportation projects: a systematic literature review**

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# A taxonomy of risks in PPP transportation projects: A systematic literature review

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# A taxonomy of risks in PPP transportation projects: A systematic literature review


## Abstract

Despite the existence of previous studies on risks in Public Private Partnership transportation projects, there is still absence of an overall risk catalogue, common terminology and consistent risk structure. This research provides a comprehensive risk inventory, harmonious language and a taxonomy for risk classification. A systematic literature review was conducted that resulted in seventy-two recent papers. The Concept-driven and the Grounded theory approaches were combined for the qualitative data analysis. As a result, eighty-six unique risks were identified and grouped according to the phase of the project life cycle they are likely to occur. As obtained from the analysis, the most frequent risks in literature are “low traffic demand”, “escalation of operation - maintenance cost”, “inflation rate fluctuation”, “problems with land acquisition and compensation”, “change in laws and regulations”, and “interest rate fluctuation”. The proposed terminology and taxonomy appear to be appropriate and provide an overall understanding of risk identification and classification as well as improve the effectiveness of communications for both PPP practitioners and academics in this area.



Keywords: Public Private Partnership (PPP); risks; taxonomy; systematic literature review; transportation

# Introduction

## *Public Private Partnership (PPP) model*

The Public–private partnership (PPP) has been used globally as an innovative investment approach to deliver the public services in the construction industry (Osei-Kyei and Chan 2017). Such procurement method has been adopted in different sectors such as energy supply, telecommunication, transportation, public housing, care and hospitals, water supply and many other sectors to serve the high demand for infrastructure development (Chan et al. 2010). Among them, the PPP scheme has been the most popular investment method in the transportation sector, particularly in the development of bridges, railroads, tunnels, airports and roads (Kwak et al. 2009). PPP projects are being exposed to a level of risk, which is further aggravated due to some of the main characteristics of PPPs, namely long duration of concession period and the involvement of a variety of participants (Ibrahim et al. 2006).

As Hwang et al. (2013) argued risks were very critical due to the features of PPP projects, risk management was crucial for stakeholders in order to reach their own objectives. Kwak et al. (2009) confirmed that poor risk management was responsible for many unsuccessful PPP transportation projects. Likewise, Carbonara et al. (2015) stated that risk management is considered as an important aspect making PPP projects become successful. However, in order to manage risks properly, they should be firstly identified and categorised, which is the initial stage in the current procedure of risk management. Risk identification is very important for PPP participants, assisting the recognition of potential risks which may occur in all phases of the project, and if managed properly, the quality of the whole project could be improved (Ibrahim et al. 2006). PPP risks are identified not only for further analysis of potential impact but also for proposing appropriate plans to mitigate the effect on the projects (Zayed and Chang 2002).

### *Previous studies on risk identification and classification*

Risks can be identified by different methods such as comparison to past projects or personal experience (McKim, 2005; Yuan et al. 2008). Previous studies have shown that most of the risks in PPP transportation projects were compiled through the literature review. For example, Thomas et al. (2003) created a catalogue of 22 risks available in Build Operate Transfer (BOT) road projects, a form of PPP investment approach; or 20 factors relating to Water, Power, and Transportation projects invested by PPP method were sought by Chan ad Cheung (2011). Also, Gupta et al. (2013) selected 41 risk factors related to BOT highway projects from the literature combining with further discussions with experts. Carbonara et al. (2015) synthesized knowledge from previous research to establish a list of 22 risks for the motorway sector in PPPs. Heravi and Hajihosseini (2011) investigated the Tehran–Chalus Toll Road project to provide a catelogue of risks that impacted significantly on the effectiveness of the project. Forty-two risk factors pertaining to PPP expressway projects were identified by the analysis of Li and Zou (2011) through the contract and interviews with related officers.

Previous researchers used the Risk Breakdown Structure (RBS) to show risk groupings in order to depict the identification and the structure of risks in projects (Mehdizadeh et al. 2012). The RBS could be also seen as a tool to investigate risks and to categorize them into groups, assisting the following steps in the risk management process, namely risk analysis and risk response (Dey and Ogunlana 2004). In general, there are two prevailing approaches for risks' classification such as the risk's nature and the timing of the project life cycle where the risk may arise (Xenidis and Angelides 2005a).

Adopting the RBS method, some studies on PPP transportation projects classified risks according to their sources. Heravi and Hajihosseini (2011) classified risks of the Tehran–Chalus toll road in Iran into different categories such as financial risks, political risks, legal risks, market risks, construction risks, force majeure risks, coordination and organization risks, and maintenance and operation risks. Suseno et al. (2015) conducted interviews with BOT experts to identify risks related to BOT post-construction toll roads in Indonesia in which they defined the risk categories in the RBS, including financial aspects,

economic aspects, business plan, technical aspects, and force majeure. Gupta et al. (2013) grouped risks in BOT road projects into 10 categories such as political risks, regulation social and legal risks, financial risks, local government support risks, commercial risks, force majeure, construction risks, operation and maintenance risks, transfer risks, and lenders' risks.

Also, considering the phase in a project where risks may occur is another method to categorise risks. Li and Zou (2011) grouped risks relating to PPP expressway projects based on the project stages in a sequence such as (i) planning, (ii) tendering, (iii) financing, design, (iv) construction, (v) operation, and (vi) transfer because the authors believed that this classification was generic to PPP projects. As for PPP transportation projects in Vietnam, Likhitruangsilp et al. (2017) classified 33 identified risk factors instead of 62 risks compiled in the previous attempt of Nhat et al. (2014) into a RBS comprising two basic groups including "General risks" and "Project-specific risks". Thomas et al. (2003) localized risks related to BOT road projects to four project phases such as (i) developmental phase, (ii) construction phase, (iii) operation phase, and (iv) project life cycle phase. With regard to risks in PPP motorway projects, Carbonara et al. (2015) suggested adding the transfer phase to the four phases defined previously by Thomas et al. (2003).

### *Research contribution*

Although PPP risk identification and classification has been studied by many researchers, there is still lack of agreements in methods for establishing a RBS for proposed projects, absence of clarity and inconsistencies in defining risk categories (Mehdizadeh et al. 2012). Specifically, in terms of the transportation sector of PPPs, previous studies have demonstrated that there is:

- Inconsistency in the checklist of risks related to PPP transportation projects.
- Lack of common language for risk identification.
- Lack of an appropriate risk taxonomy that can assist the risk management process.

Hence, this research aims to answer these questions:

- What are the risks appearing in PPP transportation projects?
- What are the appropriate terminologies of risks for PPP transportation projects?
- What should be the structure of PPP transportation risks?

The paper aims (i) to compile a new and overall risk inventory accommodating all the different risks appearing in the literature and (ii) to propose a taxonomy and terminology that can constitute the amalgamation of all currently scattered existing structures and terms regarding risks in PPP transportation projects. Such contributions are important as they will provide the body of knowledge with a common and conclusive point of reference for PPP transportation projects' risks.

### *Research boundaries*

The investment in transport infrastructure projects with private participation mainly distributed to the road subsector from 2011 to 2016 (World Bank Group 2016). According to the Organization, 35 projects in road subsector were invested with US $12.4 billion which was the largest number of projects among the total transportation infrastructure investment. This figure increased to 39 projects in 2017 (World Bank Group 2018). On that account, this study aims to have a deeper investigation of risks in PPP transportation projects, consisting of subsectors such as highways, expressways, tunnels, and roads.

The risk is defined as "*an uncertain event or condition that, if it occurs, has a positive* [opportunity] *or negative* [threat] *effect on one or more project objectives"* (Project Management Institute, 2017, p.397). However, the definition of risk has been remaining controversial among the academic community and practitioners. In the traditional view, the risk was defined as a probable event leading to a negative effect while current state-of-art research considered risk as both opportunities and threats to projects (Lehtiranta 2014). Al-Bahar and Crandall (1991) highlighted that most risk definitions in literature only emphasized on the risk's downside like losses or damages than the opposite like profit or gains. In addition, a literature review conducted by Xia et al. (2018) showed that previous studies on risks in construction projects from 1990 to 2016 mostly covered negative impacts

which mainly considered risks as threats rather than opportunities. Therefore, this research will only concentrate on the risks that are considered as threats to PPP transportation projects to align with the current practice in the industry.

## Methodology

A systematic literature review (SLR) was carried out in order to answer the research questions by gathering and analysing the existing academic papers. The SLR has been already used for both social and natural science in order not only to identify a research question but also to justify the necessity of further studies in a particular area (Swartz 2011). This method benefits the initial stage of assessing the literature on a specific topic (Petticrew and Roberts 2005). The SLR allows researchers to gather and analyse the existing academic papers systematically in order to compile a structure of quantitative summary in a specific area (Pickering and Byrne 2014).

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline is employed as the main scheme for conducting this SLR because this helps to strengthen the reporting and analysis process of the review (Moher et al. 2010). This systematic approach involves exhaustive searching for current literature using keywords to find papers in order to include in the analysis, based on specific criteria (Pickering et al. 2014). The process followed to conduct the literature review in this paper is described in Figure 1.

[Please insert Figure 1 near here]

### *The systematic literature review approach*

Firstly, academic papers related to risks in PPP transportation projects were identified and gathered using the Scopus database. This database is employed as the main tool to obtain relevant papers. Scopus has a large coverage of peer-reviewed journals, approximately 20500 records from around 5000 publishers, which is claimed as the largest database (Chadegani et al. 2017). Also, a wide spectrum of journals from different areas such as social sciences, economics, psychology,

environmental biological, agricultural, engineering, general sciences is covered by the Scopus (Burnham 2006). Additionally, Scopus has been often used in other literature review papers on PPP topic and construction risk management area (Osei-Kyei and Chan, 2015; Xia *et al.* 2018; Zhang *et al.* 2016).

Moher and Tsertsvadze (2006) supposed that the value of the systematic literature will be enhanced if the database is regularly kept up to date due to the increasing availability of new relevant research. In this study, the searched date was 1st November 2018. The "title/abstract/keyword" was used to have a comprehensive search through a powerful Scopus engine in order to capture risks related to PPP transportation project in over a period of 10 years from 2008 to 2017. The searching protocol started with full syntax as follows:

"TITLE-ABS-KEY (( risk OR uncertainty) AND ( ppp OR p3 OR bot) AND (transportation OR transport OR highway OR expressway OR tunnel OR road))"

Details about the searching and refining paper process can be seen in Table 1, starting from "Search papers" (step 4 in Figure 1) and ends with "Read and assess papers" (step 6 in Figure 1).

[Please insert Table 1 near here]

## *Selecting papers*

The initial result of the search process using the "title/abstract/keyword" provided 482 papers from listed journals. The search process then continued with only collecting English journal papers and as a consequence, 251 papers remained. Review papers were not taken into account in this research to eliminate any potential bias from previous reviews. Next, irrelevant subject areas needed to be excluded such as *Biochemistry; Agricultural and Biological Sciences; Earth and Planetary Sciences; Genetics and Molecular Biology; Physics and Astronomy; Medicine; Energy; Materials Science; Pharmacology, Toxicology and Pharmaceutics; Immunology and Microbiology; Computer Science; Mathematics; Neuroscience; Arts and Humanities; Chemical Engineering; Chemistry; Psychology*. At

the end of this step, 207 papers were chosen accordingly. Then the search was limited to only recent papers, i.e. in a period of 10 years, and this refined literature search to 152 papers. Lastly, titles, abstracts and contents of these papers were reviewed in detail to filter papers that facilitate the research questions. Among the 152 papers, some studies investigated generally risks for PPP transportation projects while others focused on risks in different subsectors of transportation such as different types of roads, bridges, railways, ports and airports. However, as mentioned previously, only subsectors of transportation projects such as highways, expressways, tunnels or roads were taken into account in this research. Also, both empirical and non-empirical studies were taken into consideration in the research. The criteria for including papers into the final list is that at least one risk considered as a threat to PPP transportation projects in these previously referred subsectors was mentioned. Finally, 72 out of 175 studies were selected for further analysis.

### *Data analysis*

The Concept-driven (top-down) and the Grounded theory (bottom-up) approaches were combined together as a main scheme for the data analysis in this research. A similar method was used in the study of Man et al. (2017) on risk-taking behaviours in construction projects. In this study, specific research questions were already identified, and the data analysis was based on those research questions. The analysis process did not follow an exhaustive searching and coding of every single line of the paper reviewed. Instead, only each segment of data from the papers, which were relevant to the topic, was coded to capture the interesting information in order to address the research question. This process is best described as the Concept-driven (top-down) approach. Meanwhile, The Grounded theory is often used in management and organization research. The method allows researchers to directly generate theory from the qualitative data using the techniques, namely (i) coding procedure, (ii) constant theoretical comparison and (iii) grounding the emerging concept (Rahmani and Leifels 2018).

Based on the Grounded theory techniques, qualitative data related to risks in PPP transportation projects was coded following three-coding approaches, namely: open, axial coding and selective coding (Man et al. 2017). During the open coding stage, qualitative data in the previous papers was divided into small chunks of meaning, and the codes were created, developed and modified through the coding procedure. In the next stage, axial coding, if units were highly similar to each other, they were constantly compared and grouped together, and the initial categories were generated accordingly (i.e. different terminologies referring to the same risk). Lastly, the qualitative data was checked using selective coding in order to determine the main groups.

The NVivo software was used as a platform to perform this analysis. This software has been used similarly for analysing the qualitative data in the study of Man et al. (2017). NVivo software can help achieve higher accuracy in qualitative research by improving the rigor of the analysis process (Welsh 2002). According to Hilal and Alabri (2013), researchers are strongly encouraged to use NVivo in qualitative studies because this software has the ability to considerably improve the quality of research (Hilal and Alabri, 2013). The innovation of the NVivo software is the capability of greatly reducing the complexity of the manual task and of allowing researchers to develop and manage the coding procedure in order to recognize themes, discover tendencies, model visually and report the result (Hilal and Alabri, 2013). In this research, the NVivo software was used to assist the three-stage coding processes and to record the frequency of risks' appearance in the qualitative data in the final list of papers.

Based on the output from the NVivo software, a list of 86 risks pertaining to PPP transportation projects and their frequencies in previous research were captured. The majority of risks were identified through the papers presented in Table 2.

[Please insert Table 2 near here]

## Research findings

### *Descriptive analysis of the research papers*

The distribution of the 72 relevant papers through the period of 10 years can be depicted in Figure 2. As can be seen, studies on risks in PPP transportation projects fluctuate through years which at least more than 2 papers related to the topic published in each year. This means that the interest in risk management of PPP transportation projects does not show any particular trend of increasing or decreasing and probably demonstrates that the research on the topic is at a mature stage. The number of papers is considerably high in the years 2010, 2012, and 2015. Especially, the highest is in 2015 which constitutes 15 papers.

[Please insert Figure 2 near here]

Figure 3 illustrates the distribution of relevant publications according to the location of the collected data. While a majority of studies were carried out in India, China, Australia, Spain and the United States, there is also limited relevant in Peru, Korea, Argentina, Poland, Chile, France, Netherlands, Portugal, Serbia, Brazil, Greece, Ireland, Nigeria, and Vietnam. This indicates that studying risks has been widely spread around the world, not only for industrialized countries but also for non-industrialized ones.

[Please insert Figure 3 near here]

### *Risk terminology*

The RBS is established to provide a harmonization of language in order to eliminate ambiguous issues in risk reporting among various projects. In the selected papers, different terminologies, as illustrated in Table 3, were used to refer to the same risks. Specifically, a majority of risks' names were proposed in the papers as a normal activity in the project life cycle or a project's characteristic rather than reflected the nature of risk such as "land acquisition and compensation" (Bagui and Ghosh 2013), "construction cost risk" (Iyer and Sagheer 2010), and "environmental protection risk" (Likhitruangsilp et al. 2017). In addition, some risks' titles were reported in the papers as a consequence rather than

a risk event such as “construction cost overrun” (Siemiatycki, 2010; Heravi and Hajihosseini, 2011), “completion delay” (Li and Zou, 2011); Pellegrino et al. 2013), “delay in land acquisition” (Bagui and Ghosh 2013), and “operation cost overrun” (Xu et al. 2010), which did not reflect consistently the definition of risk. In other words, there is still a lack of common language and appropriate titles for the risk inventory. Therefore, the name of risks in the RBS was built up and modified by combining various terms used in previous studies in order to describe properly the nature of risks as threats to the project.

[Please insert Table 3 near here]

As a result, 86 individual risks were identified, properly named and presented, as presented in Table 4.

[Please insert Table 4 near here]

### *A taxonomy of risks in PPP transportation projects*

Risks after being identified were further classified into categories under a RBS which demonstrates the comprehensive views of the risk’s structure. As illustrated by the Work Breakdown Structure, the RBS appears to provide an invaluable assistance to gain a deeper understanding on potential risks occurring in PPP projects, which is used to facilitate the risk management process (Yuan et al. 2008). Previous studies have employed a RBS as a classification method to categorize PPP transportation risks into different groups. According to Hillson (2012), the RBS is the most appropriate way to have a hierarchical structure of a long list of risks from risk identification that aids the deep insight into the distribution of risk in a project, assisting the effectiveness of risk management. Moreover, a deep insight into risk exposure to projects and businesses contributes to successful risk management (Hillson 2012).

The literature shows that all approaches for risk classification followed a criterion which emphasized in each particular aspect of risks such as the risk’s nature, the timing of occurrence or the mitigation

measure used (Xenidis and Angelides 2005a). However, owing to the development of PPP infrastructure projects over a long concession period, the project life cycle should be divided into distinct stages throughout milestones (South et al. 2018; Zou et al. 2014). Specifically, South et al. (2018) observed that the PPP project life cycle should be separated into four main phases, namely: "identification", "procurement", "design/construction" and "operate/maintain". In addition, the transfer phase was suggested to add as the main group specifically for PPP transportation projects such as roads (Thomas et al. 2003), motorways (Carbonara et al. 2015) and expressways (Li and Zou 2011). According to Thomas et al. (2003), if risks appear more than one stage, they should be assigned to the "project life cycle" group.

[Please insert Figure 4 near here]

On that account, in this research the assignment of risks was based on the phase of the life cycle of projects where they may likely to occur, which would be generic to PPP projects (Li and Zou 2011). This classification follows the suggestion of Thomas et al. (2003) and Carbonara et al. (2015). As depicted in Figure 5, there are two main groups constituting level 1 of the RBS, namely "Within specific phases of the project life cycle" (G1) and "Across the project life cycle" (G2). In which, G1 contains five distinct sub-groups (SGs) in level 2 which are the particular phases of a PPP project life cycle, namely "Identification", "Procurement", "Design and construction", "Operation and maintenance", and "Transfer". These five SGs include risks related mostly to a single phase of the project life cycle. On the other hand, G2 comprises risks occurring in any phase or more than one stage of the project life cycle, including the level 2-SGs, namely "Commercial", "Financial", "Legal risk", "Political", "Economic", "Force majeure" and "Other".

The RBS was proposed following the risk independency principle (Ebrahimnejad et al. 2010). Based on this orientation, the RBS is designed according to the awareness of listing all risks associated with PPP transportation projects and not creating any duplicate risks. Therefore, when breaking down the level

of the RBS, each risk and each category should be precisely different and independent from each other. It is obvious that when a risk is introduced in a project, it concurrently has various aspects (i.e. the timely occurrence and the source of origin). On account of that issue, the SGs in the RBS were created based on the original source of each risk in PPP transportation including “Bidding risks”, “Technology risks”, “Operation issues”, “Revenue risks”, “Tolling risks”, “Commercial risks”, “Financial risks”, “Legal risks”, “Political risks”, “Economic risks”, “Force majeure”. Risks that cannot be assigned into any SGs were gathered to form the “Other” SG.

There are five main levels in the RBS which of those represent an increasing level of detail of the project risk. The first level of the RBS (level 1) differentiates the phase-specific risks to ones to one that may appear more than one phases. Risks in each main group were then included according to the project’s phase where the risk may appear. These risks were arranged in descending score of coding which was based on how many times the risks appeared in the literature (see Table 4). Highly similar risks were grouped together to form a new SG. Furthermore, when risks in each of the lowest level in the RBS are gathered together, the risk identification checklist will be brought out. The final taxonomy in the form of a RBS is presented in Tables 5a and 5b.

[Please insert Tables 5a and 5b near here]

*Group 1 - Within specific phases of the project life cycle*

***Group 1.1 – Identification:*** Risks assigned in this group occur when initial ideas and the conception of projects are set up until a request for proposals (RFPs) is published. Most of the activities in this phase are involved in project appraisals and decision making. There are only risks in level 3 of the RBS in this group. The most frequent risk mentioned in the literature is “Problems with project approval and permits” which is coded at 1.43%. The percentage of coding means how many percents each code accounted in the total of 421 codes made from the literature. Before the construction phase commences, permissions require to be initially sought from the government organizations at different

state or local levels. Problems with project approval and permits include a prolonged approval process (Li and Zou 2011), postponements of various government policies mainly in dealing with environmental problems, wildlife, and forestry (Gopalkrishna and Karnam 2015), resulting in project approval delays (Likhitruangsilp et al. 2017). In case of Indian road projects, Iyer and Sagheer (2010) supposed that major reasons for the delay of project approvals in India were lacks of cooperation and coordination from government agencies and departments, and of legal awareness, frequent transfer of officials involved and poor supportive documentation. Likhitruangsilp et al. (2017) indicated that this risk is the most critical ones in PPP transportation projects in Vietnam. The authors assumed that incompetent and unprofessional government officials, complexities of approval procedures and frequent changes in laws and regulations were mainly responsible for the delays in project approvals and permits.

***Group 1.2 – Procurement:*** In this phase, risks may appear when an RFP is issued by the PPP sponsor until a contract is awarded and financial closure is reached. The frequency of risk "Conflicting and imperfect contract" is the highest (2.14%) among the risks in this group. Chan *et al.* (2010) explained that this risk engaged with the inaccuracy, inconsistency, vagueness, inflexibility and unclear mechanism of allocation of responsibilities and risks in the contract. In the literature, such risk was expressed in different ways such as unclear about state participant portion (Likhitruangsilp et al. 2017), contracts with non-complete clauses (Wang 2015) and no specific clauses (Domingues and Zlatkovic 2015). If the contract is incomplete, this may cause a delay in resolving contractual disputes (Valipour et al. 2015). Bagui and Ghosh (2013) indicated that the contractual challenges is one of the major risks in the concession period and therefore should be taken into consideration in risk management for BOT road projects. Besides, the risk "Change in the land value" (1.43%) is the second most frequent risk appearing in the literature within this group. The value of the land may change because of the development or inflation (Valipour et al. 2015; Heravi and Hajihosseini, 2011). According to Heravi and Hajihosseini (2011), this risk may also contribute to the poor transparency in project procedure and therefore should be properly handled by the most capable party.

***Group 1.3 - Design and Construction:*** This phase begins after the financial close, including design and construction, and ends with the infrastructure asset commissioning in which risks may happen in relation to such activities. This group contains a considerable number of risks (14 individual ones) which appear frequently in the literature. According to Perera et al. (2014), the design and construction phases are most vulnerable to risks because these phases are most demanding to which is influenced by natural and human factors. Among the risks in this group, the most frequent risk is the "Problems with land acquisition and compensation", that accounts for 3.8%, followed by "Escalation of construction cost" and "Improper design" with 3.09% and 2.61% respectively. Because transportation projects, especially road projects, require vast stretches of land, they are more likely to displace communities along the road. If there is not enough monetary compensation or unsuitable land to substitute for human resettlement and rehabilitation, this could be a trigger for public resistance and hindering of such projects. This risk may contribute to a delay in the entire schedule and overrun of the budget and therefore affect the viability of projects.

Likhitruangsilp et al. (2017) reported "Land acquisition and compensation" risk was the most severe in Vietnamese PPP transportation projects with the highest score for probability and impact. This can be explained by low money for compensation, the various fare of compensation in different provinces and the separation of roles and responsibilities of government agencies. Also, as for road projects in India invested by BOT method, the risk was ranked second in risk's importance (Thomas et al. 2003). Iyer and Sagheer (2010) explained that the risk resulted from a lack of land alternation with acceptable cost, political resistance of motivated citizens, delays in notification and survey procedures, prosecution and legal proceedings and political supports for possessions.

***Group 1.4 – Operation and Maintenance:*** Risks may be associated with the operation and maintenance procedure through a defined concession term, the longest phase in a PPP project. Figure 5 shows that most of the risks occur in this stage in which approximately 24 risks are structured in four levels of the RBS. It is worth mentioning that the risk "Low traffic demand" (level 4) accounts for the

highest percentage among other risks in the RBS, around 14.25% (60 times) in the total of 421 codes recorded through the analysis. Accompanied with these other level 4-risks, namely "Inaccurate traffic forecast", "Competitive road", "Loss due to operational problem" and risks associated with tolling, the "Low traffic demand" risk constitutes to the "Revenue risks" SG (level 3).

The traffic demand is a critical factor in recovering the investment cost through payments from end-users in a form of traffic revenue. The deviation from the forecast demand was claimed as the main factor contributing to the revenue risks in Indian highway projects (Iyer and Sagheer 2011). The criticality of "traffic demand risk" is mostly concerned in road projects in India (Thomas et al. 2003). Roumboutsos and Pantelias (2015) explained that the demand risk reflected not only the uncertainties of traffic demand forecast but also the consent to the payment from end-users. Alasad and Motawa (2015) supposed that the traffic demand relies on a wide variety of correlated and changing factors, namely demographic and income situations. Because these factors are inherently uncertain, the demand projection may be inaccurate in the future. If the traffic demand is lower than the expected traffic, this may adversely affect the project's financial viability.

***Group 1.5 – Transfer:*** When the service contract of PPP projects expires, the infrastructure is reverted to the government, and other risks may emerge in this stage. Only the "Low residual value" (0.71%) as a risk has been included in this group from the relevant research. According to Yuan *et al.* (2009), the residual value is an important issue when returning a PPP infrastructure back to the government. This risk involves overusing resources, resulting in the depreciation of infrastructure as the concession period ends (Chan et al. 2010). The residual value risk in PPP projects was clarified as the risk occurring when the concession period is terminated in which the asset of infrastructure is not in correspondence with the initial estimation of value mentioned in the contract (Yuan *et al.* 2009). Li and Zou (2011) expressed that the residual value risk is one of the most severe ones, raising the major concern of experts in PPP expressway projects in China. In case of infrastructure with a lower residual value compared to the estimated value signed in the contract, the public sector may experience the

reduction in such value, questioning to the issue with the quality and serviceability of the provided services by the public sector in the continuous operation of projects as well as the shorter life cycle of the projects. This may directly affect beneficial owners and end-users after the expiration of the contractual period.

*Group 2 - Across the project life cycle*

All risks assigned in this group may appear in any phase of the life cycle of PPP transportation projects. Most of the risks in this group belong to the macro-environment, that are in the commercial, financial, legal, political, economic and force majeure sub-categories and therefore they are probably the most difficult to be controlled. Risks in this group were classified into different group names in previous studies such as "General risks" (Likhitruangsilp et al. 2017), "System risks" (Xu et al. 2012b), "Investment Environment Risks" (Ni 2012) and "Exogenous risks" (Carbonara et al. 2015). Other risks belong to this group such as "Poor organization and coordination", "Change of project scope", "Problems related to partnership", "Poor decision-making process" and "Inappropriate schedule" were grouped together to create the "Others" SG.

The most regularly mentioned risks in this groups are "Inflation rate fluctuation" (3.80%), "Changes in laws and regulations" (3.33%), "Interest rate fluctuation" (3.33%). Inflation is defined *as "The increase of the price level of the commodities, the decrease of purchasing power of currencies, which cause the increase of cost and other consequence"* (Chan *et al.* 2010, p.141). Changes in laws and regulations refer to inconsistent applications of new laws and regulation by the local government such as taxation, land management, environmental and labour laws, causing an increase in construction and operation costs (Xu *et al.* 2012b). In addition, PPP projects may be experienced a loss due to the volitation of interest rate which is affected by the immature local economy and banking systems (Wang et al. 2004). The study of Carbonara *et al.* (2015) shows that changes in legislation and interest rate may have major impacts on PPP motorway projects if they occur. Moreover, the fluctuation of the economic factors such as interest rate and inflation may generate a project's cost overrun (Chan et al. 2010).

Therefore, if such risks arise, the project may come across with the failure in completing within the budget.

## Discussion

The proposed RBS is a combination of the two major approaches to classify risks such as the stage of the project life cycle in which risks probably emerge (see Figure 5 - "1. Risks within specific phases of the project life cycle (G1)") and the source where the risk comes from (see figure 5 – "2. Risks across the project life cycle (G2)" and sub-categories). This classification let the project team explore various aspect of risks (phase and source).

According to Gupta, Trivedi and Kansal (2013), risks in PPP projects are different from the conventional ones because they involve various complex factors such as financing, sub-agreements, taxation, technical details, and market conditions. In this study, the list of risks was built up from an exhaustive search of previous studies, that resulted in a comprehensive taxonomy. It contains 86 risks gathered from various studies, which is the highest number of risks compared to ones in 72 papers gathered in this SLR. However, Carbonara *et al*. (2015) explained that the PPP risk list cannot be comprehensive without the relevant context of projects. Therefore, the proposed taxonomy and a relevant risk list should be used as a basic but not a conclusive list when it comes to risk identification of specific PPP transportation projects. The proposed RBS should be adjusted, developed and modified according to the specific conditions of projects.

Among the identified risks in the RBS, some risks and risk SGs appear more frequently than others in the literature such as "Low traffic demand" (14.25%), "Escalation of operation and maintenance cost" (4.04%), "Problems with land acquisition and compensation" (3.80%), "Inflation rate fluctuation" (3.80%), , "Changes in law and regulation" (3.33%), "Interest rate fluctuation" (3.33%), "Financial risks" and "Revenue risks" SG. This is due to both their frequent appearance and their important role to the project and therefore should be always taken into account for further analysis. Many previous studies attempt a deep investigation to explore different aspects and relevant issues of some critical risks such

as traffic revenue risk (Bagui and Ghosh, 2012; Babatunde and Perera, 2017; Ashuri *et al.* 2012; Iyer and Sagheer, 2011; Alasad and Motawa, 2015); financial risk (Isik and Aladag, 2017; Chiara and Garvin, 2008); competence risks (Lu and Webster 2018); legal risks (Xenidis and Angelides 2005b) and social risk (Yuan et al. 2018).

Besides, there are some review papers conducted in the PPP topic in the past. For instance, Kwak et al. (2009) conducted an extensive literature review to explore different aspects of PPPs. In their study, a catalogue of risks pertaining to PPP projects was compiled from different studies in the previous period time of 20 years, excluding risk factors specializing in particular projects or regions. A risk classification was proposed based on specialised areas that risks linked to such as construction, political, financial, operation and maintenance, market, and legal risks. Osei-Kyei and Chan (2015) summarized research findings in PPP projects from 1990 and 2013 to identify important success factors. In a comprehensive literature review undertaken by de Castro e Silva Neto *et al.* (2016), a bibliometric analysis was used to explore various aspects of PPPs and Private Finance Initiatives (PFIs). The finding showed that existing work from more than 600 papers published from 1990 until 2014 mainly focused on qualitative costs and benefits, contract performance, political and institutional issues, contract design and risk sharing, and value for money tests. Similarly, a critical review was made by Zhang *et al.* (2016) to compare topics and methods used in previous studies from 2005 to 2014 between International journals and Chinese journals. In terms of PPP transportation projects, Chen et al. (2016) proposed a meta-analysis to investigate the data utilized in PPP research by dividing them into different groups including contract performance, risk, institutional factors and value for money.

Overall, the aforementioned review papers focused on various aspects of PPPs such as critical success factors (Osei-Kyei and Chan 2015), focused topics among previous works (de Castro e Silva Neto *et al.* 2016; Zhang *et al.* 2016), used methods (Zhang *et al.* 2016), and utilized data (Chen et al. 2016). The concerns raised in these reviews are different from the research questions identified in this SLR. Only the review of Kwak et al. (2009) is relevant to risk identification and classification in PPPs. However,

specifically for PPP transportation projects, there still lacks a systematic review related to risk identification and classification. On the other hand, previous studies used different terms to describe the same risk, and the risk title was proposed in these studies as a usual activity or a consequence rather than the risk event (see Table 3), which inappropriately reflects the risk's definition. Hence, this study has already addressed the gap in the body of knowledge by providing an overall risk catalogue as well as proposing a taxonomy and common terminology for risks in PPP transportation projects.

## Conclusions

Many previous studies have concentrated on risk identification and classification in PPP transportation projects. However, there is still a lack of a consistent risk inventory, common terminology and a comprehensive structure of risks. To address the literature gap, an SLR was conducted following the PRISMA guidelines to formulate a thorough risk list, standardise terminology and create an appropriate taxonomy for risks in PPP transportation projects. Seventy-two papers were finally gathered through intensive searching of the literature focusing on the last 10 years. The qualitative data in the literature was analysed using the Concept-driven (top-down) and Grounded theory (bottom-up) approaches.

NVivo software was employed as a tool for data analysis to record the frequency of risks appeared in the literature. As a result, a list of 86 risks pertaining to PPP transportation projects was compiled, accompanying with risk titles from a viewpoint of considering risks as threats to the project. Furthermore, the identified risks were classified under a RBS according to the phase of the life cycle in PPP projects where two main groups of the RBS were set up, that includes, "Within specific phases of the project life cycle" (G1) and "Across the project life cycle" (G2). Specifically, the SGs in the group G1 correspond to the specific phases of the project life cycle, namely "Identification", "Procurement", "Design and construction", "Operation and maintenance", "Transfer". The most frequent risks appearing in the literature are "Low traffic demand", "Escalation of operation, maintenance cost", "Inflation rate fluctuation", "Problems with land acquisition and compensation", "Change in laws and

regulations", "Interest rate fluctuation". Hence, it can be concluded that they are the most common risks in PPP transportation projects.

The established RBS is beneficial for risk identification and classification in PPP transportation projects. On the one hand, it lists identified risks from the literature but also mainly classifies the risks into distinct groups according to the project life cycle phase. The details of the risks increase when decomposing to lower levels of the RBS which provides profound insights into the details of risk to which projects are exposed. Moreover, risk terms are proposed as a common language, facilitating reporting activities among multiple projects, communication and lessons learned. Hence, the RBS could be very useful for both PPP practitioners and academics as it will enable them to have an overall understanding of risks in PPP transportation projects and increase the effectiveness of communication in this area. Especially for practitioners, the allocation of risks to specific phases of the project's life cycle may prove helpful for timely identification.

The research does not come without limitations. The main limitation in all relevant research endeavours is that the process of refining papers, establishing the risk titles and categorising risks into the RBS is mainly based on the authors' judgment, which could be seen as a form of inevitable bias among academic researchers. However, measures were taken to alleviate this limitation as much as possible. Such measures included cross-examination among researchers and double reviewing.

Further research in relation to this research topic can be as follows. The same approach could be conducted in the other mentioned sectors of transportation areas such as railways, ports and airports to provide an entire list of risk covering all kind of PPP transportation projects or to compare the risks in different kinds of transportation projects. Another potential avenue for further research is empirical validation. Even though the risk list was compiled from previous research, it should be validated using other approaches such as the interview or focus group discussion to explore and compare risks with different practical viewpoints.

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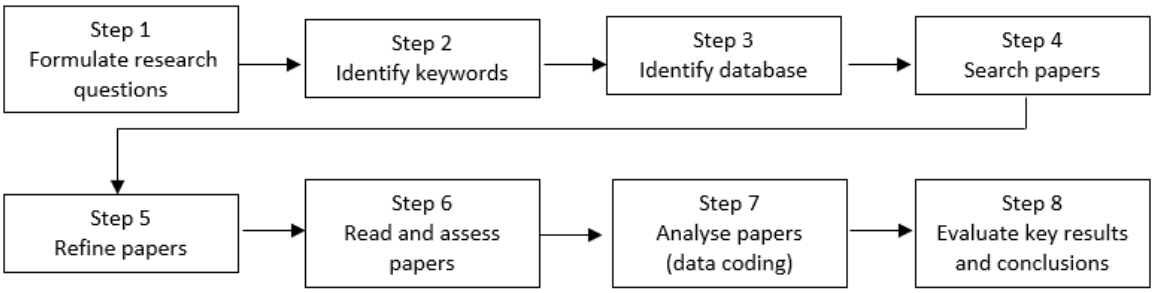



Figure 1. Steps in the SLR (Amended from Pickering and Byrne, 2014).

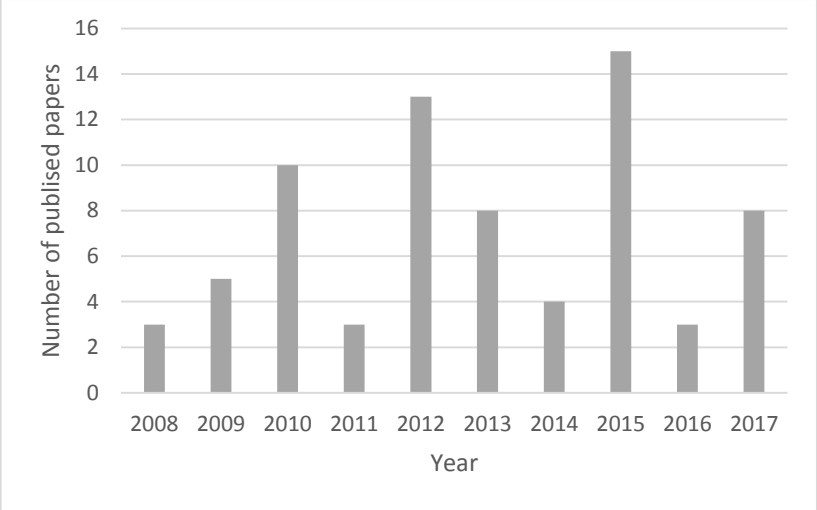



Figure 2. Quantities of selected papers published annually from 2008 to 2017

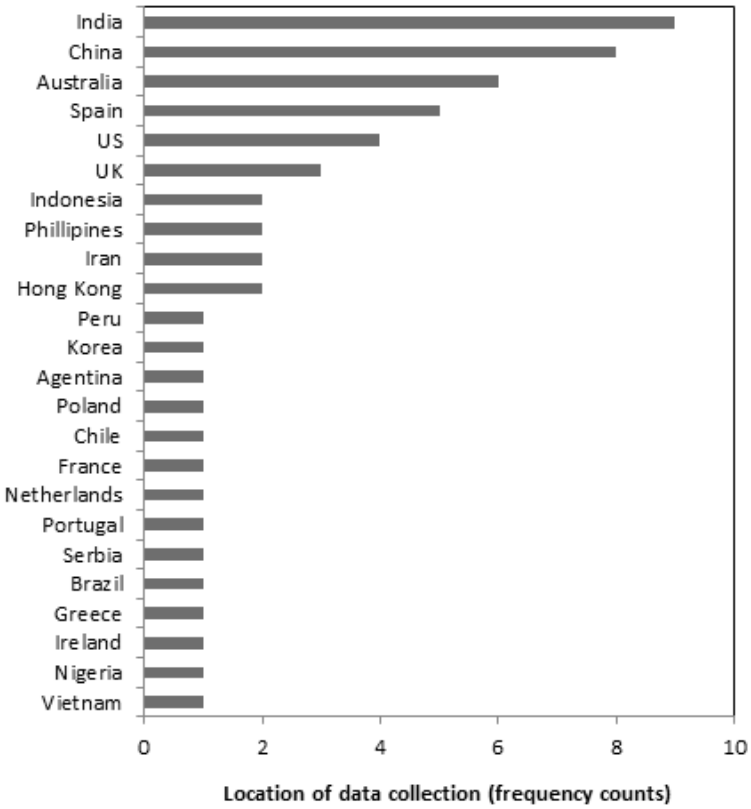



Figure 3. Distribution of selected publication by geographical jurisdiction

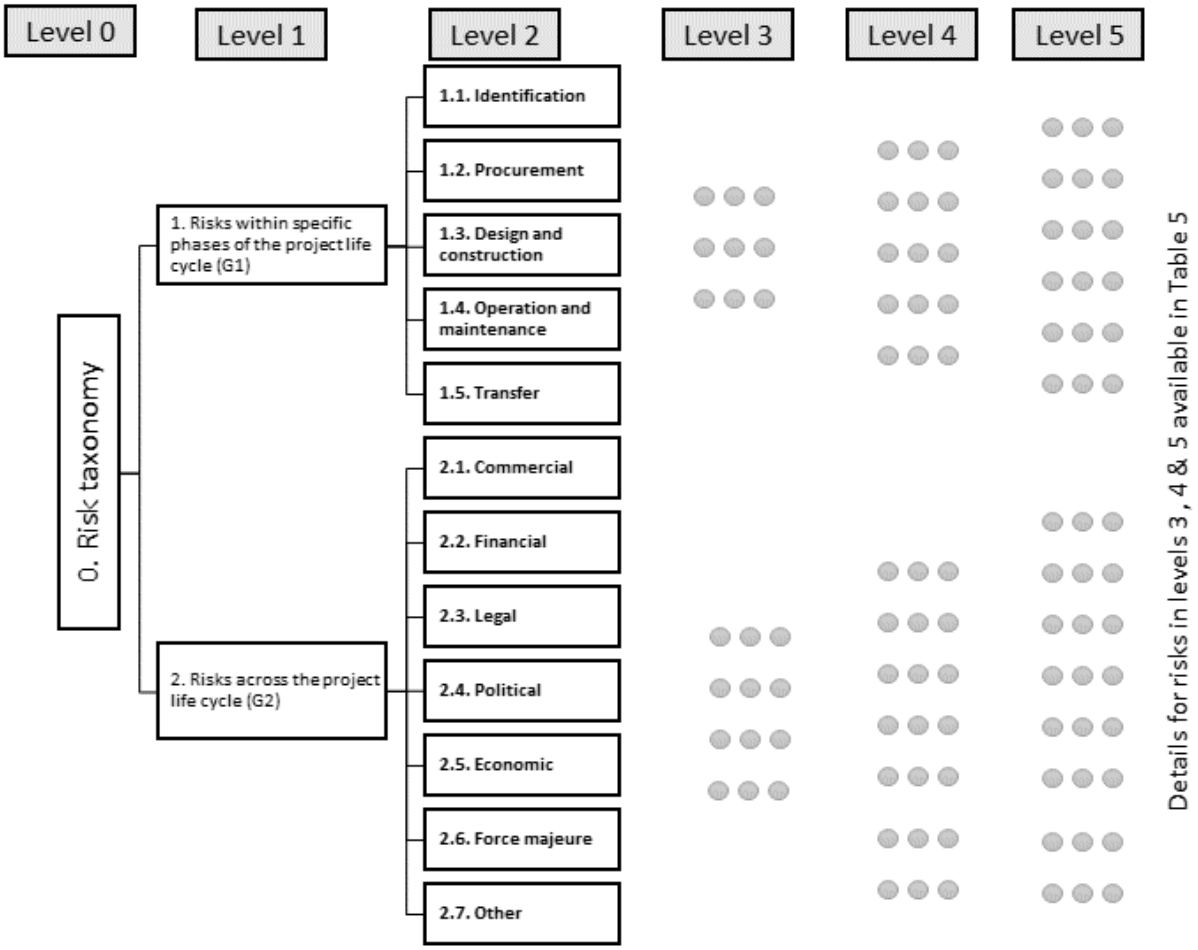



Figure 4. High levels in the RBS

Table 1. Stages to finalize the relevant paper for the SLR

| Search stage | Keyword string | Number of results |
|---|---|---|
| 1 | TITLE-ABS-KEY ((risk OR uncertainty) AND (ppp OR p3 OR bot) AND (transportation OR transport OR highway OR expressway OR tunnel OR road)) | 482 |
| 2 | Limiting the search to English journal papers | 251 |
| 3 | Excluding irrelevant subject areas | 207 |
| 4 | Limiting to recent studies only (from 2008 to 2017) | 152 |
| 5 | Reading through the titles and abstracts and details of the papers | 72 |

Table 2. Top papers mainly identified risks in PPP transportation projects

| Reference | Country | Number of risks mentioned |
|---|---|---|
| Valipour *et al.* 2015 | Iran | 26 |
| Likhitruangsilp et al. 2017 | Vietnam | 26 |
| Heravi and Hajihosseini, 2011 | Iran | 25 |
| Li and Zou 2011 | China | 24 |
| Chan and Cheung 2011 | China | 21 |
| Iyer and Sagheer 2010 | India | 22 |
| Babatunde and Perera 2017 | Nigeria | 21 |
| Xu *et al.* 2010 | China | 18 |
| Carbonara *et al.* 2015 | Unspecified | 18 |
| Pellegrino et al. 2013 | Unspecified | 16 |
| De Marco et al. 2012 | Multiple countries | 16 |

Table 3. Examples of different terminology used in the literature to refer to the same risk

| No. | Alternative terms used in the literature | Proposed risk's terminology | References |
|---|---|---|---|
| 1 | Fluctuation of interest rate | Interest rate fluctuation | (Likhitruangsilp et al. 2017) |
| | Interest rate change | | (Xu *et al.* 2012a) |
| | Interest rate fluctuation | | (Xu et al. 2010); (Chan and Cheung 2011); (Xu *et al.* 2012b) |
| | Interest rate volatility | | (Li and Zou, 2011) |
| | Higher interest rates | | (Rajan et al. 2010) |
| | Interest rate | | (Pellegrino et al. 2013); (Hanaoka and Palapus 2012); (Chung and Hensher 2015) |
| | Interest rate increase | | (Carbonara et al. 2015) |
| | Interest rate risk | | (Carbonara et al. 2015) |
| | Fluctuation of interest rate | | (AladaG and Zeynep 2017) |
| 2 | Operator inability | Operator inability | (Likhitruangsilp et al. 2017); (Li and Zou 2011) |
| | Operator default | | (Valipour et al. 2015) |
| | Inability of concessionaire | | (Chan and Cheung 2011) |
| | Staff management issues | | (Albalate et al. 2015) |
| 3 | Unclear about state participant portion | Conflicting and imperfect contract | (Likhitruangsilp et al. 2017) |
| | Contractual dispute | | (Valipour et al. 2015) |
| | Contracting challenges | | (Bagui and Ghosh 2013) |
| | Conflicting and imperfect contract | | (Chan and Cheung 2011); (Likhitruangsilp et al. 2017), |
| | Contract risk with the non-compete clause | | (Wang 2015) |
| | Contract development and negotiation | | (Johnston 2010) |
| | No specific clauses | | (Domingues and Zlatkovic 2015) |
| 4 | Delay in project approvals and permits | Problems with project approvals and permits | (Likhitruangsilp et al. 2017); (Chan and Cheung 2011) |
| | Long approval time for the project | | (Li and Zou 2011) |
| | Permit/approval risk | | (Iyer and Sagheer 2010) |
| | Various government clearances | | (Gopalkrishna and Karnam, 2015) |

Table 4. Individual risks in PPP transportation projects

| Risk (R) ID | Description | Frequency count | % |
|---|---|---|---|
| R 1 | Low traffic demand | 60 | 14.25 |
| R 2 | Escalation of operation, maintenance cost | 17 | 4.04 |
| R 3 | Inflation rate fluctuation | 16 | 3.80 |
| R 4 | Problems with land acquisition and compensation | 16 | 3.80 |
| R 5 | Change in laws and regulations | 14 | 3.33 |
| R 6 | Interest rate fluctuation | 14 | 3.33 |
| R 7 | Escalation of construction cost risk | 13 | 3.09 |
| R 8 | Improper design | 11 | 2.61 |
| R 9 | Public resistance to pay | 10 | 2.38 |
| R 10 | Conflicting and imperfect contract | 9 | 2.14 |
| R 11 | Foreign exchange fluctuation | 9 | 2.14 |
| R 12 | Imperfect law and supervision system | 9 | 2.14 |
| R 13 | Risks associated with debt | 9 | 2.14 |
| R 14 | Change in taxes, tariffs | 8 | 1.90 |
| R 15 | High toll rate | 8 | 1.90 |
| R 16 | Change of project scope | 7 | 1.66 |
| R 17 | Environmental damage | 7 | 1.66 |
| R 18 | Inaccurate traffic forecasts | 7 | 1.66 |
| R 19 | Change in the land value | 6 | 1.43 |
| R 20 | Lack of transparency in bidding | 6 | 1.43 |
| R 21 | Natural disasters | 6 | 1.43 |
| R 22 | Operator inability | 6 | 1.43 |
| R 23 | Problems with project approvals and permits | 6 | 1.43 |
| R 24 | Poor organization and coordination risk | 5 | 1.19 |
| R 25 | Problems with environmental approval | 5 | 1.19 |
| R 26 | Severe weather | 5 | 1.19 |
| R 27 | War | 5 | 1.19 |
| R 28 | Change in government's policies | 4 | 0.95 |
| R 29 | Competitive road | 4 | 0.95 |
| R 30 | Expropriation | 4 | 0.95 |
| R 31 | Financial crisis and monetary storm | 4 | 0.95 |
| R 32 | Inadequate feasibility study | 4 | 0.95 |
| R 33 | Inappropriate allocation of responsibility and risk | 4 | 0.95 |
| R 34 | Lack of cash flow | 4 | 0.95 |
| R 35 | Limited capital | 4 | 0.95 |
| R 36 | Problems with resettlement and rehabilitation | 4 | 0.95 |
| R 37 | Unexpected site condition | 4 | 0.95 |
| R 38 | Changes in economic conditions | 3 | 0.71 |
| R 39 | Disruptions due to accidents, breakdown | 3 | 0.71 |
| R 40 | Failure of toll collection equipment | 3 | 0.71 |
| R 41 | Inappropriate schedule | 3 | 0.71 |

| Risk (R) ID | Description | Frequency count | % |
|---|---|---|---|
| R 42 | Lack of a standard model for PPP agreements | 3 | 0.71 |
| R 43 | Lack of qualified bidders | 3 | 0.71 |
| R 44 | Low residual value | 3 | 0.71 |
| R 45 | Poor decision-making process | 3 | 0.71 |
| R 46 | Problems related to partnership | 3 | 0.71 |
| R 47 | Subjective project evaluation method | 3 | 0.71 |
| R 48 | Failure to meet performance criteria | 2 | 0.48 |
| R 49 | Faulty financial structure | 2 | 0.48 |
| R 50 | Higher than expected finance costs | 2 | 0.48 |
| R 51 | Inadequate government supports for toll enforcement | 2 | 0.48 |
| R 52 | Influential economic events | 2 | 0.48 |
| R 53 | Insufficient project finance supervision | 2 | 0.48 |
| R 54 | Lack of support from government officials | 2 | 0.48 |
| R 55 | Lack of supporting infrastructure | 2 | 0.48 |
| R 56 | Malpractice in tolling | 2 | 0.48 |
| R 57 | Problems related to media | 2 | 0.48 |
| R 58 | Operation changes | 2 | 0.48 |
| R 59 | Price change | 2 | 0.48 |
| R 60 | Privatization | 2 | 0.48 |
| R 61 | Problem related to construction safety | 2 | 0.48 |
| R 62 | Problems with payment | 2 | 0.48 |
| R 63 | Sanction | 2 | 0.48 |
| R 64 | Social unrest | 2 | 0.48 |
| R 65 | Unfavourable international economy | 2 | 0.48 |
| R 66 | Alteration in toll structure | 1 | 0.24 |
| R 67 | Contractual disputes | 1 | 0.24 |
| R 68 | Damage to road structures, construction equipment, labour | 1 | 0.24 |
| R 69 | Failure to meet service quality | 1 | 0.24 |
| R 70 | Faulty techniques | 1 | 0.24 |
| R 71 | High tendering cost | 1 | 0.24 |
| R 72 | Inappropriate location of booth collection of tolls | 1 | 0.24 |
| R 73 | Litigation or inordinate | 1 | 0.24 |
| R 74 | Loss due to operational problems | 1 | 0.24 |
| R 75 | Low attraction of financing | 1 | 0.24 |
| R 76 | Negligence of operation by concessionaire | 1 | 0.24 |
| R 77 | Political concerns of foreign takeover | 1 | 0.24 |
| R 78 | Poor access control due to multiple entry or exit | 1 | 0.24 |
| R 79 | Problems related to financing methods and supply | 1 | 0.24 |
| R 80 | Problems with construction logistics | 1 | 0.24 |
| R 81 | Problems with operation safety | 1 | 0.24 |
| R 82 | Road quality deterioration | 1 | 0.24 |
| R 83 | Slow operation | 1 | 0.24 |
| R 84 | Unclear project objectives | 1 | 0.24 |

| Risk (R) ID | Description | Frequency count | % |
|---|---|---|---|
| R 85 | Unexpected geotechnical conditions | 1 | 0.24 |
| R 86 | Unproven engineering technology | 1 | 0.24 |
| Total | | 421 | 100.00 |

Table 5a. The RBS of PPP transportation projects

| 1. Within specific phases of the project life cycle (G1) | | | |
|---|---|---|---|
| **Name** | **Codes (%)** | **Name** | **Codes (%)** |
| **1.1. Identification** | | **1.4. Operation and maintenance** | |
| 1.1.1. Problems with project approvals and permits | 1.43 | 1.4.1. Escalation of operation, maintenance cost | 4.04 |
| 1.1.2. Problems with environmental approvals | 1.19 | 1.4.2. Public resistance to pay | 2.38 |
| 1.1.3. Inadequate feasibility study | 0.95 | 1.4.3. Operator inability | 1.43 |
| 1.1.4. Subjective project evaluation method | 0.71 | 1.4.4. Disruptions due to accidents, breakdown | 0.71 |
| 1.1.5. Lack of a standard model for PPP agreements | 0.71 | 1.4.5. Problems with payment | 0.48 |
| 1.1.6. Faulty financial structure | 0.47 | 1.4.6. Failure to meet service quality | 0.24 |
| 1.1.7. Unclear project objectives | 0.23 | 1.4.7. Road quality deterioration | 0.24 |
| 1.1.8. Political concerns of foreign takeover | 0.23 | **1.4.8. Operation issues** | Codes (%) |
| 1.1.9. Problems related to financing methods and supply | 0.23 | 1.4.8.1. Operation changes | 0.48 |
| 1.1.10. Low attraction of funding | 0.23 | 1.4.8.2. Problem related to operation safety | 0.24 |
| **1.2. Procurement** | | 1.4.8.3. Negligence of operation by concessionaire | 0.24 |
| 1.2.1. Conflicting and imperfect contract | 2.14 | 1.4.8.4. Poor access control due to multiple entry or exit | 0.24 |
| 1.2.2. Change in the land value | 1.43 | 1.4.8.5. Slow operation | 0.24 |
| 1.2.3. Inappropriate allocation of responsibility and risk | 0.95 | **1.4.9. Revenue risks** | Codes (%) |
| 1.2.4. Limited capital | 0.95 | 1.4.9.1. Low traffic demand | 14.25 |
| 1.2.5. Higher than expected finance costs | 0.48 | 1.4.9.2. Inaccurate traffic forecasts | 1.66 |
| 1.2.6. Contractual disputes | 0.24 | 1.4.9.3. Competitive road | 0.95 |
| 1.2.7. Litigation or inordinate | 0.24 | 1.4.9.4. Loss due to operational problems | 0.24 |
| **1.2.8. Bidding risks** | Codes (%) | **1.4.9.5. Tolling risks** | Codes (%) |
| 1.2.8.1. Lack of transparency in bidding | 1.43 | 1.4.9.5.1. High toll rate | 1.90 |
| 1.2.8.2. Lack of enough qualified bidders | 0.71 | 1.4.9.5.2. Failure of toll collection equipment | 0.71 |
| 1.2.8.3. High tendering cost | 0.24 | 1.4.9.5.3. Malpractice in tolling | 0.48 |
| **1.3. Design and construction** | | 1.4.9.5.4. Inadequate government supports for toll enforcement | 0.48 |
| 1.3.1. Problems with land acquisition and compensation | 3.80 | 1.4.9.5.5. Price change | 0.48 |
| 1.3.2. Escalation of construction cost | 3.09 | 1.4.9.5.6. Alteration in toll structure | 0.24 |
| 1.3.3. Improper design | 2.61 | 1.4.9.5.7. Inappropriate location of booth collection of tolls | 0.24 |
| 1.3.4. Environmental damage | 1.66 | **1.5. Transfer** | |

| 1. Within specific phases of the project life cycle (G1) | | | |
|---|---|---|---|
| **Name** | **Codes (%)** | **Name** | **Codes (%)** |
| 1.3.5. Problems with resettlement and rehabilitation | 0.95 | 1.5.1. Low residual value | 0.71 |
| 1.3.6. Unexpected site condition | 0.95 | | |
| 1.3.7. Lack of supporting infrastructure | 0.48 | | |
| 1.3.8. Failure to meet performance criteria | 0.48 | | |
| 1.3.9. Problems related to construction safety | 0.24 | | |
| 1.3.10. Unexpected geotechnical conditions | 0.24 | | |
| 1.3.11. Problems with construction logistics | 0.24 | | |
| 1.3.12. Damage to road structures, construction equipment, labour... | 0.24 | | |
| **1.3.13. Technology risks** | | | |
| 1.3.13.1. Faulty techniques | 0.24 | | |
| 1.3.13.2. Unproven engineering technology | 0.24 | | |

Table 5b. The RBS of PPP transportation projects

| 2. Across the project life cycle (G2) | | | |
|---|---|---|---|
| **Name** | **Codes (%)** | **Name** | **Codes (%)** |
| **2.1. Commercial** | | **2.5. Economic** | |
| 2.1.1. Inflation rate fluctuation | 3.8 | 2.5.1. Financial crisis and monetary storm | 0.95 |
| 2.1.2. Interest rate fluctuation | 3.33 | 2.5.2. Changes in economic conditions | 0.71 |
| 2.1.3. Foreign exchange fluctuation | 2.14 | 2.5.3. Influential economic events | 0.48 |
| **2.2. Financial** | | 2.5.4. Unfavourable international economy | 0.48 |
| 2.2.1. Risks associated with debt | 2.14 | **2.6. Force majeure** | |
| 2.2.2. Lack of cash flow | 0.95 | 2.6.1. Natural disasters | 1.43 |
| 2.2.3. Insufficient project finance supervision | 0.48 | 2.6.2. Severe weather | 1.19 |
| **2.3. Legal** | | 2.6.3. War | 1.19 |
| 2.3.1. Change in laws and regulations | 3.33 | 2.6.4. Social unrest | 0.48 |
| 2.3.2. Imperfect supervision system | 2.14 | **2.7. Other** | |
| 2.3.3. Change in taxes, tariffs | 1.9 | 2.7.1. Change of project scope | 1.66 |
| **2.4. Political** | | 2.7.2. Poor organization and coordination risk | 1.19 |
| 2.4.1. Change in government's policies | 0.95 | 2.7.3. Problems related to partnership | 0.71 |
| 2.4.2. Expropriation | 0.95 | 2.7.4. Poor decision-making process | 0.71 |
| 2.4.3. Privatization | 0.48 | 2.7.5. Inappropriate schedule | 0.71 |
| 2.4.4. Sanction | 0.48 | 2.7.6. Problems related to Media | 0.48 |
| 2.4.5. Lack of support from government officials | 0.48 | | |

Table 5b. The RBS of PPP transportation projects

| 2. Across the project life cycle (G2) | | | |
|---|---|---|---|
| **Name** | **Codes (%)** | **Name** | **Codes (%)** |
| **2.1. Commercial** | | **2.5. Economic** | |
| 2.1.1. Inflation rate fluctuation | 3.8 | 2.5.1. Financial crisis and monetary storm | 0.95 |
| 2.1.2. Interest rate fluctuation | 3.33 | 2.5.2. Changes in economic conditions | 0.71 |
| 2.1.3. Foreign exchange fluctuation | 2.14 | 2.5.3. Influential economic events | 0.48 |
| **2.2. Financial** | | 2.5.4. Unfavourable international economy | 0.48 |
| 2.2.1. Risks associated with debt | 2.14 | **2.6. Force majeure** | |
| 2.2.2. Lack of cash flow | 0.95 | 2.6.1. Natural disasters | 1.43 |
| 2.2.3. Insufficient project finance supervision | 0.48 | 2.6.2. Severe weather | 1.19 |
| **2.3. Legal** | | 2.6.3. War | 1.19 |
| 2.3.1. Change in laws and regulations | 3.33 | 2.6.4. Social unrest | 0.48 |
| 2.3.2. Imperfect supervision system | 2.14 | **2.7. Other** | |
| 2.3.3. Change in taxes, tariffs | 1.9 | 2.7.1. Change of project scope | 1.66 |
| **2.4. Political** | | 2.7.2. Poor organization and coordination risk | 1.19 |
| 2.4.1. Change in government's policies | 0.95 | 2.7.3. Problems related to partnership | 0.71 |
| 2.4.2. Expropriation | 0.95 | 2.7.4. Poor decision-making process | 0.71 |
| 2.4.3. Privatization | 0.48 | 2.7.5. Inappropriate schedule | 0.71 |
| 2.4.4. Sanction | 0.48 | 2.7.6. Problems related to Media | 0.48 |
| 2.4.5. Lack of support from government officials | 0.48 | | |