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Identification of Various Execution Modes and Their Respective Risks for Public–Private Partnership (PPP) Infrastructure Projects

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Abstract: The public–private partnership (PPP) based model for the execution of infrastructure projects originated from Anglo-Saxon countries and was initially used in 1977 by the United Kingdom (U.K). Since then, its popularity has increased worldwide. Earlier studies by researchers and many other professional sectors and departments have introduced PPP contracts into different execution modes like Build, Operate, and Transfer (BOT); Build, Own, Operate, and Transfer (BOOT); and Build, Lease, and Transfer (BLT), etc. All definitions of PPP contracts are different but have a few common characteristics and risks. Previously, numerous pieces of literature were available on these common risks for various execution modes of PPP contracts. However, each PPP mode still has unique risks that must be identified to understand and successfully implement the PPP projects properly. This paper fills the gap mentioned above and aims to identify various commonly used PPP execution modes in infrastructure projects and their corresponding risks after placing the different PPP execution modes into four (04) different categories. Identified risks for the corresponding PPP categories were also divided into seven (07) stages of the PPP life cycle. Semi-structured interviews were conducted to gather information from thirty-four (34) PPP experts worldwide. Accordingly, interviews are transcribed and processed for thematic analysis in academic NVIVO software. These identified risks are further placed in the respective PPP category for the convenience and better understanding of the study's outcome to the users and for the subsequent prioritization and allocation of these identified risks accordingly to the PPP parties during the finalization of the PPP execution mode.

Keywords: public–private partnership (PPP); infrastructure projects; risk identification; PPP execution modes; public and private sectors; NVIVO hierarchy charts

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1. Introduction

The PPP is a venture between the public and private sectors based on the expertise of each partner to accept the respective risk for the successful execution of the projects traditionally provided by the public sector [1]. The private sector can earn a long-term contractual relationship with the public sector to improve the company's reputation. In contrast, the public sector can take the monetary benefits and use the exposure to the latest technology through the execution of PPP projects [2].

It is a fact that PPP modalities are used for the execution of infrastructure projects under uncertain environments despite their experience has reached almost at maturity level in the UK and other developed countries like France and Germany, which have

now accepted it as a traditional execution method has not produced desirable output of project performance regardless of extreme care taken at early stages of the projects [3]. The PPP-based model originated from Anglo-Saxon countries [4] and was initially used in 1977 by the UK. Since then, its popularity has increased worldwide, and in the current years, it is spreading swiftly in China [5] and other countries in Asia, Africa, and Australia on a large scale [4]. PPP regime has now spread to around 134 developing countries with 15–20% of the total investment cost of infrastructure projects [6]. PPP has now become a vital part of public procurement due to budgetary constraints, deficient technological expertise, less risk acceptability by the public sector organizations, less PPP exposure, untrained human resource, gaps in demand and supply, and political pressure for improving public services projects [7]. The PPP procurement approach is widely used for various sectors of infrastructure projects such as highways, residential colonies, health care facilities, water treatment plants, etc. [8]. Considering the complexity of the PPP procurement approach, it is essential to identify its related risks comprehensively throughout the life cycle of the PPP projects arising from the multiple dimensions [9]. It is also imperative to identify the risks of the respective modality of PPP contracts to properly allocate risks when developing the risk allocation matrix of PPP projects [10].

Earlier studies by researchers and many other professional sectors and departments have introduced PPPs in various execution modes in multiple countries like BLT, BTO, BOT, BOOT, BOO, PFI, BTL, CAO, etc. [11–13], wherein all definitions are different but have few standard features [12]. For example, in BTL, the private sector builds the infrastructure facilities, the ownership is transferred to the public sector after the completion of the project, and rights of operation of that infrastructure facility are given to the public sector. In the BTO contract, the private sector quotes the operations charges to recoup its cost from user levy charges. Both Build and Transfer are the same in these modes, but the infrastructure facilities are leased to the public sector by the BTL private sector. In such cases, the public sector pays the lease amount and the operational cost to the Concessionaire. BTL mode is usually employed for non-profit works or services such as sewer, housing infrastructure, and other dormitories [13].

A risk is an unanticipated event or state that, if triggered, has positive or negative consequences on one of the project objectives, which can be termed as opportunities or threats, respectively [14]. Famous tools and techniques used to identify risks are interviews, meetings, brainstorming, SWOT analysis, checklist items, and meetings. PPPs are more vulnerable in terms of uncertain events happening and carry various and critical risks as compared to the traditional types of public contracts, including outsourcing services and works [5]. The objectives of the study are to identify the various execution modes of PPP infrastructure projects and their corresponding risks pertaining to the respective categorized PPP execution modalities.

2. Literature Survey

The Transaction Cost Theory [15] best explains private partnerships in PPP infrastructure projects. The theory is related to the degree of risks the private party accepts depending on the future benefits and privileges in return for taking risks. Moreover, Agent Theory or Principal-Agent theory [6] also describes that the public sector must establish an environment that not only corrects the moral hazard related to the prospective private partner but also provide a conducive and attractive environment for the private partner.

In the last twenty (20) years, the research interest of scholars has increased in the PPP domain, especially in European countries [16]. The growth of PPP and its role in various projects is not a fresh concept, but it is experiencing renewed curiosity in the study of PPP as a tool for better development planning. Outstanding public debt and financial constraints are placing pressure on the state and governments around the globe for the participation of the private sector in various socio-economic development programs [17]. Moreover, it rearranges services related to the public sector by considering private sector worth and good practices to achieve better project performance than traditional procurement methods

of delivering public services [18]. Current studies locate PPP as a partnership of cooperation and contractual obligation among the state, government, and private sector to share risks, opportunities, and costs to accomplish some responsibilities and activities to accomplish a collective objective [19] as described in Transaction Cost Theory above.

Different stakeholders involved in any project under PPP procurement modes have different perceptions regarding risk assessment. As a result, disagreements may arise among stakeholders that affect the project performance [20]. Thus risk identification, followed by its allocation, is an ambiguous task [21]. Moreover, stakeholder relationship leads to a viable long-term method for improving social linkages, enlightening the value of public means, and creating a better use of taxpayer collection [20]. Intensive efforts have been placed on the improvement of ways by which the public and private sectors can strengthen corporations to provide goods and services traditionally provided previously by the public sector only. The different perceptions of the stakeholders may produce the best and fair results; that is, the outcome that reduces the possibility of bad performance [21]. The reviewed literature on different forms of PPP projects shows that most of the studies are conducted on PPP infrastructure projects. The title of most of the studies belongs to critical success factors of PPP, risk related to PPP, and the BOT tendering process for bringing value for money [22].

Every PPP agreement is differently structured, and therefore the type of risks are different for each stakeholder due to the diversity in each PPP modality [23]. Assessing all risks is key for proper project management at various stages of the project life cycle period [24]. This leads to suitable risk allocation and sharing, which is inevitable for negotiation [5] and brings transparency, fairness, and value for money to PPP projects [25]. Inconsistency in risk assessment and management is one of the barriers to the successful execution of the PPP project [26]. Lack of readiness to accept risk by either of the stakeholders delays the project [23]. Risk aversion by the stakeholders during the entire life cycle of the PPP projects due to the improper risk allocation in PPP projects was highlighted in past studies [27].

World Bank manages a facility for technical support that is known as Public–Private Infrastructure Advisory Facility (PPIAF) [13]. It summarizes the modes and types of PPP in accordance with the main attributes and characteristics of various definitions of PPP, as shown in Figure 1 PPIAF (2012, May) [28]. In this figure, PPP modalities in existing assets are surrounded by concession, operations and maintenance, management, and service contracts. PPP modalities are surrounded by BOOT, BTO, and turnkey contracts.

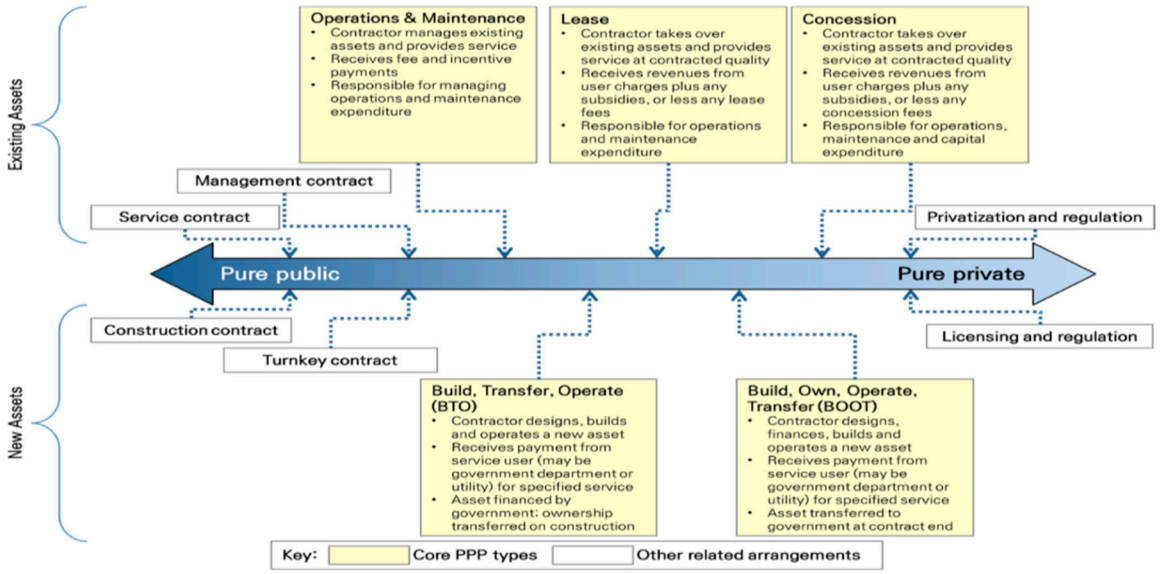

Figure 1. Core PPP contract types and categorization Public–Private Infrastructure Advisory Facility (PPIAF).

The BOT execution mode of PPP is widely and commonly used in the world, especially for greenfield projects [29]. Economic theorists consider this model as the conical form of PPP infrastructure projects due to its greatest attraction and theoretical interest [30]. BOT type of PPP modality has a positive impact on the growth of the countries and is commonly used where the public sector lacks the resources to build large-scale infrastructure facilities [31]. BOT is a contractual type whereby the private sector arranges the financing and undertakes the construction of infrastructure facilities and the operation and maintenance thereof. The private sector operates the facilities over a fixed period of time during which it is permitted to collect from the users of that project facilities in terms of appropriate tariffs, fees, levies, tolls, rentals, or charges, as agreed in the bid not exceeding those proposed rates of the bid [32] described in the agent cost theory above. The private sector then transfers the facilities to the public sector at the contract ends. BOT (Toll), BOT (annuity), DBFOT, hybrid BOT mode (toll + grant) [33], DOT, ROT, and BOR execution modes are almost similar, with slight variations in concession agreements. In BOR, the private sector has the right to make a request to negotiate for the revision of the concession at the end of the term [32]. DBFOT mode also includes the investment of private sectors to construct, design, finance, operation, and maintenance of a venture for public usage for a certain period of time and then transfer the facilities to the public sector after the expiry of the ownership period. The Concessionaire is able to collect the revenues or user levy from the facility users. The private entity collects the fee from the users as quoted in the bid submission stage. The expectations of the private sector are to collect sufficient revenues to recoup its investment in the project [34]. A similar PPP mode DBFO with no transfer phase is more efficient in terms of cost and time for PPP infrastructure projects [35]. Notable examples of projects executed on BOT or DBFOT mode in Pakistan are the Lahore Ring Road (Southern Loop) project and the Lahore–Sheikhupura–Faisalabad Dual Carriageway [36]. In order to address the failure of demand forecast, attract investors and promote privatization and investment by the private sector, BTO (risk sharing) and BTO (adjusted) modes were introduced and adopted by the Korean Government for the construction and rehabilitation of railway-related projects. Both public and private sectors share the revenues and operating costs in the BTO-rs mode of PPP infrastructure projects [13]. However, in BTO (Adjusted), the risk sharing in revenue loss is adjusted as agreed by the parties [37]. AP-PPP also falls under the BTO-PPP types of contracts [38]. One of the types or modalities of PPP contracts is the present value of revenues contract (PVR), which is an example of a flexible contract in order to minimize the demand risks of the revenues [39]. Flexibility in contracts provides various options for the public and private sectors to compensate for the risks in accordance with the concession agreement. A minimum revenue guarantee, which is also termed a minimum income guarantee or minimum demand guarantee, could be a possible inclusion in the agreement. The public sector shares the demand risk partially in infrastructure projects [13].

In the Republic of Korea, the PPP procurement types are based on whether the project facilities are to transfer back to the public sector or not on the completion of facilities of PPP projects. The foremost type is also called the revertible type, which includes BOT, BLT, BT, BTO, etc., and the other is called the non-revertible type, which includes BOO, DBFO, etc. On the basis of the collection of user fees, PPP infrastructure projects are categorized as whether to collect directly from the users or through operations and management rights, i.e., BTO, or from ownership rights, i.e., BOOT, BOO, etc. [37]. The BOO execution model is akin to complete privatization, and the private sector has no obligation to transfer the project facility assets to the public sector [29]. This execution modality is used when the private sector wants to keep ownership of the assets even after the contract ends [29]. One of the disadvantages of this mode is that the private sector uses the project's public facility throughout its life period. The public sector should create an interface between the old and new operators of the venture by making sure that the new party takes care of the system's features and that personnel are well-trained [40]. Some notable examples of projects executed in BOO mode are the Shuweihat-2 Power and Desalination Plant,

United Arab Emirates, and the Manila Water Supply and Sewerage System, Philippines. BOOT mode is also similar to BOO PPP mode, with the responsibility that the infrastructure facility is transferred back to the public sector after the pre-determined concession period [41]. BOOT is a significant PPP execution mode for the development growth of infrastructure projects. This modality is now being practiced in many developed and developing countries like Australia, the USA, Canada, the UK, India, the Philippines, Malaysia, etc. [42]. Notable examples of executed projects in BOOT mode include the Sydney Airport Link in Australia [42].

BLO execution mode includes that facility ownership remains with the private party who leases the facility to the public sector for a longer period of time without any transfer of assets responsibility. The public sector is responsible for the operations and maintenance, renewal, and replacement of assets and gives attention to maintaining the interface between the construction phase and the operation phase [40]. A few notable examples of projects executed in BLO mode are the Mount Signal Solar Project in the United States and the Delhi International Airport in India. In the BLT execution mode, the private sector leases the completed facility to the public sector or others for a concession period until it recovers its investment before transferring the facility owner to the public sector [43]. Moreover, the Concessionaire finances builds and maintains the project for a predefined period and leases the assets to the public sector for fixed revenue payment and rental payment of these assets [44].

In the LOT execution mode of PPP, the existing infrastructure facility is for efficient operation to the private sector for a certain period of time. After the completion of the predefined concession period, the facility is transferred back to the public sector [41]. Transfer–Operate–Transfer (TOT) is a PPP mode that is suitable for brownfield projects, and the facility is transferred to the public sector after the contract ends [29]. Other renowned PPP execution modalities are the SC, the MC, and outsourcing-like contracts wherein the ownerships lie with the public sector and investment responsibilities lie with the private sector. Management contracts have a slightly longer duration than service contracts [33]. Sewage treatment plants in China are mainly operated through the PPP modalities, which include BOT, BOO, ROT, OM, TOT, BOT + TOT, and others. BOT is selected for most of the cases, up to 83.7 percent of total sewage treatment projects in China [2].

In the BOLT execution mode, the private party builds and expectedly designs the infrastructure project and leases the facility to the public sector. After the end of the concession period, the facilities are returned back to the public sector. Most of the PPP modalities are suitable for transportation projects with revenue collection, but this mode is equally suitable for other social projects [41]. BLOT and BLMT execution modes of PPP are similar, with a slight difference in terms of operational responsibility in the first case and maintenance responsibilities in the second case lying with the private sector over the concession period [2]. Quite a few infrastructure projects have been executed in China on these modes since the inception of the PPP regime in the country [45].

In the Philippines, BOT law exists, which includes various PPP modalities, including BT, CAO, DOT, and ROT execution modes [37]. BT is a PPP execution mode whereby the private sector arranges finances and undertakes the construction of the infrastructure project facilities and, after its successful completion, transfers back to the public sector. The public sector maintains, operates, and recovers the investment cost from the users as per the agreed schedule. Operations and maintenance phase risks lie with the public sector due to security or strategic reasons. Whereas, in BT + LUF, the public sector recovers the finances of the project through land use by real estate developers [46]. Moreover, DBB is the PPP execution mode whereby the public sector retains a designer to deliver the whole design part and, after then, publishes an advertisement for the award of construction works separately, keeping in view the completed bidding construction documents of the designer. DB, DBO, DBOM, and DBOFM are akin with slight variations in the contractual arrangements [47]. Various projects around the world are executed on DBOFM mode, and notable examples include the Hong Kong–Zhuhai–Macau Bridge and the Tappan

Zee Bridge Replacement Project in New York. CAO is a PPP modality with a contractual arrangement wherein the Private sector develops and expands existing infrastructure facilities leased by the public sector. The private sector operates the developed facility and collects the user charges to recover his investment cost over the agreed period. Transfer facilities may or may not be linked with this type of PPP modality by the private sector [11].

Apart from the previously mentioned PPP execution modalities, BBO and DBL modes also exist for the execution of PPP projects in Indonesia and other countries but are very uncommon. The assets are built and acquired by the private party for effective management in this particular PPP mode for infrastructure projects [37]. The extent of public and private participation in various PPP types of agreement is described in the Figure 2 below.

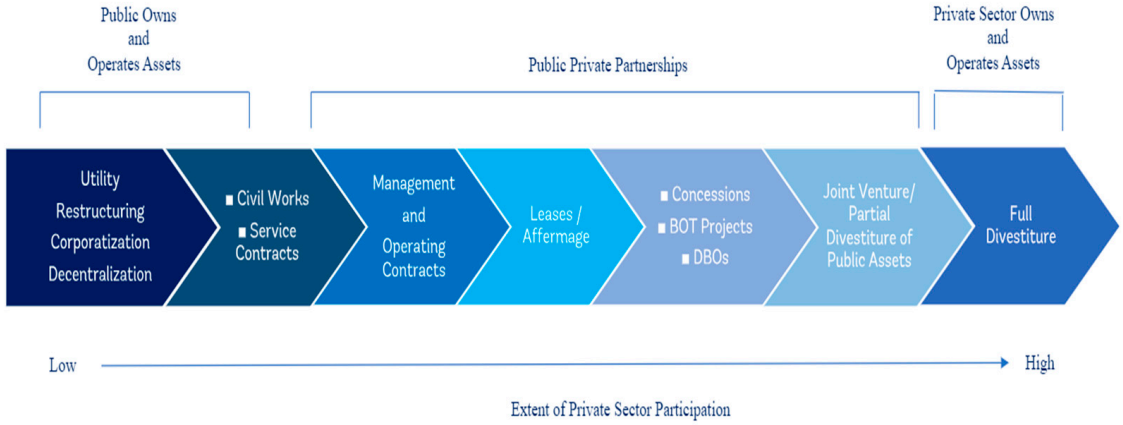

Figure 2. The extent of public and private participation (https://ppp.worldbank.org/public-private-partnership/agreements (accessed on 3 March 2020).

Moreover, most of the time is consumed for contract negotiation in PPP/PFI projects due to the uncertainty in the proper identification of risk at the initial stages, which ultimately drives the prospective bidders to quote expensive bids [25]. Researchers identified the critical success factors for PPP projects, including stable macroeconomic variables, responsibility sharing among stakeholders of the project, a stable environment politically and socially, transparency and efficiency in the procurement process, and judicious government control [48]. PPP projects normally follow the base case scenario at the time of the award of the contract, and to make it flexible, overwrite clauses in the contract agreement are included to cope with volatility in the macroeconomic variables. For dealing with such risks, the government retains most of the risks and explores different forms of PPP agreement, simulating different possibilities by the public departments to extract the risk threshold values for retaining risks. The surplus revenue generated through the approach of a flexible contract is retained with the Concessionaire, but the handsome contribution also goes to the public entity [49]. Researchers also report the results of a comparative analysis of the preference for risks in PPP projects [50]. It is broadly acknowledged that risk assessment is fundamentally required for the successful execution of PPP projects [9]. At the early stages of the PPP procurement process, public clients present the identified risk to the private party for bidding purposes, and during negotiations, these risks are allocated to the party best suitable to manage the risks [25].

3. Research Methodology

Research methodology is a source of guidance for researchers to conduct research from start to end [51]. Qualitative type interviews followed by an extensive literature review and desktop data were conducted in order to fill the gap of deficiency in the existing literature [3]. Semi-structured formats for in-depth exploratory research were developed for the identification of various modes and respective risks of PPP infrastructure projects because the goal was not to generalize the results of the study but to explore from the thorough

participation of the respondents [52]. Initially, the questionnaire was distributed to the respondents, which was revised from interview to interview, considering their suggestions for improvement from the informants [53]. Open and close-ended questions were asked in the questionnaire to give the liberty to the informants beyond the protocols as mentioned in Appendix A of the study to establish related useful additional information [54].

Most of the questions were from the interview protocol; however, additional questions were also asked from the interviewee for the sake of obtaining extra information. The current study includes the representation of informants from all over the world. Most of the respondents are from public, private, or advisory sectors, as shown in Figure 1. The list of informants has fifty (50) people. Hard and soft copies of the questionnaire were sent to them at their official addresses, email addresses, or through other electronic means. Forty (40) people responded to the questionnaire and agreed to give interviews to share their perspectives regarding the identification of various PPP modes and respective risks. Interviews are conducted in their offices, and some of them agreed to record their interviews after their consent on the Zoom meeting link. According to [55], the data saturation was completed with 30 informants. However, four more interviews were added to the study to ensure that any further information could be added to the study. Thirty-four (34) informants included twenty-five (25) male and nine (09) female PPP experts. Interviews were conducted with the personnel of various organizations, which include the public and private sectors, the Independent consultants and advisors, and the Concessionaire (SPV) organizations, as shown in Figure 3 below.

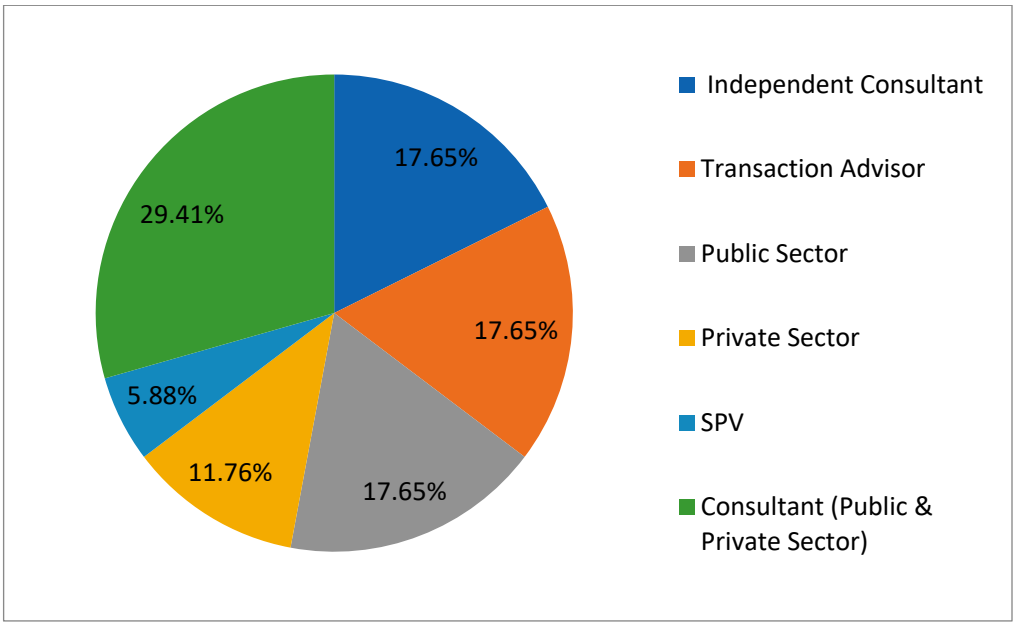

Figure 3. Organizational type.

The top-level experts and the middle-level experts from various organizations were approached through various references telephonically, zoom meetings, or meeting at their places for the interview purposes, with the range of their experiences varying from five (05) years to twenty-five (25) years, as shown in Figure 4 below.

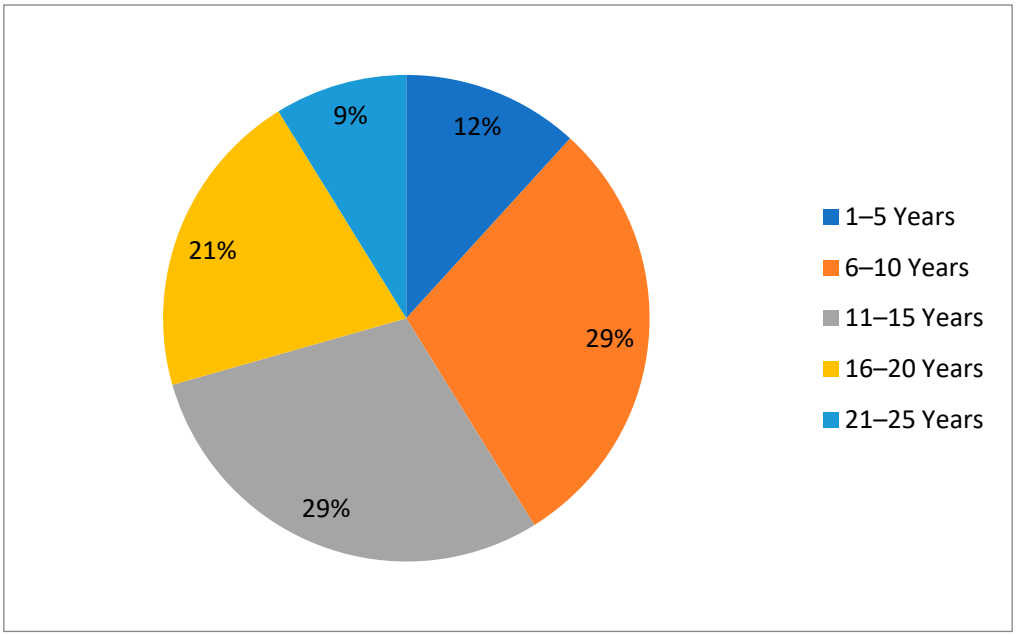

Figure 4. Experience of respondents in years.

The educational background of the respondents is shown in Figure 5 below. The duration of the interview was thirty (30) to forty-five (45) mins depending upon the satisfaction of the researchers.

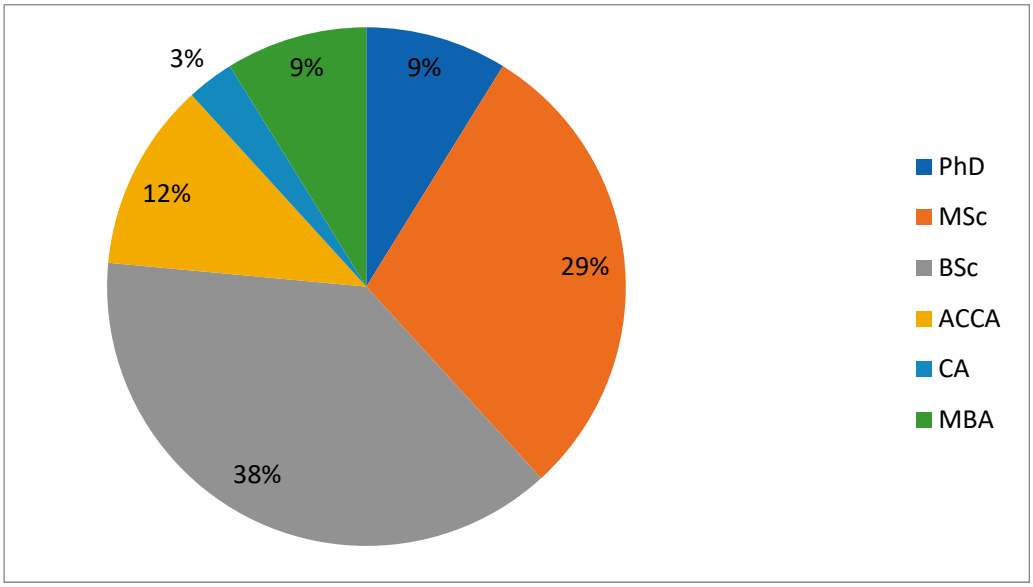

Figure 5. Educational background.

The research methodology is shown in the following Figure 6.

Six steps of thematic analysis [56] were performed for the identification of PPP modes and their respective risks. These steps are data familiarization, generation of the primary theme, searching of theme, reviewing of themes, naming of themes, and result generation. The coding method was used both for deductive and inductive reasoning, and the former started with a basic structure for coding.

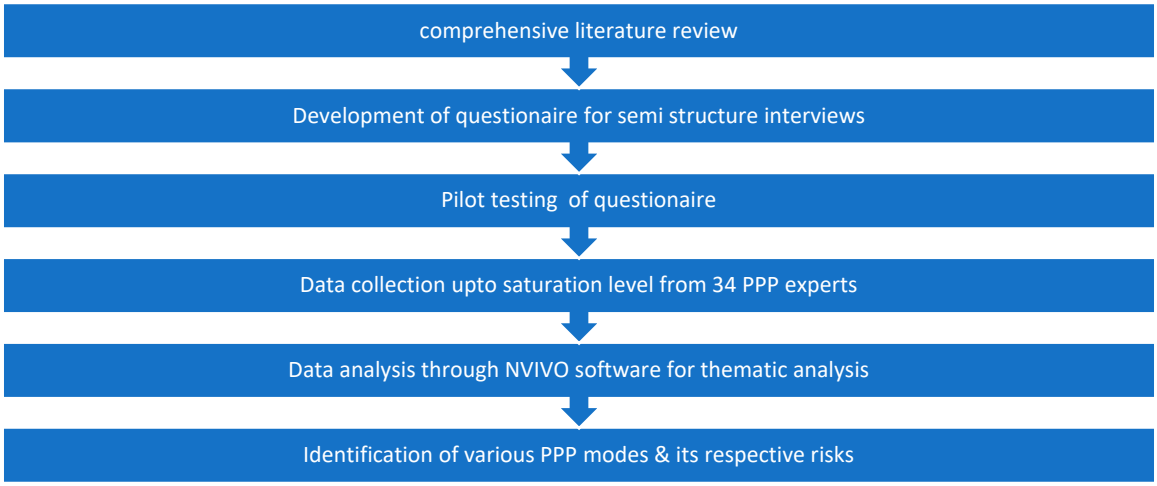

Figure 6. Research methodology.

It was performed through the NVIVO academic software, which allows for performing analysis of unstructured and qualitative data. It is also helpful for classification and rearranging the data for the users. Parent codes were created by the authors on the basis of four (04) categorizations of PPP infrastructure projects, i.e., the DBFOT-BOT type of PPP contracts, the lease–affermage BLT type of PPP contracts, ownership-BOOT type of PPP contracts, and the services, operations, and maintenance type of PPP contracts. Child nodes are grouped with mode "name". Child nodes were further divided into their respective risks identified by the interviewees after reviewing the transcribed data and labeling the codes with the names mentioned by the practitioners. The overall coding exercise in NVIVO is shown in Figure 7.

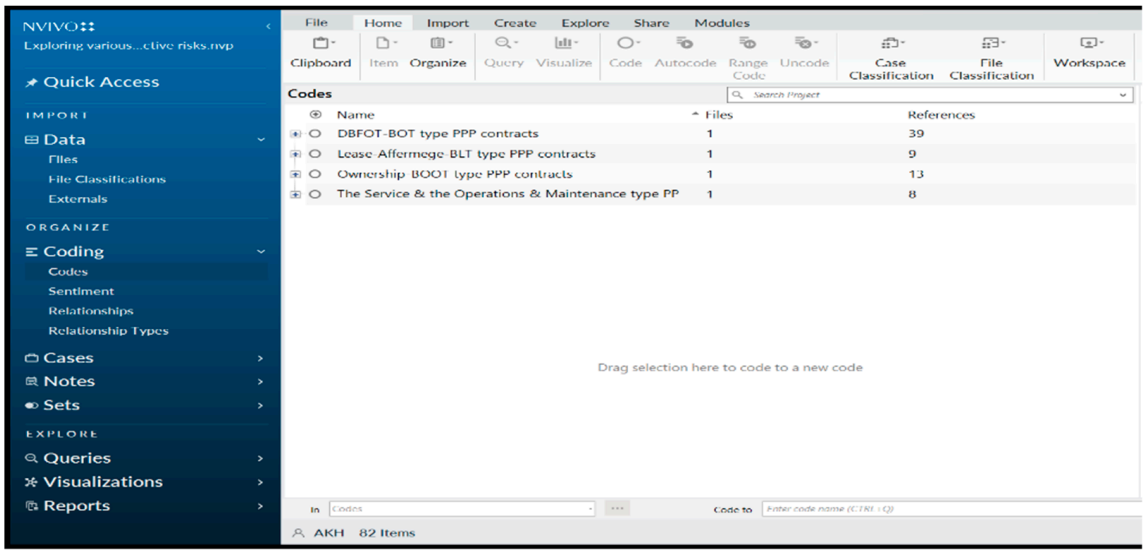

Figure 7. The NVIVO coding and the hierarchy chart.

4. Research Results and Discussion

The study identifies the various execution modes of PPP infrastructure projects adopted around the world and also the identification of associated risks of these PPP modalities. Subsequently, interview data were gathered in the form of partial audio recordings after soliciting the consent of the respondents and partially from the interview notes taken from the informant's interviews in their offices or places. Data analysis was performed on NVIVO academic software, and developed the parent codes and child codes, as

mentioned in Figure 7 above. NVIVO created the overall coding for the transcribed data, a purview of it as under;

Figure 8 shows the overall coverage of PPP modes and their respective risks by the respondents on the basis of data collected for the study. The data taken from the previous literature were also discussed with the respondents, and the concept of each perspective was supported accordingly. The world cloud shown in Figure 9 highlights the importance of each identified factor according to the perspective of the experienced personnel.

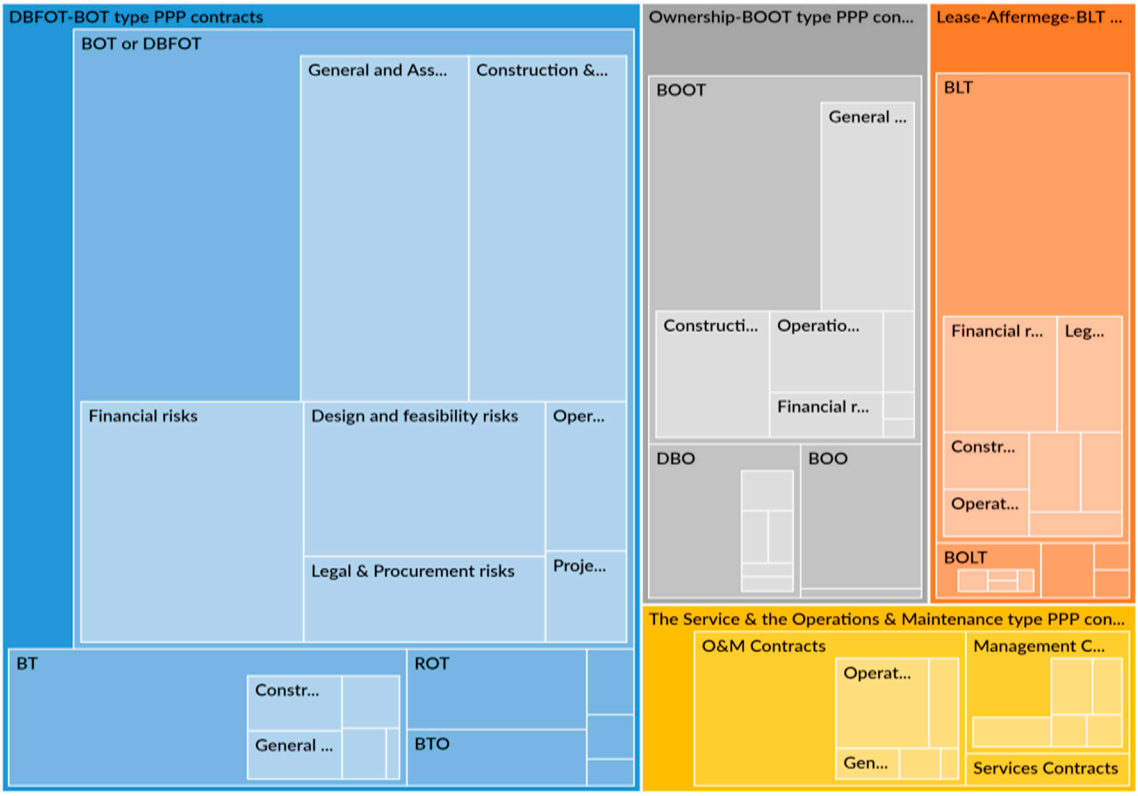

Figure 8. The purview of overall NVIVO coding of transcribed data.

Figure 9. NVIVO word cloud.

Figure 10 shows the analysis of the first category, i.e., DBFOT-BOT type PPP contracts, which include BOT or DBFOT; both modes are akin with different nomenclature according to most of the researchers, BT, BTO, DOT, DBOFT, CAO, TOT, and ROT. Most of the respondents talk about the BOT or DBFOT mode in this category along with their respective risks, which shows the importance of the BOT modality in the construction and execution of infrastructure projects around the world, especially in tolled roads and highway projects. The importance of mode under this category can be seen in Figure 10 [44]. Phang categorized the PPP risks related to infrastructure projects into the planning, design, and feasibility risks; the financial risks; the legal and procurement risks; the construction and execution risks; the operations and maintenance risks; the general and project environment risks; and the completion and transfer of assets risks. In the BOT mode of construction, the importance of the general and transfer of assets risk, the financial risks, the construction and execution risks, and the design and feasibility risks is highlighted in the following hierarchy chart.

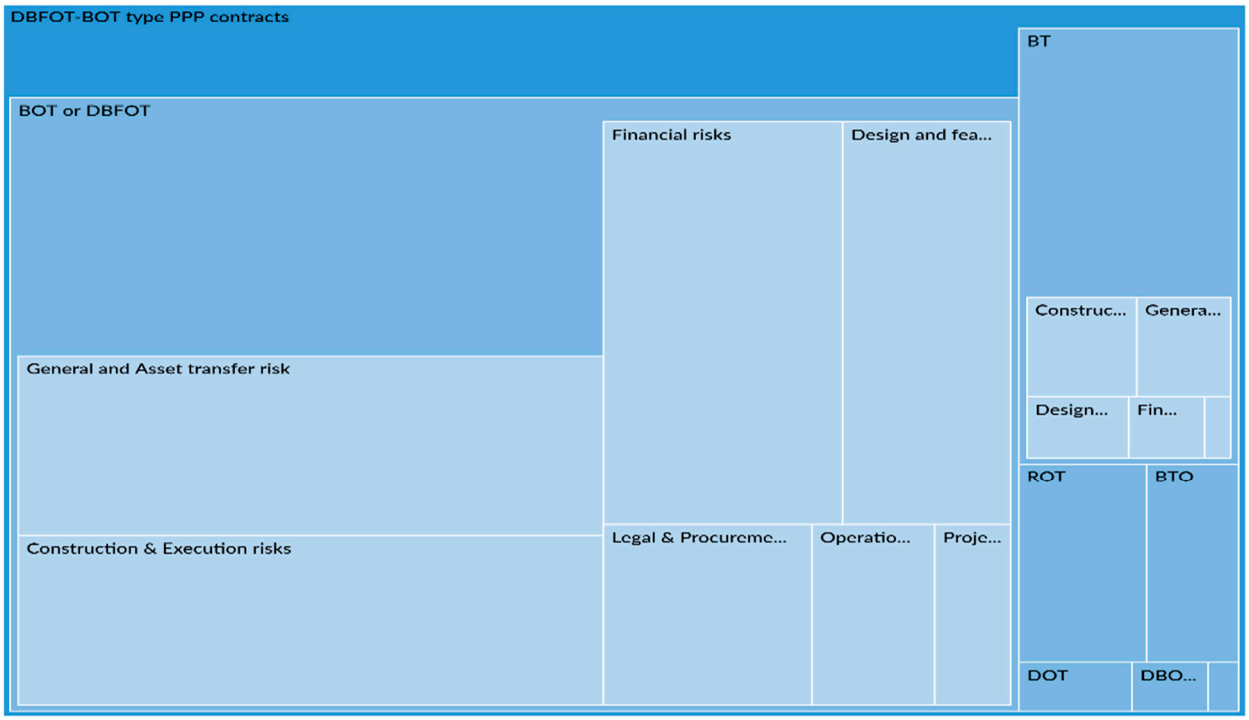

Figure 10. NVIVO coding of DBFOT-BOT Types of PPP contracts.

Broadly, two types of PPP road infrastructure projects are known as greenfield and brownfield projects. New construction, building, and developing a project is placed in greenfield type of projects, whereas rehabilitation, renovation, restoration, or upgradation of existing infrastructure facilities comes under brownfield or grey-field types of PPP projects. The earlier one is also expressed as Private Finance Initiative (PFI) in the UK, and the latter one is also termed the integrated PPP approach [57]. BOT with availability-based payment is usually conducted in social types of infrastructure projects. BT is a PPP execution mode where the public sector has two assets where either of the assets is capable of earning revenue, and the other is not. The mode of payment is managed through annuity-based or availability payments [33].

The provision of drinkable water from sea water in Saudi Arabia is being planned, where the public sector provides the annuity to the Concessionaire for recoupment of his investment in the project. Developing countries with no PPP experience have inherent risks attached to them due to a lack of experience/talent and limited competency and resources to undergo PPP projects, which vary from country to country [58]. The inherent risk, the poor cost estimation risk, the unproven engineering techniques risk, the soil contamination

risk, the poor geotechnical investigation risk, and land availability or acquisition risk are significant risks coded under the planning, design, and feasibility risks NVIVO code.

Cost estimation risk in greenfield projects is a prevalent risk. Huge differences in cost estimation at the feasibility stage of the project and at the completion stage of the project can be faced due to this risk in different PPP projects around the world. Poor geotechnical investigation is one of the reasons for inaccurate cost estimation [59]. A similar kind of risk in the shape of soil contamination was faced in one of the PPP infrastructure projects in Australia, where poor estimation added around 15% extra to the cost of the project. The contractor blamed the public sector, and vice versa, and the matter went to court. Consequently, stoppage of work was an option for private entities on that specific portion of work until the time of its resolution amicably. The extra cost was divided between the three parties by the court, and the executor bore the most part of the cost because the whole project was to be managed for a longer duration. In comparison, the design and estimation of infrastructure project is usually available for brownfield ROT types of infrastructure projects. There will be more Brownfield ROT types of PPP infrastructure projects in the future due to the deteriorated conditions of the roads and other infrastructure facilities [60].

A few significant risks related to legal and procurement risks include the insolvency of the concession company, the provision of encumbrance-free land risk, the condition precedents risks, the change in law risks, the regulatory risks, the ownership risks, and the imports and supply chain risks.

Figure 11 highlights the PPP modalities and their risks under the lease–affermage BLT type of PPP contracts. BLT, BOLT, BLOT, BTL, BLMT, BLO, DBLOT, and LOT are the PPP modalities placed under this category. The importance of each execution mode with respect o the responses of the respondents can be seen in Figure 11. In BLT mode, the Concessionaire builds and constructs the project assets and hands them over or leases them to the public sector for the recoupment of investments of the investors of the project [43]. BLOT and BLMT are alike modalities of PPP with a slight difference in the shape of separate responsibilities, i.e., the management responsibility or the responsibility of the operations, or both. For example, in the development and construction of an industrial estate, Concessionaire builds the infrastructure and leases out the residential and commercial plots to the public sector for a certain period of time, whereas the operations and maintenance responsibilities shall remain with the private sector.

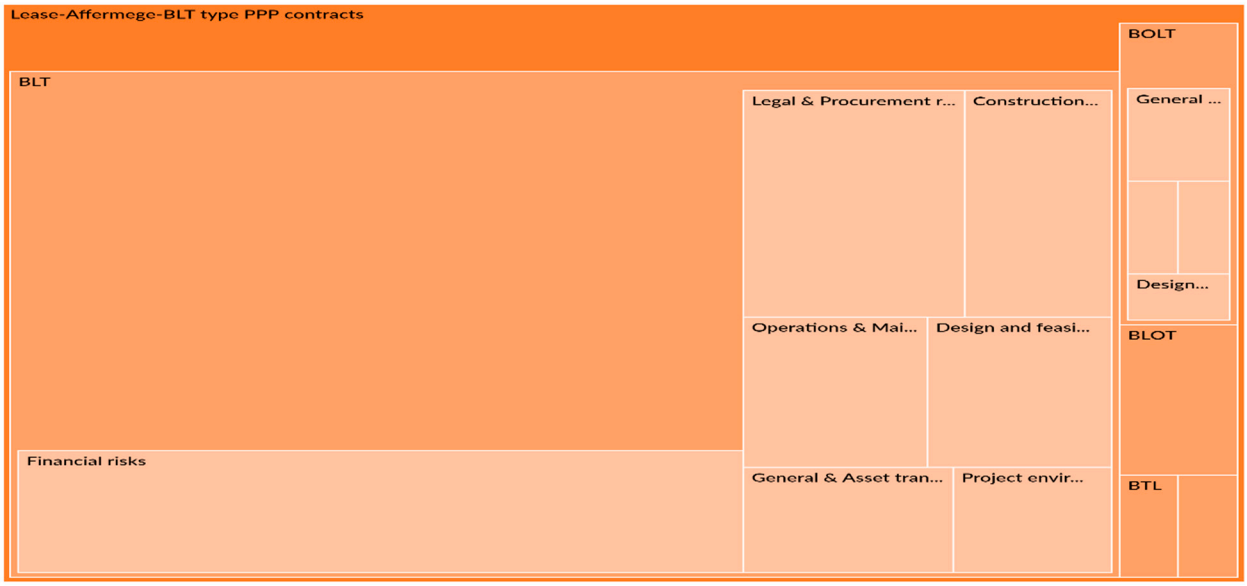

Figure 11. NVIVO coding of lease–affermage BLT types of PPP contracts.

Another major risk in PPP infrastructure projects is the availability of finance. Most of the projects failed due to this risk because, at the stage of feasibility study/initial stage, this

risk is not fully assessed by the stakeholders. Another potential risk is price escalation risk, which triggers the commonly known cost overrun risk, especially in developing countries. As the said risk is covered in the traditional types of contracts, therefore it should be covered in PPP greenfield projects by considering its severity and multifold consequences [57]. At present, there is an unprecedented price hike and currency devaluation, and ultimately, it is the responsibility of the Concessionaire to take the burden of these risks during execution. The compounding effect of these parameters is too much. Inflation risk and foreign exchange risk are also major risks in the current scenario of the world's economy and should be properly addressed at the time of developing the transaction structure of PPP infrastructure projects. Foreign currency exchange-type risks are predominantly seen in independent power producer (IPP) contracts. Developing countries are facing balance payment crises, and they have to go to the international monetary Fund (IMF); therefore, the private sector is receiving delayed payments, but in the end, they are unable to obtain foreign exchange from the market and unable to provide the dividends to the shareholders. Interest rate risk is available in all types of PPP modalities. Few transactions of PPP are available where the government can take up this risk, but in developing countries, it is unheard of where the government can take up this particular risk. After achieving financial close, the public sector leaves you with your buyers or other stakeholders. But, this is not the case in developed countries of the world. The importance of revenue loss risk, demand risk, tariff risk, commitments with financial institutes, and financial close risk cannot be ignored [50]. The competing routes risks and the force majeure risks cannot be ignored during the current COVID-19 pandemic period. Construction materials and prices of other goods have increased too much due to COVID-19; the global supply chain has been disturbed, which had severe effects on the PPP projects, where the countries are dependent a lot on imports. All these risks are placed under the financial risk NVIVO code.

A few typical risks specifically belonging to the lease–affermage BLT type of PPP contract category are explored by the practitioners the tenant/lease risks, the revenue shortfall risk, the property-related risk, and the market risks. Some of these risks are a new addition to the existing literature. However, the existing literature does not bifurcate these typical risks for this category, which create difficulty for the executors to properly identify and allocation of these risks to the concerned stakeholders.

Figure 12 elaborates on the PPP modalities and their respective risks of the ownership-BOOT type of PPP contracts. This category includes BOO, BOOT, DBO, DB, DOO, and DBOOT PPP modalities. The importance of each execution mode with respect to the responses of the respondents can be seen in Figure 12.

PPP modality wherein ownership of assets belong to the private party, i.e., BOOT types of projects, risks related to land acquisition can be easily managed by the public sector because the ownership responsibility is shifted to the private sector [37]. Also, BOOT is popular in the power sector because technology related to the power sector obsoletes, especially in a long concession period, i.e., 25 years; therefore, the public sector does not want to take ownership of assets being useless after the concession period. Asset management risks due to lack of research and development in PPP projects, depreciation risks, residual value risks, obsolescence risks, disposal risks, maintenance risks, interconnectivity with other roads, and partnership risks are typical examples of risks pertaining to ownership-BOOT type of PPP contracts.

Thus, the completion and asset transfer risks phase have more coverage in this particular category, as shown in Figure 12 above, which includes the asset maintenance risks, market demand risks, residual value of asset risks, obsolescence of asset risks, transfer of assets risks, ground condition, the conditional survey of assets risks, and the ownership of assets risks. After general and asset transfer risks, the construction and execution risks have more coverage, as shown in the above figure. This section includes vital risks like construction disputes and strike risks, construction cost overrun risks, quality risks, availability of manpower and material risks, site availability risks, schedule risks, shifting of utility risks, and scope creep risks. Corruption risks, regime change risks, political risks,

environmental permit risks, lack of R&D in PPP, and ground and weather conditions are significant risk factors of the general and environmental risks phase of PPP projects.

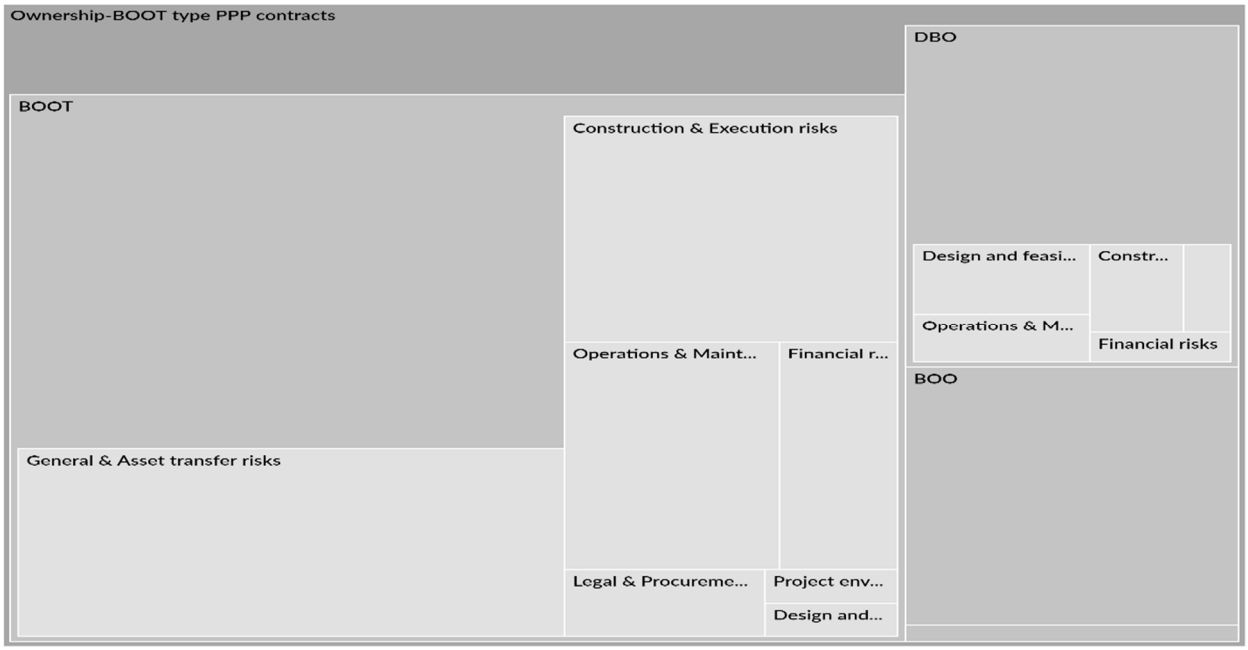

Figure 12. NVIVO coding of ownership-BOOT type of PPP contracts.

The last category of PPP modalities is the services and the O&M type of PPP contracts, which includes the O&M contracts, the management contracts, and the services contracts. In the service and the O&M type of PPP contracts, the private sector accepts the payment risk. Real estate developers, hospitals, and educational institutes are examples of the services and the O&M type of PPP contracts. Operations and maintenance risks have high weightage in this category, including performance risks; the operator's default risks, the low operating productivity risks, the low operational quality risks, and the operational cost overrun risks are prominent risks.

The deductive coding of the data was further assessed inductively by the researchers. It was found that BOT or DBFOT, BOOT, BLT, BT, BOLT, BOO, and the BOOT modalities are the most commonly used modalities around the world for the execution of the PPP projects, but BOT or DBFOT mode has a huge contribution for the execution of PPP projects around the world, especially in tolled roads and highways related infrastructure PPP projects. This is quite clear in the following Figure 13, where the NVIVO nodes are shown horizontally, and the percentage coverage of their corresponding transcribed data is shown vertically.

Finally, the identified PPP modalities for the execution of infrastructure projects were categorized, and the risks were identified along with their definitions for the respective categories summarized in Appendix B of the study and developed risk register by using both primary and secondary data [61,62]. The public sector offers a minimum demand guarantee (MDG) and minimum revenue guarantee (MRG) to attract private investment in PPP projects to cater to most of the risks in the risk register of Appendix B [63–70]. Moreover, a suitable Concessionaire for efficient project delivery is also an essential aspect of coping with these risks [18]. Due to the evolution in PPP, a slight shift from the traditional approach of PPP in the shape of revenue-based payments like BOT to availability-based payments like DBFM is also being used for the procurement of infrastructure PPP projects [51].

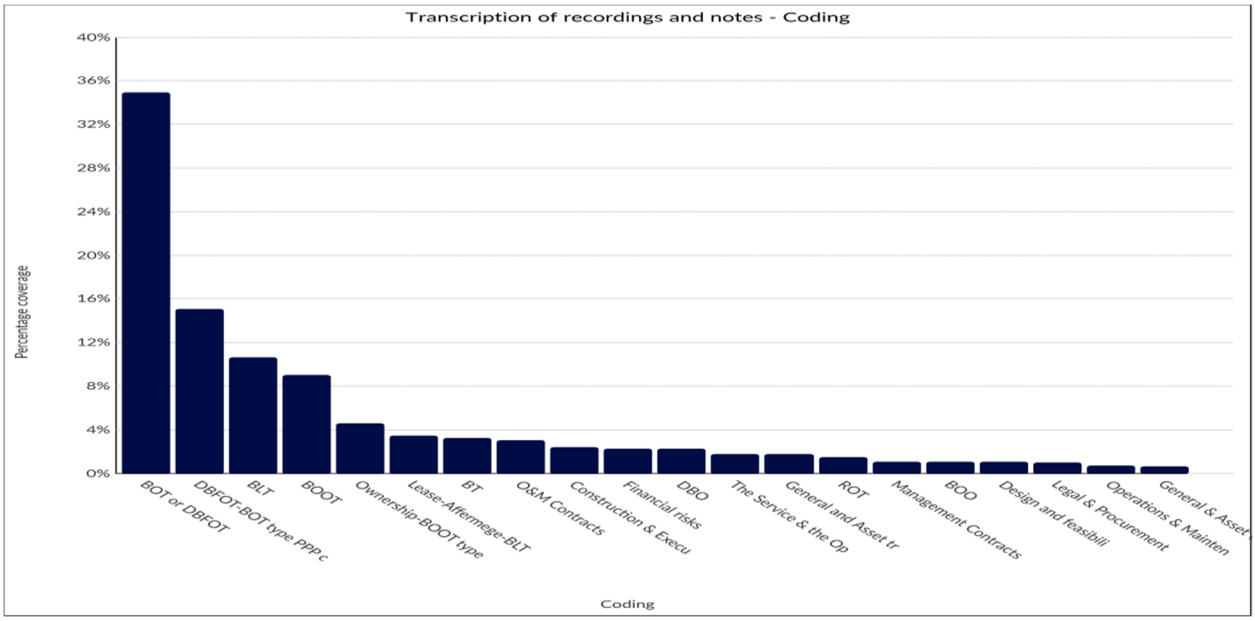

Figure 13. Percentage coverage of transcribed data.

5. Conclusions

The basic purpose of the study was to identify the various execution modes of PPP infrastructure projects and categorization of similar PPP modalities for a better understanding of the identification of risks to the respective categories. Various PPP modes were identified, and prominent modes of each category were extracted through thematic analysis on NVIVO software. BOT modality is a very commonly used mode around the world, especially in tolled roads and highways PPP projects, followed by BLT, BOOT, and O&M PPP contracts. On the basis of the difference in the arrangement of the PPP structure of these modes, the corresponding risks are also different, and the significance of each risk varies from mode to mode. This study concluded the desired results through a thematic analysis of NVIVO software and highlighted the importance and risks for each category. Four (04) categories are developed, and various modes of PPP infrastructure projects like BOT, DBFOT, BTO, BT, CAO, ROT, TOT, DBOFT, and DOT are placed under BOT-DBFOT type of PPP contracts. BLT, DBLOT, LOT, BLO, BLOT, BOLT, and BLMT are placed under lease–affermage BLT type of PPP contracts. BOOT, BOO, DBO, DOO, and ROOT are placed under the ownership-BOOT type of PPP contracts. O&M, the services, and the management contracts are placed under the services and the O&M type of PPP contracts. The respective risks of these categories are identified through literature review and data gathering approaches and placed in seven (07) stages of the PPP projects life cycle as the planning, design, and feasibility risks; the financial risks; the legal and procurement risks; the construction and execution risks; the operations and maintenance risks; the project environment risks; and the general and transfer of assets risks, except for the last category.

Previously, identified risks were not categorized in this way, and thus confusion remains there for the readers to identify and subsequently prioritize and allocate the risks to the stakeholders on the basis of risk significance, which varies from one PPP modality to another. For example, the significance of the transfer of assets risks, revenue risks, asset obsolescence, market demand risks, and productivity risks varies in BOT, BLT, BOOT, and O&M contracts. The comparison of which was made in the NVIVO hierarchy charts above. A few typical risks that specifically belong to the lease–affermage BLT type of PPP contract category are tenant/lease risks, the revenue shortfall risk, the property-related risk, and market risks. Similarly, asset management risks due to lack of research and development in PPP projects, depreciation risks, residual value risks, obsolescence risks,

disposal risks, maintenance risks, interconnectivity with other roads risks, and partnership risks are typical examples of risks pertaining to the ownership-BOOT type of PPP contracts.

The corruption risks, the political risks, and the regime change risks are the biggest threat to all types of PPP projects in developing countries and also have considerable impacts in developed countries. Researchers can prioritize the identified risks for their subsequent better allocation during the finalization of the PPP execution modality for all four categories to assess how the priority of risks changes in each category. Due to a large number of PPP execution modalities opted for the PPP infrastructure projects, it is difficult to find experts worldwide with hands-on experience in each modality, which was the limitation of the study. Therefore, these execution modalities are categorized into four (04) different categories.

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Abbreviations

PPP	Public–Private Partnership	PFI	Private Finance Initiative
BOT	Build, Operate, and Transfer	BBO	Build–Buy–Operate
BTO	Build, Transfer, and Operate	ROT	Rehabilitate/Renovate, Operate, and Transfer
DBOM	Design, Build, Operate, and Maintain	BLOT	Build, Lease, Operate, and Transfer
DBFOT	Design, Build, Finance, Operate, and Transfer	BOO	Build–Own–operate
DBFOM	Design, Build, Finance, Operate, and Maintain	BOOT	Build, Own, Operate, and Transfer
DBOO	Design, Build, Own, and Operate	BOOM	Build, Own, Operate, and Maintain
DCMF	Design, Construct, Manage, and Finance	ROOT	Rehabilitate, Own, Operate, and Transfer
O&M	Operations and Maintenance	DOT	Develop, Operate, and Transfer
DBO	Design–Build–Own	SC	Service Contract
BLT	Build, Lease, and Transfer	MC	Management Contract
BOOTT	Build, Own, Operate, Train, and Transfer	BOLT	Build, Own, Lease, and Transfer
CAO	Contract, Add, and Operate	SWOT	Strength, Weakness, Opportunity, Threat
PPIAF	Public Private Infrastructure Advisory Facility	DBOFT	Design, Build, Operate, Finance, and Transfer
TOT	Transfer–Operate–Transfer	LOT	Lease, Operate, and Transfer
DOOT	Develop, Own, Operate, and Transfer	DBB	Design, Bid, and Build
BLO	Build, Lease, and Own	LUF	Land Use Fee
BT	Build–Transfer	BOR	Build, Operate, and Renewal
AP	Availability Payment	PVR	Present Value of Revenues
BLMT	Build, Lease, Maintain, and Transfer	DB	Design–Build
DBFM	Design, Build, Finance, and Maintain	BBO	Build, Buy, and Operate
DBL	Design, Build, and Lease		

Appendix A. Questions Related to the Interview Protocol

First Part (Introduction)	• Please mention your name, position, education, and experience. • Please state the name of your company/organization. • What is the type of your organization? ○ Contractor/private entity, ○ Consultant (public sector) ○ Consultant (private sector) ○ Financier/sponsor, ○ Client/government entity/public sector, ○ Concessionaire/special purpose vehicle, ○ Independent consultant ○ Other (please mention your role)
Second Part (PPP Modes)	• How long have you been working on PPP infrastructure projects? • What modes of PPP infrastructure projects have you been involved in? • What other PPP modalities do you know in addition to the modalities mentioned in the above question?
Third Part (Associated risks)	• What are the major associated risks you have come across on various PPP modes? • What other critical risks on PPP infrastructure projects do you want to mention?

Appendix B. Identified Risks in Four (04) Different Categories along with Definitions

Risks	PPP Modalities			
	DBFOT/BOT Type PPP Contracts	**Lease/Affermage/BLT Type PPP Contracts**	**Ownership/ BOOT Type PPP Contracts**	**The Services and the O&M Type PPP Contracts**
(a)	**Planning, design, and feasibility risks**			Efficiency enhancement
1	Improper design and technical study **Definition:** Poor design team responsible for carrying out the technical studies			Unavailability of Investor
2	Land acquisition and compensation **Definition:** Difficulties faced by both client and consultant regarding route alignment for land acquisition and subsequently stay orders from the owners of the land during the compensation phase			Productivity Risks
3	Required initial approvals for a feasibility study **Definition:** Unnecessary delay in approvals from the concerned agencies at the initial stages of the project			Social Challenges
4	Improper preliminary survey **Definition:** Poor survey team responsible for reconnaissance survey			Reputation Risks
5	Inherent risks to conceiving PPP projects **Definition:** Incompetency or lack of experience in adopting the PPP modality, especially in developing countries			Performance Risk
6	Multilateral agencies and stakeholders' involvement **Definition:** PPPs have many stakeholders and agencies as compared to the traditional approach of executing projects			
7	Poor cost estimation **Definition:** Poor quantification of project items, including soil contamination and other construction items at the time of the planning stage			

Risks	PPP Modalities			
	DBFOT/BOT Type PPP Contracts	**Lease/Affermage/BLT Type PPP Contracts**	**Ownership/ BOOT Type PPP Contracts**	**The Services and the O&M Type PPP Contracts**
(b)	**Financial risks**			
8	Macroeconomic variables **Definition:** This includes inflation, GDP, Government fiscal policies, national income, international trade, and interest rate, etc.			
9	Availability of finance **Definition:** Adequate funds are available to the contractor during the construction of the PPP project phase			
10	Fulfillment of commitments with financial institutes **Definition:** This includes debt repayment to the financial institutes in an efficient manner as committed during financial closure			
11	Revenue shortfall **Definition:** Shortfall in revenues, user levies, and availability-based payments			
12	Financial rate of returns on investment Definition: Internal rate of return (IRR), return on investment (ROI), payback period, and net present value (NPV), etc., are the indicator of the risk.			
13	Financial insolvency of the host government **Definition:** The host government could not remain financially stable and became bank corrupt			
(c)	**Legal and procurement risks**			
14			Ownership of assets **Definition:** Concessionaire is fully responsible for projects assets	
15	Change in Law **Definition:** Post-bid changes in any existing law by the government that affects any of the project objectives			
16	Insolvency of the public or private sector **Definition:** Insolvency of either public or private sector			
17	Third-party reliability **Definition:** Any unexpected disagreement arising from the third party regarding the fulfillment of contractual obligations			
18	Institutional nature arrangement **Definition:** Poor institutional nature arrangement for execution of PPP Projects			
19	Encumbrances of land Definition: Illegal encumbrances cause litigation and invoke legal repercussions			
20	Legally weak partnership or strategic alliance **Definition:** PPPs are all about partnerships between the public and private sectors, which should be legally and contractually strong for durable intra-consortium counterparty			
21	Inefficient procurement process **Definition:** The procurement process should be efficient, economical, effective, and transparent, which brings value for money			

Risks	PPP Modalities			
	DBFOT/BOT Type PPP Contracts	**Lease/Affermage/BLT Type PPP Contracts**	**Ownership/ BOOT Type PPP Contracts**	**The Services and the O&M Type PPP Contracts**
22		Tenant risks **Definition:** Risks related to the leaseholder for efficient operations		
23	Lack of flexibility in contracts Definition: PPPs are complex contractual arrangements; therefore, they should be flexible enough to safeguard the interests of both parties			
24		Market demand for assets **Definition:** The project's assets are market-driven for desired revenue collection		
25		Legal aspects of the property **Definition:** lessor should lease the land to the lessee, which is legally protected against all types of litigations		
26			Expropriation **Definition:** risks of taking property or assets by the state from the owner	
(d)	**Construction and execution risks**			
27	Poor quality **Definition:** Maintaining the desired quality standards on the project during the construction and execution phase			
28	Unproven engineering techniques **Definition:** Using untested technology and inadequate engineering exposure for the construction and execution of the infrastructure projects			
29	Unforeseen construction cost overruns **Definition:** Construction cost overrun resulting from poor planning and measurements of the quantities			
30	Availability of land for use **Definition:** encumbrance free right of way is available for construction			

Risks	PPP Modalities			
	DBFOT/BOT Type PPP Contracts	**Lease/Affermage/BLT Type PPP Contracts**	**Ownership/ BOOT Type PPP Contracts**	**The Services and the O&M Type PPP Contracts**
31	Scope creep **Definition:** extensive change orders during the construction phase			
32	Inadequate health and safety measures **Definition:** Non-adoption of required health and safety requirements as per standards			
33	Delay in a construction period **Definition:** Noncompliance with construction timelines adequately			
34	Availability of labor and material **Definition:** Shortage of resources due to inadequate supply chain management of the organizations			
35	Protection of geological and historical objects **Definition:** Sometimes slight variations are required during the construction phase for the protection of geological and historical objects			
36	Shifting of utilities **Definition:** Shifting of utilities like power lines, gas lines, and other underground cables			
(e)	**Operations and maintenance risks**			
37	Operation and maintenance **Definition:** Concessionaire is responsible for the operation and maintenance of the project	Operation and maintenance **Definition:** Public sector is responsible for operations, and Concessionaire is responsible for maintenance activities	Operation and maintenance **Definition:** Concessionaire is responsible for the operation and maintenance of the project	
38	Demand and revenue shortfall **Definition:** Revenue collection is less than the forecasted demand			
40	Frequency of maintenance Definition: Major maintenance involves high cost; therefore, the frequency of maintenance matters			
41		The uncertainty in rent prices **Definition:** Uncertainty lies with the lessee to cope with the decrease in rent prices		Operational Technology
				Operational Efficiency risks
42	Toll slippages **Definition:** Week operational measures and control			
(f)	**General and project environment risks**			
43	Corruption **Definition:** Kickbacks, unjust rewards, and corrupt officials			
44	Political instability Definition: Regime change and other political chaos in the country			
45	Environmental permits Definition: Permits required from the environmental protection agencies for project approvals			

Risks	PPP Modalities			
	DBFOT/BOT Type PPP Contracts	**Lease/Affermage/BLT Type PPP Contracts**	**Ownership/ BOOT Type PPP Contracts**	**The Services and the O&M Type PPP Contracts**
46	Ground and weather conditions **Definition:** Unexpected or poor ground or weather conditions			
47	Lack of R&D in the PPP regime **Definition:** Poor R&D in the field of PPP domain			
48	Natural disasters or force majeure events **Definition:** The circumstances which are out of the control of any stakeholder reach			
49	Transfer of technology **Definition:** International bidders are the source of the transfer of technology			
50	Inherent risks **Definition:** Limited competencies and experience available for the execution of PPP projects, especially in developing countries			
(g)	**Completion and transfer of assets risks**			
51	Project transfer risks **Definition:** Transferring the project assets to the public sector as per requirements			
52			Residual value risks **Definition:** Unable to transfer the assets in normal working condition	
53			Depreciation of asset **Definition:** Devaluation of the asset at the time of transferring of assets	
54	Completion of project **Definition:** Non-fulfilment of the contractual requirement regarding the completion of the project			
55			Asset obsolescence Definition: due to long concessions of PPP, the project's assets or technology may be obsoleted	
56			Asset maintenance Definition: due to ownership of assets, asset maintenance is the prime responsibility of the private sector to properly handover	
	[42,44,58,63–123]			

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