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Analysis of Features Affecting Contracted Rate of Return of Korean PPP Projects

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Abstract: Various risk factors influence the success of public–private partnership (PPP) projects. This study analyzes the risk attributes of PPP projects and develops a regression model based on a 20-year PPP project database to quantitatively analyze the factors affecting the contracted internal rate of return (CIRR) of PPP projects. Although the risk factors of PPP projects have been widely studied, the factors affecting CIRR have not been explored. Information from the intra-info DB system managed by Korea Development Institute was used to calculate the impact of the variables on CIRR. It was observed that the CIRR of Korea's PPP projects did not reflect the risks associated with the facility types, service area, amount of private investment, and operation period accurately. Financing costs did not demonstrate a statistically significant relationship with the CIRR either. Furthermore, the CIRR of projects with a minimum revenue guarantee option was found to be higher than that of projects without. The CIRR of the current project was found to be closely related to the number of bidding competitors and the CIRR values of previous projects that are similar to the current one. This is attributed to a failure in the bureaucratic negotiation behavior of the parties due to their avoidance of responsibilities.

Keywords: public-private partnership; risks allocation; government support; contracted rate of return

Citation: Kim, K.; Kim, J.; Yook, D. Analysis of Features Affecting Contracted Rate of Return of Korean PPP Projects. *Sustainability* **2021**, *13*, 3311. https://doi.org/10.3390/su13063311

Received: 7 January 2021
Accepted: 12 March 2021
Published: 17 March 2021

1. Introduction

Public–private partnership (PPP) projects aim to use not only creativity and efficiency, but also expertise, capital, and fair risk allocation of the private sector to build and operate infrastructures [1] that were previously handled solely by the government, such as transportation infrastructure, social infrastructure including schools [2], hospitals, water and heating supply networks [3], and energy facilities [4], land development [5], and even the city re-qualification program [6]. PPP serves as an economic arrangement for financially constrained governments by providing infrastructure and enhancing the quality of service through performance-oriented management. PPP projects provide benefits to the citizens and promote economic growth through timely responses [7–10] to the rapidly growing infrastructure demands.

With the gradual change from government-led infrastructure supply to PPP, inducing the participation of the private sector, the infrastructure supply method has undergone significant changes, resulting in PPP receiving attention from the government, private sector, and academia. Furthermore, as PPP is normally applied to national infrastructure, requiring long-term and large-scale investment, uncertainty in the future forecast further amplifies the diversity of PPP research [11–13]. Osei-Kyei and Chan [14] classified PPP research into the following categories: risk management [15,16], relationship management [17–19], financial profitability [20,21], and procurement [22,23].

Research on the success factors for PPP projects has been actively conducted in recent years [14,24–26]. This research mainly involves the analysis of the critical factors for

the sustainable supply of infrastructure through PPP. This topic of research has recently attracted significant attention owing to the cases of failure at the time of initial introduction of PPP.

Korea, which introduced PPP relatively early, has also received social criticism due to the immature decision system adopted in the early stages of PPP introduction. The performance of Korea's PPP projects has come under scrutiny due to an unexpected rise in the government's payment to private firms and the bankruptcy of the PPP projects. In addition, some PPP projects have faced resistance from users due to higher fees than those of publicly financed projects.

The financial problems and poor performance of these projects are attributed to the inadequate consideration and allocation of the risks between the government and private partners [10,27–29]. Risks and risk allocations are indicated by the internal rate of return (IRR); IRR is measured at a discount rate (r) that matches the present value of the cash outflow and inflow [30–32]. As the risks increase, the private sector seeks to increase the IRR, whereas the government seeks to lower the IRR to reduce the government's fees and the tariffs of the facility users. However, a significantly low IRR reduces motivation for private investment, and an excessively high IRR results in high user tariffs and government fees; which in turn, leads to unnecessary expenditure of taxpayers' money and stiff opposition to the project's classification as a PPP. Thus, the IRR is an indicator of the balanced risk allocation of PPP projects between the government and the private sector.

This study approaches the PPP success factors through CIRR. This study aims to identify the factors that have affected the CIRR in Korea build-transfer-operate (BTO) projects over the last 20 years. CIRR is used as a proxy to indicate the risk allocation between the Korean government and private investors. A BTO project database (1994–2014) that contains detailed information on the four main stages of the procurement of BTO projects over 20 years has been used as a source of information in this study. The four stages mentioned in the database are the planning and feasibility phase, bidding and negotiation phase, construction phase, and operation phase. To the best of our knowledge, a systematic approach that utilizes real data to identify the determinants of the CIRR of PPP projects and analyze if the risks and mitigation government supports are accounted for in the CIRR has not been published earlier.

The rest of the paper is organized as follows. Section 2 contains a literature review that mentions the risks related to PPP projects and discusses how these risks were reflected in the PPP projects. Section 3 presents the mechanism followed to calculate the CIRR while accounting for the risks. Section 4 analyzes the factors that affect the CIRR values of the PPP projects. Section 5 proposes the policy implications of promoting PPP projects according to the results and presents the prospects for future studies.

2. Literature Review

The PPP contract covers almost all aspects that define the relationship between the parties, the rights and responsibilities of the parties, and the allocation of risks between them. CIRR is an indicator of the shared risks associated with the PPP project and is regarded as the most important aspect of the PPP contracts. This section presents the various risks that are associated with PPP projects and reviews the allocation of these risks in the context of risk management.

2.1. Risks Involved in PPP Projects

There are various risks involved in PPP projects. Government risk refers to the assurances made by the government regarding future payments of the projects. For instance, the government guarantees a fixed amount of predetermined revenue through the contract period when the actual out-turn revenue falls below the contract revenue. The operational risk of the cost of operating or maintaining the infrastructure exceeding the preplanned expenditure is borne by the private partner. The number of users of the infrastructure may be lesser than anticipated, resulting in lower revenues and financial

distress. In addition, adverse changes in the legal framework or policy decisions that can negatively impact the value of a PPP project become significant risks that must be borne by the government.

Previous studies [33–40] have classified risks into several categories according to the project phases, such as macro and political, force majeure, approval, planning, environmental assessment, financing, design, site preparation, construction, operation, hand-over, and others (Table 1). Additional classification systems exist, such as exogenous and endogenous [41], nature of risks, and the phase of the project [42,43] and so on. In the study presented by Keers and Fenema [44], risks were identified through workshops with those who participated in the actual project. Through a survey, the characteristics of risks were classified based on the probability of each risk occurring and its impact on the project if the risk occurs. Additional information can be found on the risk classification in [45].

Table 1. Risks in PPP projects.

Process	Identified Risk	
Macro & political	■ Regulatory change	■ Public sector budget deficit
	■ Change in taxation	■ Strong political opposition
	■ Political will	■ Lack of PPP/toll experience
	■ Unstable government	■ Inflation risk
	■ Government intervention	■ Interest rate fluctuation
	■ Expropriation of facility	■ Currency change
Force majeure	■ Natural disaster	■ Vandalism
	■ War	
Approval	■ Delays in permits	■ Detailed design approval risk
Planning	■ Poor decision process risk	■ Poor utilities access
	■ Planning permit	
Environmental assessment	■ NEPA (National Environment Policy Agent) approval	
Design	■ Design errors/deficiency	■ Unproven engineering techniques
Financing	■ Poor financial market	■ Insufficient financing ability of partner
	■ Financial attraction to investors	■ Refinancing
Site preparation	■ Site acquisition	■ Hazmat
	■ Delays in right of way acquisition	■ Availability/access of site
	■ Geo-technical condition	■ Delays in cable and pipe relocation
	■ Archeological findings	
Construction	■ Construction cost overrun	■ Commissioning on time
	■ Labor dispute	■ Change in scope/design
	■ Procurement (material availability)	■ Performance specification achievement
	■ Subcontractor disputes	■ Final acceptance
	■ Insurance coverage unavailable	■ Interface management
	■ Construction security	■ Patent infringement
	■ Insolvency of sub-contractors	■ Defects
Operation	■ Traffic demand	■ Insurance coverage unavailable
	■ Toll price change	■ Security
	■ Competing facilities	■ Service quality
	■ Withdrawal of supporting networks	■ Early termination risk
	■ Maintenance cost overrun	■ Traffic information system
Hand-over	■ Premature obsolete risk	■ Residual transfer value risk
	■ Needs for expansion	
Others	■ Change in private partner share	■ Conflict between private partners

Source: Recreated the table based on Lewis (2001); Department of Treasury and Finance (2001); Bing et al. (2005); Checherita and Gifford (2007); Hodges and Dellacha (2007); World Bank (2011).

The project cost exceeding the estimated expenditure is a major risk during the site preparation, design, and construction phases. This is attributed to inefficient construction and management practices, resulting in poor coordination among suppliers and delays in the subsequent phases [36]. Unsatisfactory engineering and design analyses in the preliminary stage can lead to cost overruns. For instance, the final cost of the Cuernavaca–Acapulco toll road was approximately twice that of the preliminary estimation and was

delayed by 30 months [46]. The announcement of a large-scale transportation investment project increases the price of the surrounding land. Therefore, the land acquisition cost exceeds that of the original plan, thereby increasing the project cost. This increase in cost is because of external factors rather than mismanagement or inefficiency of the private investors in delivering the projects; thus, the government shares the risk. For developing countries, land acquisition/site availability along with creditworthiness of the project sponsors and availability of finances is more critical than other risk factors [47]. The government supports private investors financially through interest-free and/or low-interest loans, subordinated loans, operational subsidies, management and repair, and interest subsidies, in addition to direct subsidies.

The operating cost in the operational phase may exceed the estimated value due to mismanagement and/or significant changes in the operation scheme. However, the maximum amount of risk is involved in the demand for infrastructure. The demand risk in newly built transportation facilities is globally acknowledged [33,36]. The government provides options to mitigate these risks with schemes, such as minimum revenue guarantee (MRG), least present value of revenues (LPVR), and deferring payments of the concession fees (DPCF) [48], and so on. The MRG option guarantees the contracted revenue to the concessionaire in case the actual out-turn revenue is lower than the contracted revenue. The innovative feature of the LPVR approach is that the concession period is flexible, whereas, normal PPPs have an end date specified in advance. DPCF is an option provide to private partners to reduce the financial risk of delaying the paying concession fees. When studying real options [42], the above strategies are expressed as managerial flexibility and are utilized to model risk management incurred from future uncertainty. In addition to the risks arising due to demand uncertainties, one of the most significant risks borne by foreign investors is the risk arising due to fluctuation of the exchange rate. This risk arises because the revenue is generated in the local currency, while debt and interest payments are performed through a foreign currency. If exchange rate fluctuations exceed certain limits, the government offsets a portion of these losses by adjusting tariff rates, providing subsidies, or changing the length of concession. Government support related to PPP projects is summarized in [42,49].

However, the various government incentives presented above are of no use during political instability. Therefore, political stability is another important risk factor that is an exogenous factor and cannot be resolved by government guarantees or commitments [50]. Detailed examples of PPP-related and individual risks are presented in [36].

2.2. PPP Success Factors and Risk Allocation

The success of PPP could be guaranteed by identifying the key factors and their smooth implementation through project management process. It is to be noted that if project success indicators (or project performance measurement) [51–56] differ from project success factors, the former and latter refer to standards that evaluate success and events that contribute to success, respectively [51,52,57,58]. This study focuses on success factors than indicators evaluating the success.

Tiong et al. [59] proposed six critical success factors (CSFs) to increase the probability of winning in the BOT PPP. The six CSFs include entrepreneurship, picking the right project, a strong team of stakeholders, an imaginative technical solution, a competitive financial proposal, and the inclusion of special features in the bid. Additionally, the CSFs suggested by most studies do not deviate significantly from the CSFs proposed by Tiong et al. [60]. Qiao et al. [60] further subdivided the six CSFs into 13 CSFs, reflecting the characteristics of Chinese PPP projects. Zhang [61] approached the CSFs of the PPP from the win-win principle between government and private investors. However, Li et al. [62] attempted to interpret the relationship in a more balanced manner by weighing the positive and negative features that influence the attractiveness of PPP/PFI rather than a win-win situation. In recent years, research on a win-win situation for the PPP project has been actively conducted. A win-win situation indicates the condition wherein both parties satisfy

their own interests in a balanced manner [63]. In a Park et al. [64], the parties involved in the proposed PPP project were expanded to users as well; the water and sewer system PPP projects were the subjects of the case analysis to examine the changes in interests of the three parties. Satisfying the both parties' interests implies that the government's support is not excessive; that is, private profits are not excessive. Therefore, a win-win situation includes options for revenue sharing [65,66]. Carbonara and Pellegrino [67] studied the optimal conditions required to achieve such a situation with various pairs of revenue ceiling and revenue floor, using the real option model.

Here, picking the right project means that the project that is presented to private investors must be promising. Tiong et al. [59] stated that if the demand for the project is sufficient or in the near-monopoly market, such requirements can be satisfied. In addition, limited competition in the bidding and strong political assistance has a positive influence on making the project more promising. A strong team of stakeholders means partnership between stakeholders. Zhang [61] extended this to key entrepreneurial leadership, good relationship with host government, and rich experience in international PPP projects. An imaginative technical solution refers to the new techniques that private companies must develop for the success of the PPP projects. Accordingly, technical solution should be sound and innovative, along with being cost-effective. Competitive financial proposal has a vast meaning. Tiong et al. [61] attributed the (1) low construction costs, (2) reasonably high debt to equity ratio, (3) acceptable tariff levels, and (4) a short construction and concession period to a competitive financial proposal. In PPP, maintaining financial soundness means that the risk transfer between government and private investors must be adequate. Therefore, government support, such as MRG, construction subsidy, or concession periods, are offered to provide opportunities for private investors to hedge risk. There is a wide variety of studies on how risk should be properly distributed between two parties.

The risk should be allocated to the party that can better manage the risk, i.e., the risk should be allocated such that the impact of that risk on the project is minimized. Therefore, striking the right balance in risk allocation can become critical to the success of a PPP because it incentivizes private partners to produce efficient infrastructure services [14,24,67–69]. The literature on risk allocation not only discusses the risks and their impacts but also provides directions for both parties to successfully implement PPP projects.

Bing et al. [34,35] performed a classification analysis on the risk allocation between the government and private investors. The government is more suited to bear risks, such as government stability, site availability, and exchange rate fluctuation, while the private sector ought to take responsibility for risks, such as delayed design changes, financial attraction of the project, and user demand for the project. Ke et al. [28] performed a similar study to that of Bing et al. [34,35] and identified risk allocation preferences in China's PPP projects. They selected only 1 (expropriation and nationalization) out of 37 risks to the public sector, whereas the private investors bore the majority of the risks at the project level, such as financial risks, delayed completion of construction, changes in construction and operation, and delayed supply. Despite the optimal allocation of risks between both parties, the inability of the government to implement the assumed responsibilities caused the PPP project to fail. This problem is further exacerbated for PPP projects initiated in an environment of political instability. Therefore, governance is an important factor in risk allocation. Leigland [70] and Wang et al. [29] demonstrated the importance of the quality of governance by discussing various factors, such as corruption control, government effectiveness, regulatory quality, and the rule of law. These factors can mitigate the negative influence of the risks assumed by private investors. Zhang et al. [71] observed that the governance in China was not mature enough to attract private investment for the country's PPP projects. They presented a few suggestions to improve private investment in Chinese PPP projects, such as detailed and complete concession contracts and coordination with relevant departments. Recently, the literature on risk allocation not only discusses the risks and their impacts but also provides directions for both parties to successfully implement PPP projects. Osei-Kyei et al. found that effective risk management is the most important

factor for successful PPP based on a survey of international PPP experts and the results of the mean index analysis [72]. In addition, meeting the output specifications, reliable and quality service operations, and adherence to time were identified as key factors for successful PPP. Recently, Wang et al. analyzed the influence relationship of various risk factors through social network analysis [26]. In addition to finding key risk factors, they discovered the chain reactions between the risk factors. The linkages of risk found in this study are legal change→government credit→contract risk, and imperfect legal and regulatory system→corruption→change in market demand→insufficient revenue in the market.

Finally, inclusion of special features means that a private partner participating in the PPP can lead to a successful PPP procurement if it exhibits special features that can alleviate the concerns of the host government. These concerns include the behavior of private investors to focus only on profit taking.

In addition to the aforementioned six CSFs categories, studies that argued the importance of a sufficient pre-qualification process, such as value for money assessment (VfM) [73,74] in terms of life-cycle management, and a study that extended the risk dimension to include social risks [75] were conducted. Recently, as a new form of the PPP mechanism, research on social investment bonds [76,77], which focuses on channeling for social funding into social infrastructure in terms of social impact of the investment, is actively being conducted. However, this literature review does not deal with it because it is beyond the scope of the study.

Existing studies compile PPP success factors through extensive literature reviews [29,33,34,43,59–61,73–75,78] and workshops [44], and determine important factors through expert surveys [34,44,60,62,74,75], including Delphi [45] or in-depth interviews [29,44,61]. Survey opinions are expressed in various ways, although expert surveys form the basis of the analysis results. However, such expert questionnaires have a drawback in that there is room for the subjectivity of experts to be involved, and biased opinions because of limited experience may be derived as a result of the survey. This study is different from previous studies in estimating the influence of the success factors of PPP by statistical analysis of data accumulated over 20 years without relying on experts.

Because the CIRR is the outcome of the negotiations between the two actors, it can be used as a dependent variable to describe the behaviors of the two negotiating agents. In addition, a comparison of the impacts of the factors affecting CIRR allows the two actors to select the elements that ought to be focused on. The development of PPP over the past 20 years has enabled the provision of tangible and realistic guidance to the two negotiators of PPP projects. This guidance is necessary because studies that use analytical approaches based on future scenarios are impractical owing to the assumptions made with regard to the future conditions and unverified demand forecasting.

3. Negotiations and CIRR

This section presents the negotiation process of PPP projects and measurement of CIRR. A competent authority first assesses a candidate PPP project's profitability, public benefit, and user affordability. Once the project is designated as a PPP project, the authority puts out a request for proposal (RFP) and selects the preferred bidder.

Regarding unsolicited projects, the benefits for the original proposer vary by country. Korea provides up to 10% additional points to the original proposer. In the Philippines, if the price of the proposal presented by a third party is lower than that of the original proposer, the original proposer is provided an opportunity to submit a revised proposal. In Indonesia, the first proposer can receive 10% additional points, and can have the right to amend the proposal, or receive compensation for the intellectual property rights of the original proposal from the final winner of the bid.

The authority then negotiates with the preferred bidder according to the bidder's interpretation of the future risks associated with the project. The bidder prepares a portfolio of the impacts of the risks of the project and negotiates according to a future scenario that

is considered to be the most probable one while accounting for uncertainty. The most important outcome of the negotiation process is the rate of return of the PPP project. The rate of return represents the expenditure and revenues for a given project while accounting for uncertainties and risks.

The rate of return of the PPP project is determined with equation (1). It is measured from the present contracted value of cash outflow, which is an initial capital investment used to build the facility, and the contracted revenue from the operations. CIRR is measured at a discount rate (r) that matches the present contracted value of the cash inflow, as shown below.

$$\sum_{i=0}^{n} \frac{CC_i}{(1+CIRR)^i} = \sum_{i=n+1}^{N} \frac{OR_i - OC_i}{(1+CIRR)^i} \quad (1)$$

n: Period (years) from the project's launch to completion of construction prior to the launch of service
N: Service period (years) after completion of construction
CC_i: Contracted annual expenses for completion of construction (excluding the amount of the government's financial subsidy)
OR_i: Contracted annual operational revenue
OC_i: Contracted annual operational cost (excluding corporate tax)
CIRR: Contracted (pre-tax real) rate of return of the project (CIRR)

Equation (1) not only accounts for the project cost in the calculation of CIRR, but also includes the revenue estimation reflecting risks. The risk arising due to poor engineering or design, as mentioned earlier, is reflected in the cost, while the demand reflects the uncertainty of future demand. Therefore, the CIRR can be viewed as a parameter that accounts for the risks associated with the PPP project. Thus, probably, the CIRR is different for each party due to different estimation on future risks, unbalanced information, etc. CIRR, which is interpreted differently for each party, is adjusted by other factors and finally determined as one value. There are several additional factors that affect CIRR before a satisfactory agreement is reached. In this study, the clue to these additional factors was derived from PPP success factors identified in the previous studies, because most success factors, other than cost and income, are not reflected in CIRR. These include restricting competition, good governance, adequate risk allocation, etc. It is to be noted that the success factors are not the only factors affecting the success of one of the two parties. According to the study of Li et al. (2005) [62], success factors can be perceived positively by one side and negatively by the other. This tendency is particularly significant in the case of risk transfer. The studies on optimal risk allocation present conflicting opinions on the reason for picking the right project as suggested by Tiong et al. (1992) [59]. According to the former study, risk transfer can be performed relatively smoothly in a competitive system, while the latter study states that private investors are more interested in limited bidding competition. Additionally, considering the concession period, Tiong et al. (1992) [59] suggested that the financial proposal can be made more competitive by reducing the period of exposure to risk as much as possible. However, other studies [23,79] interpret the extended concession period as an opportunity to reduce financial burden caused by the risk.

4. Analysis of the Determinants of CIRR

4.1. Data

This study used a 20-year BTO PPP project database (1994–2014) to analyze the determinants of CIRR for BTO PPP projects. This system was known as the infra-info DB system [80] and was built and managed by the Public and Private Infrastructure Investment Management Center (PIMAC) of the Korea Development Institute (KDI). The database contains detailed information on each stage of the BTO PPP projects. The four stages have been listed below.

1. Request for proposal notice or third-party proposal notice;
2. Concession agreement;
3. Construction;
4. Operation.

4.1.1. Dependent Variable: CIRR

The variation of CIRR is shown in Figure 1. The average after-tax CIRR continued decreasing after the adoption of the PPP system in 1994. The real after-tax CIRR has been approximately equal to 6% since 2007.

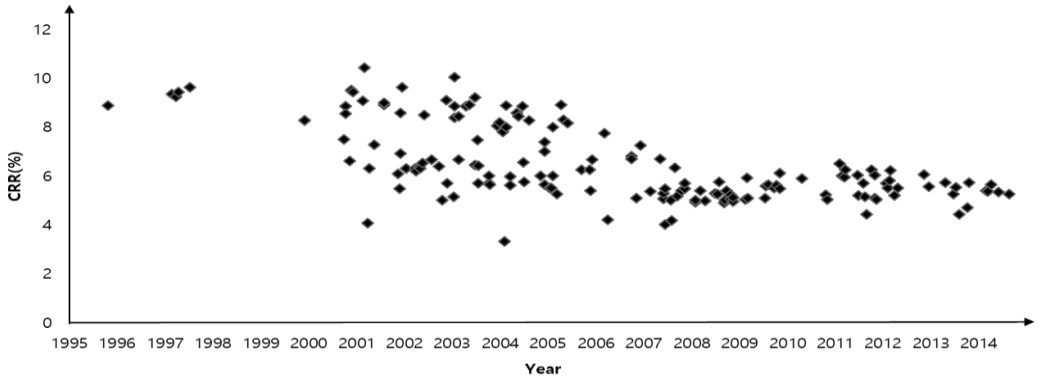

Figure 1. Variation of the after-tax CIRR of BTO projects. Source: KDI PIMAC infra-info DB system.

The after-tax CIRR values for different facilities are shown in Table 2. Among the BTO projects signed between 1997 and 2014, 162 projects were related to road, rail, port, and environmental facilities. The average CIRR of all these facilities was equal to 6.47%, according to the real after-tax rate. It varied from a minimum value of 3.33% to a maximum value of 10.43%. The average CIRR, according to the current after-tax rate, was 11.04% and ranged from a minimum value of 7.09% to a maximum value of 15.95%. The risk premium, which is calculated by subtracting five-year government bonds yield from the current after-tax rate represents the reference rate, averaged at approximately 5.4%. The average real after-tax CIRR for environmental projects was the lowest at 5.72%, followed by road (6.76%), rail (7.83%), and port projects (7.99%).

Table 2. Summary statistics of the after-tax CIRR for different project groups.

		Min	Mean	Max
1. Road projects (60)	Real	4.21	6.76	10.03
	Current	8.38	11.34	15.53
	Premium	2.50	5.77	10.50
2. Rail projects (9)	Real	5.03	7.83	10.43
	Current	9.23	12.60	15.95
	Premium	4.65	7.86	10.49
3. Port projects (18)	Real	5.25	7.99	9.62
	Current	8.41	12.73	15.10
	Premium	3.40	7.40	9.52
4. Environmental projects (75)	Real	3.33	5.72	8.44
	Current	7.09	10.21	13.87
	Premium	1.84	5.37	9.00
Total (162)	Real	3.33	6.47	10.43
	Current	7.09	11.04	15.95
	Premium	1.84	5.40	10.50

Source: PIMAC Infra-info DB system.

4.1.2. Independent Variables

The CIRR is affected by various factors, such as the financing cost of a PPP project, project characteristics, government support, degree of the PPP market maturity, and parties' negotiation behaviors. Table 3 summarizes the independent variables and presents the basic statistics for the variables.

Table 3. Explanatory variables and descriptive statistics.

Category	Explanatory Variable	Explanation	Statistics			
	Variable Name		Min	Mean	Max	Std. Dev
Financing cost	Risk free interest rate (Rf_5 years)	Market return of five-year treasury bond as of the date of agreement signing (%)	2.39	5.16	12.20	1.76
Project characteristics	Facility type	Road (Road), rail (Rail), port (Port), and environment (Environ)	-	-	-	-
	Service area of the project (Authority)	Central government project, local government project, central government-managed local government project	-	-	-	-
	Operation period (O_Period)	Operation period as stated in the agreement (months)	120.00	310.99	600.00	119.05
	Project size: Total private investment (Ln_P_Investment)	Natural logarithm of total private investment (USD)	13.19	18.07	21.87	1.80
	Solicited/unsolicited (Solicit)	Solicited proposal and unsolicited proposal	-	-	-	-
Government support	Ratio of construction subsidy (Sub)	Ratio of construction subsidy out of total project costs (%)	0.00	38.36	94.48	24.69
	Minimum revenue guarantee (MRG)	Projects with or without MRG option	-	-	-	-
Pre-contract process	Project preparation period (prepperiod)	Length from the date of receipt of project proposal to the date of designation of the preferred bidder (months)	1.00	18.89	98.00	16.42
	Negotiation period (negoperiod)	Length from the date of designation of the preferred bidder to the date of agreement signing (months)	1.00	19.15	84.00	16.10
	Value for money assessment (vfm)	Whether value for money assessment was carried out or not	-	-	-	-
Market maturity	Negotiation experience (Exp)	Negotiation experience of the authority	1	25.23	75	19.42
	Competition rate (Bid_compet)	Number of bidders in the selection process of the preferred bidder	1.00	1.62	5.00	0.86
Negotiation behavior	Average CIRR of similar recent projects (IRR_S_three)	Average CIRR of three recent PPP projects of the same type facility (%)	4.40	6.60	10.43	1.51
Time	Time	Year of the agreement signing	-	-	-	-

Source: Created by the authors.

Financing Cost (Rf_5 years)

The private partner prepares the financial resources for the PPP projects through debt instruments typically issued by commercial banks, international finance institutions, export credit agencies, and/or corporate bonds. If a project is highly risky, it may not be able to obtain any debt financing. However, less risky projects enjoy lower borrowing costs. This implies that the financing cost is dependent on the level of risks involved in a PPP project. Therefore, if the financing cost is reduced, a PPP project becomes an attractive investment alternative, thereby encouraging more private investors to participate and lower the rate of return of the PPP project competitively. The average financial market cost was used as a proxy for the financing cost of a PPP project in this study. The interest rate on five-year government bond yields, based on the signing date of the concession agreement of the BTO project, was used as an indicator of the financing cost of a PPP project. The five-year government bonds yield demonstrated a downward trend, reaching a maximum of 12.30% in 1997 and a minimum of 2.39% in 2014.

Facility Type

PPP projects are classified according to the type of facilities they offer. Road, rail, port, and environmental facilities are selected as independent variables to study their different impacts on CIRR. For instance, environmental PPP projects, such as sewage treatment, waste landfill, and recycling facilities, are generally implemented to replace the aging facilities or to expand their capacities. These brownfield projects have lower demand and operational risks than greenfield projects. In addition, road and railroad PPP projects are known to have higher revenue risks during the early stages of operation than other facilities.

Service Area of the Project (Authority)

The service area of a PPP project is assumed to be another independent variable. The demand and operation risks vary according to the local or inter-regional nature of the project service area. Local PPP projects are expected to be riskier than national PPP projects. In addition, the CIRR values of local PPP projects are higher than those of national PPP projects. The impact of the service area on the CIRR is dependent on the characteristics of the competent authority. This is because local PPP projects are managed by the local government, whereas national PPP projects are managed by the central government. It is noteworthy that central governments are more capable of promoting PPP projects with lower rates of return because of their higher capacity, superior negotiating skills, and greater administrative power than local governments. This is the extension of the quality of governance [29,70] that was reviewed before the case considering the difference between the national and local governments.

Operation Period (O_Period)

The operation period of the PPP project is another variable that may affect the CIRR. A longer operation period is more likely to be exposed to extra investment, in addition to other risks. It is possible that financing costs may increase due to long-term investment premiums. However, a long contract can also reduce CIRR. It promotes conditions that are conducive to innovation by incentivizing private partners to develop unique and innovative solutions for process organization and the provision of products and services. It is noteworthy that the average operation period for BTO projects is 310 months and varies between 120 and 600 months.

Project Size: Total Private Investment (Ln_P_Investment)

The amount of total private investment was selected to analyze the impact of the project size on CIRR. Large PPP projects may expose private partners to more risks than smaller projects. Large PPP projects may face additional risks associated with the initial stages of the process due to high bidding costs, pre-contract time overruns, and the financial

availability risk, which is dependent on the availability of funds once a project has been awarded. In addition, risks related to land availability and civil complaints may be more significant for large projects than they are for smaller projects. The project with the smallest total private investment is the sewage treatment plant project (0.53 million USD), and the largest project is the airport railway project (3.13 billion USD).

Solicited or Unsolicited Projects (Solicit)

This variable analyzes the impact of solicitation on CIRR. The information possessed by the government and the private partner on the risks of the project depends on the manner of initiation of the PPP project. It is expected that an unsolicited project would have a lower CIRR than that of a solicited project. This variable is based on the second factor out of six CSFs suggested by Tiong et al. [50], which discusses 'picking the right project' because private investors may have more understanding and information about the market than governments when they propose a new project. The reason that a private investor proposes a PPP project is because there is a sufficient demand and they can make a profit, which can be reflected by this variable setting.

Construction Subsidy: Ratio of Construction Subsidy (Sub)

The construction risks in a PPP project include unexpected increments in costs and delays. The Korean government may provide construction subsidies to a private partner to reduce the risk and improve the bankability of projects. The construction subsidy is considered to examine the effect of the government grant on CIRR. The percentage of average construction subsidy in the total project cost for BTO projects was 38.36% and varied between 0.0% and 94.98%.

Minimum Revenue Guarantee (MRG)

Governments will only attract private participation if investors are confident of earning reasonable returns. The Korean government provides support or assurances for a certain degree of risk. The Korean government guaranteed to provide 90% of the projected revenue agreed upon in the concession agreement for a period of 20 years for BTO projects initiated between 1995 and 2003. Projects initiated from 2004 to 2005 were guaranteed 70–90% of the projected revenue for 15 years. Since the revised system was instituted in 2006, the government guarantees 65–75% of the projected revenue for 10 years only for solicited projects. However, the MRG scheme was repealed in 2009. MRG is assumed to be an independent variable to examine the effect of government support on CIRR. It is expected that PPP projects with MRG will have lower CIRR than those without MRG. Although the MRG has already been reflected in the equation (1) that determines the CIRR, the fact that the change of CIRR is significant in time series, even with the change of the MRG system, emphasized the need to investigate whether the role of MRG exists.

Project Preparation Period (Prepperiod) and Negotiation Period (Negoperiod)

The pre-contract process period, project preparation period (from the date of receipt of the project proposal to the date of designation of the preferred bidder), and negotiation period (from the date of designation of the preferred bidder to the date of the agreement signing) are considered to be independent variables. It was found that both the project preparation period and the negotiation period spanned approximately 19 months on average.

The duration of the pre-contract stages can be frustratingly long and costly, thereby causing the private partner to bear large advisory cost overrun risks. However, a competent authority often takes advantage of the pre-contract process period to gain more leverage over the private partner. Therefore, the pre-contract process period is expected to positively impact CIRR.

Value for Money Assessment (VfM)

This study also analyzes the impact of the VfM assessment on CIRR. The competent authority conducts a VfM assessment on a candidate PPP project and uses those results to approve or disapprove the PPP project. The authority compares the whole life cost of the Public Sector Comparator (PSC) to the Private Finance Initiative (PFI) in the VfM assessment while accounting for risk from the government's viewpoint. In addition, a financial analysis is conducted as part of the VfM assessment to calculate the appropriate project cost, user fee, and government subsidy from the government perspective. It is likely that the CIRR will be reduced by performing a VfM assessment.

Negotiation Experience (Exp)

A competent authority that is experienced in negotiations may influence the outcome of CIRR. This is because the experience provides expertise through learning, which is later reflected in the determination of CIRR during negotiations. It is expected that the negotiation experience of the authority would impact the CIRR negatively. Negotiation experience is expressed as the number of PPP projects, whose maximum value was 75, and the average was 25.23.

Competition Rate (Bid_compet)

The bidding competition rate, which indicates the number of consortiums that participated in the bidding process, is included as an independent variable. It may represent the maturity of the Korean PPP market. The average number of bidders was 1.62, and it varied from a minimum of 1.0 (one bidder) to a maximum of 5.0 (five bidders). A higher bidding competition rate is expected to reduce CIRR.

Average CIRR of Recently Similar Projects (IRR_S_three)

CIRR is also influenced by the bargaining parties' strategy or behavior. We assumed that the negotiation behavior was a strategy adopted by the parties to avoid responsibility or blame for the negotiation results. Although the negotiation behavior of the parties is not related to the risks existing in PPP projects, it significantly impacts the determination of CIRR.

Quantification of negotiation behavior is difficult because it includes a variety of negotiation strategies, and there exists no database that contains information on negotiation strategies. To account for this limitation, the average CIRR of recently implemented BTO projects that belong to the same facility was used as a proxy for the negotiation behavior variable.

4.2. Model Establishment

4.2.1. Model

In this study, a multiple regression model was used to analyze the relationship between two or more independent variables and the dependent variable. Regression analysis is a statistical analysis method that assumes a mathematical model and estimates this model from the data of the measured variables to determine the functional relationship between variables. When expressed mathematically, the regression model can be broadly divided into a part representing a trend and another part representing an uncontrollable error. In this study, the part that represents the trend is denoted by the product of the regression coefficient β_i's (i = 1,2 ... α) and the explanatory variable, and the uncontrollable error is denoted by ε_i whose mean is 0, following a normal distribution.

Accordingly, the regression model (2) is established based on the following explanatory variables: negotiation practices, financial market conditions, project characteristics, government support, institutional environment, and factors of maturity of the private investment market. It is noteworthy that the time variable is included in the model to account for the transient variation of CIRR.

In a study by Salman [74], a viability model was constructed with the PPP success factor as an explanatory variable and the model output as a viability index. In the study, return on investment is applied as an element that affects the viability of a project through PPP. However, this paper used it as a dependent variable. The analysis conducted in the study concludes that return on investment has a significant impact on the viability of the project. In other words, the higher the return on the investment, the higher is the viability. This study, which expressed return on investment as CIRR and considered it a dependent variable, goes beyond the results of Salman [74] by performing a statistical analysis to understand the influence of factors on the change in return on investment.

$$y_i = \beta_0 + \beta_1 time_i + \beta_2 X_{2,i} + \beta_3 X_{3,i} + \beta_4 X_{4,i} + \cdots + \beta_a X_{a,i} + \varepsilon_i \quad (2)$$

where y_i denotes the after-tax CIRR for a project i and $time_i$ represents the year of the contract signing. X is the explanatory variable of the project i of a particular type and is a control variable that can affect y_i. α refers to the number of explanatory variables, excluding $time_i$.

In addition, two models are considered in this study. Model 1 denotes a basic model that includes the average CIRR values of the previous three projects. Model 2 assumes the average CIRR values of the previous five projects to be explanatory variables, instead of the average CIRR values of the previous three projects. Model 2 is designed to study the variation of CIRR for a longer duration than the analysis period of Model 1. The results of the application of the regression model are shown in Table 4.

Table 4. Results of the regression model estimation.

Category	Explanatory Variable (Variable Name)	Model 1		Model 2	
		Coef.	Std.Errors	Coef.	Std.Errors
Financing cost	Risk free interest rate (Rf_5 years)	0.005	0.077	0.001	0.093
Project characteristics	Rail	−0.012	0.362	−0.648	0.437
	Port	0.797 *	0.345	0.534	0.353
	Environment	−0.093	0.275	0.092	0.28
	Service area of the project (Authority)	0.186	0.201	0.132	0.205
	Operation period (O_Period)	−0.001	0.001	−0.001	0.001
	Project size: Total private investment (Ln_P_Investment)	0.086	0.062	0.041	0.066
	Solicited/unsolicited (Solicit)	−0.157	0.177	−0.101	0.184
Government support	Ratio of construction subsidy (Sub)	−0.008 *	0.003	−0.011 **	0.003
	Minimum revenue guarantee (MRG)	0.605 **	0.212	0.543 *	0.226
Pre-contract process	Project preparation period (prepperiod)	−0.001	0.004	0.005	0.005
	Negotiation period (negoperiod)	0.005	0.005	0.009	0.005
	Value for money assessment (vfm)	0.006	0.223	0.196	0.233

Table 4. *Cont.*

Category	Explanatory Variable (Variable Name)	Model 1		Model 2	
		Coef.	Std.Errors	Coef.	Std.Errors
Market maturity	Negotiation experience (Exp)	0.013	0.007	0.010	0.007
	Competition rate (Bid_compet)	−0.257 **	0.08	−0.255 **	0.08
Negotiation behavior	Average CIRR of similar recent projects (IRR_S)	0.547 *** (IRR_S_three)	0.082	0.616 *** (IRR_S_five)	0.09
	Time	−0.089 *	0.041	−0.095 *	0.044
	Intercept	181.378 *	83.24	192.900 *	89.15
	Observations	150		142	
	Adjusted R-squared	0.748		0.731	

Source: Created by the authors, Note: Signif. codes: '***' 0.001, '**' 0.01, '*' 0.05.

4.2.2. Correlation Analysis

In this study, correlation analysis was performed to determine the appropriate explanatory variables to improve the suitability of the regression model (See Table 5). The results of the Pearson's correlation analysis of independent variables (excluding nominal variables) indicated that there was no value that showed a strong correlation of ±0.7 or more to suspect multicollinearity. The risk free interest rate (Rf_5 years) and average CIRR of similar recent projects (IRR_S_3) were found to exhibit a relatively strong negative correlation with negotiation experience (Exp), −0.51, −0.46, respectively, and the total private investment (Ln_P_Investment) and the operating period exhibited considerably high positive correlation (0.54).

Table 5. Results of the correlation analysis.

	IRR_S_3	*Rf_5 years*	*Exp*	*O_Period*	*Ln_P_Investment*	*Sub*	*Prep_Priod*	*Nego_Period*
IRR_S_3	1.00							
Rf_5 years	0.37	1.00						
Exp	−0.51	−0.46	1.00					
O_period	0.54	0.02	−0.13	1.00				
Ln_P_Investment	0.33	−0.07	0.15	0.54	1.00			
Sub	−0.21	−0.08	−0.27	−0.36	−0.54	1.00		
Prep_Period	−0.08	−0.15	0.16	0.22	0.29	−0.05	1.00	0
Nego_period	0.21	0.05	0.05	0.22	0.34	−0.27	0.18	1.00

Source: Created by the authors.

4.3. Results and Discussion

4.3.1. Cost Borne by the Private Partner

PPP projects become an attractive alternative when the interest rate of the financial market decreases, leading to increased competition between investors in PPP projects. This lowers the rate of return proposed by the competing bidders, thereby decreasing the CIRR. However, the CIRR values of PPP projects did not indicate the existence of a statistically significant relationship with the interest rate on five-year government bond yields, which is an indicator of the financing cost of a PPP project. This is attributed to the fact that large construction firms and financial institutions, with sufficient credit and financing capabilities, invested in Korean PPP projects. In addition, investors who participated as shareholders disbursed direct loans. This implies that they have little incentive to maximize their returns through low financing costs.

4.3.2. Project Characteristics and Government Support

Project characteristics, such as facility types, different authority, amount of private investment, and operation period, did not directly affect the CIRR. It was expected that an increment in the total private investment would lead to increased risk aversion for the implementation of PPP projects, thereby increasing the proposed rate of return and CIRR. However, the amount of private investment did not demonstrate any statistical significance. Long operation periods increasing the operational and investment risks were also found to be independent of the proposed CIRR.

Consequently, the CIRR for environmental projects was the lowest, followed by projects for roads, rails, and ports (See Table 6). It is known that demand in the early stages of operation of road and railroad projects is relatively higher than that of port and environmental projects. However, after the commencement of operation, the volatility of the demand decreases, and accordingly, the risk of fluctuations in operation period is relatively higher in the port projects. In the case of ports, the traffic volume of the port has a relatively high risk of demand because the vessel based logistic is highly influenced by economic fluctuations and opening or closing of routes. The fact that the port projects have an ultra-long term of approximately 50 years proves that the risk due to uncertainty is high. However, it is difficult to state that the average agreement rate of return for environmental facilities and railroad facilities is statistically significantly higher or lower than that of road projects, as it does not show statistical reliability. This means that construction and operation risks are not systematically different.

Table 6. Result of the CIRR analysis according to facility type.

Type		Average CIRR (%)
Solicited project	Road	8.101
	Rail	8.469
	Port	8.313
	Environment	5.650
	Total	6.897
Unsolicited project	Road	6.043
	Rail	5.575
	Port	6.853
	Environment	5.816
	Total	5.983

The variable representing the difference between the solicited and unsolicited project was not statistically significant, but the coefficients reflecting the difference for both models 1 and 2 were estimated as negative (−0.157, −0.101), confirming the direction. Because the dummy variable was applied for the unsolicited project, it means that the CIRR for the unsolicited project is lower than that of the solicited project. This is related to the concept of 'picking the right project' by Tiong et al. [59]. If the private sectors propose a new project, it is highly likely to present a project with high financial profitability based on better information on the market, and thus they have a room to lower the CIRR.

However, the construction subsidy that was directly provided by the government to concessionaires during the construction period seemed to reduce the CIRR of PPP projects, albeit by an insignificant amount. A 1% increment in construction subsidy produced a reduction of 0.008% in the CIRR. The MRG is a conditional government subsidy, but the construction subsidy is an unconditional subsidy. Hence, the direct subsidy has a seemingly higher influence on lowering the CIRR. In contrast, the MRG option, which is one of the government's representative risk-sharing policies, did not reduce the CIRR. Although government support has the potential to significantly reduce the CIRR, the rate was found to be 0.60% higher in projects with an MRG option at a 99% confidence interval.

An additional analysis was conducted exclusively on road projects with an MRG option to study its impact on CIRR, as shown in Table 7. However, the analysis revealed

that the CIRR of projects with the MRG was higher than that of the projects without the MRG option. This anomalous trend was observed because the CIRR had been calculated by consulting previous projects without accounting for the application of the MRG option, despite the relatively high CIRR in the early stages during the introduction of the PPP system (see Figure 1).

Table 7. Results of the regression model estimation for road BTO projects.

Category	Explanatory Variable	Model 1	
		Coef.	Std.Errors
Financing cost	Risk free interest rate (Rf_5 years)	−0.065	0.122
Project characteristics	Service area of the project (Authority)	0.688 *	0.296
	Operation period (O_Period)	0.002	0.003
	Project size: Total private investment (Ln_P_Investment)	0.148	0.13
	Solicited/unsolicited (Solicit)	0.008	0.313
Government support	Ratio of construction subsidy (Sub)	−0.006	0.006
	Minimum revenue guarantee (MRG)	1.239 **	0.423
Pre-contract process	Project preparation period (prepperiod)	0.005	0.009
	Negotiation period (negoperiod)	0.006	0.006
	Value for money assessment (vfm)	0.236	0.358
Market maturity	Negotiation experience (Exp)	0.042 *	0.02
	Competition rate (Bid_compet)	−0.045	0.112
Negotiation behavior	Average CIRR of similar recent projects (IRR_S_three)	0.386 *	0.148
Time	Time	−0.282 *	0.105
Intercept		565.589 *	211.763
Observations		57	
Adjusted R-squared		0.834	

Source: Created by the authors, Note: Signif. codes: '**' 0.01, '*' 0.05.

These findings differ from previous research results. According to Clerck and Demeulemeester [81], who studied the behaviors of government and private investors through game theory, appropriate compensation causes more bidders to participate in the market and lowers bidding cost. However, the analysis results indicating that the government's incentive plays a negligible role should be interpreted as an exceptional case in Korea.

4.3.3. Pre-Contract Process, Market Maturity, and Negotiation Behavior

A noteworthy result of this study is the identification of the effect of market competition (competition rate) on the CIRR. The analysis demonstrated that the CIRR of PPP projects was closely related to the number of competitors or the degree of market competition. It was observed that the addition of a single competitor reduced the CIRR by

0.257%. This indicates that increasing the competition is an important strategy that the government must adopt to strengthen public interest in PPP projects, thereby leading to lower construction subsidies and user fees. Prequalification for the selection of the preferred bidders is in line with the study of [81], which analyzed that three players at the prequalification were advantageous in terms of optimal investment and average payoffs. Although this study was limited to the case when the number of bidders was increased from three to four, it was found that increasing the number of bidders could lower the bidding price.

However, the VfM assessment did not demonstrate the presence of a statistically significant relationship with the CIRR. A VfM assessment compares the total life-cycle costs between the PSC (public sector initiative) and PFI (private finance initiative). The results of the VfM assessment determine the approval or disapproval of a PPP project. The CIRR of a project that undertook a VfM assessment was expected to be lower than that of a project that did not undertake the assessment. This is because a higher CIRR can increase government contribution, which reduces the probability of the PPP project clearing the VfM assessment. However, the statistical analysis revealed that there was no significant difference between the CIRR values of a PPP project that undertook a VfM assessment and a PPP project that did not. These results suggest that there is a need to improve the content and method of the VfM assessment. Other pre-contract process factors, such as the project preparation period and negotiation period, had no significant impact on the CIRR.

Thus, the CIRR values of previous projects that are similar to the current one were found to be the most influential factors in determining the CIRR of a PPP project in Korea. These results suggest that each party accounts for the CIRR values of previous projects to avoid responsibility and blame while negotiating the outcomes without considering the risks associated with these projects. This negotiation behavior appears to be a major obstacle that may prevent the successful promotion of PPP projects in the future.

5. Conclusions

This study analyzed the factors affecting the CIRR of PPP projects and their relationship by employing statistical techniques to process the actual data of the BTO projects performed in the past 20 years in Korea. It was expected that an analysis of the CIRR of PPP projects would present a technique to balance the risk-taking behavior of the private investors and the government. It was assumed that each risk factor would have its own contribution in determining the CIRR. However, the study revealed that the CIRR values of Korea's PPP projects did not accurately reflect the risks associated with the project characteristics. The risks associated with the facility types, service area, amount of private investment, and operation period were not sufficiently reflected in the CIRR. It was also observed that even the financing cost of the project did not demonstrate a statistically significant relationship with the CIRR. In addition, the MRG option, which was one of the Korean government's representative risk-sharing policies, did not reduce the CIRR. On the contrary, the CIRR for PPP projects with the MRG option was found to be higher than that of PPP projects without the MRG option. The CIRR of previous projects that are similar to the current one was found to be the most influential factor in determining the CIRR of PPP projects. Changes in CIRR play an important role that can be interpreted as increasing the financial burden of the government while decreasing the financial burden of the private sector, or vice versa. This indicates a fault in the bureaucratic negotiation behavior due to the reluctance of either party in assuming responsibility and blame for negotiating outcomes. This implies that we must rethink our negotiation practices. The fact that CIRR was not affected by the changes in government support, such as MRG, which directly affects the financial changes of private investors, indicates that there was no procedure to reverify this from an objective perspective. This necessitates the re-examination of the factors affecting CIRR.

Although many factors were found to have an impact on CIRR, the reason that the factors including pre-qualification variables, such as VfM assessment, length of negotiation,

project preparation, and negotiation experience, did not have a statistical significance is because of their relatively low influence on the CIRR as compared to that in previous projects. This can be attributed to the fact that they indirectly affect the CIRR such that the change is insufficient to significantly change the CIRR. These variables cannot be considered to have a direct impact on CIRR-like subsidies.

Some variables were statistically insignificant, but they provided evidence to identify the direction of the impact on the CIRR (positive or negative). Even though the variable that distinguishes between solicited and unsolicited proposals is not statistically significant, it was found that unsolicited projects lower the CIRR.

However, this study observed that the CIRR was closely related to the number of bidding competitors, thereby implying that increasing competition was an important instrument that the government could employ to increase public interest in PPP projects. Although these findings are not new, the fact that the increase of one bidder influences the CIRR to decrease by 0.257 is considered a contribution of this study. It is necessary to disclose project and bidding information, simplify implementation procedures, increase guarantees and compensation for failed proposals, etc. to encourage competition in the PPP market. In particular, it is necessary to develop a policy that relieves the burden of preparation cost to lead to competition amongst the private sector. [54]. Recently, preparation costs have been increasing, and PPP project preparation costs, including those of VfM tests, are considerably higher than in the early days of PPP and that of traditional public procurement [71,80]. In an environment where there is no compensation for project preparation costs, many private companies will not enter the PPP market, resulting in the lack of competition.

The results of this study cast doubt on the current risk-sharing schemes implemented in Korea. It is imperative for the government and the private partners to accurately account for the risks to effectively promote PPP projects. The risks must be gauged and analyzed, and explicit rules should be instituted for government support to promote the seamless execution of PPP projects.

The results of this present important policy implications for Korea and other countries that are interested in promoting successful PPP ventures; our results are therefore essential to identify key risk factors and facilitate appropriate risk allocation. Further research—that is, case studies in countries with different budget and PPP systems—is needed to review and verify the results presented in this study. These studies should cover the full range of aspects related to governance, including responsible policy making, budgeting, and accountability to the public for the use of public resources for PPP projects.

Additionally, a wider variety of factors that may influence the CIRR needs to be investigated in future studies. Research may include areas such as, the characteristics private sector consortium, investment and equity structure of the project, credit rating, knowledge of the construction and operation of specific facilities, profit of construction and operation investors, and loan interest rate on actual financial commitments. It will be extremely interesting to analyze the impact of factors that were not considered in this study and their importance in comparison to other factors.

Author Contributions: The authors K.K. developed the main theme of the article, K.K. and J.K. performed the work on data collection, regression analysis; K.K., J.K., and D.Y. contributed equally to the final dissemination of the research investigation to form the article; D.Y. contributed to the review and editing of the article. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Korea Development Institute, grant number 2018-16.

Institutional Review Board Statement: Ethical review and approval were waived for this study, due to the openness and non-personnel character of the study.

Informed Consent Statement: Patient consent was waived due to the openness and non-personnel character of the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy.

Conflicts of Interest: The authors declare no conflict of interest.

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