Cumulative Effects on the Change of Residual Value in PPP Projects: A Comparative Case Study

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Abstract: Public private partnerships (PPPs) have been adopted widely to provide public facilities and services. According to the PPP agreement, PPP projects would be transferred to the public sector. However, problems related to the subsequent management of ongoing PPP projects have not been studied thoroughly. Residual value risk (RVR) can occur if the public sector cannot obtain the project in the desired conditions as required in the agreement when a project is being transferred. RVR has been identified as an important risk in PPPs and has greatly influenced the outputs of the projects. In order to further observe the change of residual value (RV) during the process of PPP projects and to reveal the internal mechanism for reducing the RVR, a comparative case study of two PPP projects in mainland China and Hong Kong was conducted. Based on the case study, different factors leading to RVR and a series of key risk indicators (KRIs) were identified. The comparison demonstrates that RVR is an important risk that could influence the success of PPP projects. The cumulative effects during the concession period can play significant roles in the occurrence of RVR. Additionally, the cumulative effects in different cases can make the RVR different because of different stakeholders' efforts on the projects and ways to treat RVR. Finally, alternatives for the public sector to treat RVR were proposed. The findings of this research can reduce RVR and improve the performance of PPP projects. **DOI: 10.1061/(ASCE)IS.1943-555X.0000272.** © *2015 American Society of Civil Engineers.*

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Introduction

Public private partnerships (PPPs) have been widely adopted by the public sector because of limited funding and skills for the development of infrastructure projects (Ke et al. 2012; Thomas Ng et al. 2013). So far, PPPs have contributed greatly to the successful delivery or regeneration of infrastructure facilities and supply of high quality public services (Hodge and Greve 2007; Lee and Yu 2012; Cruz and Marques 2012; Tang et al. 2013). However, as echoed with other PPP research (e.g., Chan et al. 2010; Liu and Wilkinson 2014), the authors' prior study indicated that many problems such as downfall of product or service performance, functional problems, decrease of profitability, low possibility of refinancing, deterioration of maintainability, decline in operability, and failure of sustainability occur when PPP projects are transferred back to the host governments upon the expiry of the concession period, and these problems related to the subsequent management of PPP projects had close relationships with residual value risk (RVR) (Yuan et al. 2015). RVR in PPPs can be defined as "the risk that on the expiry or earlier termination of the services contract the asset (tangible or intangible) is not in accordance with the value (originally estimated by the government), at which the private party agreed to transfer. As a result, the public sectors could suffer the loss of the residual value, and the private sector could also suffer the loss of compensation from the government due to different residual values" (Yuan et al. 2015). RVR has thus been viewed as a critical issue when PPP projects are reverted to the public sector (Private Finance Panel 1996; Hall 1998; Jin 2010). If not well controlled, RVR will cause a variety of negative influences like high maintenance cost, low quality service, and functional problems in facilities that fail to meet the prescribed requirements in PPP contracts.

Many PPP contracts usually clarify performance specification and conditions of transferred projects (HM Treasury 2007). For instance, a client for a tunnel PPP will state his/her requirements (as an output specification) for the provision of services or the availability of the tunnel system, primarily in terms of journey times, traffic capacity, frequency of maintenance, quality grade, operating hours, and maximum failure levels. However, the public sector, which can greatly influence the success of a PPP project during the long-term process of planning, construction, operation, and transfer, may neglect the effect of the residual value (RV) change, and the risk may be substantial because of the cumulative effects of the RV change (Algarni et al. 2007). As a result, many PPP projects could not provide quality public goods and services after the concession period is

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over (Ng et al. 2010; Chan et al. 2010). Finally, RVR occurs and leads to a high loss of residual value, which is influenced by many factors, including project performance, function, profitability, maintainability, operability, sustainability, and the possibility of refinancing (Private Finance Panel 1996; Yuan et al. 2015). For example, the return of the Hong Kong Western Harbour Tunnel was reduced at least 60% because of an unreasonable toll adjustment mechanism (TAM) during the concession period. Hence, it can be concluded that the cumulative effects on the change of RV in PPP projects are an important cause of RVR (Algarni et al. 2007).

Meanwhile, factors that influence the change of RV always occur simultaneously and may interact with one another. The interactions among the different factors during the concession period have cumulative effects on RV (Yuan et al. 2015). Risk planning should therefore carefully consider and evaluate these interactions to ensure that RV upper limits are not breached. On the other hand, the change of RV could accumulate through additive or interactive processes. The effect of interaction between two actions on the RV could be complicated and may lead to a loss of RV that is worse than originally defined in the agreement. Furthermore, National Public Private Partnership Guidelines edited by Infrastructure Australia (2008) indicated that poor maintenance of the assets results in many disputes and losses, and the public sector cannot obtain the return in the desired conditions (e.g., improved service level and well-functioning facilities).

Therefore, two questions need to be answered in order to help PPP projects keep high value of tangible and intangible assets to deliver value for money (VfM) and reduce RVR:

- First of all, how do the cumulative effects influence the change of RV in PPP projects?
- Secondly, how can the cumulative effects be reduced to decrease the RVR in management of PPP projects?

This paper mainly focuses on answering the first question and partly tries to figure out the second question. A comparative case study between mainland China and Hong Kong was adopted to investigate the cumulative effects on the change of RV in PPP projects. Then the RVR framework proposed in the authors' prior work provided a tool to analyze the role of the public sector in RVR management and to identify the critical factors resulting in RVR in different PPP contexts. The authors' prior work clarified the perception of RVR in PPP projects and presented a precise definition and meaning of RVR in PPP projects through a research survey (Yuan et al. 2015). Meanwhile, six critical risk factors leading to RVR were identified and a RVR model was proposed, by which the cumulative effects of the interaction of different risk factors were preliminarily identified.

Different from the authors' prior work, this paper compares the difference between two cases in Nanjing and Hong Kong to illustrate the cumulative effects on the change of RV in PPP projects and to figure out how to reduce the cumulative effects to decrease the RVR. The paper is organized as follows. The next section describes the research methods, followed by a brief introduction of cases. After comparing the cases by a RVR framework in PPPs, the paper discusses the cumulative effects, the roles of the public sector, the treatment methods of RVR in cases, and suggestions to improve the RVR management, before it reaches the final conclusions.

Research Methods

In many PPP studies, case studies have been viewed as a useful technique to explore how to make decisions, how to successfully implement PPP projects, how to manage the contract, and how to better manage and allocate risks (Zheng and Tiong 2010; English and Baxter 2010; Haughton and McManus 2012). Although there have been extensive studies focusing on the strategic and project management levels, further investigations are needed to identify and evaluate the practices and lessons learned from real PPP projects so as to capture specific project features; gain a deeper understanding of project implementation; and provide useful implications for PPP developers, project investors, and policy makers. Case studies can be an effective research approach for this purpose (Chen 2009). However, as different PPP projects have unique project and country environments, a comparative case study would be more appropriate to obtain common experiences. Comparative case studies have been widely employed to compare and evaluate the effectiveness of policy/decision making and project management and to identify the similarities and differences of different cases. Thus the advantages and disadvantages of each case can be characterized, and how these concern the decision makers, managers, and investors can be demonstrated (Lee and Yu 2011).

In this study, two cases, one from Nanjing in mainland China and the other from Hong Kong, were compared to identify the critical issues related to RVR, to analyze the cumulative effects on the change of RV in PPPs, and to explore the appropriate methods to treat RVR. Data of these two PPP projects were gathered through primary documentary analysis of contract documentation and secondary documentary analysis of government and the reports of the private sector.

In order to implement a comparative case study, the RVR framework proposed in the authors' prior work was used (Fig. 1). This framework included risk factors and related key risk indicators (KRIs), different stages at which RVR could occur, and possible effects on the changes of RV. It is a useful tool to observe and analyze RV problems for a real PPP project from the period of preconstruction to the stage of project transfer or the stage of project operation. Usually, PPP projects could be transferred on expiry or earlier termination of the services contract. In different countries or regions, the situation would be different. Through case studies, the changes of RV can be observed to verify the occurrences of RVR, to understand the methods to treat RVR and their effects on RV, and to identify significant factors of RVR management and valuable leading KRIs. Case studies are helpful to investigate the dynamic relations between an observed phenomenon (project arrangements) and their context (change of RV). The current case study focuses on identifying different factors that could result in loss of RV. Moreover, a series of leading KRIs that can indicate the emerging problems in different stages can also be identified. KRIs are measures used in management to indicate how risky an activity is, and they can be used to measure the influence of the aforementioned factors on the change of RV (e.g., the degree of design defects could measure the influence of the problems related to product or service performance and project function). A detailed list of possible leading indicators is shown in Fig. 1. The emerging problems may include downfall of product or service performance, functional problems, decrease of profitability and low possibility of refinancing, deterioration of maintainability, decline in operability, and failure of sustainability. Furthermore, cumulative effects of risk factors in different projects can also be discussed and possible methods for the public sector to treat RVR can be proposed. The research method is also shown in Fig. 1.

Case Introduction

Case Selection

Case 1 is the Yangtze River Tunnel in Nanjing (NJYRT), and Case 2 is the Western Harbour Tunnel in Hong Kong. These two projects

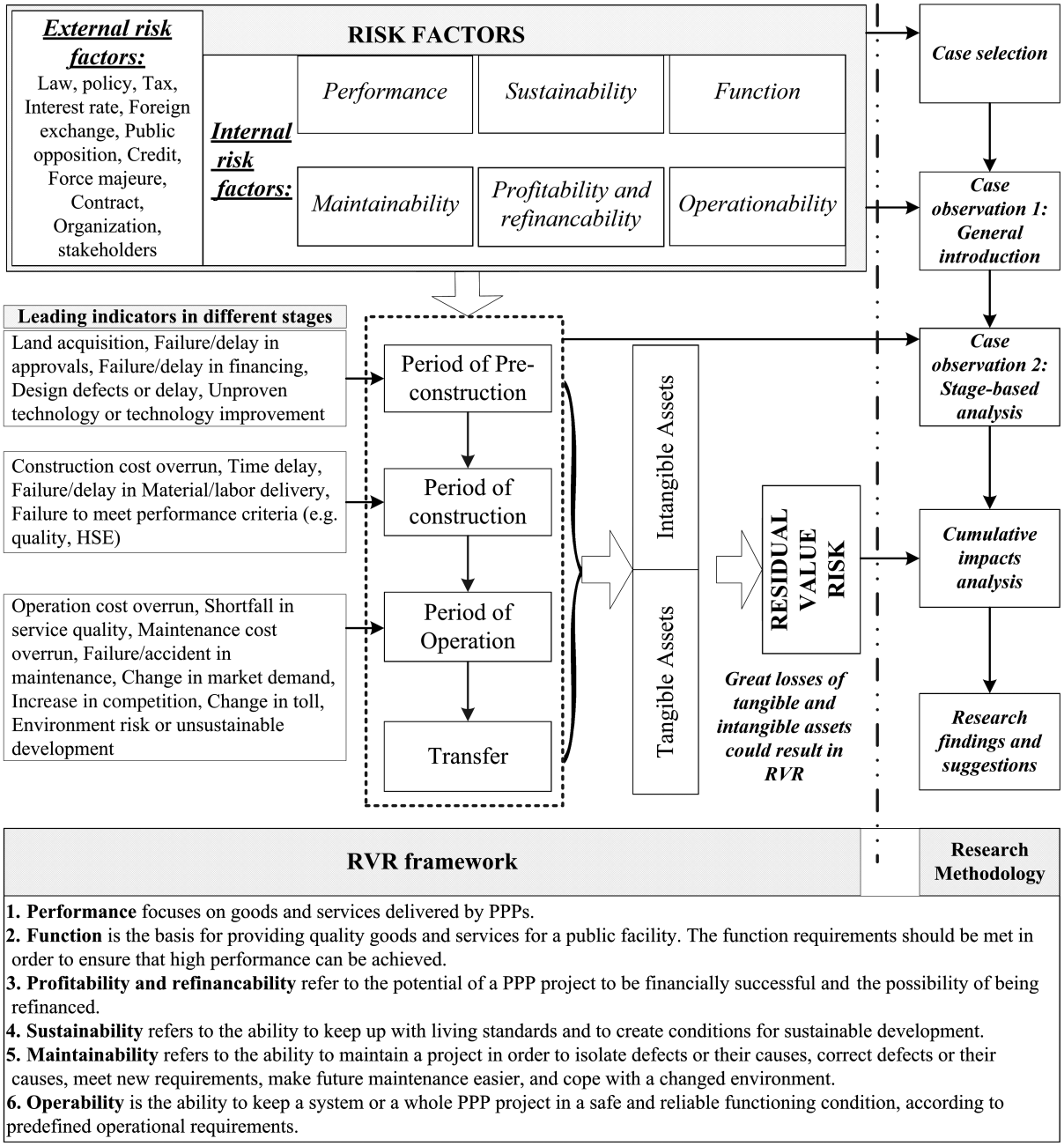

Fig. 1. Framework of RVR and research method

were selected for several reasons. The selected two cases are the representatives of PPP projects in developing and developed countries/regions. The findings from the case study could hold true for other national and international projects that may have different environments, stakeholders, agreements, etc. Case 1 in mainland China is a typical PPP project in a developing country, in which political and economic environments, the opinions of stakeholders, and the process and contents of agreements are similar to other developing countries. For Case 2, the public administration systems are similar to those in developed countries, although Hong Kong has been transferred from the United Kingdom to China. Hence the experience from Case 2 will provide a useful reference for other developed countries. The main differences between these two cases are different political systems. In mainland China, top party/state leaders and officials play the most important roles in the decision-making process. In Hong Kong, a system of governance is led by a Chief Executive and an Executive Council, with a two-tiered system of representative government and an independent judiciary. Therefore, the public sector adopts different ways to treat RVR and the change of RV is different in the two cases. However, these two cases are also similar to each other. Both of them were important local tunnels in each city. The private sector was introduced to these two PPP projects to meet complicated technical, managerial, and financial requirements (Zhang et al. 2009; Yuan et al. 2010). There were similar problems related to tolls in these two projects, but the public sectors' methods to deal with the problems are different in each case because of different economic and political environments. Therefore, these cases provided an interesting and attractive case comparison for the change of RV. Moreover, how the government and private sector deal with the problems can influence RV in PPP projects.

The focuses of these two PPP cases were the price adjustments that could result in RVR. The different treatment methods by the

Nanjing local government and Hong Kong government can reflect how the RV changes and which factors could influence RV. In these two cases, the expected RV of PPP projects can be qualitatively described according to the proposed definition of RV in Yuan et al. (2015). The tangible assets include the tunnel itself; related facilities (e.g., traffic monitor system, traffic signal system, lighting system, fire prevention system, ventilation system, drainage system, etc.); and related technical and management files and documents. The intangible assets of these two cases include all nonphysical resources and rights that belong to special purpose vehicles (SPV) like the organization, intellectual property, reputation, and market share as mentioned previously. Meanwhile, multiple factors can lead to a change of RV in both cases from the perspectives of performance, function, maintainability, profitability and possibility of being refinanced, sustainability, and operability. Therefore, the comparative case study aims to identify which factors could lead to RVR and how these factors can be measured by different KRIs in each case.

Case 1: Nanjing Yangtze River Tunnel

Case 1 in mainland China, the Nanjing Yangtze River Tunnel (NJYRT), is the first dual three-lane tunnel crossing the Yangtze River in Nanjing city, with a length of 5,853 m. The tunnel carries three lanes of traffic traveling in one direction at a design speed of 80 km/h according to the Central People's Government of the People's Republic of China (CPG of PRC 2010). Two of the lanes are 3.5 m wide and the third will be 3.75 m wide. There will also be 0.5 m-wide pathways on each side to assist with evacuations in an emergency. The tunnels feature 12 cross connections spaced approximately 300 m apart. The internal diameter of each tunnel is 13.3 m; the external diameter is 14.5 m. This is a very large and complicated city tunnel. Related information was collected from local government and local major media [Nanjing Daily Newspaper (NDN), Xinhua Daily Newspaper (XDN), and Yangtze Evening Post (YEP)].

As the capital city of Jiangsu Province, Nanjing is the host city of the 2014 Youth Olympic Games, a big city along the Yangtze River (the longest river in China). Recently, the urban planning of Nanjing city (2010–2030) has been approved by the central government, and Nanjing has been determined as the key city in eastern China. The local authority of Nanjing is now focusing on facilitating the development of the transportation system to provide quality service. By 2030, at least 16 channels across the Yangtze River will be put into use, including 6 bridges, 2 tunnels, 3 metro lines, 3 light railways to northern Jiangsu Province and Anhui Province, as well as 2 high speed railways (CPG of PRC 2010). Therefore, the introduction of the private sector into infrastructure development (e.g., metro, bridge, and tunnel) helps obtain more capital, improves the management level, and achieves value for the cost of public projects. The PPP method was used in the NJYRT, whose total investment was US$530.64 million, equal to 3.3 billion RMB (the date of currency conversion was January 19, 2015) (Zhao 2006). The NJYRT was planned to be a fast passage connecting Nanjing's main urban zone with the Jiangbei new urban zone of Nanjing, greatly improving communication between the northern and southern banks of the Yangtze River, as well as further shortening travel time. Thus, more convenient public service would be achieved (Yuan et al. 2010).

Many problems (e.g., construction complexity, time delay, and debate on the toll level) occurred during the development of the Nanjing Yangtze River Tunnel PPP project, which led to early termination of the agreement. Obviously, the RV in this project could be influenced when the tunnel was transferred to the public sector. The problems that occurred in different stages of this project cumulatively affected the RV.

Case 2: Hong Kong Western Harbour Tunnel

Case 2, the Hong Kong Western Harbour Tunnel (HKWHT), was the first dual three-lane harbor tunnel built in Hong Kong and in Southeast Asia. It is the third tunnel to cross Victoria Harbour after the Cross Harbour Tunnel (CHT) and Eastern Harbour Tunnel (EHT), linking the newly reclaimed land in West Kowloon with Sai Ying Pun on Hong Kong Island (SCMP 1997). The US $967.5 million project (equal to 7.5 billion HKD, with a date of currency conversion on January 19, 2015) incorporates a 2 km immersed tube tunnel and tunnel structures, and as a principal arterial it includes 10 km of associated roads (40 km of lanes) and 17 bridges. The HKWHT was part of the airport core program (ACP) that formed the framework for the development of the new Hong Kong International Airport. The related information was collected from the local government, Legislative Council Panel, and the local major media South China morning post (SCMP).

In the late 1980s, the Hong Kong government forecasted that the population and the number of vehicles would grow greatly in Hong Kong. The growth in the number of cross-harbor trips was one of the reasons for the initiation of the HKWHT. The Hong Kong government also forecasted that the number of daily cross-harbor person trips would increase by 86% from 1.4 to 2.6 million, and goods vehicle trips by 129% from 34,000 to 78,000 over the same period (Transport Department of Hong Kong 1989). By the early 1980s, the two existing harbor crossings (CHT and EHT) were carrying far more vehicles per day than their design capacity. Therefore, the HKWHT was recommended and expected to provide sufficient additional capacity to meet the cross-harbor road traffic demand until the 21st century. Hence the main objectives of the project were to relieve growing traffic congestion on the two existing harbor crossings and to contribute to the transport infrastructure links such as the new airport that opened in 1997 (Omega Centre 2012).

In fact, the performance of the HKWHT has been disappointing to date during its period of operation in spite of high expectations from both the government and general public. Both traffic volumes and revenue have been consistently well below estimates. Western Harbour Tunnel Company Ltd. (WHTCL) has responded by increasing toll levels five times to 2013, but this has only resulted in further reductions in traffic volume and queues at the other two harbor crossings, which have lower tolls (WHTCL 2010). The project has thus been criticized for not meeting its original objective of relieving congestion at the other crossings. Moreover, the general public has asked the local government more and more frequently for the early return of the tunnel (Wilbur Smith Associates 2010; Cheng 2012). Without regard to the opinions of the general public, the Legislative Council Panel on Transport of Hong Kong (LCPTHK) plans to keep on enforcing the agreement until the end of the concession period (LCPTHK 2010, 2013). So far, the HKWHT has not been transferred to the public sector. The RV of Case 2 could be different from the estimation in the agreement because of low traffic volumes and revenue.

Observations on the Cases

Critical Issues in the Period of Preconstruction

Case 1: Successful Procurement, High Technical Difficulty, and Urgent Needs for NJYRT

As the first large-scale transportation build operate transfer (BOT) project in Nanjing City, the procurement of the NJYRT was elaborately designed. However, the technical difficulty of the Yangtze

River tunnel was in fact very high, which was the most important risk factor for the concessionaire. Meanwhile, the needs of the private and public sectors for the tunnel were very strong because most transport tasks were undertaken using the first, second and third Nanjing Yangtze River bridges before the operation of the NJYRT. These bridges were built in 1968, 2000, and 2005, respectively. The huge demand greatly exceeded the capability of the previous three bridges. The details are shown in Table 1.

Case 2: Detailed Feasibility Study, High Expectations on the HKWHT, and Unsuccessful Procurement

The decision to introduce the private sector to build, operate, and maintenance the HKWHT was made very carefully, which could greatly benefit subsequent works like procurement and construction. As in Case 1, the government and general public had very high expectations for the HKWHT. For all stakeholders, the HKWHT would provide a brilliant future. On the contrary, the procurement of the HKWHT was not successful to some extent because of excessive changes from when the bidding was initially planned to when the formal agreements was signed (September 1990 to July 1992). Another critical issue was the debate on the toll charges and adjustments that would be applied in the operation period (LCHK 1993c, b). The toll adjustment, which was called the toll adjustment mechanism (TAM) in the HKWHT, allowed the operator to increase the tunnel toll by US$1.29 whenever its internal rate of return (IRR) fell below 15% in simple terms. The TAM was discussed over and over again (Robertson 1998). The details are shown in Table 1.

Critical Issues in the Period of Construction

Case 1: High Construction Complexity, HSE Risks, and Time Delay

As mentioned earlier, the difficulty of construction was very high in Case 1, and hence the construction risk was high. Health, safety, and environment (HSE) incidents cannot be avoided in such a huge project. Moreover, cost overrun and completion delay were inevitable because of the high complexity of construction and many HSE incidents. The details are shown in Table 1.

Case 2: Ahead of Schedule, Cost Overrun, and Environmental Effects

The construction period of Case 2 was from August 1993 to April 1997 (Robertson 1998). The entire project was completed slightly ahead of schedule as many advanced technologies were adopted. However, the project costs experienced an overrun mainly because of the associated buildings and roads (Omega Centre 2012). Meanwhile, the environmental effects during the construction were extraordinarily huge because Case 2 was a city tunnel crossing the Central Business District and a residential community. The details are shown in Table 1.

Critical Issues in the Stage of Operation

Case 1: Debate on the Toll Level and Early Termination of Concession Period

The Yangtze Tunnel was not put into use until 2010. From 2009 to 2010, the toll level of the tunnel had been debated between the local government and the China Railway Construction Corporation Group (CRCC). The core issue of negotiation between the public and private sectors was the toll level. The tunnel was finally returned to the public sector before its operation under public pressure. However, road users are still charged after the private sector withdrew from the tunnel. As shown in Fig. 2, most drivers prefer the first and second Nanjing Yangtze River bridges. The details are shown in Table 1.

Case 2: Debate on the TAM and Toll Level, Asking for Early Termination, Possible Extension of Concession Period

The TAM that was designed by WHTCL and approved by the government led to frequent toll adjustments (LCHK 1993a; Omega Centre 2012). In the operation of the HKWHT, the TAM was introduced to achieve the target rate of return, ranging from 15 to 18.5%. The toll was initially proposed to be US$3.87 for private cars (Omega Centre 2012). According to the TAM, the operator could increase the tunnel toll by US$1.29 whenever its IRR fell below 15%, which means the operator can arbitrarily increase the toll if traffic levels are lower than the forecasted volume and revenue falls short (Robertson 1998). The TAM can be viewed as the adjusting device between the public and private sectors. For the private sector, the TAM, which can reduce the uncertainty of the income stream and return, can provide an effective tool and better control to deal with the risks related to cost overrun, inflation, decrease of traffic flow, etc. Therefore, the purpose of the TAM was to provide WHTCL with a reasonable but not excessive return and maintain a stable toll regime for road users. WHTCL could be ensured to earn sufficient revenue to pay its debts. For the public sector, the government can control the pricing of the tunnel through the TAM. The toll was nonetheless adjusted many times since its opening because of the TAM. The general public still prefers to use the other two tunnels despite severe congestion, as shown in Fig. 3 (LCPTHK 2013). The high toll level of the HKWHT has greatly influenced the reputation of WHTCL compared to other tunnel companies. Furthermore, many people are asking for early termination of the PPP contract for a free toll in recent years, although the concession period could be extended by the government because of low traffic volume and revenue (LCPTHK 2013). The details are shown in Table 1.

Another problem in the operation of the HKWHT is related to the project function. The HKWHT was supposed to provide good connectivity with the road network as indicated by Omega Centre (2012). In reality, the HKWHT was poorly integrated with the road infrastructure in HK, like Route 3, Route 7, the West Kowloon Expressway, and the approach roads connecting to Tsim Sha Tsui and other parts of Kowloon, which hindered urban development in Hong Kong. Meanwhile, the lack of bus services, particularly airport buses before 2008, also created inconvenience for the residents (Omega Centre 2012). Therefore, the HKWHT did not successfully reduce traffic congestion, especially during peak hours.

Comparison of the Cases

How the RV of Project Changed during the Concession Period

The comparison of these two cases focuses on the change of RV in PPP projects. The most important features of the cases were the mixture of economic benefits, political power, and public opinions. The early termination of Case 1 and the debate in Case 2 all resulted from multiple factors as mentioned before. By using the proposed model in Fig. 1, factors that affect the change of RV have been identified, as shown in Figs. 4 and 5.

During the comparison, two critical issues should be highlighted. One is KRIs that can indicate the emerging problems in different project stages influenced by external effects, and the other is risk factors that can directly affect the RV of PPP projects. KRIs can measure how risky an activity is and play critical roles in a risk management framework. In this comparative case study, the model

Table 1. Critical Issues in Cases during Concession Period

Case	Stage	Critical issue	Description	References
Case 1	Preconstruction	Successful procurement	The public unlimited competitive bidding was used. The call for bidding was published in mainland China, Hong Kong, and Taiwan. The bid evaluation committee was composed of 6 academicians in China Academy of Engineering and 35 famous experts. After defeating more than 10 bidders, the SPV is finally composed of CRCC, Nanjing Transportation Corporation Group, and National Capital Management Company of Pukou District	Reid (2006), Zhang et al. (2009), Zhao (2006), Khasnabis et al. (2010), Ke et al. (2008)
		High technical difficulty	The geological conditions of the tunnel were very complicated. The tunnel passed through multiple geological layers, including silt, fine sand, gravel, pebble, and weathered rock	
		Urgent needs for NJYRT	The predicted IRR would be 14%, and future revenue was attractive to the private sector. According to prior research, the predicted IRR should be at least 7%, which means that the return for the private sector can be acceptable. Usually, IRR was less than 10% in India, and it will have high financial viability for PPP transportation projects if the IRR can reach 15% in China. The NJYRT was expected to strengthen accessibility, shorten traffic time, improve the value of lands, and facilitate the development of the local economy. The equivalent number of passenger car units (PCUs) per day was predicted to reach 100,000 per day in 2010 and 150,000 per day in 2030	
	Construction	High construction complexity	The TBMs (tunnel boring machines) used in the project had an external diameter of 14.5 m, which is close to the world record in size. The depth of earth covering the tunnels ranged from a minimum of 5.5 m to a maximum of 30 m, except in the section under the river, where the minimum covering depth was 10.2 m. The maximum longitudinal gradient was 4.5% and the minimum 0.6%. The minimum vertical radius of curvature was 7,500 m	CCRN (China Construction Railway News) (2012), Reid (2006), NDN (2009), NDN (2010a)
		HSE risks	HSE incidents occurred during the construction period. A severe machine fault of TBM happened during construction because of operational mistakes, which resulted in many casualties. Furthermore, negative environment effects were also made by the construction process because many chemical mud loss control additives were used in the project to solve the problem of leakage resulting from low quality segments of tunnel	
		Time delay	The actual costs of the project were more than US$643.2 million, which were larger than the initial investments of the Yangtze River tunnel, which were US$530.64 million. The construction was planned to be completed in three years from 2005 to 2008. However, the duration of construction was actually from 2005 to 2010	
	Operation	Debate on the toll level	When the tunnel construction was almost complete, the online public opinion poll organized by Nanjing major media indicated that about 93% of citizens preferred the free tunnel. Faster, cheaper, and more convenient services provided by this PPP project were the expectation of the general public, who do not know what PPP is. The toll of the tunnel was initially set as US$3.20 for one trip, which means people had to pay at least US$6.40 per day for a round trip. The first Nanjing Yangtze River Bridge is free. The local government experienced high pressure from the general public	XDN (2010), NDN (2010b), YEP (2014)
		Early termination of concession period	The toll has not been canceled but reduced to US$1.60 for one trip. So far, the traffic volume of the Yangtze River tunnel is still low compared to its design capability and the first Nanjing Yangtze River Bridge. According to the latest statistics, the PCU of the tunnel is about 40,000. Fig. 2 shows that most vehicles choose the first and second Nanjing Yangtze River bridges. Less than 15% of vehicles choose the Yangtze River Tunnel. The original expectations of the public sector and general public have not been achieved, which eventually leads to low traffic flow	

Table 1. (*Continued.*)

Case	Stage	Critical issue	Description	References
Case 2	Preconstruction	Detailed feasibility study	The idea of the HKWHT was first proposed in 1976. Before the project's plan was finally enacted, there was a long-term enabling and decision-making process. Furthermore, a series of feasibility studies were also undertaken prior to the construction of WHC. The report entitled "Additional Cross Harbour Facilities: Study of Long Term Options 1981" proposed three options for the alignment of the HKWHT. In 1984 and 1989, more detailed studies, entitled "Study on Harbour Reclamations and Urban Growth" and "Second Comprehensive Transport Study," were conducted by Western Harbour Crossing Consultants (WHCC), which were composed of more than 10 government departments, to demonstrate the possibility of investments in the HKWHT. The final reports of the HKWHT were released in 1991 by the Hong Kong government, Highways Department, and WHCC (HKG, HD, and WHCC), which indicated that the HKWHT was feasible and capable of attracting investments from the private sector	Wilbur Smith Associates (1976), Wilbur Smith Associates (1981), Hong Kong Standard (1984), TDHKD (Transport Department of Hong Kong Department) (1989), HKG, HD, and WHCC (1991a), Ng (1993), Omega Centre (2012), SCMP (1992)
		High expectations on the HKWHT	For the local government and general public in Hong Kong, the initiation of the HKWHT was the method to resolve the problems of traffic congestion, to provide much needed relief for the two existing cross-harbor tunnels, to form part of the key strategic networks to ACP, and to facilitate development of the western side of Hong Kong. Meanwhile, the concessionaire wished to earn favorable profits from the HKWHT. According to government estimates, the SPV, WHTCL, was expected to earn a net revenue of US$7.74–10.79 billion during the concession period	
		Unsuccessful procurement	Although many investors were interested or formed consortiums to prepare the bid, only the WHTCL composed of the Cross-Harbour Company, CITIC Pacific, and Kerry Properties ultimately submitted a bid. The changes during the procurement included additional work on a road that was not in the original plan, measures proposed by the government to compensate the affected residents, high financing costs for all bidders, and heavy insurance requirements to cover all risks undertaken by potential contractors, all of which resulted in the withdrawing of bids and the reduction of competition in tender and bidding. Furthermore, negotiation between concessionaire and government was too long because the project was part of the ACP, and the project would be transferred from the British government to the Chinese government after 1997	
	Construction	Ahead of schedule	The construction work included the harbor tunnel between West Kowloon and Sai Ying Pun (immersed tube road tunnel) and other associated buildings and roads. First, the tunnel was composed of 12 precast units that have been fabricated out of the sites to facilitate the construction. Meanwhile, a satellite global-positioning system was used to ensure the unit was precisely located on the seabed, to ensure high quality of the tunnel. At the end of the construction period, progress was slowed because of too much contracting work for many associated roads connected to the tunnel and buildings. At the same time, the negotiation between the government and taxi company on toll levels also contributed to the slow progress. Despite these negative issues, 95% of the entire project was in fact completed at the end of 1996. The HKWHT finally opened in April 1997, ahead of the predicted open time of August 1997	Wong (1998), TDHKD (1989), Delfino and Lee (1996), Robertson (1998), Omega Centre (2012), Yue (1992), HKG, HD, and WHCC (1991b), Griffin and Yue (1992)
		Cost overrun	The large amount of associated buildings and roads included an associated approach road to the HKWHT, ventilation building, a major interchange, a new section of the elevated road along Connaught Road West, and a toll plaza at the tunnel entrance on the Kowloon side. The costs have been adjusted many times over the years. The estimated construction costs were US$516 million, while the actual price was US$838.5 million. Additionally, the Hong Kong government spent another US$361.2 million on road improvement and traffic management schemes to facilitate the smooth flow of traffic and prepare for the opening of the HKWHT	

Table 1. (*Continued.*)

Case	Stage	Critical issue	Description	References
		Environmental effects	WHCC required that the concessionaire should be responsible for reducing the environmental effects, including noise, air and water quality, visuals, and land use during the construction and operation. Many measures were undertaken by the concessionaire to reduce the environmental effects. Nearby residents were compensated with double-glazed windows and air-conditioning for the reduction of noise and dust generated. The pollutants from the construction site runoff were required by WHCC to be diverted through sediment traps to reduce water quality effects. Moreover, many green areas were introduced to soften the landscape to a certain extent to reduce visual and land use effects. These measures made by the concessionaire caused extra costs. Meanwhile, these measures also made the concessionaire spend more time. Actually, the project could have been completed at the beginning of 1997 as mentioned before. Because of these measures, the HKWHT opened in April 1997, although it was ahead of the predicted open time	
	Operation	Debate on the TAM and toll level	The debate on the TAM and toll level started from the feasibility study. In the stage of operation, the debate became more intense, which caused principal problems. The HKWHT opened on April 30, 1997, and the PCU of the tunnel was 20,000 in 1997. The PCU was expected to increase greatly when Route 3 and the new airport opened in 1998. Meanwhile the surcharge for passengers using the tunnel was approved by the government because of low traffic volume in 1997. The PCU of the HKWHT increased from 30,000 to 40,000 in 1998 and 1999, but WHTCL still used its right to increase tolls. Since December 2000, the increased tolls have led to a fall in traffic on the HKWHT; for every percentage increase in revenue, there has been an equivalent drop in traffic volume The TAM was supported by the government for its attractiveness to the investors, although it was criticized by the Legislative Council, who argued that there was not enough control over toll increases and the minimum IRR (15%) was too high. Finally the TAM was approved by the government because the government worried that any real amendments to the TAM would reduce the attractiveness of the project to investors and banks The traffic level of the HKWHT has never reached its expected level. The recorded traffic volume has been lower than the designed capacity since the operation of the HKWHT commenced. During the year of commencement, the traffic volume was around 20,000 vehicles per day, which is less than half the original estimate of 59,000 vehicles by the Transport Department. Therefore, the toll has been adjusted many times since its opening, which not only further reduced the traffic volume but also made the general public averse to the HKWHT, so the traffic flow is still low	LCHK (1993c, b), LCPTHK (2010, 2013), WHTCL (2010, 2011, 2012, 2013, 2014), Delfino (1997), Wong (1998), Robertson (1998), HKG, HD, and WHCC (1991a)
		Asking for early termination	Many people asked the Hong Kong government to require returning the project ahead of 2023 and reducing the price so that more of the general public can use the project. However, the government stressed that the agreement between the public and private sectors should be completely executed to ensure that the commitments of the government can be implemented and the authority of the government can be protected	
		Possible extension of concession period	The government was considering extending the concession period of the project to compensate the private sector because of low traffic volume and revenue	

Uncongested Nanjing River Tunnel

Congested Nanjing 1st and 2nd Yangtze River Bridges

Fig. 2. Comparison among Nanjing Yangtze river tunnel and Nanjing first and second Yangtze River bridges (images by Wei Xiong and Chuang Ji)

shown in Fig. 1 is used to identify different KRIs in Case 1 and Case 2 during the periods of preconstruction, construction, and operation based on six risk factors. The goal of developing two sets of KRIs in two cases is to identify the relevant metrics that provide useful insights about potential risks in Case 1 and Case 2. In fact, the objectives of RVR management are the improvement of tangible and intangible assets, which can be viewed as strategic initiatives in the management process (Yuan et al. 2015). The identified six risk factors in Fig. 1 are the potential risk-related events that are important linkages between RVR and KRIs and can be used to identify KRIs. The linkage of RVR to core strategies helps pinpoint the most relevant information that might serve as an effective leading indicator of an emerging RVR. The KRIs identified in Case 1 and Case 2 are shown in Figs. 4 and 5. For example, in Case 1 (Fig. 4) technical complexity indicated possible problems related to performance and function in the stage of preconstruction; construction quality and HSE indicated possible problems related to sustainability and maintainability in the stage of construction; and public satisfaction, toll level, and traffic flow indicated possible problems of profitability and operability. In Case 2 (Fig. 5), low competition in procurement indicated possible problems related to performance and sustainability because of possibly questionable proposal and concessionaire when the project was in the stage of preconstruction. Construction cost in the stage of construction in Case 2 indicated possible problems related to performance, function, and profitability. Toll adjustment and traffic flow indicated possible problems of profitability, maintainability, and operability in the stage of early operation in Case 2. A detailed description of KRIs in different stages of the two cases is presented as follows.

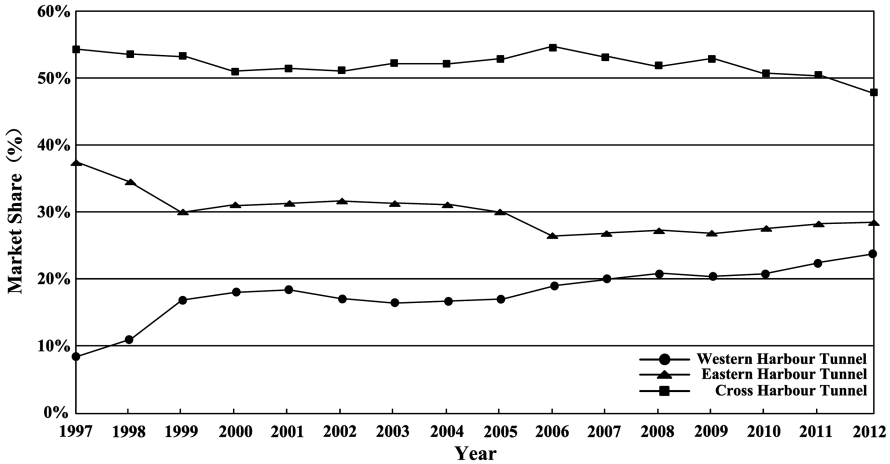

Fig. 3. Comparison among western harbor tunnel, cross harbor tunnel, and eastern harbor tunnel

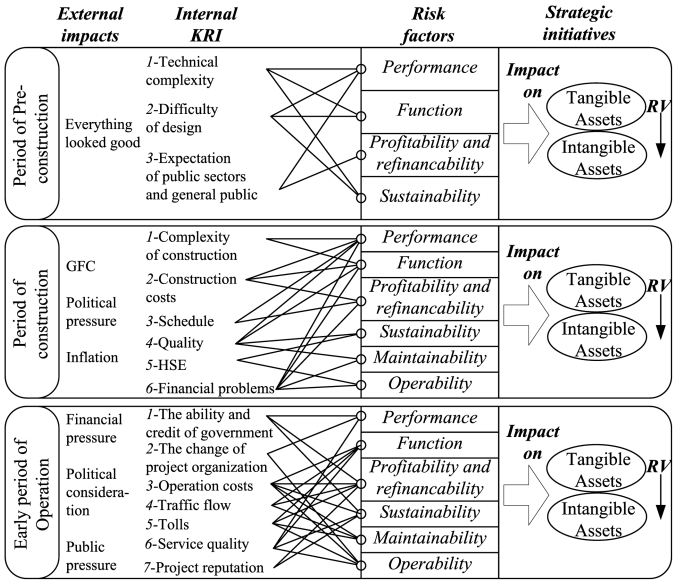

Fig. 4. Identified risk factors and RV changes for the NJYRT

Period of Preconstruction

For Case 1, the identified KRIs were technical complexity, design difficulty, and expectation of public sector and general public. The prepared work for the project was actually organized well. CRCC was finally selected as the private partner, which was the best candidate in China to design, build, and operate this large-scale tunnel. At the same time, the project obtained support from both the government and general public with high expectations. However, these high expectations would possibly hinder the development of the project; once the requirements cannot be met, the performance and profitability of the project could be influenced. Additionally, the high complexity of the tunnel could result in difficulty of design for project performance, function, and sustainability (Hodge and Greve 2007).

For Case 2, the identified KRIs were procurement competition, debate on the TAM, and expectations of the public sector and general public. In this case, the initiation, procurement, and financing works were sufficiently prepared. A careful feasibility study was a positive factor for subsequent implementation. But the HKWHT included excessive affiliated projects as a critical part of ACP. At the same time, the competitiveness of procurement was inevitably influenced: only one bidder finally submitted its bid for the project (Tam 1999). In order to attract the private sector, the flexible toll mechanism was proposed, which caused long-term debate. The high expectations on Case 2 from the government and general public also greatly influenced the project, where intangible assets (like reputation and goodness) could be harmed if the requirements could not be met.

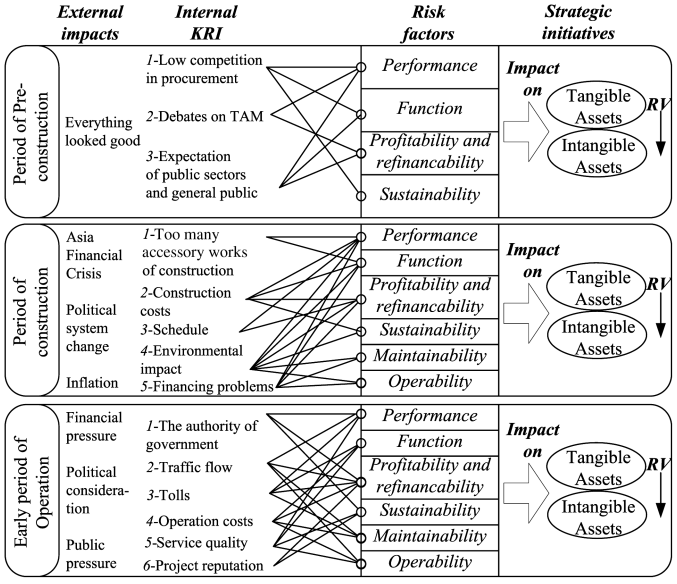

Fig. 5. Identified risk factors and RV changes for the HKWHT

There are two common grounds for Case 1 and Case 2 because of similar culture and economic environment. In each case, the stakeholders all had high expectations for the projects, and there were urgent needs for the projects to relieve growing traffic congestion and develop the regional economy. Therefore, the two cases initially obtained strong support from the governments and general public, who would benefit from the development of the projects. Moreover, there were many differences between the two cases because of the different political systems and decision-making mechanisms, as presented in the section "Case Selection." Compared to Case 1, Case 2 had advantages of scientific decision making and comparatively transparent public management. Careful decision making was lacking in Case 1, and capital restraints and urgent demands for new infrastructure were the main reasons for initiating the NJYRT. Different from the NJYRT, the HKWHT was proposed after very cautious and long-term studies. However, strong governance in mainland China to some extent facilitated the process of decision making because a decision making of 16 years (1976–1992) was impossible for a local infrastructure in mainland China. All of these differences in this stage would change the RV of projects differently.

Period of Construction

For Case 1, the identified KRIs are construction complexity, construction costs, schedule, quality, HSE, and financial problems. High complexity of construction in this stage strongly influenced the value of PPP projects. As a result, two important issues for the private sector, construction costs and duration, were changed. Therefore, the profitability and ability to be refinanced were affected in this period. Meanwhile, the global financial crisis in this period led to high inflation of material prices, financing costs, and other relative costs, as well as policy changes (KPMG Company 2009) that further worsened the quality, financial conditions, HSE, etc. Relative effects on performance, function, sustainability, maintainability, and operability occurred not only because of construction problems but also because of changing external economic and political conditions.

For Case 2, the identified KRIs are accessory works of construction, construction costs, schedule, environmental effects, and financial problems. Environmental risk in PPP projects is usually a concern of the government and can lead to various accessory works, which would cause construction cost overrun. Many prior studies have supported this opinion (Marques and Berg 2010, 2011; Chan et al. 2014). Thus the profitability and the ability to be refinanced were also influenced in the construction period. Many financial problems can result from important political events, such as the return of Hong Kong from the United Kingdom to mainland China. The value of the project was indirectly influenced. Many critical projects (e.g., the Hong Kong New Airport and HKWHT) during the transfer period were approved by the Central Government of mainland China. Hence the construction of the HKWHT was also affected by the change of political system

because the commitments and trustworthiness of government were questioned by investors. Thus the panic caused by transferring Hong Kong did in fact influence the market, which further led to inflation of finance costs and material costs, and loss of investor confidence (Schenk 2000). The obvious evidence was the 1997 Asian financial crisis. Although the construction was completed ahead of schedule, the concessionaire spent two more months before opening to facilitate the construction, reduce the environment effects, and coordinate the relationship with stakeholders. Special purpose vehicle (SPV) had to compensate the residents of 2,200 flats, affected by excessive traffic noise, with double-glazed windows and air-conditioning, in a package expected to cost up to US $15.48 million. Meanwhile, there could be function, performance, maintainability, and operability problems for the tunnel, approach road, and associated buildings because of relatively poor quality resulting from fast construction.

For these two cases, they both faced the pressure of financial crisis, politics, and inflation, which all resulted in cost overrun, negative environmental effects, and financing problems. Special attention should be paid to two issues. First, political factors were important for these two cases. For the NJYRT, political support directly facilitated the development of the project in spite of negative effects from the high complexity of construction and global financial crisis (GFC). Otherwise, the project never would have moved an inch. For the HKWHT, the situation was different. The local government of Hong Kong intended to support the project and provide many favorable terms to concessionaires. Because of the completely different political system in Hong Kong, the Legislative Council did not have the same opinions as the local government and constantly provided additional requirements, which caused many critical issues that should have been discussed by the general public, government, and Legislative Council. Second, the construction period was short for both Case 1 and Case 2 compared to the 30 year concession period. Moreover, the interactions of multiple factors as mentioned before greatly affected the RV of projects in the next stage.

Period of Operation

For Case 1, the identified KRIs are the ability and credit of government, the change of project organization, traffic flow, tolls, operation costs, service quality, and project reputation. The RV of the project was greatly changed by early termination of the concession agreement. For the public sector, the decision to terminate the contract early was based not only on the opinions of the general public but also on the consideration of gaining the right to control the tunnel (NDN 2010b; XDN 2010; Yuan et al. 2010). For the private sector, problems related to construction have resulted in a change of profitability (predicted IRR can reach 14%), which is the most important issue that concerns the private sector. As presented by Khasnabis et al. (2010), the return for the private sector can be acceptable if the predicted IRR can reach 10% in India. Ke et al. (2008) indicated that PPP transportation projects can obtain high financial viability if the IRR can achieve 15% in China. The statistics from J. P. Morgan (2012) showed that the average IRR was from 10 to 12% for a toll road. Hence the predicted IRR of 14% in the NJYRT was attractive for the private sector. Meanwhile, high traffic flow and low operation costs can provide a stable cash flow for PPPs, which has been viewed as a critical success factor in PPPs and could be a way to earn profits and enhance the viability of a PPP project (Tang et al. 2013). On the other hand, public opposition to the toll road in Case 1 could possibly make traffic flow and operation income decrease compared to predicted income in project planning (Zhao 2006). From the perspective of RV management, the decision of the local government damaged both tangible and intangible assets of the project. The local government had to pay US$739.68 million for returning the NJYRT, with huge investments in urban development including three metro lines, two bridges, another tunnel crossing the Yangtze River, and many urban regeneration projects at the same time. Moreover, the annual operation costs of the tunnel are about US$24.12 million, which mainly depend on traffic flow (Zhao 2006). However, the traffic flow of the NJYRT was very low because the price was not changed from 2010 to 2011, and the local government just reduced the price slightly since 2011. It is hard to predict how much reasonable capital will be put into normal maintenance and operation of the tunnel. Moreover, the physical conditions of the tunnel can still not be guaranteed because of the questionable capability of the Chinese government (Yuan et al. 2010). The commitment of the public sector to the private sector and general public is always a problem, which has been identified as the most critical risk factor in Chinese PPP projects (Chen and Doloi 2008). As a result, the project's sustainable development, future refinancing, and predefined operational requirements are all questionable.

For Case 2, the identified KRIs were the authority of government, traffic flow, tolls, operation costs, service quality, and project reputation. The RV of the project was greatly changed by frequent toll adjustments. The traffic flow in Case 2 has never achieved the predicted volume and the performance of the tunnel was below the target set in the agreements. The toll for a private car has been adjusted from US$3.87 to US$7.09 since 1997 (WHTCL 2010). Firstly, the subsequent problems since the construction period (e.g., cost overrun and environmental effects) had a large effect on the early operation of the HKWHT. When the HKWHT was first opened, the toll level was higher than other tunnels. Considering that additional costs had been paid for construction and financing, WHTCL did not reduce the toll. In fact, low traffic volume always existed for the HKWHT. Compared to its designed traffic capacity (about 150,000 vehicles per day) and expected traffic volume (about 75,000 vehicles per day soon after its opening in 1997), actual traffic flow was far lower than forecasted (daily average vehicle volume was just 63,991 in 2014, with the maximum volume of 76,295 on December 16, 2012). Higher toll levels compared to the CHT and EHT are not the only reason for its low traffic volume. The incomplete road network and lack of a bus network were also considered as critical factors leading to low traffic volume (Omega Centre 2012). Although the HKWHT is not quite considered successful in terms of its financial status, relieving traffic congestion, and facilitating land development, many efforts have been made to strengthen its intangible assets, including establishment of a 24-h customer service hotline, maintenance management system, sponsorship of the Hong Kong marathon, midnight empty taxi promotion, undergraduate student internship program, midnight goods vehicle promotion, WHT scholarship at The University of Hong Kong, full coverage of 2 G and 3 G cellular mobile phone network, etc., which indirectly improve performance, sustainability, function, maintainability, and operability (WHTCL 2010). For the private sector in this case, the problems related to operation were a mixture of construction and the unreasonable TAM, which resulted in the change of profitability. First, the TAM allows the private sector to increase the toll when IRR is lower than 15%, which resulted in more frequent toll adjustments that cannot help improve the revenue but reduce the market share. Second, the TAM led to many debates from the general public and public media. The private sector and public sector in this project were suffering from high public pressure because potential toll adjustments would greatly influence traffic costs of general public. Third, the more toll adjustments were used, the less revenue was earned, and so the more toll adjustments had to be used. It was a vicious circle. On the other hand, the private sector made great efforts to

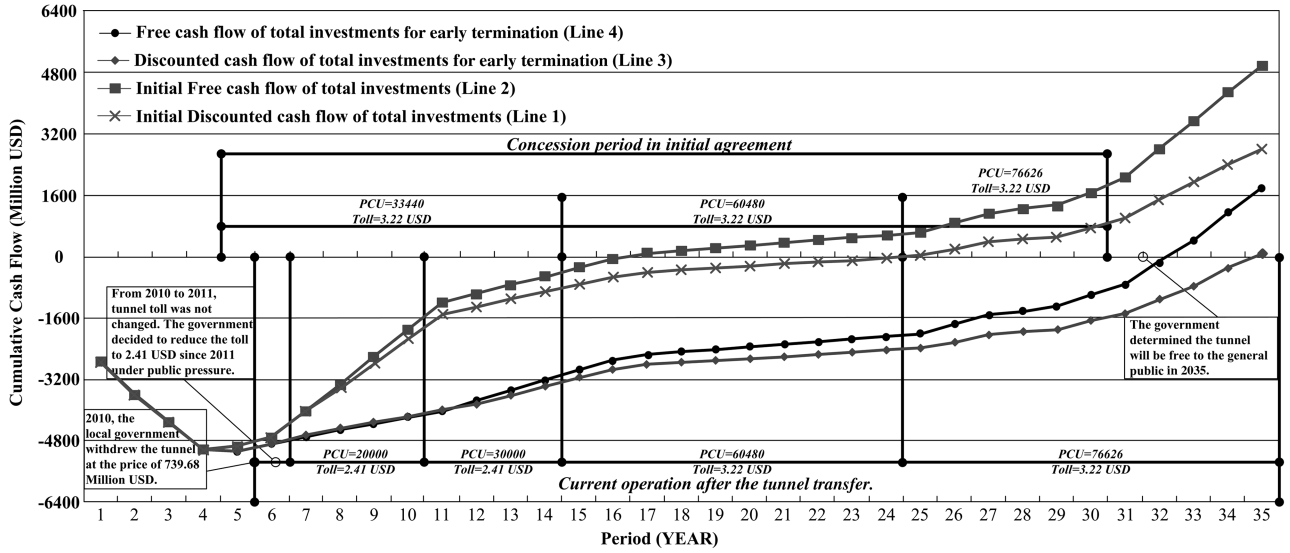

Fig. 6. Comparison of cumulative cash flow for the NJYRT between the initial plan and current status

reduce the negative influence attributable to the high toll level. According to the latest annual report of the HKWHT, the daily average vehicle volume and profits (IRR = 3.68%) of the project are increasing (WHTCL 2010). Therefore, the RV of Case 2 could be greatly enhanced in the next 5–10 years if the private sector keeps on strengthening the intangible assets like project reputation. Additionally, facing high pressure to reduce the toll and take back the HKWHT in advance, the public sector in this case conformed to the agreements with the private sector and played the role of regulators and governance to help the project improve performance (LCPTHK 2013). For instance, five roads have been or will be finished to connect the tunnel to increase traffic volumes (Omega Centre 2012). Meanwhile, the public sector keeps on coordinating the relationships between the private sector and general public, although the public media always complained about and criticized the HKWHT.

For these two cases, debates related to tolls are their common problem during the operation period. High toll levels greatly influenced the profitability and the ability to be refinanced in both cases. The most interesting issue in the two cases is that the methods adopted by the public and private sectors were very different, which made their RVs very different. In order to meet the requirements of local users and consider the government's benefits, the Nanjing local government terminated the NJYRT early. However, the toll level of the NJYRT was not reduced greatly after being transferred to the public sector because the government spent about US $739.68 million during the early stages (NDN 2010a, b). Meanwhile, the government had to spend additional costs on professional operation and maintenance work to keep the tunnel's performance and function high. The traffic volume of the NJYRT is still at a low level, and the revenue cannot meet the normal requirements of operation and maintenance so far. Different from the Nanjing local government, the Hong Kong local government insisted on protecting the interests of the private sector. The concession agreement signed by the government and private sector is the most important issue abided by the Hong Kong government, although the TAM was also questioned. The high toll level of the HKWHT was always the key point of debate, but the Hong Kong government considered that early termination or renegotiation would harm the interests of the private sector in the HKWHT or potential investors in other projects. Therefore, the public and private sectors in the HKWHT made great efforts to improve the traffic volume and project performance. The recent released annual report indicates that the HKWHT is becoming profitable, the market share is increasing, and the possibility of RVR in the project is going down (WHTCL 2010).

Comparison of RV in Cases from the Perspective of Cumulative Effects

According to the previously mentioned comparison, the RVs of these two PPP tunnels were changed in different stages because of cumulative effects.

Cumulative Effects in Case 1

Although Case 1 is a short-term PPP project because of the early termination of the agreement, the cumulative effects of the six risk factors on the RV can be clearly identified. As shown in Fig. 6, the comparison of initially predicted free and discounted cumulative cash flow and the currently predicted free and discounted cumulative cash flow at the time of early termination indicates that early termination strongly influences the value of a PPP project. According to Fig. 6, the value suffers greatly when the PPP project is transferred because of continuous effects of different risk factors. The initial financial analysis is shown in Line 1 in Fig. 6, which indicates that the payback period of total investments is 25 or 26 years, the IRR about 14%, and net present value (NPV) of the project at least US$482.4 million (discount rate = 5% at the time in 2005). When the project was returned to the government earlier than set in the agreement, the corresponding financial analysis is shown in Line 3 in Fig. 6 based on the recent traffic flow statistics. In Line 3, the data of PCU from 2010 to 2015 are collected from recent traffic flow statistics, and the data of PCU from 2020 to 2030 are the same as the initial financial analysis. According to Line 3 in Fig. 6, the payback period of total investments would be 35 or 36 years, which is longer than the initial concession period; the IRR will be less than 10% (the profitability has been greatly changed in this case), and the NPV of the project will be about –US$160.8 million. The comparison demonstrates that tolls, traffic flow, the decision-making of local government, and public satisfaction could strongly and directly affect the profitability and sustainable development of a PPP project. In fact, the profitability of PPP projects usually cannot be set in the contract in China because this is a very risky clause for the public sector (Ke et al. 2012). In early BOT or PPP projects in China, the fixed return

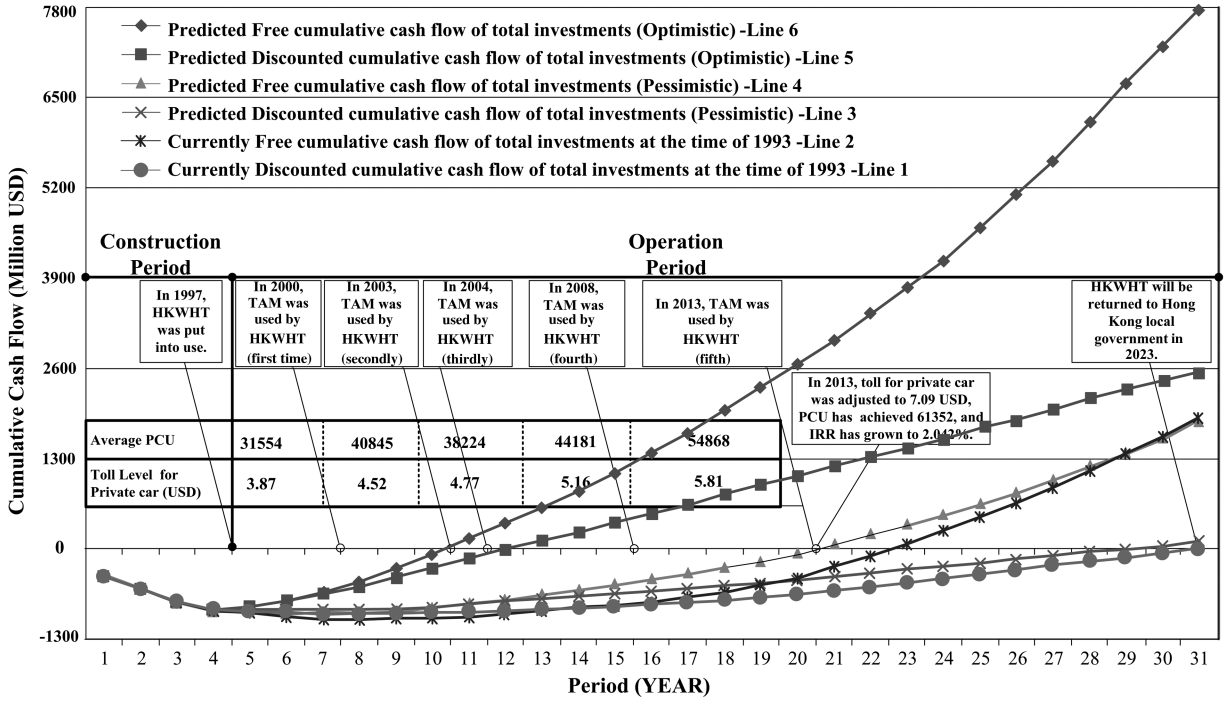

Fig. 7. Comparison of cumulative cash flow for the HKWHT between the initial plan and current status

clause could have been inserted into contracts to give guaranteed rates of return for the private sector (Choi et al. 2010). However, these clauses are becoming illegal because of changes in laws and policies in recent years, which resulted in many disputes in many of China's prior PPP cases (Ke et al. 2012). Hence, profitability cannot be ensured in a PPP agreement in China. Private participants usually may be enthusiastic about securing opportunities to profit from the risk transferred from the public sector in a PPP project (Li et al. 2005). Therefore, the public sector can provide commitments to help the private sector secure their reasonable profits to absorb more private capital investing than other infrastructure projects. However, the financial status in the case of the NJYRT obviously cannot attract more investments to refinance. Therefore, the quality of service performance and high level of maintenance were also influenced indirectly. In 2010, the local government withdrew the tunnel by paying US$739.68 million to CRCC. The actual profits obtained by CRCC can be estimated as US$64.32 million, in which additional costs caused by inflation and technical complexity were not included. However, the predicted NPV of the project was at least US$482.4 million according to Line 1 in Fig. 6. Therefore, CRCC in fact suffered great losses.

In this case, no one was the winner. The government should pay large amounts of capital for the projects. Therefore, local government is still collecting tolls in order to recover its investments now that the tunnel is back to the public sector. Meanwhile, the value of the project could be greatly influenced by questionable technical and management abilities of the local government. Furthermore, early termination reflects that the governance of the local authority was too tough, and it will hinder other investments because of low commitment from the government. The reputation and credit of the public sector was challenged. The private sector not only failed to obtain more financial benefits, but also lost reputation because they kept up the toll. In this case, the general public cannot obtain cheap and quality public service because of unprofessional management of the local government, which did not meet their expectations on this project and further reduced end-users' satisfaction. First, speedy, efficient, and cost-effective delivery of the project were not achieved because of construction cost overrun and construction time delay. Second, the value for money through optimal risk transfer and risk management was not obtained for the taxpayer or general public because of the early return to the public sector, which could further reduce the benefits of tunnel users and the stakeholders of the NJYRT. Third, the creation of added value through synergies between the public and private sector was not obtained. The improvement of service quality for the general public disappeared without the integration and cross transfer of the public and private sectors' skills, knowledge, and expertise. In fact, better and more efficient public services enhance quality of life, support sustainable economic growth, and assure those that fund and rely on them that their public services are responsive, provide value for money, and are continually improving. In particular, the general public prefers the public service to be well organized and efficiently run, accountable and fair, aware of the needs of all citizens, swift to respond, reliable, consistent and clear, easy to use, and delivered by knowledgeable staff. Therefore, the satisfaction of the general public or end-users can be used as a KRI to measure possible risks.

Meanwhile, the PPP project transferred to the public sector was basically a new project. There are great uncertainties for the project RV when it is transferred to the government. Although the critical components of the tunnel (like pavement, related facilities, and equipment) are totally new, the ability of the government to operate and maintain the tunnel was always doubtful because the government needs to build a new organization to manage the project. All in all, the losses of the RV for this PPP project thus can be described as obviously low profitability and ability to be refinanced; unsustainable development; and uncertain performance, function, maintainability, and operability.

Cumulative Effects in Case 2

Case 2 is a typical PPP project. So far, the RV of the HKWHT is still changing, influenced by the cumulative effects of the six risk factors. The RVR in Case 2 has become smaller in recent years because of interactions between cumulative positive and negative

effects. As shown in Fig. 7, the comparison is made between initially optimistic predicted free and discounted cumulative cash flow (Lines 5 and 6), initially pessimistic predicted free and discounted cumulative cash flow (Lines 3 and 4), and currently predicted free and discounted cumulative cash flow (Lines 1 and 2). Obviously, the value had suffered great losses in the first ten years because of very low traffic volume, low project reputation, and low market share. The optimistic prediction (shown in Line 5) indicates that the payback period of total investments is 12 or 13 years, the IRR about 15.5%, and the NPV of the project about US$2.58 billion (discount rate = 5% at the time in 1997). The pessimistic prediction (shown in Line 3) indicates that the payback period of total investments is 21 or 22 years, the IRR about 5.58%, and the NPV of the project at least US$1.94 billion (discount rate = 5%). According to the traffic flow statistic, the currently predicted discounted cumulative cash flow (Line 1) demonstrates the financial analysis when the project was returned to the government with the same total investments. In Line 1 of Fig. 7, the data of PCU and finance from 1997 to 2013 are collected from real traffic flow statistics and annual reports, and the data of PCU from 2014 to 2023 are predicted according to prior data using the time series method. According to Line 1, payback period of total investments would be 29 or 30 years (longer than both the optimistic and pessimistic predictions), the IRR 4.75%, and the NPV of the project about US$0.21 million. Undoubtedly, the financial status of the HKWT has been significantly influenced by the TAM, low traffic flow, and public satisfaction. Moreover, the performance, profitability, maintainability, and sustainability of the HKWT have been reduced to a different extent because of extensive economic and public pressure. Finally, the residual value would have to suffer losses.

In fact, the cumulative effects on RV in this case were not only the superimposed effect at the time axis, but also the cause-and-effect relationship among different factors as time went, where toll adjustment was the source of most problems. In this case, both the public and private sectors have been put in an awkward position.

For the government, the HKWHT was initially proposed to provide sufficient additional capacity to meet the cross-harbor road traffic demand and relieve growing traffic congestion. As shown in Fig. 3, the PCU of the HKWT in 2013 was about 61,000 and the market share was about 24% of the three cross tunnels (WHTCL 2010). Compared to the HKWHT, CHT and EHT are suffering heavy traffic congestion. For instance, the PCU of CHT is about 120,000 and has exceeded its designed capacity of 78,000. Although the PCU of the HKWHT has been slowly growing in the past five years, the traffic flow is still being attracted by lower tolls in both CHT and EHT. Hence, the appeal from the general public and media to reduce the toll of the HKWHT has never stopped since 1997. Additionally, the requests to ask the government to withdraw the tunnel earlier are heard without end. The HKWHT actually plays a very important role in adjusting traffic flow. Its relatively high toll makes more vehicles choose the CHT or EHT, which results indirectly in the reduction of traffic congestion in the middle of Hong Kong. Meanwhile, quality service has always been provided by the HKWHT, whose performance, function, maintainability, and sustainability were kept at a relatively high level. The Legislative Council in Hong Kong even considered extending the concession period of the HKWHT in order to make up for the losses because of low traffic flow and to continue to maintain a comparatively high level of service, maintenance, and operation (LCPTHK 2013).

However, it seems that the only method to deal with the financial problem for the private sector (WHTCL) is to frequently increase tolls. According to the agreement, the operator can increase the tunnel toll if its IRR falls below 15%. WHTCL may keep increasing the toll until the concession period ends because the IRR cannot be higher than 15% unless the PCU increases greatly. Different from the NJYRT, the governance of the local authority was not as tough. Although WHTCL continually adjusted the toll, the government insisted on enforcing the contract. Therefore, the reputation and credit of the public sector was recognized in this case, which not only facilitates more efforts made by the private sector for the project, but also attracts more investors to participate in PPP projects in Hong Kong (e.g., Disney Park). In fact, the value of the project has been maintained at a relatively high level because the private sector's technical and management capabilities are excellent. The relatively high level means that both tangible assets and intangible assets in the HKWHT are improving. For tangible assets, through major infrastructure renovation, carriageway resurfacing, repainting works, and implementation of maintenance management system and regular engineering training system, the maintenance level, traffic status, and public satisfaction were greatly improved. For intangible assets, the market share and revenue are still increasing and the IRR has been improved to 3.68%, according to the recent annual report of the HKWHT (WHTCL 2014). The SPV of the HKWHT has made great efforts to improve the attractiveness of the tunnel, including distribution of gasoline coupons, car care service coupons, movie and parking coupons for shopping malls, and tunnel coupons. Therefore, the reason for the huge loss in the past 20 years for the HKWHT is very complicated because of the cumulative effects of public decision, political change, economic recession, and toll adjustment. In addition, the private sector cannot obtain more financial benefits and could lose goodwill if they keep on adjusting the toll based on the current situation, which will further result in a lack of convenient and cheap public service for the general public.

Findings from Comparative Case Study

The result of the case comparison indicates that residual value could be changed significantly and suffers losses in different regions with different political, economic, and cultural environments. Some important findings can be obtained.

First of all, RVR is an important risk that could ultimately influence the success of PPP projects. For both cases, the success of the projects has been greatly challenged. The cumulative effects can play very important roles in the occurrence of RVR. The change of RV was greatly influenced by the identified six risk factors from multiple aspects from one stage to the next, which can ultimately lead to a huge loss of RV for PPP projects. The interaction among risk factors of PPPs and their changes during the concession period can ultimately result in RVR because of long-term cumulative effects. RV change originates not only from a single factor but also interactions of multiple factors. The change of RV accumulates step by step through whole processes of the project. Figs. 8 and 9 demonstrate how the cumulative effects influence the change of RV in PPP projects. For both cases, the cumulative effects during the entire process are similar to one another. According to Figs. 8 and 9, the change of RV was influenced in different stages. From the stage of preconstruction to the stage of operation, different effects identified from Figs. 4 and 5 could influence the RV of PPP projects. There are internal causal relationships among different effects from different stages as shown in Figs. 8 and 9. From a long-term perspective, the cumulative effects in the two cases occurred gradually during the project process. Many different effects interacted during the project process. The effects could interact with one another at the same stage of the PPP projects and could act on the effects of the following stages. The pattern of interaction or action then

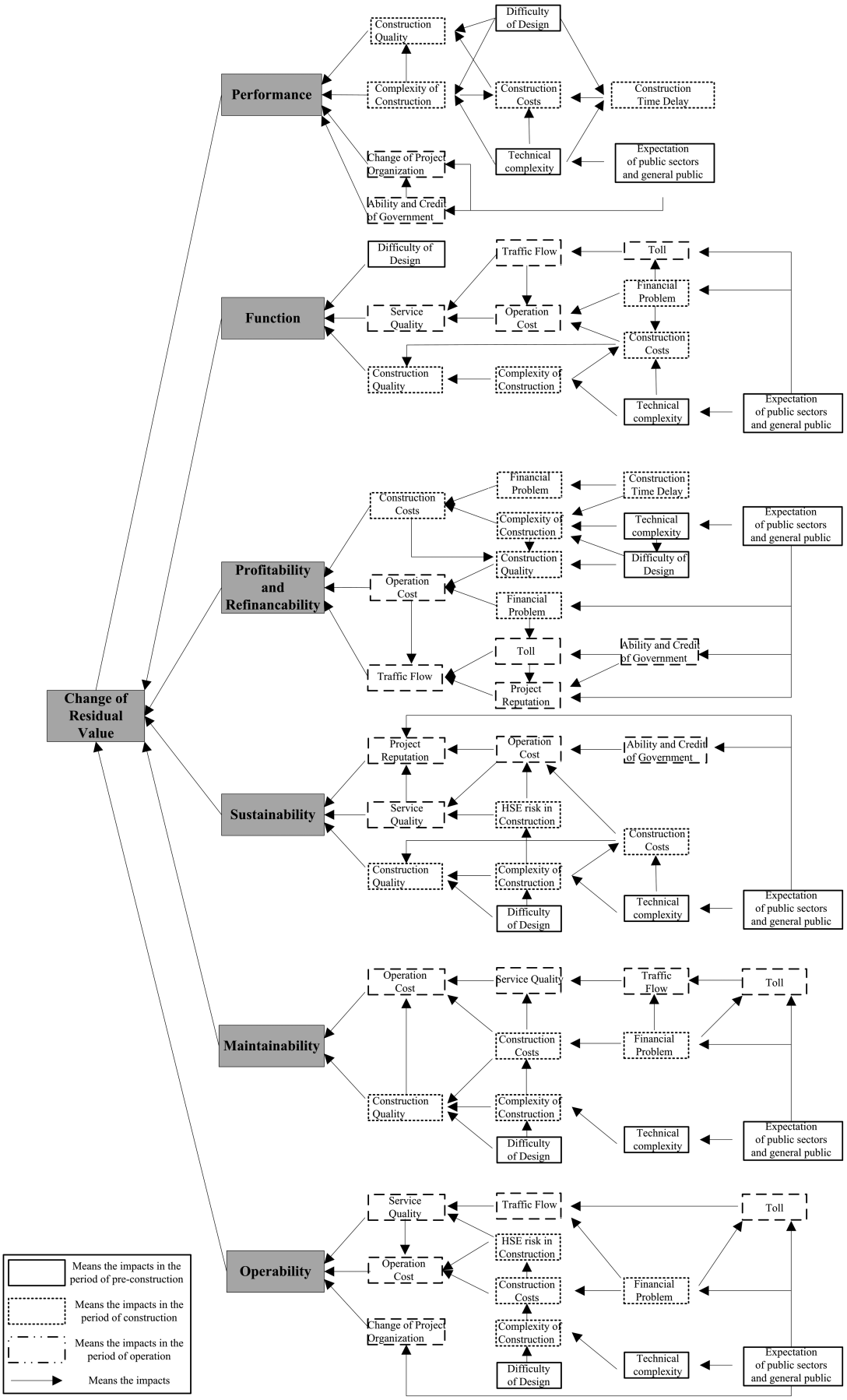

Fig. 8. Cumulative effects during the concession period for the NJYRT

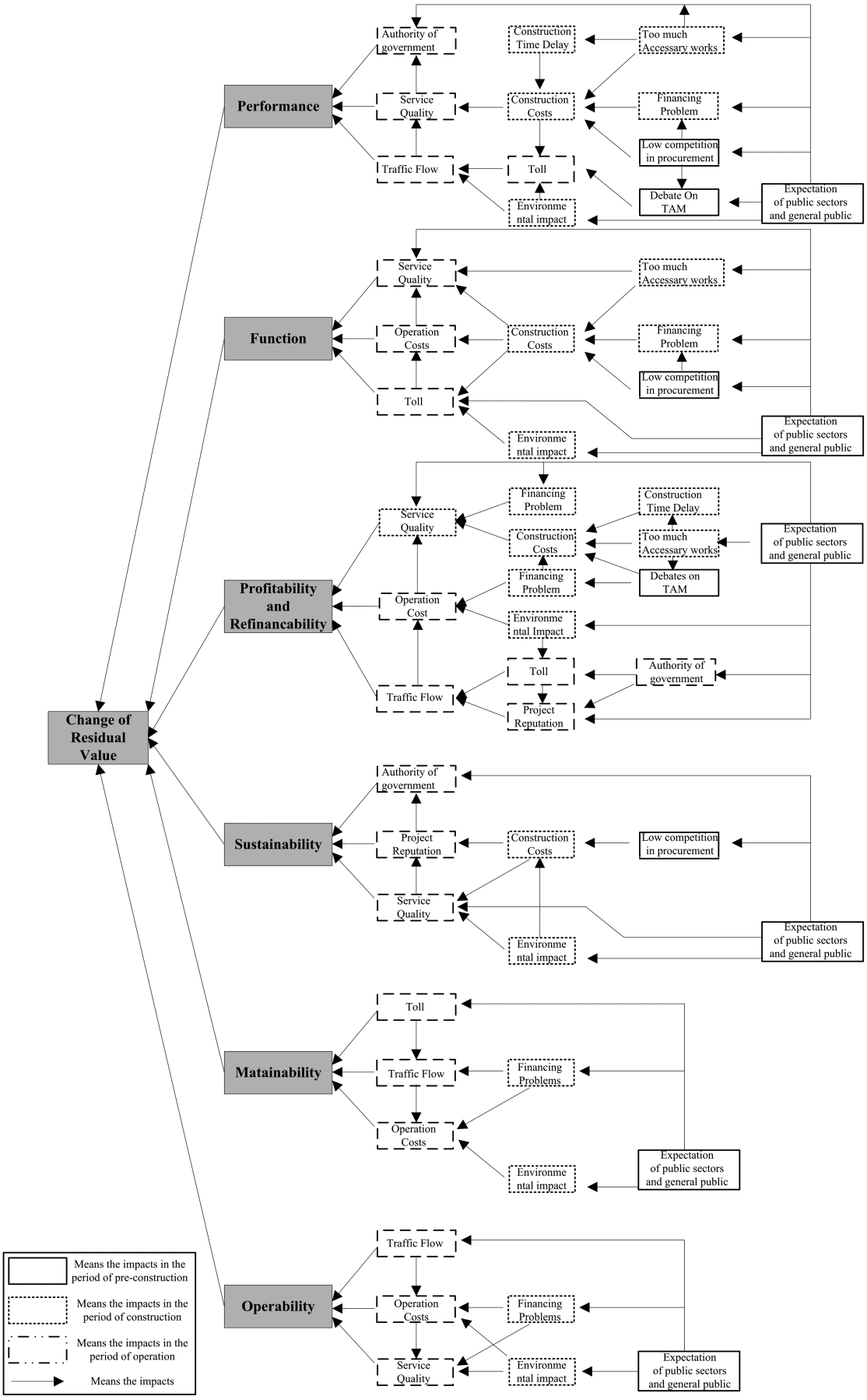

Fig. 9. Cumulative effects during the concession period for the HKWHT

produced new effects that were greater than the sum of their parts, which can ultimately change the RV of PPP projects. Hence, the RVs of the two PPP cases were not changed suddenly, but gradually varied with the change of interaction or action from the effects in different stages under the influence of cumulative effects.

Secondly, the methods to reduce cumulative effects for decreasing the RVR in the management of PPP projects are different because public and private sectors make different efforts and adopt different ways to treat RVR. The public sector plays a significant role in RVR management. The way to treat RVR from the perspective of the public sector greatly influences the change of RV. In Case 1, the local government could have avoided losing reputation and goodwill if the public sector could have helped the private sector communicate with the general public and provide short-term subsidies to the private sector. The economic growth would have helped the private sector pass through the hard times at the early stage of operation, and the public sector could have absorbed more investments from other private sectors, used the money paid for the return of Case 1 to develop other infrastructure, and won higher reputations. In Case 2, the public sector has acted as a coordinator in the PPP project to supervise the private sector to meet the public's requirements from technical and management perspectives and to help the general public better understand PPPs. Meanwhile, the private sector in Case 2 managed the HKWHT at a high level. Case 2 is now becoming better according to a recent issued annual report of WHTCL (2014). Therefore, the two cases have different results because the local governments adopted different treatment methods on RVR.

Conclusions

The appeal of PPPs as an effective method to provide public facilities and services in different countries is growing. A successful PPP implementation should not only focus on the early concession period, but also the whole process of PPPs, including initiation, procurement, construction, operation, and transfer, so as to ensure that the public sector can obtain the return in the desired conditions according to the agreement. This paper attempts to shed light on the management of RV in PPPs, from both theoretical and practical perspectives. It has presented a comparative case study in mainland China and Hong Kong. It examined how the RVR occurred and how to treat RVR in different regions of political and economic environments.

The RVR framework proposed from the authors' previous work provides a useful tool to observe and analyze RV problems for real PPP projects. Moreover, the RVR framework provides an effective way to identify significant factors in RVR management, valuable leading KRIs, and the change of RV in different cases. Two cases from mainland China and Hong Kong were introduced. Based on detailed analysis of these two cases, different factors leading to the change of RV and a series of KRIs that can indicate the emerging problems in different stages were identified. Furthermore, this study investigated the dynamic interactions of multiple factors during the PPP project arrangements. The comparison of these two cases was conducted based on a RVR framework at different project stages, followed by discussion on the cumulative effects in the different projects, and alternatives for the public sector to treat RVR have been proposed.

According to the comparative case study, two important findings were revealed. First, RVR is an important risk that could ultimately influence the success of PPP projects. Cumulative effects during the concession period play significant roles in the occurrence of RVR, in which the change of RV is accumulated step by step. Second, the comparison of the two cases shows that RVR varies with the cumulative effects as the public and private sectors may make different efforts on the projects and adopt different ways to treat RVR. Reasonable decision making from the government and great efforts from the private sector are very critical to avoid cumulative effects, which could lead to downfall of product/service performance, functional problems, decrease of profitability and low possibility of refinancing, deterioration of maintainability, decline in operability, and failure of sustainability.

The comparative case study offers useful insights for reviewing different RV changes, RVR management, and RVR treatment methods in PPPs. Moreover, the findings from the comparative case study provide a basis for improving RV in PPP projects and effective ways in meeting the requirements of the public sector to obtain the desired PPP projects when the concession period expires. Although this research on RVR helps improve understanding of cumulative effects in PPP projects, there are some limitations. First, the cases used in this paper are from mainland China and Hong Kong; though carefully selected, they may still lack representativeness compared with those in other countries. Second, the cumulative effects that influence the RV of PPP projects need to be evaluated through an expert system, mathematic modeling, and practical application in actual PPP projects, which can be used to quantify the cumulative effects on RV and PPP projects. This quantification would provide unique value for the formulation of related agreement clauses, process monitoring of RV change, and success of project transfer. Furthermore, the cause-and-effect relationships among different KRIs should be clarified in future research by system simulation to develop a RVR prediction model based on actual project data, which would provide a meaningful contribution to the knowledge.

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