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Effects of project governance structures on the management of risks in major infrastructure projects: A comparative analysis

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Abstract

Large infrastructure construction projects are prone to risks. Using desktop review and interviews with stakeholder organizations in two major infrastructure projects (the Yi-wan Railway Construction Project in China and the Northern Gateway Toll Road (NGTR) Project in New Zealand), this study investigated how different project governance structures affect the management of risks. Comparative analysis shows that project governance provides a structured mechanism to identify and address risks as they occur. Despite varied context, two projects relied upon flexible contractual arrangements to leverage risks among project participants. While a centralized, single-agent governance was adopted in the form of Project Management Headquarters (PMH) in Yi-wan Railway project, an alliance governance structure was used in the NGTR project. The former enabled top-down risk allocation whereas the latter encouraged proactive solutions to risk sharing. The research outcomes will inform the decision making among project stakeholders on establishing appropriate project governance arrangements in order to achieve target risk management outcome. By comparing real-time projects of varied scope, complexity and significance, the findings contribute to an improved understanding of the relationship between project organizations and project risk management.

Keywords: Project governance; Risk management; Infrastructure construction projects; Comparative case study

1. Introduction

Complexities and uncertainties are endemic in large infrastructure construction projects. The uniqueness and individuality of infrastructure projects, such as construction of a railway network, airport or tunnel, often come from their distinctive social and environmental requirements. Complex interfaces (Osipova and Eriksson, 2013), less prior experience (Tang et al., 2006), along with varieties of stakeholders (Olander and Landin, 2005) can add more difficulties to managing risks on these projects.

Over the past decade, considerable effort has been put into developing various methods, tools, standards and processes for dealing with project risks (e.g. Baccarini and Archer, 2001; Chapman and Ward, 2003; Del Cano and De la Cruz, 2002; ISO, 2009; OGC, 2007; PMI, 2009). The basic rationale underlying many of these techniques is the integration of risk management into a structured process to solve uncertainties and complexities faced by the project team. Turner (2009, p. 209) highlighted that the essence of project management is risk management. Such a viewpoint treats project risk management as a central approach to increasing the chance of project success.

By introducing a 'dynamic' concept, some emergent research, including joint risk management (Doloi, 2009; Rahman and Kumaraswamy, 2004) and risk formation mechanisms (Xiang et al., 2012), has advanced risk management theories in the context of construction projects. In recent

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years, a relationship-oriented perspective on risk management, especially in large infrastructure projects, has been advocated (Tsamboulas et al., 2013; Ward and Chapman, 2008). The research focus in project risk management has largely shifted from identifying new risks to investigating the factors that might lead to different risk management outcomes.

A mechanism of risk sharing and transfer has been favored in practice and widely used on many large civic construction projects. For instance, relational contracting (Rahman and Kumaraswamy, 2004) and integrated project organizations (Wood and Ellis, 2005) were two methods commonly used to mitigate risks across stakeholders. De Man and Roijakkers (2009) examined how the governance structure of alliances in the construction sector could balance control and trust in dealing with risks. Osipova and Eriksson (2011a,b) empirically explored the effects of cooperative procurement on the management of risks in construction projects. In their recent paper, Osipova and Eriksson (2013) encouraged academics and practitioners to reflect further on how to combine different management systems to achieve successful joint risk management.

Despite the above achievements in project risk management research, there is still a lack of in-depth case studies, including studies of processes and studies of real-time projects, that can increase the understanding about risk management in large infrastructure projects. There is a dearth of studies that examine how different governance structures influence the risk management process and thus achieve differing outcomes. The research reported in this paper seeks to bridge this gap by empirically investigating and comparing the effects of different governing structures on the management of risks in two major infrastructure projects. To achieve this goal, two research questions were formulated.

1) How do different governance structures affect the management of risks in large infrastructure projects?
2) What key elements within their project governance structure make the outcomes of risk management differ?

The paper begins by presenting an overview of the governance theory in project management, followed by a review of key elements of risk management in large construction projects. A case study method and comparative analysis will be presented in the Research method section. Two large infrastructure projects in different contexts, the Yi-wan Railway Construction Project in China and the Northern Gateway Toll Road project in New Zealand, will be presented as case studies of how their governance structure influences the management of project risks. A comparative discussion reveals the reason why the outcomes of risk management in two projects differ. The paper ends with a conclusion and suggests future research directions.

2. Literature review

2.1. Governance approaches to managing construction projects

Governance theory was originally developed from policy research in political science (e.g. Friedmann, 1980; Krieger, 1971; Nachmias and Greer, 1982). It has nowadays outgrown its initial context and has been applied in different industries, including the construction sector (Howes, 2000; Pryke, 2005; Reve and Levitt, 1984). As firms in the construction industry are largely project-based organizations, the governance application can be divided into two interrelated dimensions: corporate governance and project governance.

Corporate governance has been treated as synonymous with the good and transparent management of firms and institutions. Müller (2009) argued that the aim of project governance is the consistent and predictable delivery of project's planned contribution to the portfolio and thereby to the achievement of corporate strategic objectives within a corporate governance framework. Garland (2009) reinforced this point by emphasizing that project governance is, or should be, established to fulfill one primary objective: to enable efficient and effective project decision-making. Project governance provides a structure or a framework that articulates the objectives of the project, the means of attaining those objectives and the means of monitoring performance (Turner, 2009).

There is a considerable variation in the ways construction projects are organized. Williamson (1975) initiated the pioneer work and compared market governance with organizational governance by using transaction cost analysis. Reve and Levitt (1984) analyzed the ways of using construction contracts to govern construction transactions. However, the range of governance options open to any firm is limited by the institutional context within which it trades (Winch, 2001). This led to a discussion of embedding organizational and environmental elements in a contracting relation when selecting project governance forms.

Transaction cost economics described four alternative feasible forms of organizations, namely firms, markets, hybrids and bureaus (Williamson, 1996). In construction projects, Reve and Levitt (1984) defined a principal–agent relationship as a professional relationship between the client and the third party consultant to manage construction works taken by contractors. This principal–agent relationship was regarded by Turner and Müller (2004) as the key in forming an effective governance structure.

The problems associated with the principal–agent relationship, however, include the adverse selection problem and the moral hazard problem (Turner, 2009). Over the past decade, a variety of approaches has been developed to address these problems. Control, flexibility and trust are three basic mechanisms that can be built into the project governance design to eliminate uncertainty and complexity in both organizational and environmental contexts (de Man and Roijakkers, 2009; Osipova and Eriksson, 2013).

Shiferaw et al. (2012) exemplified project governance systems that are established by governments to improve the performance of public investment projects. These systems include such as the Gateway Review Process (Office of Government Commerce, UK), the Norwegian Quality Assurance System and the Dutch MIRT Rules of the Game. In recent years, an alliance delivery model for governing large infrastructure projects has been widely applied in countries such as Australia (Manley, 2002; Rowlinson et al., 2006) and New Zealand (State Services Commission, 2012). In spite of different projects and procedures,

a common objective of these governance systems is elimination of project failure and possible replication of such a system in future public projects.

2.2. Risk management in major infrastructure construction projects

Differing from small and medium-sized construction projects in which routine practice can be applied, major infrastructure construction projects often involve a multitude of different tasks with a range of features (Shiferaw et al., 2012). They require more complicated organizational structures to deal with a number of elements in risk management. The risk management elements that are common in large infrastructure projects include:

- Multi-layer relationships: There is a wide variety of stakeholders in a large infrastructure project, all with differing objectives. There is a need to manage the relationships of these stakeholders effectively. Turner and Müller (2004) emphasized the importance of partnership among project participants, within which their objectives are aligned to achieve the best result for all. By incorporating relational risks into a project governance structure, risks of conflict and interactions of human factors, such as bounded rationality and other moral hazards, can be better understood, predicted and planned for. Good communications of risks are also of paramount importance (Atkin and Skimore, 2008).
- Cost, time and safety: There are numerous cases where large infrastructure development projects provide familiar examples of delays and budget overruns due to unique site conditions (Kean, 2011), hidden transaction costs (Sha, 2011), or disputes among the parties (Toor and Ogunlana, 2010). Additionally, in large construction projects, due to the involvement of many workers, many large and heavy plants, a great amount of materials, complex construction operation, multi-interface and complex management activities, the accident rate is higher than that of common construction projects (Guo et al., 2013).
- Procurement and contract: According to Aliza et al. (2011), project procurement can be a 'great' environment for ethical issues with its low-price state of mind and competition. There are some gaps that could lead to illegal activities or unethical behavior in large construction projects with complex contractual relations and multi-level supply chains (Osipova and Eriksson, 2011b). Public development projects may also need to consider regional interests and requirements to use local labor and suppliers (Shiferaw et al., 2012). Availability of resources and issues of labor productivity is critical factors that may impact on the process of construction. Those factors are considered by Collyer and Warren (2009) and Meng (2012) as 'dynamics' inherent in the supply side of environments.
- Environmental and social concerns: The construction site and construction wastes of large infrastructure projects, particularly roading and tunnel projects, are likely to impose environmental and associated social impacts (Martin and Point, 2012; Vazquez et al., 2013). Environment-related effects on surrounding livelihoods and the ecological and urban systems can be a delicate issue to deal with. In countries such as France (Mallard and François, 2013) and New Zealand (Pidwerbesky et al., 2003) where environmental preservation is a top priority, construction design and specifications are required to pass strict scrutiny to avoid errors that can severely jeopardize safety and contribute to environmental and social consequences.
- Construction innovation: Large construction projects often generate economies of scale that can drive innovations in construction technology and engineering solutions. The construction team often have a better opportunity to investigate alternatives, such as new materials and engineering design, beyond normal construction practice. Such innovations can also bring about unexpected risks. Harty (2005, 2008) and Tombesi (2006) suggested that successful innovation requires consideration of the social and organizational contexts in which it is applied. When adopting innovation into construction projects, a stakeholder-centered approach is also required, along with an established risk assessment methodology (Murphy et al., 2011).
- Economic return: Financing large infrastructure projects has been a popular topic over the last decade. A wide variety of funding models have been used in practice depending on the sources of funds and their proportion. Recent transport sector liberalization, together with the global economic crisis, favors Public–Private Partnerships (PPP) to attract private investments in transport infrastructure projects (Tsamboulas et al., 2013). In many developing countries, large infrastructure projects are partially funded by foreign capital such as loans and financial aid for a development purpose (Shiferaw et al., 2012). Whichever financial models used, whether the project can generate viable economic return or longer-term benefits for local development has been a major concern among project stakeholders.

The literature review shows that while the findings in past research have clear implications for the role of project governance structures in influencing a set of elements in risk management, the added value of how these structures affect each element has not been demonstrated. As suggested by a few empirical studies, there is a need to understand the conditions and factors in a project governance system that may affect risk management outcomes and to identify appropriate solutions. To improve this understanding, a comparative case study method is adopted in this paper. An analytical framework comprising the key elements in risk management will be used in the following sections to guide case studies and the comparative analysis.

3. Research method

A case study method was adopted for this research due to its theory-building nature (Eisenhart, 1989; Yin, 2003). Applying a case study method is also a response to the research needs proposed by Söderlund (2004). In examining the state of project management research, Söderlund (2004) suggested that the field lacks in-depth case studies, studies of processes, and studies in real-time that would be beneficial in building theories for understanding fundamental issues of projects and project organizations. In recent years, governance theory has been

adopted into construction practice for managing large infrastructure projects. It is important to investigate contemporary projects in detail to achieve a better understanding about how different applications of governance structures influence risk management in these projects.

The objective of this research dictates a comparative analysis. According to Stake (2006), conducting the comparative case analysis is a means of examining how the program or phenomenon performs in different environments. Yin (2003) suggested that the logic underlying the use of multi-case studies requires that each case needs to be carefully selected so that it either predicts similar results or predicts contrasting results. In selecting cases, George and Bennett (2005) proposed three criteria as a general rule. First, the cases should be relevant to the research objectives and research questions; second, the cases should provide diversity across contexts, and third, the cases should provide opportunity to study the complexity of the contexts.

Access to data in relation to large infrastructure projects in different contexts is also critical in initiating comparison. In line with these criteria, two projects, namely the Yi-wan Railway Construction Project in China and the Northern Gateway Toll Road Construction Project in New Zealand, were selected as case studies in this research. As shown in Table 1, the two projects provided the researchers with opportunities to study the topic of interest in two different contexts. Being able to access project information and collect in-depth interview data had made a cross-country comparison possible. Variations in stakeholder composition, governance structure and associated management systems also provide distinct diversity between two cases.

International comparisons require articulated conceptual framework (Yin, 2003). The two selected projects differ in various aspects such as their political, social, economic and cultural dimensions. However, according to Dogan and Pelassy (1990), for a comparative study, it is a matter of how we compare rather than what we compare. In order to create insights, comparative analysis in this paper is focused on the key elements of risk management in large infrastructure construction projects, which are identified in the literature review, including: multi-layer relationships; cost, time and safety; procurement and contract; environmental and social concerns; construction innovation and economic return.

Methods for data collection included participatory observations, interviews and document studies. The details of data collection methods for two case studies are shown in Table 2. In May 2009, as project facilitator in Yi-wan Railway construction project, researchers organized a focus group in the form of a risk management workshop within the Project Management Headquarters (PMH), investigating how the elements intrinsic in project governance affect the way in which risks are managed. 42 representatives from stakeholder organizations attended the workshop. Between 2009 and 2010, follow-up interviews with 9 key stakeholders were conducted during 5 site visits. Qualitative data on perspectives and insights of these participants were captured, including:

- emerging risks that were identified by different stakeholders during the project construction process
- initiatives adopted by relevant stakeholders to address the emergent risks
- effectiveness of such measures to address risks and possible alternatives.

Between 2011 and 2012, the first researcher had been involved as an advisor in the post-project appraisal program undertaken by both central and local governments in China. Further detailed information on project operations and risk management performance was obtained. The interview records together with other types of qualitative data were analyzed by using content analysis method (Krippendorff, 1980). This method was applied to categorize the interview information into the analytical framework of risk management elements.

In 2009, the New Zealand Constructing Excellence (2009) conducted semi-structured interviews with the main project actors in the Northern Gateway Toll Road (NGTR) construction project

Table 1
Case study selection according to three criteria.

Case study	Criteria1: Data accessibility	Criteria 2: Research objective relevance	Criteria 3: Case diversity across contexts
Yi-wan Railway Construction Project, China	• Researchers' direct involvement in the project provides access for first-hand data collection • First researcher being involved in the post-project appraisal program • Having access to project evaluation outputs	• A centralized, single-agent governance in the form of Project Management Headquarters • Top-down risk allocation with contractors passively sharing risks	• Railway project • A major public investment program • Operating in specific context in China
Northern Gateway Toll Road Construction Project, New Zealand	• Researchers participated in a number of industry workshops and seminars regarding the governance system and associated procurement applied in the NGTR project • Having access to project evaluation outputs • Interviews with former project participants	• An alliance governance structure • Horizontal risk sharing mechanism with each construction team proactively managing risks	• Highway project • First toll road and first roading project in New Zealand to actively work on reducing its carbon footprint • Operating in specific context in New Zealand

Table 2
Methods of data collection in case studies.

Case study	Data collection methods
Yi-wan Railway project	1) Risk management workshop: focus group with 42 representatives from stakeholder organizations in May 2009, including • 14 contractor representatives • 8 project managers • 5 resource managers • 9 subcontractors • 4 client representatives • 2 contract managers 2) Interviews with 9 key stakeholders during 5 field visits between 2009 and 2010, they were those who attended the risk management focus group, including: • 3 contractor representatives • 2 project managers • 1 client representative • 2 subcontractors • 1 contract manager 3) Participation in post-project appraisal program between 2011 and 2012
Northern Gateway Toll Road project	1) Participation in industry workshops and seminars between 2009 and 2011 2) Desktop studies of New Zealand Constructing Excellence evaluation reports and industry reports of relevance in second half of 2012 3) Interviews with 5 former project participants and 1 representative of the Ministry of Transport in April 2013, including • 2 project managers from two contractor teams • 2 representatives from New Zealand Transport Agency • 1 risk manager from former Alliance Office • 1 representative of the Ministry of Transport

in New Zealand. To follow up the Constructing Excellence's study, between 2009 and 2011, the researchers participated in a number of industry workshops and seminars regarding the governance system and associated procurement applied in the NGTR project. In 2012, the researchers conducted an updated study which involved review of Constructing Excellence's reports and other industry reports of relevance. In April 2013 the researchers conducted interviews with 5 former NGTR participants and 1 representative of the Ministry of Transport. The interviews focused on the following questions.

- What were the factors and/or drivers for the adoption of alliance governance structure?
- How was the alliance governance system organized and how did it influence the working relationships among the project actors?
- Under the existing governance, what tools were used in risk management?

The alliance governance structure in NGTR was regarded as a successful model in New Zealand and has since been applied to other large infrastructure projects across the country. The review materials issued from the Government and the construction industry were also studied to supplement the interview data in order to draw an in-depth picture of how alliance governance was carried out, as well as its effects on risk management. The interview records were transcribed, coded, and analyzed using NVivo 9 qualitative data analysis software.

In this paper, data analysis was undertaken at two levels. The first level deals with individual case description and analysis (Eisenhart, 1989). This analysis answers the first research question as to how different governance structures affect the management of risks in large infrastructure projects. The elements of risk management are analyzed in each case. The second level deals with comparison between two cases in order to answer the second question, namely, what key features within their project governance make the outcomes of risk management differ? The analysis focuses on finding 'why' there is a difference in terms of the relationship between project governance and risk management performance. In what follows, the case studies are presented using a synthesis of qualitative data.

4. Case studies

4.1. The Yi-wan Railway construction project

4.1.1. Project description

The Yi-wan Railway was part of China's major public investment program to develop a comprehensive railway network with 'four vertical and four horizontal' lines across the country. The total investment value was RMB 27.489 billion (approximately USD 3.325 billion), in which RMB 4.802 billion was from the National Railway Construction Fund, USD 0.5 billion (approximately RMB 4.134 billion) was a loan from the Asian Development Bank (ADB), RMB 11.952 billion was an aid loan from the China Development Bank (CDB), with the remaining funds sourced from the national railway bonds and local

governments. The construction of Yi-wan Railway commenced in January 2004 and was completed in August 2010. The railway was put into use in December 2010.

The Yi-wan Railway project involved construction of 377 km of railway, 12 railway stations, 159 tunnels, 253 bridges and a large number of viaducts. The length of tunnels and bridges accounts for 74% of the total length. This construction project was commonly regarded by the interviewees as one of the most complex projects, which involved diverse geological conditions, a multitude of sub-projects, unknown risks in constructing underground tunnels, and challenges for construction innovation.

4.1.2. A single-agent project governance structure

Fig. 1 illustrates the governance structure on Yi-wan Railway project. The findings of the focus group workshop identified the stakeholders to the project and divided them into two groups: the external and internal stakeholders.

4.1.2.1. External stakeholders. External stakeholders included Government departments at different levels, such as the National Auditing Commission, the Ministry of Finance, the Ministry of Railways, National Development and Reform Commission, and local governments. Those authorities, on behalf of the general public, were to supervise quality performance of the project, ensure health and safety, and facilitate a supportive environment for project construction. Investment entities, as those mentioned earlier, included the funding authorities and lending entities. Staged investigations into the use of funds were undertaken by these funding bodies throughout the construction process. The Yi-wan Railway project was the first pilot project in China that applied an insurance policy. The construction process was insured against major disruptions and damage from natural disasters and from other contingencies. A number of specialized engineering consultancies were contracted to the project to eliminate or reduce errors that might occur during the project design and construction.

4.1.2.2. Internal stakeholders. The focus group classified the internal stakeholders into four intimately-related groups directly working on the project. The Project Management Headquarters (PMH) which was established on behalf of the client Wuhan Railway Bureau, was responsible for oversight and management of the overall project. PMH adopted a dynamic project appraisal system which had mandatory control gateways for stakeholder needs assessment, evaluation of risks, uncertainty analysis, and for other important decisions. The involvement of PMH at the stages of front-end, project preparation and decision-making was significant. Before the commencement of construction, PMH conducted five comprehensive geological surveys in order for early identification of potential risks.

The Fourth Surveying and Design Institute (affiliated with the Ministry of Railways) was tasked with the surveying and design work. In total, 20 large civil construction companies were involved in the construction and 7 on-site engineering consultancies were in charge of construction supervision and assisting PMH in monitoring and controlling construction budget, quality and schedule.

4.1.3. Effects of single-agent governance on risk management

The Yi-wan Railway Construction Project was the first civil construction project in China that introduced a risk management system in the construction process. A centralized approach to project management was adopted by the Project Management Headquarters (PMH). PMH provided a framework to coordinate activities of different stakeholders throughout the entire project life cycle. PMH stipulated specifications of 'construction geological survey and pre-survey geological forecasting mechanisms', with a primary focus on managing risks of high probability in the construction of tunnel projects.

The techniques of tunnel drilling and associated safety issues were the two largest sources of risks identified in the Yi-wan Railway project. The technical challenge arose from the highly complex geological conditions in surrounding areas.

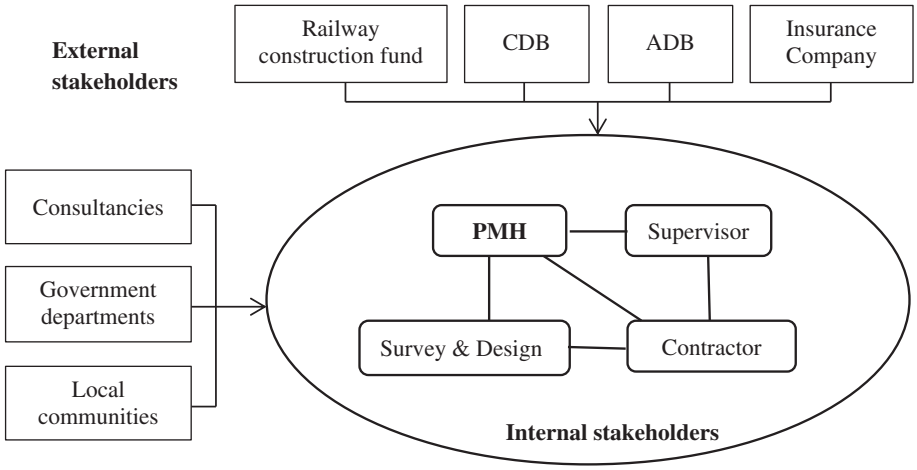

Fig. 1. Governance structure of Yi-wan Railway construction project.

Most construction sites were located in karst and lava mountain regions. None of the chief engineers and project managers had prior experience in tunneling at such sites. Safety of construction workers operating in such conditions became a major concern as tunnel digging may cause permeable flooding and ground collapse.

Empowered by the client, PMH had the authority to introduce any changes needed into contractual and procurement arrangements in dealing with complexities and risks. A comprehensive risk management system was introduced, with Chief Executive of PMH in charge of the overall risk management. A risk management team was formed within PMH, including representatives from all internal stakeholders. The tasks of the risk management team included such as identifying the potential risk sources, assessing their likelihood and impacts, and formulating mitigation measures. The effects of Yi-wan governance features on key risk management elements are tabulated in Table 3 below.

The sheer size of such projects and their technical complexities, however, limited the time for in-depth risk analysis. According to the PMH representatives, PMH had concentrated its efforts only on the risks of perceived high occurrence with big impact. Once such a risk was identified, PMH was able to quickly assemble a specialist team to deal with that risk. Management of lower-occurrence and lower-impact risks was diffused from PMH to other internal stakeholders. A cost-plus-incentive-fee contract was set up between the client and contractors. As PMH was responsive to risks as they occur, the contract was flexible in incorporating various incentive clauses as the project continued. The project visibility to public was high. The rolling-wave type of risk management proved to be effective in such contexts. Centralized power, technical and financial capability, and flexible contractual arrangements across the project were identified as key success factors in risk management.

4.2. The Northern Gateway Toll Road construction project

4.2.1. Project description

The Northern Gateway Toll Road (NGTR) was the first toll road in New Zealand to be fully electronic and was one of New Zealand's largest and most challenging roading construction projects. It extends the Northern Motorway (State Highway 1) 7.5 km further north from Orewa to Puhoi and provides an alternative to the two-lane road through Orewa and Waiwera. The motorway project involved the construction of 5 culverts, a twin tunnel section and 6 major bridges including 3 large viaducts: Waiwera twin viaducts (537 m span), the Nukumea Eco-viaduct (180 m span) and the Otanerua Eco-viaduct (256 m span). It was the first State Highway to be progressed by tolling as well as the first roading project in New Zealand to actively work on reducing its carbon footprint (NZTA, 2009).

The total value of NGTR was expected to be NZD 360 million (approximately USD 235 million) and expected to take four years of construction. The project was initiated in March 2004. The road opened ahead of schedule on 25 January 2009, at a total cost of NZD 340 million, NZD 20 million under budget. From Day One, the inclusion of key social and environmental measures had the unexpected benefit of highlighting the importance of people working on the project and had encouraged a hotbed of ideas for continuous improvement (Primavera, 2007).

4.2.2. The Northern Gateway Alliance

The Northern Gateway Alliance (NGA) was formed in March 2004 to design and construct the NGTR. The alliance was comprised of eight organizations, including the New Zealand Transport Agency (NZTA) which is New Zealand's State Highway manager, Leighton Construction, Fulton Hogan, URS New Zealand, Tonkin & Taylor, Boffa Miskell, United Group and VSL. The road passes through a diverse landscape containing steep topography, large tracts of native bush, streams, estuaries and areas of pastoral farmland.

According to findings from the Constructing Excellence (2009), the high-risk nature of the construction work, together with its potential consent risks and complex engineering challenges, had led to the NZTA's decision to select an alliance model for this project. Follow-up interviews by the researchers found that the success of the Freeflow Project which was the first alliancing project in which NZTA (then Transit New Zealand) had been

Table 3
Effects of governance features on Yi-wan Railway project risk management.

Risk management elements	Governance features
Safety	• PMH used a dynamic process of risk identification and management; • PMH established a cascade of safety objectives at different levels of management for individual project participants; • The safety indicator was included in the performance assessment system which was associated with reputation scoring for individual organizations.
Environmental conservation	• Setting up PMH risk management team; • Stakeholder engagement: the PMH risk management team liaised with the local governments and community representatives to regular meetings in order to identify possible environmental damage that could be caused by construction activities.
Investment viability	• Cost control was set as a priority of PMH; • Expertise on secondment from the client to help design the cost management process; • Building capabilities within PMH to deal with potential issues such as variations, changes to design and costing adjustment.
Schedule	• A relationship-building workshop was held before the project started in order to agree on the schedule planning and objectives; • Staged monetary incentives to project participants in contract arrangements; • Throughout the whole project life cycle, PMH organized a series of meetings with those participants to confirm target schedules at review points; • Reputation was also a factor. Bulletin announcements about project progress on a regular basis were to encourage improvements in collaborative risk management.

involved was another factor for adopting a similar governance structure on the Northern Gateway Toll Road.

The alliance structure, as shown in Fig. 2, was made up of the Project Alliance Board (PAB) which makes governance decisions on a monthly basis and the Alliance Management Team (AMT) which deals with the day-to-day management of the site. PAB was comprised of directors of all alliance participants and included representatives of Central Government agencies such as the Treasury and the Ministry of Transport. While AMT acted as a project management organization to coordinate construction activities, PAB challenged the team's decisions to ensure that the delivery of the project is driven by value rather than cost. The vision statement, objectives and alliance principles were created through a number of workshops. The focus was on building a single alliance culture among six key organizations from the outset of the project.

4.2.3. Effects of alliance governance on risk management

Geological issues such as difficult geology, steep terrain and sensitive natural environment within the designation of NGTR had created significant design and construction challenges, as well as the risks associated with these challenges. Environmental and social measures, cost, quality, schedule, availability of labor, and managing collaboration among alliance participants were deemed by the project office as important elements in their risk management.

The alliance shared risks. As part of the agreement, alliance participants had waived the right to sue each other. This had the impetus of ensuring that alliance organizations selected people with experience and with a quality performance record. Life-cycle risk management was used, including a risk model, Active Risk Manager (ARM), a software program purchased in 2006. Given that the alliance structure was similar to that of an enterprise, the ARM provided an Enterprise Risk Management (ERM) process to proactively support the management of risks and opportunity (Active Risk Ltd., 2009). According to interviews, ARM was not simply a risk modeling tool; it also provided a systematic picture of risk situations across the whole project. The use of ARM had helped ensure that budgets and time schedules were observed by all alliance members.

Other benefits provided by ARM, as highlighted by interviewees, included such as wider visibility, better risk communication, and real-time monitoring and reporting of risk information across organizations. Desktop studies and interviews reveal that the way in which each risk management element was dealt with largely resided with the mechanisms inherent in alliance governance structure. The effects of alliance governance of NGTR on key risk management elements are reported in Table 4 below.

5. Comparative discussion

The Yi-wan Railway construction project and the Northern Gateway Toll Road project used two distinct models of project governance: the centralized, single-agent model and the alliance model, respectively. Case studies have illustrated the effects of their governance features on project risk management. The discussion in this section shows differences and similarities between the ways of managing risks under two governance models (See Table 5).

A collaborative way of working and of managing project risks was apparent in both cases. However, the extent of control, trust and flexibility varied significantly between two cases. A centralized single agent for project management in Yi-wan Railway project involved a controlling approach to risks in order to meet considerable demands of the project. To a large extent, interviewees from PMH felt they were responsible for a wider set of stakeholders, particularly the financial entities such as the Asian Development Bank and China Development Bank, to ensure their investment viability. In comparison, the alliance model adopted in the Northern Gateway Toll Road project encouraged a trust-based approach to risk sharing and created a sense of project ownership across different stakeholders.

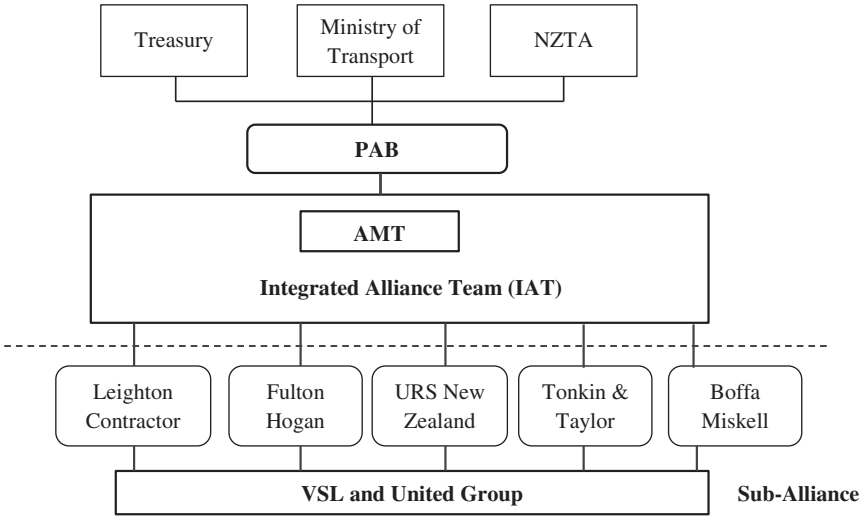

Fig. 2. The Northern Gateway Alliance governance structure.

Table 4
Effects of alliance governance features on risk management.

Risk management elements	Governance features
Time and quality	• Pain-share and gain-share mechanism created an incentive to complete the works ahead of time and defects free. • 'Defect-free on opening day', as one of the Key Performance Indicators (KPIs) of the alliance, had driven decisions towards regular quality review and control.
Cost	• Monthly cost review within Alliance • Budget was divided into different disciplines and into different teams, with each team manager in charge of monitoring and reporting risks. • An independent costing estimator • Cost savings were shared by the alliance as a whole.
Availability of labor	• In-house skills training within Alliance • Alliance team aimed to leave a legacy of training in the regional construction industry
Environmental and social measures	• Environmental monitoring was a part of the consent process. • Incentives in the alliance agreement encouraged healthy competition and innovative solutions. • All inductions, pre-start workshops and tool box meetings had integrated the agreed sustainability and environmental achievements. • Contractors were trained to continuously address environmental and social concerns. • A communications plan was in place including regular newsletters and monthly meetings with a Community Reference Group.
Collaborative mechanism	• Alliance was regarded by interviewees of this research as a truly collaborative model. • 'Value for money' was manifested in the contractual arrangement between the client and alliance participants. • The pain-share and gain-share principle provided the formal basis for alliance governance.

In both cases, a degree of flexibility was built into the contractual arrangements to distribute risks among project participants. Performance-based bonus as an effective incentive was applied in both projects to motivate the designers and contractors in cost saving and construction innovation. This result is in line with findings from Osipova and Eriksson (2013) who examined the effects of control-oriented and flexibility-oriented management systems on the implementation of joint risk management in two construction projects. The performance assessment system used in both cases also encouraged those contractors to form a closer partnership with the design companies in achieving better results.

Leadership and ability to envision solutions were essential for PHM to manage risks of all types on the Yi-wan project. PHM was empowered by the client to be responsive to any uncertainties and changes. There were both established and ad hoc actions taken by the PHM. However, the alliance governance model on the Northern Gateway Toll Road project provided a clear risk-sharing methodology, a means to practice the established risk management principles in arriving at a successful outcome. The message of alliancing as an equal part was established from the beginning and reinforced through all kinds of team-building activities (Doherty, 2009). Pain-sharing and gain-sharing mechanisms created a sense of ownership not only for the participant organizations but also for individuals who were working on the project. The improved performance in risk management and in labor productivity had come from exploiting the benefits of using that ownership culture.

A lack of prior experience in managing risks for major railway projects might be a reason for PMH to diffuse risks by adopting a top-down approach and introducing insurance mechanism. In comparison, the example of cost savings through innovation on the NGTR project highlights the importance of collaboration between project actors in managing risks that cannot be identified at the outset of the project. The integration of know-how creates a basis for innovation (Lahdenperä, 2012). Essentially, it is the alliance relationship development process that is pivotal to achieving 'value for money', as it enables trust, knowledge transfer, and continual goal alignment (Arino et al., 2005; Hipkin and Naudé, 2006). The relationship development process also plays a major role in team integration between client/owner organizations and non-owner participants (Love et al., 2011).

In Yi-wan Railway project, there was an attempt to create a dynamic risk management environment by setting up risk

Table 5
Comparison of governance features in two case projects.

Features	Yi-wan Railway project	Northern Gateway Toll Road project
Organization	Risk control through a strong and centralized PMH leadership and ability	Risk sharing through equal ownership alliance-wide
Decision making	Ad hoc (rolling-wave) decisions for managing risks when they occur	Proactively building risk management objectives into project agreement at the outset
Capability	First time introducing risk management system and an insurance mechanism in large railway construction projects, strong leadership was needed.	The client, NZTA, had capability and robust systems for dealing with risks; Active Risk Manager enabled more effective risk management.
Communication	From PMH down to internal stakeholders	Equally among alliance parties
Risk management mechanism	Risks were allocated from top to down (PHW to other internal stakeholders), from inside (internal stakeholders) to outside (insurance company)	Risk sharing spread across alliance organizations (including both the client and project participants)

management teams in response to specific uncertainties. In the interviews, both PMH representatives and major contractors pointed out that the client was focused on the progress of the project. Regular client inspections and site visits took place in the course of the project. Several project managers working in PMH were seconded from the client organization. According to Turner and Müller (2004), client presence in the project organization can certainly make a difference in terms of how the project participants perform. Similarly, at the Northern Gateway project, the client NZTA also took a participatory approach, being part of the alliance. This had enabled NZTA to follow the process more closely and to plan for the changes in cooperation with the construction team.

It appears that the entire process of risk communication on the Yi-wan project started at the PMH level and then passed down to internal stakeholders. This was not the case in the Northern Gateway project. Communicating risks and risk management solutions were continually maintained between alliance participants. Effective and frequent risk communication had contributed to joint learning and joint problem-solving. This communication also happened in parallel with a reporting process from Alliance Office AMT to the decision-making group PAB. Alliance participants, therefore, had more flexibility and authority over the way they managed risks together.

A positive risk sharing process and a cross-organization decision making process were inherent in an alliance model whereas a more centralized top-down approach to risk communication and mitigation was evident in Yi-wan project. It is this 'responsibility allocation' mechanism that is at the heart of their governance structure, however, resulted in different outcomes of their risk management. Cross-case comparison shows that to improve risk management for large infrastructure projects, an analysis of risks and project organizational structure relations at the stage of project feasibility will be beneficial. In attaining better results for project risk identification and mitigation, consideration of most appropriate project management mode is needed at the outset of a project.

6. Conclusions

Governance theory provides a new perspective to gain a better understanding of the relationship between project governance and risk management. The governance structure in construction proposed by Reve and Levitt (1984) served as a prototype for considerable variations in the ways that construction projects can be organized. The major focus of this paper was to compare two large infrastructure projects to understand how the different governance arrangements could potentially influence the process of risk management and thus contribute to varied outcomes.

The construction industry in both China (e.g. Cheng et al., 2009) and New Zealand (e.g. Wilkinson, 1998, 2001) has undergone considerable changes in the past decade in terms of project management. A comparative case study method was adopted to examine two projects, the Yi-wan Railway construction project in China and the Northern Gateway Toll Road project in New Zealand. A centralized single-agent model and an alliance model were applied in the two projects, respectively. Cross-case comparison shows that project governance provides a structured mechanism to identify and address risks as they occur. Both cases had included flexibility in their contractual arrangements to leverage risks among project participants.

The research in this paper confirmed many of the issues from previous studies associated with project organizations and alliancing approach in construction. The findings suggest that top-down governance on the Yi-wan Railway project implied a more responsive, controlling approach to project risks, whereas alliance model on the Northern Gateway project generated a sense of ownership and represented proactive solutions to risk sharing and management across participant organizations. Research data and post-project reviews conducted by the Government and industry associations show that both governance structures had contributed to improvements in risk management. In terms of managing relational risks, the alliance model seemed offering a more structured approach that may well suit major infrastructure projects.

By providing in-depth case studies and cross-country comparison, this research is hoped to encourage international knowledge transfer and mutual learning in project risk management. The two projects, although different facilities, present some of the greatest challenges facing engineering and management disciplines. The economic, social and environmental implications for future projects of a similar type are substantial. Being the first pilot project introducing a risk management system, the Yi-wan Railway project served as a reference for Chinese practitioners to improve risk management methods in major construction projects. From a comparative viewpoint, the case of the Northern Gateway project highlights the importance of an ownership culture in implementing an alliance model.

Case studies have implications for the organization and management of major infrastructure construction projects, particularly in situations of high-risk, complexity and high performance requirements. The study limited the scope of analysis by emphasizing project-wide stakeholders and their relationships. The context, within which the project stakeholders operated, such as the political, economic and social factors, was left outside the scope of analysis. In-depth comparative study is needed to accommodate these contextual factors and examine how these factors might affect the implementation of different governance models. Further empirical studies of management systems in large infrastructure projects are also needed to better understand 'what worked well?', and 'under what circumstances?' in order to design appropriate forms of governance for managing risks. Finally, this research suggests that longitudinal, participatory studies are needed and, perhaps, will work best for more in-depth cross-case comparison.

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