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Risk-bearing capacity as a new dimension to the analysis of project governance

Chen-Yu Chang *

Bartlett School of Construction and Project Management, University College London, 1–19 Torrington Place, London WC1E 7HB, United Kingdom

Abstract

Project governance has been recognized as a critical factor to the success of project delivery in practice. Accordingly, this research aims to demonstrate that the notion of risk-bearing capacity (RBC) can be drawn upon as a new dimension to the analysis and design of project governance. An effort is made to link this concept with the definitions of governance employed within the literature of transaction cost economics and corporate governance. The RBC approach distinguishes itself from extant views of project governance through its ability to quantitatively integrate organizational (e.g., delivery system), contractual (e.g., risk-sharing ratio) and financial (e.g., insurance cover) measures. This novel approach provides an avenue for incorporating the project's historical construction and operating data into the design of project governance; an advantage with the potential to exponentially increase as a torrent of digital data is made available through the deployment of emergent information technologies (e.g. building information modelling).

1. Introduction

Project governance is increasingly acknowledged as a critical factor for the successful delivery of construction projects (HM Treasury, 2007). Whereas the root of "governance" can be traced to the Latin word "gubernare" (meaning: steering) (Müller, 2010), this term was not popularly used within social sciences literature until the last two decades (Dixit, 2009). The prevalent acceptance of this term is primarily attributed to the development of organizational economics in general and Oliver Williamson's transaction cost economics (TCE) in particular. As reviewed by Biesenthal and Wilden (2014), these approaches (TCE and agency theory) are influential in shaping the way project governance is analyzed within project management literature (Müller, 2009, 2010; Müller and Turner, 2005; Winch, 2001).

The current state of project governance literature is qualitative in nature. This research therefore represents a departure from this

tradition by developing a quantitative approach to the study of project governance. There are two reasons for seeking a complementary theoretical foundation: First, organizational economics is normally developed within the context of generic organizational forms (e.g., market, hierarchy, hybrid) with characteristics distinct from project organizations, so resorting to more rudimentary principles of governance as the starting point of theorization could provide a new frontier for the study of project governance. Second, both TCE and agency theory are formalizable (Gibbons, 2005a), and taking any step towards this end could exploit their modelling power to a greater extent.

In seeking a new dimension for the study of project governance, this research probes the fundamental function that governance structures are supposed to serve within TCE. Whilst Williamson defines governance structure in fairly broad terms, in its application the definition must be modified to accommodate context-specific subtleties. Corporate governance is chosen as a focus application area for exploration because of its strong influence on prior studies of project governance. In principle, the central role of governance structures is to maintain the order of transactions. In the course of

* Tel.: +44 20 76791266.
E-mail address: chen-yu.chang@ucl.ac.uk.

project implementation, order may be disturbed by random risks or opportunism-induced behavioural uncertainty. How to efficiently manage risks should be placed in the center of project governance design. In current construction practice, three types of means are commonly employed to manage risks. Organizationally, the choice of delivery systems (e.g., traditional procurement, relational contracting) could change the intensity of behavioural uncertainty (Ive and Chang, 2007). Contractually, the choice of contract forms (e.g., lump-sum, cost-plus) can shift risk exposure between parties (Smith et al., 2006). Financially, the use of financial protection (e.g., bonding, insurance) can reduce a project's overall risk exposure. How to efficiently manage transactional hazards through these three means is the overarching issue in the design of project governance. This research maintains that the concept of risk-bearing capacity can provide a coherent basis for integrating the decisions of the three means and thus shed new light on the analysis of project governance. This assertion is substantiated by a mathematical model that allows the choice of optimal risk-sharing ratio and insurance decisions to be determined simultaneously. A great benefit of the risk-bearing capacity approach (hereafter the RBC approach) lies in the ability to harness project lifecycle data (costs, risks and financial protections) to inform upon the design of project governance. The strength of this approach in quantifiability will grow significant as enormous new data becomes available resulting from the proliferation of building information modelling (BIM) and sensory instruments. The study of project governance is, in itself, a bona fide multidisciplinary undertaking (Söderlund, 2004) and it is hoped that the theoretical contribution of this research towards the development of the RBC approach can provide an alternative to the design of project governance. Whilst this research focuses on the context of projects involving a large fixed lump-sum investment (i.e., capital projects), the arguments can be readily applied to the analysis of other types of projects (i.e., IT projects).

Introductions aside, this paper contains five sections. In Section 2, the existing studies of project governance are reviewed so as to underscore the existence of a knowledge gap in the lack of a quantitative alternative to project governance analysis. A comprehensive approach is taken by revisiting the way governance structures are originally defined within TCE literature and in what ways they have been adapted in applications to corporate governance research. In Section 3, an attempt is made to illuminate the potential of the RBC approach as a keystone for project governance analysis through the exposition of its theoretical underpinnings, the problems it can address, and its feasibility in integrating procurement decisions. Section 4 provides a discussion of the significance and implications of the new approach. A concluding section follows.

2. Literature review

2.1. Prior studies on project governance

As evidenced in the upcoming special issue on project governance in this journal, governance issues provide a vibrant research area. Following the OECD's definition of corporate governance (Organisation for Economic Cooperation Development, 2004), project governance is normally defined as "*the structure through which the objectives of the project are set, and the means of attaining those objectives and monitoring performance are determined*" (p.311) (Turner, 2009). Sometimes, project governance also cover the organizational issues arising in the interface between project and parent organization (e.g., Project Management Office), and within the parent organization of the project investor (corporate governance) (Winch, 2014). The approaches employed in the analysis of project governance are as diverse as the study of organizations itself, including agency theory, transaction cost economics, shareholder theory and resource dependency theory (Biesenthal and Wilden, 2014). Of them, only the works drawing on agency theory and TCE are directly relevant to the current research.

Since the 1980s, the potential of TCE has been recognized by project management researchers (see Chang and Chou (2014) for a review). Two types of TCE applications should be distinguished: one stream draws on the concept of transaction costs in forming part of the explanation (e.g.,van den Hurk and Verhoest (2014)) whilst the other attempts to build a TCE based theory of project organizations. The former by far outnumbers the latter within existing literature, seemingly owed to TCE's ability to exist alongside other arguments. Whilst synthesis can enrich a multidisciplinary research field, being content with ad hoc applications of TCE arguments could inhibit the advancement of theoretical understanding. Among the few theorizing attempts, Winch (2001) builds on TCE to analyze the choice of both horizontal governance (for transactions between the owner and her suppliers) and vertical governance (for transactions between first-tier contractors and subcontractors down the supply chain) in construction. He maintains that the arrangement of traditional design-bid-construction systems can be seen as Williamson's 'trilateral governance' since the designer assumes the role of control actor in charge of verifying performance, facilitating negotiations, and assisting in dispute resolutions. This paper expounds the concept of 'professional governance' to capture the key features of traditional procurement systems, including the separation of design from construction (with the effect of mitigating ex post opportunism), standardized intangibility of the service (ensuring the owner knows how services will be delivered), performance default remedy supported by the professional institution (e.g., Institute of Civil Engineers), unlimited personal liability of the designer, and high reputational damages at risk in the event of sub-performance. Contracts can achieve "hierarchical effects" by specifying authority systems, providing incentive systems, using administered pricing systems, providing conflict resolution procedures, and standardized operating procedures. As regards the governing of supply chains, the contractor is advised to choose one of four generic governance structures (sequential spot market, quasi-firm, consortium, joint venture) on the basis of asset specificity and frequency. Whilst Winch (2001) is soundly grounded in the TCE framework of 'make or buy' decisions, it is worth noting that the evolution of TCE has been influenced by the experience of antitrust law enforcement (Williamson, 1996). This is why the main interests of TCE exist on the polar types of governance (market and hierarchy). When it comes to the governance decisions of 'permanent'

organizations (contractor, developer, designer, material supplier), Winch's framework is instrumental. Not so in the analysis of 'temporary' organizations, where instead of being confined to the TCE framework, there is benefit in developing a customized theory of project governance on the basis of more rudimentary principles of governance design.

Floricel and Miller (2001) provide another theorizing attempt. The authors argue that in the planning and implementation of large-scale projects, a project should seek 'robustness' in the planning stage to immunize performance from environmental disturbances and enhance 'governability' by improving cohesion (project participants' willingness to stay with the project and solve the problems caused by disturbances), resources (financial reserves to cope), flexibility (ability to restructure the project itself) and generativity (ability to develop creative responses). Whereas potentially these dimensions can provide useful guidance for the design of project governance, further effort should be made to operationalize their content.

The highly influential agency approach also has impacts upon the study of project governance. Müller and Turner (2005) attempt to discern the conditions under which relational contracts, alliance contracts, and conventional contracts would be more suitable in terms of business culture (trust based v.s. transaction based) and business challenges (simple v.s. complex). Evidently, a discrete classification system can differentiate project governance types in a compact way. However, in practice the demarcation between them can be blurred and thus there could be a need to "decompose" project governance into key elements for analytical purposes.

There is no denying that the vibrant development of project governance literature and the diversity of perspectives bodes well for its future. Nonetheless, in terms of sophistication, depth, rigor, and consistency by which the progress of a research field is judged (Durisin and Puzone, 2009), there is little sign that project governance research is catching up with the advanced field of governance study (e.g., corporate governance research). Case studies are overly relied upon in substantiating conceptual constructs, and attempts should therefore be made to operationalize the terms to make them measurable and to "harden" research methods towards the establishment of evidence via rigorous hypothesis testing. This research represents an attempt towards these ends.

2.2. Prior studies on governance and corporate governance

The popular use of "governance" in academic writings could be credited to Oliver Williamson's celebrated works on transaction cost economics. Williamson defines governance structure as "*the institutional matrix in which the integrity of a transaction is decided*" (p. 378) (Williamson, 1996), which serves to "*provide cost-effective relief against maladaptation hazards*" (p.5) (Williamson, 1996). In the study of governance, the central issues therefore lie in the "*identification, explication, and mitigation of all forms of contractual hazards*" (p.5) (Williamson, 1996).

In its application, modifications need to be made to the general definition of governance. Corporate governance is one of the most studied governance types, with its vast body of literature providing profuse examples of how to reflect context-specific factors in the definition of governance (see Table 1). According to Becht et al. (2003), the term "corporate governance" dates back to Eells (1960), which defines it as "*the structure and functioning of the corporate polity*". Since the publication of seminal theoretical works in the 1970's and 1980's (Fama and Jensen, 1983; Jensen and Meckling, 1976), the rapid growth of corporate governance literature has justified itself as a field (Durisin and Puzone, 2009). Since corporations are a dominant form of business organization in the market economy, a critical role of corporate governance is to ensure the providers of corporate funds (shareholders and debt-holders) can attain a good return on their investment (Shleifer and Vishny, 1997). The influence of the agency approach can be seen in the modelling of corporate governance as a complex relationship between the corporation's management and its key stakeholders (Becht et al., 2003). The second view stresses the functions that corporate governance is meant to serve, including control (John and Senbet, 1998), capability to adapt in the presence of quasi rents (Zingales, 1998), and the ability to align management's individual interest with social interest (Tirole, 2001). These functions are satisfied in practice through the design of board structure, securities, and incentive schemes (Hermalin, 2013). Collectively, the study of corporate governance is built upon an understanding of the relationships between key stakeholders, alignment instruments, and the objectives of governance design. The variety of corporate governance definitions within literature attests that the definition of governance should reflect analytical emphasis. This practice helps liberate thinking from the confines of the existing project governance framework in order to develop a new approach.

Table 1
Definitions of corporate governance in the economics literature.

Reference	Definition
Eells (1960)	The structure and functioning of the corporate polity
Hart (1995)	A mechanism for making decisions that have not been specified in the initial contract
Shleifer and Vishny (1997)	The ways in which the suppliers of finance to corporations assure themselves of getting a return on their investment
Zingales (1998)	Governance system as the complex set of conditions that shape the outcome of the ex post bargaining over the quasi-rents that are generated in the course of a relationship
John and Senbet (1998)	Mechanisms by which stakeholders of a corporation exercise control over corporate insiders and management such that their interests are protected
Tirole (2001)	The design of institutions that induce or force management to internalize the welfare of stakeholders
Becht et al. (2003)	A problem involving an agent – the CEO of the corporation – and multiple principals — the shareholders, creditors, suppliers, owners, employees, and other parties with whom the CEO engages in business on behalf of the corporation
(Hermalin (2013))	The product of decisions in many dimensions: board structure, security design, incentive schemes and the like

Source: this research.

3. Towards a RBC approach of project governance

In this section, an attempt will be made to explain why the RBC approach can serve as a feasible framework in prescribing solutions to the issues involved in the design of project governance. For this purpose, this section is aimed to answer three questions: What is the risk-bearing capacity approach? What issues is this approach suited to address? How feasible is it in resolving the issues as claimed?

3.1. What is the RBC approach?

The notion of risk-bearing capacity is aimed at measuring the limit under which the contracting parties could begin desiring to pull out of, rather than continue, the contract. The identification of such a cut-off point would better reflect the full cost of risk bearing and thus improve the design of governance structure in mitigating the transactional hazards. Quasi rents can serve as a good measure of risk-bearing capacity (Chang, 2013a,b,c, 2014). By definition, quasi rents refer to the return in excess of the minimum required for a trader to carry on the transaction in the post-contract stage (Milgrom and Roberts, 1992). The potential effect of quasi rent on organizational design was systematically explored for the first time by Klein et al. (1978). The reasoning is simple: When both parties are locked into the trading relationship, the party with a greater quasi rent will appear to be more vulnerable. As such, the magnitude of appropriable quasi rent can act as a good predictor for the size of transaction costs (Gibbons, 2005a). This reasoning leads to asset specificity being identified as the most serious inhibitor to market efficiency. However, Chang (2013c) presents a variant on the way quasi rents can be analytically applied by interpreting it as the limit of the downside risk that one contracting party is willing to bear before opting out (Chang, 2013a,b). This limit would be affected by the project governance, contract form and financial protection used. This new perspective seeks to integrate available measures by considering the cost of these measures against the benefits resulting from the improved risk-bearing capacity as a result of their use. In what follows, an attempt will be made to show the possible way of incorporating these measures into the risk-bearing capacity framework.

According to TCE, the general objective of governance design lies in the efficient use of measures to mitigate the costs of maladaptation. It follows that the study of project governance should be concerned with the employment of most cost-effective 'means' to moderate the hazards that would overshadow the trading relationships between the owner and external project participants throughout the project lifecycle.

3.2. What issues are the RBC approach suited to address?

This section discusses the issues that can be addressed within the RBC framework. Project production involves collaboration between parties with complementary assets (human or physical capital). The worthiness of a project primarily depends on how well the procurement process is managed. In practice, there are three types of means to enable the owner to achieve her project goals: organizational, financial and contractual (see Table 2).

In TCE, getting the governance structure right is regarded as the decision of first-order importance in terms of its impact on efficiency (Williamson, 1996). In construction procurement, the choice of procurement systems bears the same importance as this decision determines to what extent the project can be delivered earlier and the holdup threat can be mitigated (Ive and Chang, 2007). Delivery speed is mainly determined by how far design and construction can be overlapped, which in turn depends on the fragmentation of procurement systems. In this respect, management system $\succ$ design-build $\succ$ traditional method ($\succ$: superior to). Once the project goes into the post-contract stage, the owner is gradually locked into this project as her switching cost increases along with more investments being sunk (Chang and Ive, 2007). In the event of project disruption, the owner has to confront tough negotiations with the contractor in order to avoid incurring switching costs. The level of difficulty for an owner to place a replacement contractor is a key determinant of her bargaining weakness post contract. The degree of vulnerability can be measured by the deviation from the 50:50 split in negotiations. According to the Nash bargaining model, the owner would need to concede ground because she has a greater quasi rent than the contractor in both traditional procurement (Chang, 2012) and PPP procurement (Chang, 2013a). The holdup threat would become severe when the owner needs to change requirements *ex post*. To mitigate this type of hazard, the procurement system that allows the sequential tendering of work packages can give the owner greater flexibility to change at a later stage. In this sense, management system procurement has a clear advantage over

Table 2
Key procurement decisions.

	Problem	Focus	Strategy	Type
First-order economizing	Delivery speed	Revenue	Get project governance right	Organizational
First-order economizing	Holdup problem	Transaction cost	Get project governance right	Organizational
First-order economizing	Risk-bearing limit	Production/transaction cost	Get financial protection right (e.g. insurances)	Financial
Second-order refinements	Moral hazard problem (designer)	Production cost	Professional governance	Institutional
Second-order refinements	Moral hazard problem (contractor)	Production cost	Get risk allocation right	Contractual
Second-order refinements	Risk-bearing limit	Production/transaction cost	Get financial protection right (e.g., performance bonds)	Financial

Source: this research.

design-build as under the latter, an owner would not make changes without paying an exorbitant price after the design-build contract is placed at an early stage. As a result, management system ≻ traditional method ≻ design-build (≻: superior to) (Ive and Chang, 2007). The reversal of bargaining power is the origin of most contracting hazards in construction procurement. To what extent the owner's vulnerability will be taken advantage of is actually a probabilistic problem. In recent decades, construction partnering/alliancing has been promoted as the cure for this hazard (Infrastructure UK, 2013; Latham, 1994). Partnering is meant to change project participants' attitude from confrontational to cooperative in resolving problems. It is hoped that, in the face of an unforeseen event, the contractor can put mutual objectives ahead of individual interests by actively seeking a solution rather than exploiting it as an opportunity for extra gains. From the perspective of organizational economics, the effect of partnering is tantamount to enlarging the "self-enforcing" range of the contract (Klein, 1996; Telser, 1980), thereby reducing the transaction costs that would be induced by holdup motives.

The third decision of first-order importance is associated with the use of insurances to improve the financial viability of the project. In the Gateway review process (Office of Government Commerce, 2007), it is advisable for the owner at the outset (Gateway 1: Business Justification) to consider insurances as a means to reign in risk exposure to an acceptable level. Considering the above, the longer and more complex the contract the stronger the demand for insurances. A proper use of insurances could fundamentally change the feasibility of a project, so it should be deemed just as important as the decision of procurement strategy.

Governance design should also examine second-order (marginalist) refinements for moral hazard problems (Williamson, 1996). In commissioning project works, the owner faces a fundamental contracting problem in whether the undertakers will perform at their best. According to Principal-Agent theory (Hart and Holmstrom, 1987), this problem arises when, under asymmetric information, the owner cannot gauge the agent's performance solely by the output. For instance, good performance may result from flukes and bad performance may be caused by uncontrollable risk. Given that "effort" is not contractible, the agent's best effort can only be elicited. First, as for the designer's motivation, reputation seems the main driver. However, "professional governance" (in Winch's term) can perhaps drive the designer to perform design tasks with due diligence and could not provide the designer with strong incentives to develop a design scheme that is not only aesthetically appealing, but also buildable and sustainable.

As for the contractor's motivation, an effective solution is through choosing a different form of contract. In practice, there are two common choices: fixed price contract (strong-powered incentives) and cost plus contract (weak-powered incentives) (Chang, 2014; Smith et al., 2006). Under the former, the contractor can retain all the cost savings. If the scope of work can be clearly defined, this contract provides high-powered incentives to improve production efficiency (Tadelis, 2012). Financial instruments can also help achieve second-order refinements, including bonds (tender bonds, performance bonds), guarantees (parent company guarantees), and warranties (collateral

warranties) (Hillebrandt et al., 2002; RICS, 2012). Most of the major owners require the contractor to have various financial protections in place. Greater complexity of the project normally results in financial protection being more intensively used. For example, in the standardized PF2 contract (HM Treasury, 2013), there are a number of chapters associated with financial protections, including Chapter 13 (Warranties), Chapter 14 (Indemnities, Guarantees), and Chapter 17 (Insurances). Compensation on termination for contractor/owner default also has implications for governance design (Chapter 23–25), as it can mitigate one party's appropriability hazards arising from the other party's unilateral action.

Table 2 provides a summary of four principal means used to align divergent interests between parties within construction procurement. Of them, only organizational, contractual and financial measures are under the owner's control. These decisions should not be treated as solitary decisions as one could have spill-over effects on others. The first example is that financial protection may have a bearing upon the efficacy of organizational means. A performance bond provides the owner with compensation on the extra expenses in the event of contractor performance failure. With part of the switching costs covered, this protection could strengthen the owner's post-contract bargaining power to curb the contractor's holdup threat and thus undermine the relative advantage of fragmented procurement systems over design-build. The second example is the close connection between procurement system and contract form. Most design-build projects use lump-sum contracts, whilst incentive contracts are more likely employed in the projects using traditional methods. Since three means tend to be utilized in cluster (i.e. high correlation between the choices of procurement system, contract form and financial protection), there should be a complementarity between them (Brynjolfsson and Milgrom, 2013). In a system involving interdependent interactions of sub-systems, there would be multiple local maxima (Rivkin, 2000). Project governance possesses some characteristics of this type of system. Without an integrated approach, the effects of complementarity and trade-offs among three means would not be fully scrutinized in crafting the optimal governance structure for a project.

3.3. A preliminary assessment of the feasibility of the RBC approach

The cardinal virtue of the RBC approach is its ability to quantitatively integrate the decisions of three means: organizational, contractual and financial. Since the incorporation of the organizational means entails considerable work, the following demonstration case is chiefly focused on the coupling effect between the contractual and financial means.

First, the choice of governance structures may greatly affect the riskiness of the project. In the analysis of discrete governance structures (Williamson, 1991), the size of anticipated disturbances is deemed essential for governance choices. In governing transactions with inconsequential disturbances, the market can adjust itself and restore efficiency. However, if the transaction is subject to mid-range disturbances, a contract with highly

adjustable mechanisms will be needed. An example is the coal long-term supply contract between the Nevada Power Company and the Northwest Trading Company (Joskow, 1985, 1988). This contract contains a price adjustment mechanism to allow for 10% price change in conjunction with the mechanisms of information disclosure and dispute resolution. However, for transactions in the face of highly consequential disturbances, contracting will lose out to hierarchy as the preferred governance structure in affecting adaptability. From the perspective of TCE, the optimal governance choice is closely related to the magnitude of foreseen disturbances. Actually, the choice of procurement systems (traditional method, design-build, management system) can change the project's risk-bearing capacity through three channels: First, the delivery time can be shortened by increasing the overlap of construction and design. In doing so, the increase in project net present value as a result of shorter delivery time can translate into the owner's buffer for unexpected shocks. The second channel is through decision rights assignment in order to change the adaptability costs of project governance. With decision rights, the decision maker can choose the course of action that maximizes his own interest in negotiations. However, the downside is it would intensify the other party's holdup tendency (Arrunada et al., 2001). In Hart and Holmstrom (2010), the friction in affecting adaptability is captured by the cost of shading, which could undermine a project's risk-bearing capacity. Empirically, a recent attempt at modelling and measuring the adaptability costs of traditional procurement system with econometric methods would prove a possible path forward (Bajari et al., 2014). Alternatively, the cost of decision rights assignment can be evaluated using real options analysis. Third, workload volatility is the one of the largest operational risks facing the contractor. For repeat owners who have a programme of work to carry out, conditioning the award of future work on the contractor's current performance might not only mitigate holdup threats, but also attract a discount in bidding prices. The net benefit of relational procurement can be incorporated into the RBC framework using either econometric methods or real options analysis.

Second, contractual arrangements can fundamentally change the risk impact a project can withstand. The most important function of the contract is to specify the allocation of payoff rights between parties. How to allocate risk-bearing ability is the cornerstone of Principal-Agent theory (Roberts, 2007). In the agency relationship, transferring risk from the principal to the agent has a cost. On the one hand, the cost varies with the agent's risk-bearing ability (represented by his risk attitude under no wealth constraint); on the other, it is to do with the riskiness of the transaction (measured by the variation in payoffs). The principal has to trade off the cost of risk transfer against the benefit from the agent's additional effort induced by risk-sharing. As shown in Chang (2014), the concept of risk-bearing capacity can be formally accommodated into the Principal-Agent theory. But, unlike the Principal-Agent theory, the RBC approach is concerned with where the random shock actually eventuates on the probability distribution curve, instead of just the spread of the distribution. It is argued that the downside shock in excess of the risk-bearing limit should be priced differently as those situations would

trigger the agent's intention to opt out of the transaction and thus cause extra cost.

Third, it is evident that use of financial instruments can raise a project's risk-bearing capacity. Insurances are generally used to protect against miscellaneous risk sources (e.g., all construction risks), whilst guarantees are mostly designed for a specific type of risk (e.g., contractor default and non-performance). As demonstrated in Chang (2013c), the net effect of these two instruments can be fit into the calculation of risk-bearing capacity. The third instrument is associated with the design of termination mechanism. Commercial contracts often stipulate money damages as a mechanism of contract remedies. The compensation amount may change one party's return from the contract and its variations. The right to terminate the contract with cash compensation is tantamount to granting the defaulting party the option to buy back the contract for a strike price equal to the compensation amount (Mahoney, 1995). In return, it is hoped that the grantee can charge a lower risk premium to reflect lower appropriability hazards. The desirability of providing compensation on termination should be evaluated on the cost/benefit basis. Again, real options analysis is a useful tool for this purpose.

Whilst, as summarized in Table 3, three types of means can be fit into the RBC framework in principle, it is useful to go further in order to demonstrate the feasibility of the RBC approach through a numerical example. Suppose a well-reputed developer plans to invest in an upmarket housing project in central London. Compared to delivery time and cost, the owner prioritizes quality as utmost importance. To maintain the full control of design, the owner chooses the traditional method. Suppose, according to the owner's internal quantity surveyor, the most likely construction cost is £50 million. It is expected that the owner's exacting quality requirements could expose the contractor to a significant cost overrun risk. This downside risk (w) is a uniform variable in the range of 0 and £20 million. The resolution of this risk would become a perverse incentive for the contractor to shade on quality, so the investor considers using an incentive contract to induce the contractor to work harder towards her interest.

Following Chang (2014), apart from the forecast cost (£50 m), the outturn cost (C) is also affected by the random shock w and the contractor's effort at cutting cost (a):

$$C = 50 + w - a. \tag{1}$$

The payment consists of two parts: target cost (£50 m) and an incentive pay contingent upon the risk-sharing ratio ($b, -1 \leq b \leq 0$)

$$P = 50 + b(50 - C). \tag{2}$$

The contract is said to be low-powered when $b = -1$ (known as cost-plus contract in practice) and high-powered when $b = 0$ (known as lump-sum contract). Under this incentive, the contractor has to decide how much effort to exert by considering the cost of effort in order to maximize the utility of the payoff from the project (x):

$$U(x) = -e^{-\gamma x} \tag{3}$$

Table 3
Three main elements of project governance and their effects on risk-bearing capacity.

	Effect on risk-bearing capacity	Valuation method	Basis of evaluation
Organizational means (choice among traditional method, design-build, management system) Differs in			
Delivery time	Using a fast-tracking procurement system can increase the owner's risk-bearing capacity.	NPV approach	Increase in project NPV owing to early delivery
Decision rights assignment	A good assignment of decision rights can increase risk-bearing capacity through lowering adaptability costs	Econometric estimation or Real options analysis	Change in adaptability costs
Frequency of transactions	Would increase risk-bearing capacity and reduce holdup-induced transaction costs	Econometric estimation or Real options analysis	Monetary value of continuous workload + change in adaptability costs
Contractual means (contract forms) Differs in			
Risk-sharing ratio	Greater risk transfer have a mixed effect on risk-bearing capacity.	Principal-Agent model	Additional benefit from the effort induced – cost of risk transfer – change in breakup loss
Financial means			
Insurance	Increase	NPV approach	Expected value of the risk impact prevented as a result of the cover – risk premium
Guarantee	Increase	NPV approach	Expected value of the risk impact prevented as a result of the cover – cost of guarantee
Compensation for default	Mixed	Real options analysis	Decrease in price due to compensation clauses – cost of this compensation

Source: this research.

where γ indicates the Arrow–Pratt coefficient of absolute risk aversion (Arrow, 1964; Pratt, 1964).

The owner anticipates a severe overrun risk, so requires the contractor to purchase an insurance to protect against this risk. To simplify, the insurance has no deductible and the insurance premium is proportional to insurance cover (B): λB. As shown on the solid line in Fig. 1, the contractor just needs to bear the insurance premium if the random shock turns out to be below the cover. In worse cases where the shock is over the cover, the loss will be reduced by the same amount as the cover B.

A project's RBC should be evaluated on the basis of quasi rent. In principle, the contractor has two buffers (Chang, 2013a): the contractor's markup and the potential loss resulting from deploying sunk assets to an alternative use. To simplify, assume that the machines and equipment used in the project are all rented, so the second term can be ignored. Suppose, under weak competition, it is expected that the winning contractor can make a profit of 5 m from this project. The profit then serves the function of the contractor's buffer. Under the incentive contract (Eq. (2)), the contractor only bears a proportion of the cost shock. All together, the contract may break up if

$$(-b)(w-B) \geq 5 \Rightarrow w \geq \frac{-5}{b} + B. \tag{4}$$

The negative sign in front of b is to ensure it is positive because, by definition, b lies in 0 and -1. The second bracket in

Eq. (4) indicates the contractor's net risk exposure after accounting for the insurance cover B.

As shown in the Appendix A, the optimal risk-risk ratio is determined by the following equation (Eq. (A-8)):

$$5 + b(B-L) - 40b^4 = 0 \tag{5}$$

In this equation, there are two parameters: contract breakup loss (L) and insurance cover (B). Table 4 shows the optimal
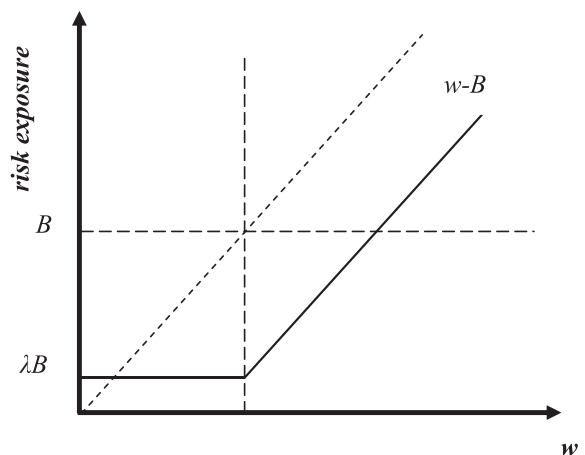

Fig. 1. The relationship between random cost shock and the cost borne by the contractor.

risk-sharing ratios in cases where each of the two parameters take a low, medium or high value respectively. When the breakup loss is held constant, a greater insurance cover will reduce the optimal risk sharing ratio (closer to -1), meaning that the availability of insurance products reduces the owner's need to rely on the contractor in managing risks. By contrast, under the same insurance cover, a large breakup cost (mostly caused by process specificity) leads to an increase in the likelihood of high-powered incentive contracts (b closer to 0) being employed. Whereas offloading more risk to the contractor could increase the expected breakup costs, it can also yield benefit through strengthening the contractor's incentives to cut cost (Eqs. (A-4) and (1)). Under the model setting, the benefit from cost savings outweighs the additional breakup cost.

From Eq. (A-8), it is evident that the RBC approach is able to solve the two decisions in an integrated way. In the near future, enormous new data will become available as a result of the wide application of BIM and sensory instruments; data sources which can improve the reliability of risk modelling. In practice, subjective evaluation of probabilities is a common practice when historical data are not available. The prior distribution of a parameter can be updated on the basis of real data using Bayesian statistics (Efron, 2013). The RBC approach makes it possible to amalgamate the fast-expanding study of big data with the design of project governance.

4. Discussions

As opposed to the existing views, the RBC approach aims to make quantitative comments on the soundness of project governance with the hope of opening a new frontier whereby major procurement decisions can be integrated. As seen in the development of a value for money assessment of PFI (Private Finance Initiative) projects, both qualitative and quantitative methods prove useful in decision making (HM Treasury, 2006). It seems sensible to expect that both the qualitative and quantitative approaches likewise have a role to play in advancing the theory of project governance.

Table 4
Optimal risk-sharing ratios for the cases with different contractor's risk attitude, contract breakup cost and insurance cover.

Project attributes	Insurance cover	Optimal risk-sharing ration (b)
Low specificity (L = £10 m)	No cover (B = 0)	−0.40
	Medium cover (B = £10 m)	−0.60
	High cover (B = £20 m)	−0.75
Medium specificity (L = £15 m)	No cover (B = 0)	−0.31
	Medium cover (B = £10 m)	−0.50
	High cover (B = £20 m)	−0.68
High specificity (L = £20 m)	No cover (B = 0)	−0.25
	Medium cover (B = £10 m)	−0.40
	High cover (B = £20 m)	−0.60

Source: this research.

In the RBC framework, project governance is treated as a mix of organizational, contractual and financial means. These means jointly determine how much random shock a project could withstand. With this approach, the owner can design project governance in accordance with the expected project risk exposure by choosing the optimal mix of three means. Currently, these means are studied as different topics (organizational means (project governance/delivery system/procurement route), contractual means (risk management, risk allocation), financial means (risk management, insurance, bonding)). Breaking the false line between these means can allow the cost/benefit of them to be evaluated jointly and prevent over-protection (as it is too costly) or under-protection (as it exposes the owner to too much risk). Following the optimal choice prescribed by the RBC approach can therefore improve the design of project governance in efficiency terms. Secondly, the new approach can establish itself as a positive theory for understanding project governance practices. The key prediction is that the employment of three means is a reflection of their relative costs. For example, as shown in the numerical example, the insurances provided by professional insurers and contractors can be deemed a substitute, meaning a significant change to insurance premiums could prompt a systematic shift to contractual risk-sharing pattern in construction procurement.

The RBC approach can also provide assistance to procurement decision making throughout the project lifecycle. At the stage of contract design, the owner can use this approach to:

1. Check if the project governance suggested by the consultant is resilient enough to withstand the predicted level of risk exposure based on the most likely winning bid;
2. Determine the most economical use of the protection measures for a foreseen level of risk exposure, including risk-sharing ratio, insurance cover, performance bond and payment retention percentage.

At the tender stage, the owner can deploy this approach to extract unrealistic bids. In many failed projects (such as Channel Tunnel Rail Link project and East Coast Rail Franchise contract), the owners were actually alerted to the over-optimism of the winning bid but no action was taken. This is probably due to a lack of solid reasoning to act against a generous offer that is broadly in line with the ambiguous concept of value for money. Yet, through the lens of RBC, the danger of accepting an unrealistic bid can be fully revealed in the form of extra costs arising from the greater likelihood of contract breakup.

In the operational stage, the owner can use this approach to predict the contractor's decision on assets renewal. In projects involving both construction and operation elements (e.g., PFI project), the contract period normally lasts longer than 25 years, during which the private investor is obligated to make periodic investments to keep the assets in working conditions. However, evidence indicates that the owner would face uncertainty at asset renewal points (normally every 7–10 years), such as when Metronet decided to opt out of its contract prior to the first renewal point (National Audit Office, 2009). The RBC approach could

inform the owner of the likelihood that the contractor would renew the assets as stipulated.

The RBC approach has three insights for practitioners: first, contract breakup potential should be explicitly recognized and modelled in the design of project governance (because the occurrence of breakup will result in substantial more cost); second, the effects of organizational, contractual and financial means on the efficiency of project governance should be jointly considered; third, the owner can improve procurement efficiency by seeking the optimal use of three means suggested by the RBC approach.

The RBC approach has a close connection with Floricel and Miller (2001). The concept of 'cohesion' is captured because quasi rents measure trading parties' willingness to continue with the transaction. The dimension of 'resources' is also considered in that the RBC approach seeks to find the most cost-effective strategy for handling risk impacts (cash reserve mentioned in Floricel and Miller (2001) is just one of the choices). As regards flexibility and generativity, the RBC approach accounts for the value of options that could strengthen the owner's flexibility and project participants' drive to solve problems using appraisal techniques (e.g., real options analysis). Comparatively, the RBC approach can not only address these four dimensions, but also provide a way to integrate them quantitatively.

5. Concluding remarks

Project governance is a relatively new concept within project management, and the growing interest in this topic is mostly attributable to the maturity of economic theories of governance. Both TCE and agency theory have been influential in prior studies of project governance. This research submits that this line of inquiry should go further to tap into the formalizability of these theories and develop a quantifiable approach to project governance design. This research draws upon the concept of risk-bearing capacity to provide an avenue to integrate the choices of organizational (e.g., choice of delivery system), contractual (e.g., choice of risk-sharing ratio) and financial (e.g., choice of insurance cover) measures that are determined independently in current construction practice.

Compared to existing perspectives of project governance, quantifiability is a distinguishing feature of the RBC approach. The widespread applications of BIM will lead to project data being more systematically stored in digital forms. An emerging issue is how to harness these new data sources to improve procurement decisions. In this regard, the RBC approach provides a flexible framework to enable the study of project governance to benefit from the fast-expanding research on BIM and big data.

Appendix A. Derivation of the relationship between risk-sharing ratio and insurance cover

The contractor's payoff from the project is made up of three parts: construction cost, which is chargeable, cost of efforts

($h(a)$), which is not chargeable (McAfee and McMillan, 1986), and insurance premium (λB). Following the tradition of the Principal-Agent theory, the cost of effort is assumed to be in a quadratic form (Laffont and Martimort, 2001),

$$h(a) = 0.05a^2. \qquad (A-1)$$

The contractor's net payoff (x) from the project depends on the realization of the random shock.

$$x = P - C - h(a) = (1+b)(a-w) - 0.05a^2 \qquad (A-2)$$

The contractor's goal is to choose a level of effort so as to maximize his expected utility. With an insurance cover B in place, the contractor's risk exposure is reduced to the range, $B \sim 20$. Substituting Eq. (A-2) into Eq. (3) gives

$$\max_a -e^{-\gamma(a+ba-0.05a^2-\lambda B)} \left(\int_B^{20} e^{\gamma(1+b)w} \frac{1}{20} dw \right). \qquad (A-3)$$

The impacts of random shock are modelled in the second bracket of Eq. (A-3). The first-order condition of Eq. (A-3) yields

$$a = 10(1+b). \qquad (A-4)$$

As shown in Eq. (A-2), the owner tries to transfer $(1+b)w$ to the contractor. The premium for taking this risk can be estimated by the standard formula: $1/2\gamma\sigma^2$ (Gibbons, 2005b), where γ is the risk-bearer's coefficient of absolute risk aversion and σ the standard deviation of the transferred risk. To simplify the calculation, the contractor is assumed to be risk neutral, i.e., $\gamma = 0$, so the contractor's surplus is

$$S_C = P - C - h(a). \qquad (A-5)$$

The owner's surplus (S_O) is equal to the project's market value (V) net of the payment to the contractor

$$S_O = V - P.$$

For the owner, the decision question is how to choose a risk-sharing ratio so as to maximize the total surplus (TS) of the project:

$$TS = S_C + S_O = V - C - h(a) - \lambda B = V - (50 + w - a) - 0.05a^2 - \lambda B \qquad (A-6)$$

where w actually eventuates will affect the total surplus yielded. The contractor's quasi rent is £5 m. It means that, if w is over this value, the contractor prefers to back out of the contract. Considering the breakup threshold in Eq. (4) and the contract breakup cost L, the expected value of the total surplus (ETS) becomes

$$ETS = V - (50-a) - \left[\int_0^{\frac{-5}{b}+B} \frac{w}{20} dw + L \int_{\frac{-5}{b}+B}^{20} \frac{1}{20} dw \right] - 0.05a^2 - \lambda B. \qquad (A-7)$$

The first-order condition of Eq. (A-7) gives

$$5 + b(B-L) - 40b^4 = 0. \qquad (A-8)$$

A further elaboration of the logic and justification of this modelling strategy can be found in Chang (2013c, 2014).

Conflict of interest

There is no conflict of interest.

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