STUDY ON THE GOVERNANCE OF CONSTRUCTION CONTRACT FROM THE INCOMPLETE CONTRACT PERSPECTIVE

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CONTENTS

1. Introduction

1.1 Background

It has been widely acknowledged that construction projects, especially infrastructure projects are inextricably linked to people's daily lives. Infrastructure is essentially considered to be a kind of physical means that support fulfilling the desires that spans the public scope as a composition of goods as tangible and service as intangible with complex functionality[1)]. As a significant provider of social welfare, the low efficiency and poor performance of construction projects have long been a puzzle to the researchers and related practitioners[2)-7)]. And therefore, seeking for effective solutions on the issue has been continuously concerned by a variety of fields.

The large-scale construction project is full of complexity by a number of factors. Firstly, it is heavily influenced by natural factors like geological conditions. In addition, due to its long construction period, it is also extremely vulnerable to weather conditions during process of construction. As a result, construction project is more sensitive to risks. And then, there are numerous participants with different areas of responsibilities involved such as the client, the contractor and the engineer, etc. Because of the coexistence of cooperation and conflict of interest among them, the behaviour of project participants has to be jointly regulated and maintained by various disciplines and rules. Moreover, first-phase preparations are also onerous since it not only requires high technical competence but some subjective such as expected utility and objective factors (for example, government policy or social environment) are also needed to be carefully considered. Therefore, the investment in the early stage is also indispensable. Consequently, parties usually choose to conclude a construction contract in order to ensure the smooth implementation of construction project which has been regarded as an effective means for project management.

From an economic point of view, function of the contract has been defined and explained as a kind of agreement on bilateral commitment of behaviors between contracting parties in many studies[8)-10)]. While the traditional contract theory has been assumed that a contract should completely contain the agreements as to how to specifically deal with all incidents that are expected to occur in the future, incomplete contract is the contract which does not specifically describe all the conditions that may arise during the execution period but the rules to cope with them[11)]. For construction contract, it acts as the records of the description of all possible risk factors and allocation methods of losses[10)-13)]. And due to the high uncertainty during construction period, the construction contract is regarded as a typical incomplete contract because of its indescribability of all unforeseen contingencies, contract variations are commonly observed during construction period. Such incompleteness may exactly give rise to the opportunistic behaviours of contracting parties and finally result in utility reduction of

the construction project. Since appropriate designed contract is expected to play a significant role in the improvement of efficiency of construction project, in order to cope with the situation, contract variation rules have been stipulated in construction contract.

In the field of incomplete contract theory, researches on the design of contractual mechanisms for mitigating the negative impacts caused by incomplete contract are not uncommon. Grossman and Hart (1995)[14], who is a leading figure in the profession, has proposed an effective mode which has already been applied to the construction field. Instead of renegotiation between contracting parties assumed in general incomplete contract theory, by stipulating risk sharing rules and contract variation rules in the contract and handing full right of contract variation to the client, the negative effects such as hold-up behavior brought by the incompleteness of construction contract can be inhibited theoretically. However, deviations between theoretical assumptions and practical conditions make it inadequate to only rely on contract clauses, discussions on other mechanisms and governance methods are in great request.

Furthermore, currently, there are mainly two ways to improve the efficiency of construction project. One is management and the other one is governance. For a long time, researches on construction projects have been focused on the scope of project management. It is defined as the decision-making process that controls the achievement of project objectives[15]. However, it has to be emphasized that the construction project is essentially different from enterprise project where the management theory originated from. Sha (2017)[16] indicates that construction project is located outside the company but within the market while the enterprise project is located inside the company where the client manages the project within hierarchical interior. That is to say the objective of enterprise project is subject to the strategic goal of the company since the initiator of the project is the company himself. Conversely, construction project is initiated by the client and undertaken by the contractor through selection process by the market. Therefore, the project objective is determined by the client and may not be consistent with the strategic goals of the contractor. Under such circumstances, governance mechanism may bring enlightenments on mitigating project failures. Sha (2017)[16] conceptualizes construction governance as an effort to make legally independent participants with divergent long-term interests and strategic goals work together towards a shared goal, achieving positive results for all parties. As a higher level than management, governance is enabled through different forms of flexibility which implies less control and more autonomy. Therefore, for the construction project as a temporary multilateral organization engaged in one-shot customized tasks, both management and governance mechanism are expected to work along both lines in harmony for project success.

1.2 Problem statement

The construction projects are playing an increasingly significant role not only in

providing products, services and infrastructure for daily lives, but also in the development of the social and economy in terms of strategically transform the practice and processes of the organization[17]. And it has been deeply recognized that project inefficiency or even failure could lead to significant losses not only for the client but also decreases in social welfare. Although various types of contract standards have been published for both domestic and international construction projects to help improving project efficiency, due to the substantive characteristics of construction contract as incomplete, opportunistic behaviours originated from contract variation process caused by indescribability of unforeseen contingencies is definitely inevitable.

In the field of incomplete contract theory, mechanisms for the sake of avoiding such inefficiency has attracted tremendous attention of scholars and yielded many fruits. However, construction contract has distinctive feature from the analytic target in the previous researches. In addition, there is still a certain gap between the reality and the theoretical settings. Therefore, this research would like to find out what are the effect factors of the incompleteness of construction contract, and then if the mechanism of contract variation rules play effective role on mitigating inefficiency of construction project which is caused by opportunistic behaviours of contracting parties. Finally, we want to see if there are some effective contract governance mechanisms to deal with the issue.

1.3 Objective of research

The objectives of this research are mainly complying with the awareness of the issues. Generally, it analyses the structure of construction contract with a holistic approach attaching importance to the issue of project inefficiency caused by the incompleteness of contract, and then proposes mitigation methods from the perspective of construction contract governance. To be more clearly, they can be classified as the follows:

- To clarify the effect factors on incompleteness of construction contract
- To investigate the applicability and functionality of contract variation rule stipulated in construction contract basing on the characteristics construction project.
- To discuss the essential conditions for the contractual mechanisms to be effective through theoretical analysis and give practical advices.
- To verify the optimal contract model on mitigating the negative effects brought by opportunistic behaviour from the perspective of cognition effort exerted by contracting parties initially.
- To analyse the structure of relational governance for construction contract in China by the method of comparative study through a case study.

1.4 Scope of research

Summarily, the research tends to solve problems in the field of construction project from the perspective of economics. It mainly focuses on the inefficiency issues such as hold-up problem where bargaining power has been strategically used to expropriate the surplus of the other party. Because of the special structure of construction contract, renegotiation, as a general way of determining the remaining redistribution, assumed in incomplete contract theory is no longer appropriate since it has been replaced by contract variation rules. Nevertheless, contract variation rule is usually perceived to be consistent with the idea of incomplete theory and in addition, as a typical incomplete contract, construction contract could be considered to be a unique branch in the system of incomplete contract theory. Accordingly, in this research, mechanisms such as decision-making and governance on the both sides to the contract have been analysed by mathematical modelling based on game theory and it aims for improvement of project efficiency. On the other hand, the research also refers to the field of construction governance and indicates its structure under the situation of China. However, governance mechanism is regarded to be quite flexible since it not only includes formal but also informal institutions which heavily rely on socio-cultural background. Therefore, specific design of mechanisms has not been involved in this research since they are beyond the scope of this work.

1.5 Expected contribution

In this research, I have attempted to conduct studies on the governance of construction contract associated with the theory of incomplete contract for inefficiency issues in the field of construction project. The originality of the thesis could be summarized in 3 points. The first one is that the research focuses on the incompleteness of incomplete contract and takes the construction contract as research object where the contract variation is conducted through the contract variation rules instead of renegotiation. This is decisively different from conventional incomplete contract theory which takes the sales contract as research object. Moreover, the thesis analyzes the relational governance with the consideration of Chinese relationship. Hopefully, the conclusions and suggestions proposed in this thesis could be as the reference framework or may bring some inspiring ideas in this aspect for both practitioners and administrations.

Firstly, this research attempts to make some ingenuity in the perspectives of viewing the problem. While chapter 3 theoretically verified the applicability and functionality of the contract variation rules, the deviations it pointed out in accordance with the true structure of construction contract which could be regarded as the incompleteness of incomplete construction contract should be paid to an important finding of this investigation , since the indispensable preconditions of successfully implementation of the contract variation put forwarded in the thesis could be used as a breakthrough

whether in practice or in research area. Moreover, the suggested advanced functionalities of the dispute board and mechanisms outside of contract variation rules also have guiding significance with high operability in the construction governance practice.

Chapter 4 takes ex ante cognitive efforts exerted by contracting parties on the design of construction project as a medium to evaluate the optimal contract mode in dealing with the negative impacts brought by opportunistic behaviours during contract variation due to the inappropriate initial design. It is based on the premise that although the construction contract stipulates the contract variation rules in order to evade the renegotiation, when there exists incompleteness of the construction contract, the inefficiencies are still possible to be caused by opportunistic behaviours taken by contracting parties. Although this is not the former of the idea on cognition effort, the analysis with this variable under the context of construction contract has not been conducted so far which can be regarded as creative. It proves the superiority of design-build contract from a different perspective which may also feasible for analysing other contract modes. This part is only a theoretical verification of the effects of various forms of contract on restraining strategic behaviour. But the analysis performed in the study is also a contribution towards the appreciation of contractor's participation at the project planning stage.

Finally, chapter 5 conducts a case study on Chinese construction contract. For project governance of international construction work, the understanding of construction contract terms is regarded as a crucial step. In addition, Japanese contractors may be required to accumulate the knowledge on the Chinese style of construction contracting governance as a background of the extensive role of Chinese contractors in international markets for infrastructure development. However, there is scarcely any theoretical research on this field has been conducted. This research clarifies the structure of contractual customs in Chinese construction market through comparative study with FIDIC form. It theoretically explains that the difference is resulted from the different assumptions on relationship between contracting parties. Moreover, it also points out the existence of relational governance in Chinese construction contract. As a starting point, it is prospectively that such analyses and considerations will continue to be implemented for other countries and therefore knowledge on governance of construction contract will be widely accumulated.

1.6 Organization of the thesis

This research aims to examine governance measures of reducing inefficiencies caused by the incompleteness of incomplete construction contract with the consideration of the specific contract structure. The thesis is organized as follows.

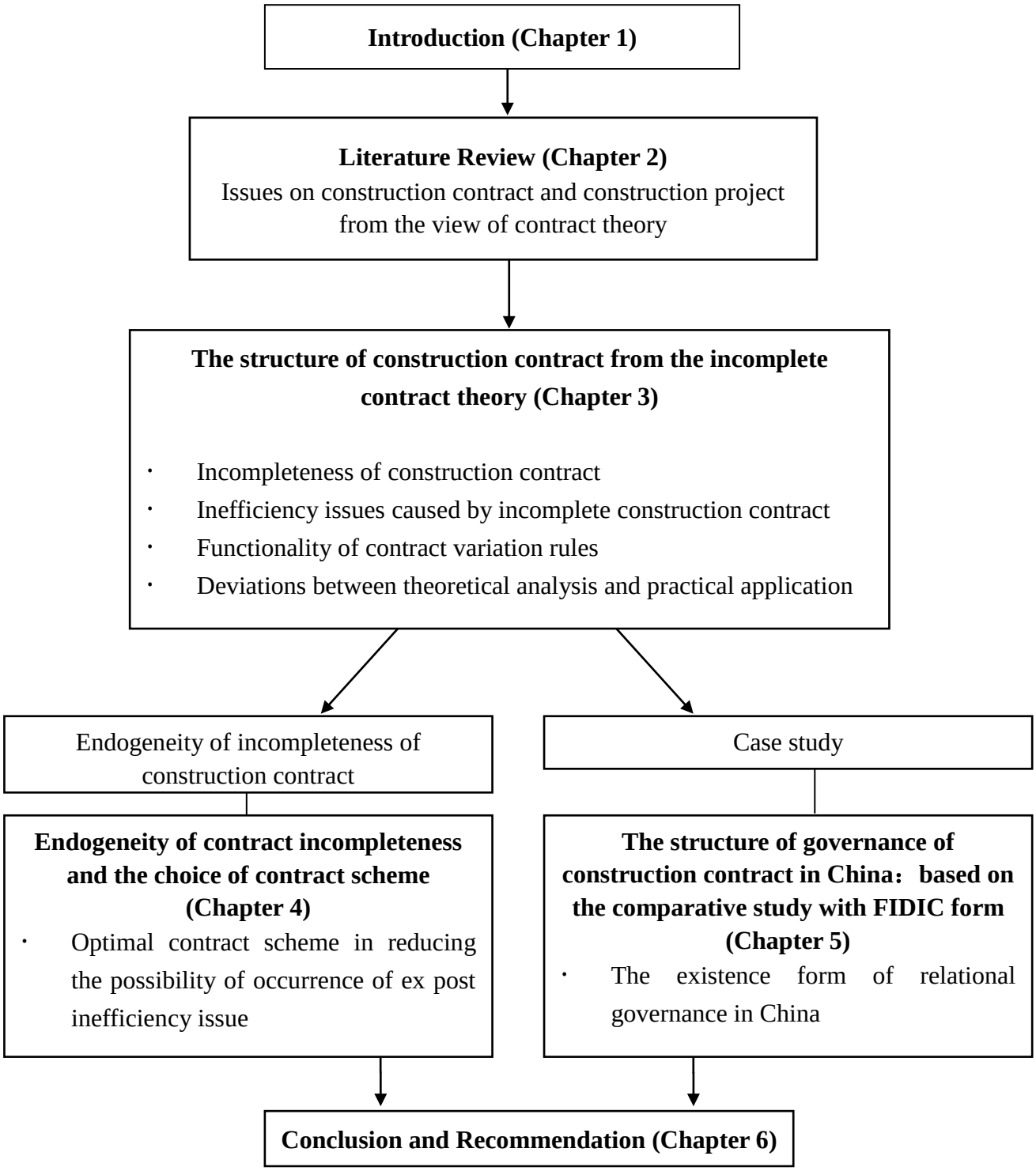

Figure 1.1 The structure of thesis

The structure of thesis is showing in the **Figure 1.1,** it is consisted of 6 chapters. The thesis starts with an orientation by chapter 1 which includes the general background, establishment of research territory and the basic content and significance of the study. And then chapter 2 provides literature reviews of previous researches on the subject of contract theory which starting from the origin of the contract and followed by complete and incomplete contract theory. It summarizes the current research fruits, research trends and continued in-depth possibilities thereof. This provides the theoretical basis for understanding the original idea of the research. In addition, it also involves necessary knowledge in the field of construction projects and shows the existing problems and shortcomings in terms of theoretical applications which may be helpful for a better grasp of the ensuing contents.

Chapter 3 firstly discusses the existence of incompleteness of construction contract and the inefficiency issues it may bring to the construction project. Basing on the major premise that the construction contract is a typical incomplete contract, this chapter then verifies the rationality and functionality of the contract variation mechanism stipulated in construction contract by mathematical model on the basis of the research findings of Hart (1995). It shows that when the contract variation will be perfectly enforced in an ideal situation, incompleteness of incomplete construction contract can be completed. And then the insufficiencies of the practical implementation of contract variation rules will be discussed incorporating with the structure of construction contract. Besides the deviations between theoretical analysis and practical application, this part also points out that in practice, the contract variation rules may not play its role due to noncompliance by the contractor, since there are no effective mechanisms to guarantee its implementation. In summary, in construction projects, inefficiencies caused by opportunistic behaviors are difficult to control completely due to incompleteness of incomplete construction contract.

Therefore, following the logic of previous chapter, in the context that contract variation rule cannot be perfectly enforced in an ideal situation, chapter 4 analyzes the two situations of imperfect-enforceability and non-enforceability of contract variation with the consideration of the endogeneity of incompleteness of construction contract. It theoretically verifies the optimal construction contract mode in the aspect of suppressing the occurrence of opportunistic behaviour from the root cause. This part focuses on the guarantee mechanism of ex ante contractual efficiency and analyzes incentives of contracting parties to reduce negative effects brought by contract incompleteness by introducing cognitive effort under the situation of conventional contract and design-build contract.

Finally, during contract variation process, when there exists cognitive distortions between contracting parties, dispute settlement has to be conducted. Therefore, chapter 5 conducts a case study in China based on the comparative study between the standard construction contract of China and the FIDIC form. This part aims at explicating the custom of contracting in the construction market of China by analysing the standard

form of construction contract for public works compared with FIDIC, the international standard form of construction contract. The result implies that the structure of contracting rule in the standard form in China is almost same with the FIDIC form except the operation rule of dispute resolution process. We have pointed out that the substantial difference between these two standard forms arises from the existence of relational governance in Chinese construction market.

The final chapter 6 makes a comprehensive summary of the main conclusions of the study. In addition, the limitations of the present study are also indicated and directions for the future studies on the similar topic are proposed.

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2. Literature review on contract theory

2.1 Introduction

In this research, inefficiency issues within construction project are focused and investigated from perspective of incomplete contract. Researches and analysis on contract have been conducted in numerous research fields such as law and economics since a long time ago. Contract theory clearly covers a wide variety of situations. It can not only interpret many phenomena but also provide analytical ideas which have far-reaching influences around the world. In addition, contract management and governance are also treated as important segments for the high efficiency of construction project. Be begin with, this chapter is going to provide a theoretical background by means of literature review. This section will firstly give a review on contract theory including complete and incomplete contract and followed by a summary of some of the relevant concepts in the field of construction project.

2.2 Literature on contract theory

2.2.1 What is contract?

Before going into theoretical part of contract theory, it is necessary to have a certain understanding of concepts related to the contract.

In economics, there has been a discussion based on the premise of the traditional market economy. Most of the cases in general discussion take well formulated market as a prerequisite that traded goods are extremely standardized, which for example what kind of quality should be traded is quite obvious for market participants. However, it is nearly impossible for actual transactions to be done under such a well-maintained market. In practice, for example, asymmetric information between sellers and buyers exists in most of transactions such as information on the quality of traded goods. Moreover, most of the actual transaction is not an immediate one[1)]. There must be a considerable deferred exchange from the beginning of business relationship to the end[2),3)]. Accordingly, in the case of such time-consuming exchange transactions, there is an incentive for opportunistic behaviour for both parties[1)]. On the other hand, as stated by Chou et al. (2011)[4)], since stable structure, certainty, predictability, and controllability are strongly needed by people in nature[5)-7)], formal arrangements are therefore often counted by individuals on reducing uncertainties and promoting the stability of structure in order to strengthen their control. These formal arrangements include authority, social and hierarchical structures within organizations[8)-11)], regulatory framework [12)], and contracts[13), 14)].

The simplest definition of a contract as a legally binding agreement has been given by

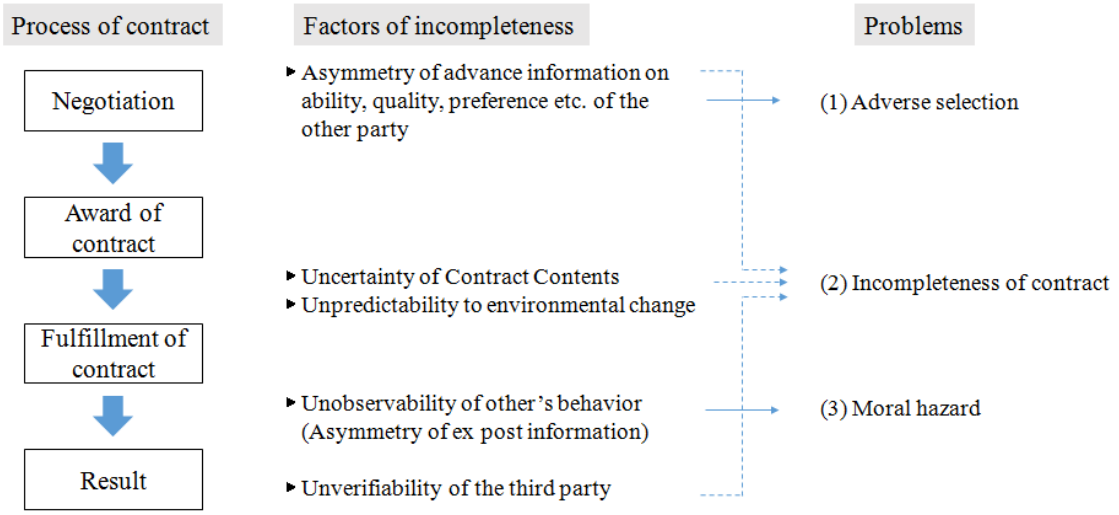

Figure 2.1 Problems of contract economics[3)]

many scholars[15)-17)]. A slightly more elaborated definition is 'an agreement between two or more parties. Each party is bound by performing or being subject to a specific act agreed multilaterally, and each party is also entitled to obtain the rights promised by other parties[15)]. From an economic point of view, the contract can be considered as an agreement on bilateral commitment of behaviors between the two parties[18)]. It governs the right, obligations and liabilities of the parties. The determinacy of the contractual obligations of both parties is the basis of a successful contract[16)]. According to the five basic elements of contracts summarized by Macneil (1969)[19)]: (1) cooperation, (2) economic exchange, (3) future planning, (4) possible existence of external sanctions, and, (5), social governance, therefore, contract researches can be viewed as an effort on a) explanations for economic exchange behaviour in the context of continuing regulated relationships or b) development of efficient governance mode of exchange relationship and its improvement[20)].

However, in reality, there are various restrictions existing from signing of the contract to the end of the transaction. For example, various expenses may be occurred during the contract period or sufficient information has to be secured for the contract to play its role smoothly. Since there is a complicated and time-consuming process starts from the time that contracting parties negotiate for contract content, signing the contract to the contract fulfilment, contractual issues arising from various factors will be inevitably arise[3)].

As showing in the **Figure 2.1**, while asymmetry of information during pre- and post-contract period may lead to adverse selection and moral hazard which belongs to scope of complete contract, incompleteness of contract takes place throughout the whole process. Theories on contracts in economics have been developed mainly on such issues occurring in each process[3)]. From the late 1960's to the 1970's, the academia had

ushered in a breakthrough due to the introduction of the novel concept of private information and the emergence of hidden action in contract environments which brought the studies of contracts into the current academic range of complete contract theory. Furthermore, it not only built the foundation of the theory of incentives and information economics but also provided the original formal tools for enterprise theory, corporate finance and general theory of economic institutions. After that, contractual theories on long-term or dynamic contracting were evolved in the 1980s and 1990s. While developments of the analysis of ownership and the rights of control have been gradually conducted by the approaches of contract renegotiation, relational contracts and incomplete contract theory, these perceptions also establish the basis of a well-rounded enterprise and organization theory[21]. Reviews on complete contract will be briefly conducted in the next section in this chapter followed by detailed descriptions of incomplete contract.

2.2.2 Complete contract theory

Generally, a complete contract should describe all of the events that may occur in the future as well as the obligations (actions taken by agent, allocation of income) in each case in the form of verifiability by the court in advance. In other words, when parties come into a contractual relationship by signing a complete contract, their rights and obligations in response to every possibility of the future have to be perfectly defined. Since the initial contract specifies the optimal rights and obligations of contracting parties in each case in the future, there is no need for them to make contract variations in accordance with unforeseen contingencies or new information[22].

For a complete contract to be signed, there are also some prerequisites which are complementary with the definitions mentioned above. Firstly, people are assumed to be rational since the contract terms can be written explicitly and fully implemented, and contracting parties can accurately predict contingencies and handle it agreed by both sides. Moreover, from a legal standpoint, contracts are always considered to be obligationally complete due to the perfect enforceability of the third party, for example, the court[23]. And thus, it is said that the contract that can be renegotiated cannot be treated as complete. It is only the one that binds the contracting parties until the business relationship is over[24]. This also implies that both the substantive provisions and the intentions of contracting parties should be fully completed and determined[22),25)]. In addition, from an objective point of view, the environment for signing the contract is also strictly constraint that it must be similar to a perfectly competition market[26]. And the last point is that there is no cost to conclude and fulfil a contract. Accordingly, if the contract imposes more restrictions on the actions of the parties, the contract will be considered to be more complete[4), 27)-29)].

After the maturation of analysis on the efficient contracts with certainty and symmetric information, gradually, along with saturation of the studies on the contract with accurate understanding of uncertainties, the contractual situation of asymmetry information

began to be concerned by more and more scholars. At this time, incentive contract theory has been increasingly refined and in turn being enriched by the development of incentive constrains and participation constraints[21]. Basically, hidden-information problem and hidden-action problems are regarded as the general types of incentive problems. Problems of hidden information refer to the situation that the agent may conceal some personal information with specific characteristics from the principle and it is often considered to be the cause of adverse selection, while problems of hidden actions will result in moral hazard due to unobservable actions taken by the agent[21]. Therefore, finding solutions of adverse selection and moral hazard have become the core issue of research content. The standard model of complete contract is identified as principal-agent model [29].

Under the framework, the principle is facing with multiple agency risks cause by asymmetric information between the two parties[30]. The characteristic of the theory lies in clarifying the type of moral hazard exists between a company and its stakeholders on the premise of asymmetry information. In the 1980s, principal-agent theory has been greatly developed by Holmstrom (1979)[31] which analyzes contractual relationship by model based on economic theory of information economics and game theory[32]. However, since the principle is enabled to both predict contingencies in the future and identify differences in risk preferences of the two sides, the appropriate contract can be accordingly designed. Such characteristic contract allows the principle to optimally allocate the risk to the agent and maximize the benefits from motivation. Therefore, principle-agent theory is known as the theory of optimal contract design[33]. Although the context of this framework belongs to the nature of complete contract, due to the constraint of asymmetric information, it can only be considered as the optimal contract within the restrictions of limited knowledge of future preferences and options [29),34)].

However, in reality, due to some inevitable practical factors, the contract will not be completed in full. Different from the preconditions assumed in the optimal contracting, in an uncertain environment, relational behaviour of contracting parties and the full enforceability of the contract by the third party is unpractical. That is to say, under the complicated contractual situations, the bounded rationality of contracting parties may lead to an imperfect description of the future states and solutions of unforeseen contingencies. Moreover, the third party may also have insufficient capacity to fully understand the original intentions of both sides and misinterpretations on contract terms may also be likely to take place[21]. In addition, owing to the development of transaction cost economics, behaviors related to contract is no longer free. As a consequence, the contract is largely being incomplete.

2.2.3 Incomplete contract theory

In the real practice, it is impossible for a contract to cover everything in advance on account of excessive possible events in the future[35]. Since the contract is legally protected, in order to make the contract play its due function, the contracting parties

may try to clarify the contents and describe necessary matters as much as possible at the stage of contract drafting. However, as envisaged by the economics of contract, the contracting parties may not obtain all the information that necessary for concluding a contract. Even if all necessary information can be obtained and it is possible to explicitly write the contract with such an enormous amount of content, the occurrence of unforeseen contingencies cannot be fully predicted[3)].

In more detail, according to the literature summarized by Hattori (2012)[3)], there are mainly three reasons why contract is incomplete[36), 37)]. Firstly, there is a limit to the capability of information search of human beings. That is, the contracting parties cannot obtain all the necessary information at the time of drafting the contract. Secondly, it is basically impossible to predict future changes[38)]. Even if all the necessary information is available at the time of contract establishment and all thinkable possibilities can be described in the contract, because of the occurrence of unforeseen contingencies, changes of the contracting parties themselves and the external environment surrounding them is unavoidable. The third point is limited enforceability of contract fulfillment due to unverifiability of contracting parties for performance of the contract against the third party such as the court. These reasons for incomplete contract are all said to be attributed to bounded rationality of human beings proposed by Simon (1976)[39)].

On the other hand, as a development of the literature on earlier transactions cost[40)], incomplete contract models are endowed with various of transaction costs. In addition to the cost for obtaining necessary information for drafting contract mentioned above, the cost of writing contracts is also a daunting number. That is, even if all the contingencies could be foreseen by contracting parties in advance, the description of all of them in a contract is very impractical since it will lead to unaffordable costs. Moreover, sufficiently clear stipulation of contract terms with no ambiguity also involves numerous of manpower and time. The last one is the cost of contract enforcement, since the enforceability of contract is based on the full understanding of the contract terms by the third party and the capacity of identifying the contingencies and actions[29)].

When contract become inevitably incomplete, renegotiations on the content of contract variation by contracting parties becomes inevitable[29)]. This is because contracting parties are locked in such long term contractual relationship with large relation-specific investments[41)]. A relation-specific investment is a kind of capital investment which produces value only within a certain relationship. Asset specificity is a property that the asset is able to offer its high value only for the business relationship with the counterparty while it is quite difficult to produce similar value in transactions with other potential counterparties[32)]. In other word, it can be regarded as a kind of sunk cost, since once the investment has been made, there is nearly no other use for it except target product. But it has to be emphasized that it could also be refers to a kind of immeasurable cost that generated from or invested for maintaining the sustained and long-term relationship for such as human resources[42)]. As the contract is incomplete due to the uncertainty in the future, under such circumstances, there is a possibility that such

investment will be cheaply bought from the producer in the process of renegotiation where generates the investment problems. That is because renegotiation gives contracting parties a chance to take advantages of others specific-investment for depriving some of the other's gains. In more detail, when ambiguous and rough contract terms have been stipulated in the initial contract, it is necessary to carry out renegotiation by contracting parties if unforeseen contingency takes place. Base on the premise of renegotiation, as a result of taking into consideration the possibility of being deprived of own interest during renegotiation, the contracting parties may choose to diminish ex ante investment which is called hold-up problem[43]. The ease of being held-up in the later period is proportional to the amount of relation-specific investment. In order to settle the matters due to contract incompleteness, mechanisms such as institutions, law systems and organization should be taken into consideration[3].

Mechanisms designs for incomplete contract to mitigate the inefficiency caused by investment problems have long attracted the attention of many economists. It is suggested that the typical mechanisms are contractual arrangement and asset ownership[23].

Pioneering researches have been conducted by Grossman and Hart (1986)[44] and Hart and Moore (1990)[45] which theoretically analyzed the boundary of enterprise known as the theory of property rights[46]. They introduce residual rights of control and build GHM model to explain the optimal allocation of the ownership of such control right. The theory indicates that physical assets should be held by the party who can benefit from external transactions. Meanwhile the property owner may be more motivated to make specific investment. Furthermore, the studies also account for the incentive problem of employees in the firm by indicating that the control over physical asset may also lead to the control of human asset. Basing on a summary of the ideas, Hart (1995)[47] further systematically expounded related concepts and provides the explanations on a number of economic institutions and economic phenomena from the perspective of property right under the frame work of incomplete contract. Around the same time, for the other aspects of incomplete contract, Aghion, Dewatripont and Ray (1994)[48] proposes the ADR model for dealing with the hold-up problems in the context that when renegotiation between contracting parties breaks down, the initial contract has to be implemented as a basis point. In this case, if the initial contract and bargaining power can be appropriately allocated, the hold-up issue can be avoided.

Then, as the extension of previous work, Hart and More (2008)[49] argue the idea from a new perspective that the contract serves as a reference point basing on the parties' feelings of entitlement in a contracting relationship for judging the true outcomes. It indicates that if a party fails to obtain the expected outcome permitted in the contract, then he may be likely to take some opportunistic behaviors. Although a flexible contract can solve the problem by adjusting outcomes when uncertainties take place, it is also vulnerable to inefficient shadings. Accordingly, an optimal contract should be traded off between the flexibility and rigidity. As an experimental evidence of the idea of reference point, Fehr et al. (2011)[50] conduct the research to empirical support the behavioral

assumptions of Hart's paper. However, since the hold-up problem has not been involved, Hart (2009)[51] focuses rigid contract with fixed price and takes hold-up and asset ownership into consideration. He indicates that indexation contract and the reasonable distribution of asset ownership are effective in preventing such issue. Moreover, along with the abundance of property theory, there are also review articles on this topic. One of them is conducted by Aghion and Holden (2011)[52] with discussions on several criticisms. Aghion et al. (2013)[53] summary the application issues of incomplete contract theory on internal organization.

Besides the scope of property rights, researches on incomplete contract from other points of view are also blooming. Aghion and Tirole (1997)[54] focus on the issues on the optimal allocation of formal authority and real authority between the principle and the agent by trading off of the agent's incentive and the loss of control of the principle. Although Hart and Moore (1988)[55] have emphasized that the incompleteness of contract mainly generates from the observable but unverifiable by the third party on some key variables such as specific investment because the bounded rationality is hard to be measured. Anderlini and Felli (2004)[56] make an attempt on focusing some difficulties in analyzing incomplete contract with bounded rationality and further discuss the issue in the case of the existence of complexity costs. Tirole (2009)[57] establishes the model containing bounded rationality by introducing cognitive effort exerted by contracting parties and makes the incompleteness of the contract turn to exogenous. In 2015, Tirole[58] further develops the cognition issue by allowing the contracting parties to have information acquisitions before contract design.

Tirole (1999)[29] gave a classical review on development of incomplete contract theory. It has to be emphasized that although incomplete contract theory has made remarkable achievements in explaining a number of economic phenomena, there are still critical opinions especially the farfetched point between the causes and fundamental assumptions of incompleteness has attracted criticism which even has an impact on its foundation. However, the incomplete contract theory has been developed only for decades, so there are still broad spaces for development.

2.3 Literature on construction contract

2.3.1 Construction project

In recent large-scale construction projects, there are many cases that it nearly takes decades for a construction project to be put in use from land acquisition to planning, design, construction and completion. Generally, the project is planned based on the formulated budget at the stage of planning, and the construction contract is concluded basing on the design and specifications drawn up in the plan. Therefore, within such long period, in addition to the mistakes on the purpose and scale made by the client, the issues such as changes in social and economic circumstance during construction period,

changes in the conditions of construction specifications and the appropriateness of completed work in terms of expected utilities have been regarded as the common problems and even the key to the success of the construction project[59]. The greatest concern of the client is the realization of specified functionality and expected utilities of the project.

Construction is regarded as a product-oriented project with various of dimensions[60]. According to Bunni (2013)[15], it can be divided into the following kinds:

(1) Longevity lifecycle of the project starting from initiating stage to completion.

(2) Large number of participants from related fields are required to perform their roles.

(3) Many construction projects are heavily influenced by the objective factors such as geological conditions and unpredictable natural environment.

(4) Some civil engineering projects require high professional qualification, high technology and complicated process.

(5) Coexistence of communication and cooperation, interests and conflicts among many of participants and parties.

(6) Construction projects are vulnerable to the endogenous risks caused by related personnel.

Accordingly, the construction project is featured by high investment, high risks and high degree of uncertainty. In addition, the construction project, especially infrastructure project is closely related to the social welfare and people's life, the inefficiency issue thereof has attracted a lot of attentions by researches in various fields.

Doloi (2013)[61] analyses the roles and responsibilities of the key stakeholder in construction project to examine the reasons of the poor cost performance in the Australian construction industry. Kim et al. (2009)[62] develop a structural equation model for predicting the success of international construction project under uncertainty and show its accurate prediction capacity through comparative analysis. Kim et al. (2009)[63] quantify the probability of delays in construction project by applying Bayesian belief network based on a questionnaire survey. In addition to theoretical analysis, some case studies have also been conducted. Fugar and Agyakwah-Baah (2010)[64] investigate the main causes of delay issue of construction projects in Ghana. Kaliba et al. (2009)[65] examine the issue of the cost escalation and schedule delays in road construction projects in Zambia. Wright and Fergusson (2009)[66] conduct a case study in New Zealand in order to show the benefits of the NEC ECC form of the contract.

2.3.2 Construction contract

Construction project is said to be a multi-components activity and one of them is regarded as business dimension which requires the establishment of contractual relationships with various stakeholders[60]. Construction contract is a kind of agreement that the contractor agrees to complete the construction work by his capacity such as technical skills and labour force and the client makes the payment for the completed construction work. It is composed of contractual conditions which stipulate the rules

between contracting parties and contract documents on the specifications, quality and quantity of construction work[59]. It also includes items such as contract purpose, contract price, and contract durations[67].

As mentioned above, construction project is regarded to be high-risk, the significant function of construction contract is 'to describe all possible risk factors regarding the performance of the project and specify the allocation method of losses thereof' [68].

In the field of construction project, there are various kinds of standard forms of construction contract for both domestic and international project. For example, AIA contract documents issued by the American Institute of Architects, New Engineering contract drew up by Institution of Civil Engineers and the FIDIC forms based on the opinions of experienced experts of the Federation Internationale des Ingenieurs Conseiles which have been widely popularized internationally. For the domestic standard contract conditions, they are formulated mainly in accordance with the domestic conditions, for example, GCW (The standard From of Agreement and General Conditions of Government Contract for works of Building and Civil Engineering Construction) in Japan and the Construction Contract for Construction Project Model Form in China. Although the clauses in standard forms may be cumbersome, complicate and often difficult to understand, as an agreed result made up by the industry, on one hand, it could save time and costs spent for negotiating contract contents by individuals themselves. On the other hand, it could help the risks to be allocated equitably between contracting parties [69].

As mentioned in the above section, construction project is featured as long-term, a large number of participants and sensitive to external environment. It is full of uncertainties such as geological conditions, nature conditions, design change, change of scope of work and changes in contractual environment. Therefore, construction contract is characteristic of the occurrence of contingencies that are difficult to be forecasted and even controlled by contracting parties, from this point of view, construction contract is definitely a typical incomplete contract[70]. Accordingly, due to the high degree of incompleteness of construction contract, in order to deal with the occurrences of the events that could not be predicted at the time of concluding the contract, contract variation will be carried out between contracting parties[67].

It has been indicated in many literature that construction contract is particularly featured which is quite different with the sales contract. Beside the factors of complexity, the long-duration of the project, large scale and changes in price and workload during the performance of the contract, etc., as indicated by Adriaanse (2016)[69], the most essential distinction lies between construction contract and other manufacturing processes is that completion of construction work by the contractor is strongly required before any payment has been made. This is also supported by the contract stipulations in nearly all forms of construction contracts that the contractor is obligated to complete the construction work. And it has been regarded as the basic setting of models in the literature related to the analysis of construction project and construction contract[17),71)-73)].

Since contract termination by the contractor is forbidden, when additional cost and extension of construction period have been caused due to unpredictable risks, settlement on losses sharing between contracting parties has to be reached and the responsible party has to bear the risks. Omoto (2001)[70] had divided the risk events that may occur during construction period according to the nature of risk events into exogenous risks and endogenous risks. For the exogenous risks which is caused by external factors, instead of describe all the possibilities as a complete contract do, the construction contract stipulates risk sharing rules and contract variation rules for dealing with the uncertainties. In addition, when contracting parties fail to reach an agreement, there are also dispute settlement rules stipulated in the contract in this connection or sometimes statutory intervention may also be required. In order to enable the construction contract to play its role efficiently under the framework of inevitable incompleteness, appropriate design on contract rules is also a hot topic.

Therefore, there are many researches accumulated so far in the field of construction management on the topic of the particularities of construction contract, as well as the research cases on the structure of construction contract.

Kobayashi et al. (2001)[17] reveal theoretically that the construction contract can lead the infrastructure project to social efficiency level by satisfying some conditions and shows the limitations and desirable contract mode under the moral hazard situation. Omoto et al. (2001)[70] make a comparative study between GCW and FIDIC red book (4^{th} edition) and points out the essential difference in terms of verification rules of the two contracts. Onishi et al. (2003)[71] examine the defect liability in construction contracts and indicates that the effective liability rules in different context. Moreover, Onishi et al. (2002)[72),73] focus on the dispute issue and the contractor's claim behaviour and analyses the impact of third party adjudication on the efficiency settlement of disputes by use of a game theory approach. Shi et al. (2006)[74] investigate the efficient mechanism of moral hazard control under the framework of PFI project and they (2010)[75] also theoretically clarify the double moral hazard issues in construction project within the scope of game theory. Chapman and Ward (2008)[76] point out that a balanced approach of risk sharing is significant for a best practice and the aspects such as full integration of contract choice decisions, uncertainty management are also practical and beneficial in construction project. On the other hand, Zhao et al. (2011)[77] established a model of dynamic risk allocation in construction project from the perspective of incomplete contract. And Walker and Pryke (2009)[78] also conduct a study on the necessities of the incompleteness of construction contract documents by analysing its role, definition and dimensions. Malhotra and Lumineau (2011)[79] theoretically and empirically verify the relationships between trust and collaboration in the medium of the nature of provisions as an aspect of contract structure.

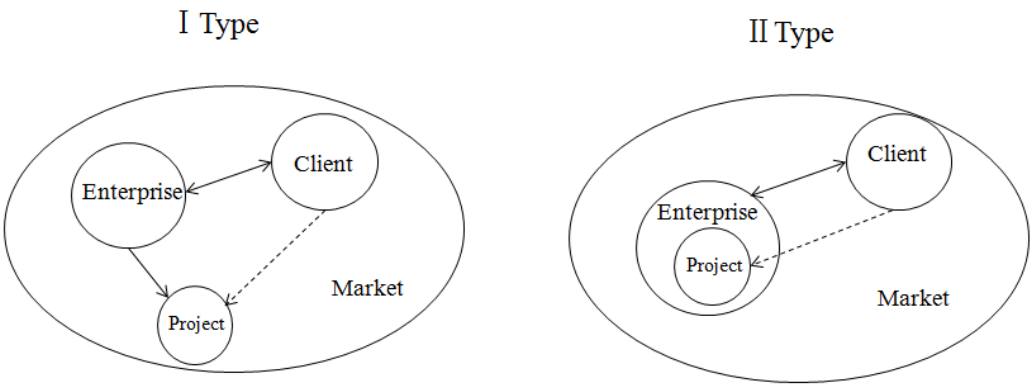

Figure 2.2 Project and project-based enterprise[80)]

2.3.3 Construction management and construction governance

It is acknowledged that the construction project is a kind of unique existence which is essentially difference with the projects within the enterprises. The **Figure 2.2** clearly shows the difference between the construction project and the enterprise project.

Sha (2017)[80)] defines the Ⅰ type as inter-firm organization. This form of organization is consistence with that of construction project. It shows that the project is located in the market where outside the enterprise. As we may know the establishment of a construction project is initiated by the client and the contractor is screened out from the market through competitive bidding. In this sense, both the client and the contractor are independent companies and they have to establish a partnership for an independent project in the market. On the other hand, for the Ⅱ type, the nature of organization form is defined as intra-firm organization. This type is said to be suitable for the project such as software development project within an IT enterprise. Since the project in the graph has been included in the enterprise, it means that the initiator of the project is enterprise and there is the internal relationship between the project and the enterprise of the organization. Generally, the enterprises support their day-to-day business through such kind of projects.

However, although 9 perspectives on research in project have been concluded by Turner (2013)[81)], it has been indicated by Sha (2017)[80)] that the mainstream theory of project management is optimization school which is originated from Ⅱ type project and was designed to handling relationships between different functions within a single organization and did not involve the relationship between organizations. Therefore, the current project management theory has some certain limitations on dealing with the issues in construction project.

Moreover, construction management is defined to be a series of management activities for rational settlement on decision-making problems throughout the entire project cycle during the whole process. In brief, construction management mainly focuses on the issue of decision-making basing on the prerequisite of rationality. However, when

taking the complexity of the construction project of both exogenous factors and endogenous factors into consideration, transactions costs will actually increase with such avoidless incompleteness of the construction project. In order to reduce such unnecessary cost, in addition to the comparative rigid management way, friendly relations and cooperation between the contracting parties is also strongly required. Project governance which is a more flexible mechanism serves as a kind of complementarities is required to play to the score during the whole project process.

Currently, many researches on project governance have been accumulated. Ulrika Badenfelt (2010)[82] focused on the control mechanisms of partnering arrangement through qualitative analysis methods. He found that the governance mechanism may be differ in different phases of the project and building long-term relationships and displaying the client's power over the contractor is effective in preventing opportunistically behaviour. Rahman and Kumaraswamy (2002)[83] conducted a case study on joint venture project in China and indicates the importance of cooperative teamwork and amicable adjustment process. Sheng, et al. (2006)[84] found that communication has a strong positive effect on project governance in terms of relational norms which can reduce the negative effects of decision-making uncertainty. Pauget and Wald (2013)[85] identify three ideal types of relational competence which are able to accelerate and promote the effective and efficient functioning of the networks in project governance. Moreover, by means of survey, Lu et al. (2014)[86] and Poppo and Zenger (2002)[87] both pointed out that relational governance is a significant aspect in project governance and it function as complements with contracts governance.

However, there are still no unified definition and dimension of this concept. In addition, paper about project governance in construction field is limited since it is strongly affected by social environment and social systems in different regions. Accordingly, most of researches are from the perspective of empirical study where deficient of theoretical analysis is also the current status.

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3. The structure of construction contract from the incomplete contract perspective

3.1 Introduction

Since complete contract theory is based on the premise that all the contingencies that may occur in the future can be specifically described in the contract, it mainly focuses on the issue of moral hazard and adverse selection due to asymmetric information. However, in reality it is impossible to describe all the conditions that may arise in the future in a contract. Even if it is feasible to specify all contingencies, the existence of transaction costs makes it prohibitively difficult to be complete. Based on this fact, the basic themes of incomplete contract are the design of supplement mechanisms such as institutions, laws and organizational structures in order to mitigate the inefficiency brought by the incompleteness. Underinvestment caused by ex post hold-up behaviour has been considered to be one of the significant issues in the field of incomplete contract theory. Many scholars have focused on the causes and control mechanisms of such issue, with Hart (1995)[1)]'s discussion of hold-up problems as pioneer. On the other hand, because of the characteristics of construction project, construction contract has also been regarded as a typical kind of incomplete contract. Moreover, since construction projects, especially the infrastructure projects, are closely linked to social welfare, the under-investment caused by ex post hold-up behaviour may lead to serious losses.

Currently, most of the literature related to the analysis of hold-up issue take the classical model designed by Hart (1995)[1)] as the bench mark. Similarly, in the field of construction contract, although it has been found that Hart's model functions effectively in dealing with hold-up problem, analysis concerning with the special structure of construction contract and deviations from the reality have not been mentioned yet. This research theoretically exams the applicability of Hart's model under the construction project and indicates the nonnegligible preconditions in accordance with the structure of construction contract and realistic conditions. And then we also show the directions of the roles that should be further played by Dispute Board. On the other hand, by taking practical issues into consideration, the research also gives the entry points of the settlement mechanisms of hold-up problem under the situation where contract variation rules and dispute board make no difference.

The rest of this paper is organized as follows: In order to show the basic philosophy of this study, section 3.2 summarizes the theoretical background on construction contract as incomplete contract. After this, in section 3.3, particularities of construction contract are explained to clarify its specific structure. Section 3.4 applies the model of hold-up problem considered by Hart (1995) to construction contract while section 3.5 shows the

deviations between the preconditions of Hart's model and realities. Section 3.6 discusses Dispute Board's further functionalities on promoting the satisfactions of proposed preconditions and also gives some entry points of governance mechanisms under the true situation. The last section 3.7 includes summarization of conclusions and also envisages the future research directions.

3.2 Overview of contract theory

3.2.1 Literature review

In complete contract theory has been developed rapidly during those decades from a variety of perspective[2)-5)]. Hold-up issue has been regarded as the typical problem in the field of incomplete contract theory and also accumulates many classic theoretical models[6)-9)]. As the pioneer of the researches on incomplete contract, Hart (1995)[1)] proposes an idea in one of the prime works for dealing with the hold-up issue through the design of the contract structure. He indicates that under the situation of incomplete contract, if the control right of design change can be fully entitled to the principle, when unforeseen contingency takes place, contract variation can be implemented without opening a gate to the hold-up behavior in short-term transaction. But, the mechanism does not work when the transaction is not real-time trading. In other words, when there is a certain time before putting into production such as the situation of construction project, hold-up behavior still cannot be avoided.

Since the construction contract is also a typical incomplete contract due to its complexities, researches on the efficiency improvement of construction project from the perspective of incomplete contract are also no small amount. Brux (2010)[10)] discusses the dual character of renegotiation through the case of transport concession contract and finds that outcome of renegotiation can also be cooperative when both contracting parties expect long-term cooperation. Similarly, Kobayashi et al. (2001)[11)] conduct a theoretical analysis on construction contract and points out that social efficiency can be achieved with the satisfaction of some conditions under the good-faith society. Hart (2003)[12)] develops a model for analyzing the public-private ownership and shows that the choice between PPPs and a conventional one generally depends on the complexity of writing service provisions or building provisions. Chang and Ive (2007)[13)] take reversal of bargaining power of contracting parties afterwards into consideration and try to manage the hold-up issue in construction projects. They suggest that the client should choose the procurement system in accordance with the project properties. Walker and Pryke (2008)[14)] build a framework for analyzing the causal relationship between the incompleteness of construction contract and losses due to claim issues. In addition, some empirical researches have also been conducted. Cruz and Maruqes (2012)[15)] define the main determinants for renegotiations by conducting a case study of Portugal and indicate that concession duration and investment may likely to give rise to

renegotiation. Chang and Ive (2007)[16] also analyze the hold-up issue through a case study of the channel tunnel. They point out that the strength of a lump-sum contract should not be over-reliance where hold-up issue still remains seriously.

However, there is still lack of theoretical analysis by modeling the issue with the context of incomplete contract on the field of construction contract. In addition, renegotiation is always regarded as the blasting fuse of hold-up behavior. The specific structure and characteristic of construction contract have not been focused and combined with incomplete contract theory which generates some distortions with the actual situation. Therefore, standing on the perspective of incomplete contract, this research is going to apply Hart's idea to show the documental rationality of construction contract and then points out the limitations and deviations between practical conditions by dissecting the structure of construction contract.

3.2.2 Definition of contract

In economics, there has been a discussion based on the premise of the market economy. Most of the cases in general discussion take well formulated market as a prerequisite where traded goods are extremely standardized and all the information is available for market participants. However, it is nearly impossible for actual transactions to be done under such a well-maintained market. In practice, asymmetric information between sellers and buyers commonly exists in most of transactions. For example, information on inferior products may be deliberately hidden by the seller. Therefore, in order to alleviate such problem, it is necessary to devise various ways such as signing a contract in accordance with individual transactions. For this reason, it is said that rather than capturing economic phenomena in the form of 'market', the dimension of contracts seems to be more explicit[17].

The general definition of the contract has been given by many scholars that a contract is an agreement aimed at specifying a relationship of rights and obligations between two or more parties. It is established in the situation where one party applies a specific matter and the other party agrees to accept it[11),18)-21)]. A valid contract should explicitly specify the basic constitutive elements which involve the obligations that must be fulfilled by the contracting parties, method of performance, place, period, expected results and the implementing party under a certain situation[18]. After the contract has been signed, all the decisions during contract implementation period have to be made with the preferences of contracting parties and the contract terms. The contractual relationship will terminate with completion of the contract[22].

Along with development of society and economic, types of contracts have also evolved from single and simple type to a great diversity of forms. In the age of the specialization and refinement of a social division of labor, although the mixture of contract types is extremely common and emerges more contract modes, these basic types of contracts with strong adaptability have been widespread. This paper mainly involves two contract types. One is sales contract which has been taken as basic contract in the study of

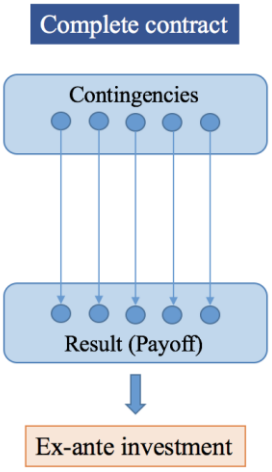

Figure 3.1 Complete contract
(Adopted from Omoto et al. (2001)[26])

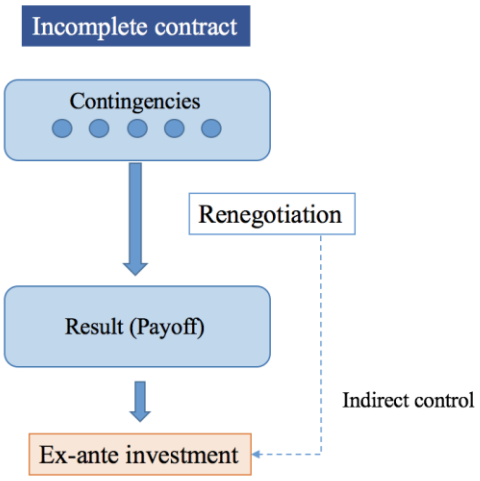

Figure 3.2 Incomplete contract
(Modified from Omoto et al. (2001)[26])

contract theory. The other one is a kind of service agreement which contracting on the completion or the achievement of commissioned work and has been widely applied in construction field.

3.2.3 Complete contract and incomplete contract

Traditional contract theory which is so-called complete contract theory is based on the precondition that a contract should completely contain the agreements as to how to specifically deal with all incidents that are expected to occur in the future. Research theme related to complete contract theory is mainly searching for ways to solve the problem of moral hazard and reverse selection due to asymmetry of information among contract parties[11]. The image of complete contract is showing by **Figure 3.1** where contingencies and its results are represented by one-to-one correspondence. Since it is assumed that under the situation of complete contract, all the contracts can be concluded costless no matter how complicated the content is. Therefore, whenever and whatever the contingency takes place, the corresponding result will be referred to the contract clauses. However, in reality, the contract that based on above assumptions of contract theory is impracticable.

When taking the economic transactions in real life into consideration, a majority of trading participants may keep a kind of relationship within a period of time, therefore, at that time such economic transactions are clearly much more complicated due to the increasing uncertainties over time[22]. In addition, it has been recognized that writing the contract is no longer costless and there is also the case that the contract is too complicated to write. Incomplete contract is based on these facts and starts with the situation that the contract is unable to be written. One of the origins indicated in literature is that people are not rational economic man[23], because it may be extremely

difficult for them to anticipate every eventuality and to decide how to deal with them initially[24), 25)]. Moreover, incomplete contract models are usually oriented by the existence of transaction costs which can be regarded as another origin of the incompleteness. As summarized by Tirole (1999)[25)], the first one is regarded to be the searching cost of possible conditions. In spite of the factor of predictive ability of human being, since acquiring information is no longer free, it is quite costly to make definite predictions on possible conditions which may occur in the course of trading. The second type is the cost of writing contracts. It is also costly to stipulate the binding contract terms which is sufficiently clear with no ambiguity. Therefore, there may be the case that some conditions and obligations are unable to be described in the contract, or have been stipulated ambiguously. Ant the last one is the cost of contract enforcement. In order to enforce the contract at the time of contingency upon contract terms and actions, enforceability by the third party has to be guaranteed with certain expenditures.

Accordingly, incomplete contract is generally defined as the contract which does not specifically describe all the conditions that may arise during the execution period[26)]. The image of the concept is shown in **Figure 3.2**. The general setting is that it is impossible for a contract to fully specify all the risk events that may occur in the future in advance, let alone the corresponding behaviours that should be taken by the contracting parties under the situation. Therefore, when the unexpected contingency takes place during contract execution period, the resolution has to be renegotiated by contracting parties where the consequence is greatly dependent on bargaining power of contracting parties under the general situation.

However, since people are self-interested, the renegotiation may not play its effective role in many cases. Unfulfilled gaps in the contract may be taken as an advantage to expropriate others which may lead to various of inefficiency issues. Hold-up issue is one of the major issues caused by the incompleteness of contract that result in inefficiency of ex ante investment. Therefore, when the contract cannot be perfectly written at the beginning, mechanisms that can plug those gaps or improve such inefficient contract conditions are necessary. Moreover, the design of governance mechanisms which act as a complementation such as institutions, laws and organizations also becomes the basic topic of incomplete contract theory.

3.2.4 Relational specific transaction and hold-up problem

Under the situation of manufacturing or construction industry, transactions always involve relation-specific investment. In construction project, in order to commence the construction work, both the client and the contractor have to invest for some preparatory work such as temporary constructions or procurement of materials, etc. Or, to put it another way, in parallel to some commercial construction projects such as real estate project, there are also some small construction projects for example, building a road. The construction of road is a kind of relational specific investment because without the completion, the other projects may become valueless due to no access. Such investment

for construction set-up is called relation-specific investment because it is valuable only within the transaction relationship. Once such investment has been made, it is impossible to be recovered ex post and turns to be sunk cost. Moreover, since the construction work is traded exclusively among trading parties and cannot be easily resold to third parties, it is considered to be relation-specific asset for the client and its utilization value can only be recognized by the client.

Under this background factor, one side or both sides of contracting parties may take opportunistic behaviours and try to occupy the extra gain from trade. According to the explanations given by Itoh (2003)[27], before conclusion of contract, there may be many potential trading partners for each party. However, after relation-specific investment has been made with a certain trading partner within contractual relationship, since termination of the transaction becomes extremely costly for either or both sides at this time, there may generate a certain degree of monopoly power between contracting parties. When the initial contract is incomplete and ex post renegotiation is likely to occur, there is a great probability that the problem which impedes efficiency may take place[27]. Hold-up problem is the inefficiency issue that the benefits of investors cannot be protected since ex ante specific investments restrict him from gaining expected future profits. It often leads to ex ante inefficiency by under investment since part of the returns of relational specific investment may be deprived by the other party through renegotiation. Since relational specific investment put both sides in the state of monopoly, in addition to the existence of asymmetric information, renegotiation may become quite difficult. It is the case that even if the agreement could be settled efficiently, the contracting parties may also suffer losses due to lengthy negotiation and some extra costs caused by delay in conclusion. Nevertheless, current researches are mainly focus on the under-investment issue caused by the hold-up behaviour. In addition, since some of the specific investment is not limited to money, for the sake of analysis, the amount of such relation-specific investment is considered to be observable but unverifiable in order to guarantee the smooth implementation of renegotiation.

3.2.5 Contract and verifiability

Verifiability under the framework of incomplete contract means the ability equipped by the court or arbitrator to verify or observe the messages transferred between contracting parties on all variables such as weather or effort level[25]. This concept is also closely relevant to the causes of incompleteness of contract. According to Hart and Holmstrom (1986)[28], incompleteness of the contracts is caused by the observability of contracting parties but unverifiability by the third party on states of the world and people's behaviours. Or even if it is possible to verify all the variables, it may be too costly for the contract terms to be stipulated precisely enough for the courts to learn about it without deviations. Therefore, the contract is based on unverifiable contingencies and enforceability and consequent to be necessarily ineffective.

Under the situation of construction project, since it is impossible to specify all of the

contingencies that may take place in the future, the occurrence of unforeseen contingencies may probably give rise to disputes between contracting parties due to cognition deviations. Similarly, in order to settle the disputes that arising from contract implementation period, it is crucial that whether the contracting content related to the causes of disputes can be objectively verified by the third party. In construction field, in spite of some verifiable contractual terms such as construction price or construction period which can be clearly stipulated in contract, for some other uncertainties such as investment content, it is impossible to be explicitly stipulated in the contract. Moreover, there are also common situations that the unprofessional third party is incapable of observing the realization value of uncertain factors objectively. Under such situation, it is difficult for the court or the third parties to arbitrate the dispute issues basing on the visualized state of the uncertainties[26)].

3.3 The structure of construction contract

3.3.1 Transaction conditions of construction contract

For construction contract, it is considered as a record of agreement that both the client and the contractor have obligation to comply with the agreed matters stated in the contract[11)]. In addition to the definitions, there is a unique characteristic of construction contract that the contractor is obligated to complete the construction work. As mentioned by Omoto et al. (2001)[26)], construction contract is the contract that the contractor has to complete and maintain the construction work specified by the client with utilization of labor, materiel and machines.

It has been commonly identified in nearly all forms of the contract conditions that one of the primary obligations of the contractor is the completion of the agreed work specified in the contract[19)]. The FIDIC red book[29)] which has been widely used in international construction projects as the international standard form of construction contract, makes it clear in Clause 4.1 Contractor's General Obligations that 'the contractor shall be responsible for the adequacy, stability and safety of all site operations and of all methods of construction of the works' and Clause 8.2 Time for Completion: 'the contractor shall complete the whole of the works, and each section (if any) within the time for completion for the works or section'.

On the other hand, according to Standard condition of contracts for public works in Japan[30)] (short for GCW), the client and the contractor have to fulfil the contract in compliance with the design documents and comply with the laws of Japan. The contractor has to complete the specified construction work within the stated schedule and deliver it to the client. The client has to pay the price correspondingly. Contractual relationship is made to be effective by promising that one party has to complete the specified work on time and the other side pays compensation for the outcome of the work. With regard to any means which are necessary for the completion, unless there

Table 3.1 Criteria of contracting types between sales contract and construction contract[31)]

Contracting type of construction contract	Contracting type of sales contract
(1) The contractor should follow the instructions of the client to construct the specified work. (2) Construction materials may be provided by the client. (3) It may include repair and processing work.	(1) The contract is signed for the transfer of the ownership of a certain product in a certain place by installing work with little technical skill. (2) The producer unifies the specification of product in advance with a certain standard. And then after receiving orders with a certain price, the producer supplies the product according to the specified standard. (3) The producer supplies the uniformly standardized product according to the orders using his own material.

are special provisions in the contract documents, the contractor has to take responsibility for making decisions. Such statements make it clear that the contractor has to complete the specified construction work by overcoming all possible difficulties and termination by the contractor is not permitted.

Therefore, construction contract is fundamentally different from the general sales contract where completion of the construction work is defined as the fundamental obligation. Basing on the Fundamental directives of Stamp Tax Law No.2 document (1977)[31)] given by Japan national tax agency, contracting type of construction contract is showing in the **Table 3.1**.

From the above comparison, it could be summarized that for the sales contract, the trade good has already been produced or with a unified standard by the producer. In other words, the buyer has no right to ask for the production in accordance with his own specification but to purchase the corresponding product according to his demand. Therefore, the sales contract mainly focuses the behaviour of the ownership transfer of the finished product or a kind of certain service. On the other hand, as stated above, the construction contract is the agreement on completion of specified work within a certain period. Different from ownership transfer behaviour of sales contract, it gives the attention on construction process and completion of the final product. In construction project, the design and specifications of the final structure is provided by the client, so the contractor's obligation is to complete the work in accordance with the client's requirement. In other words, all the efforts made by the contractor is for the realization of the utility expected by the client. Such single-item-production makes that the final constructions work is only valuable for the client and this is so-called relational specific transaction.

Accordingly, in order to implement the contract smoothly, definition of completion is

indispensable which should be based on verifiable variables. Although completion of the work has been defined in a variety of ways, according to Kasai (2009)[32], completion with the defects which are not essential to utilization has been widely accepted. More detailedly, in the case of construction contract, if the final work can be considered to have processed a certain degree if completion, or in other word, when performance of the final work has achieved a certain level, even if there still exists incomplete performance, the contractor would be entitled to request for payment of contract price on the basis of his verifiability of completion of work. Since it is always quite difficult for the contractor to perform perfectly over the details according to the design documents due to complexity of construction project, if the perfect completion where no defect should be remained is required, great constraints will be imposed on the contractor's compensation claim. Conversely, incompletion conforms to the case that even if the construction work has been delivered, the defects are extremely serious that the original utility cannot be actualized where it is impossible for the client to benefit from it. Consequently, in a word, whether the final construction work has reached the performance level that could bring corresponding social benefit is a necessary benchmark of judgment for completion. This is also in accordance with the stipulations in both FIDIC red book and GCW.

Such consideration has also been accepted by the standard of construction contracts of both FIDIC red book[19] and GCW. According to Clause 10.1(a) in FIDIC red book, it also defines that 'the work can be regarded as completion although there are some minor outstanding work and defects which will not substantially affect the use of the works or section for their intended purpose'. Similarly, Clause 31 in GCW also defines the condition of completion of the work in the similar way: after passing the test on completion conducted by the client according to the drawing and specifications, the construction work can be approved to be completed. In a word, it requires that the works must have passed the tests on completion as a condition precedent for the works to be considered to have been completed.

Moreover, although there is consistency on the definition of completion of the work, the mode of payment of the two contract forms is differently stipulated. In GCW, the contractor is entitled to request payment for contract price after the tests on completion by the client, the payment by the client can only be made after the completion of the work. However, since FIDIC red book is the remeasurement contract, as the term implies, the contractor will be paid in accordance with the exact construction or execution on each element of work[19].

As a whole, both FIDIC red book and GCW take the completion of construction work as the basis of contractual obligation and their definitions on conditions of completion are essentially the same. Such feature makes the construction contract have its own structure which is quite different from other contract forms. However, for the payment method, while FIDIC red book stipulates piecework payment in terms as a remeasurement contract, as a Japanese 'ukeoi' contract, GCW requires one-off payment after the completion of contract.

3.3.2 Contingencies in construction contract

Construction project has been considered as risky transactions for a long time since it is quite sensitive to an extremely large amount and diverse of hazards and risks. During the execution of contract, uncertain factors which beyond the control of contracting parties may lead to eventual payment impediment due to such as delay or disability. Accordingly, construction contract is the one contains various uncertain factors and complicated rules[32)]. Along with the development of today's construction industry, there are even more complicated problems whether in practice or contract design.

According to Clause 18 stated in GCW, unforeseen contingencies are defined as the events which are unable to be predicted by contracting parties and have not been stipulated in the contract conditions. It could be classified into two dimensions according to behavioural agents – the client and the contractor in accordance with their characteristics. In FIDIC red book, unforeseeable is defined by Clause 1.1.6.8 as the event which is 'not reasonably foreseeable by an experienced contractor by the date for submission of the Tender'.

When such contingencies take place, from the perspective of the client, since he is mainly concerned with the utilization value of the infrastructure work, in brief, only the client is able to identify or cognize the social benefit that could be brought by the construction work, if the unforeseen contingency may lead to decline in utilization value of infrastructure, for example the city planning or relevant policies are changed, in order to guarantee the prospective utility, design change will be proposed by the client. On the other hand, since the contractor is mainly responsible for the construction work, he should be more familiar with the actual condition and construction process. At the time of signing the initial contract, construction method has to be determined through available data and the contractor's past experience. However, deviations between preconditions in initial contract and actual situation are normally observed during execution period by the contractor, so in some cases, the initial construction method could no longer be applicable for the following work. Under such situation, change of construction method will be proposed by the contractor.

Nevertheless, unlike the types of contract analyzed in most literature of incomplete contract, when the contingencies that have not been stated in the initial contract take place, the general settlement of such condition in construction contract is due to contract variations and risk sharing rules stipulated in the initial contract instead of renegotiation.

3.3.3 Incompleteness of construction contract

In contract theory, there are significant differences between complete contract and incomplete contract. While complete contract is defined as the one that all of the variables that may affect contract conditions have been specifically stipulated in the contract, Hart (1995)[1)] has defined the incompleteness of contract as lack of contingent

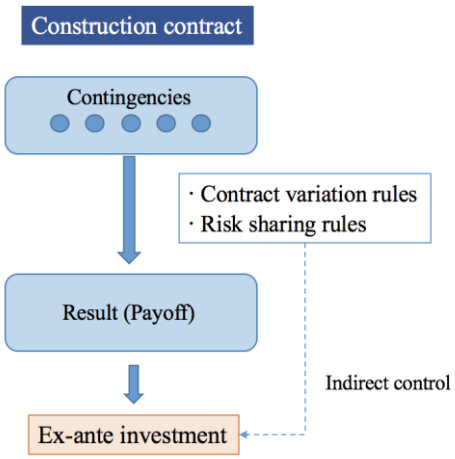

Figure 3.3 Construction contract as an incomplete contract
(Adopted from Omoto et al. (2001)[26])

plan. At this point, construction contract can be regarded as a kind of incomplete contract in the same way. According to Bunni (2013)[18], construction project is featured by long-term where generates various of hazards and risks, complex natural conditions, requirement of high technical capacity, large number of participants with different background and goals and therefore inevitable opportunistic behaviours by contracting parties.

As a consequence of those reasons, it is extremely difficult for construction contract to cover all of those uncertainties in initial contract. Therefore, similar to general incomplete contract theory, changes due to unforeseen contingencies are normally observed in the process of the performance of the contract in the field of construction. In the general settings, when there is no relevant clause to be referenced by, contracting parties will have to determine the content related to change issues through renegotiation. However, under the situation of construction contract, contract rules which corresponding to the settlements of unforeseen contingencies have been stipulated in advance in construction contract. The **Figure 3.3** describes the structure of construction contract under the framework of an incomplete contract.

As shown in the figure, different from general structure of incomplete contract, instead of renegotiation between contracting parties, the construction contract stipulates contract variation rules and risk sharing rules in order to deal with occurrence of unforeseen contingencies. In other words, when risk event takes place which has not been described in the initial contract, the corresponding settlement can be derived by those contract rules. Accordingly, contract variation can be implemented through an efficient and objective way ideally. Therefore, since bargaining power of contracting parties does not serve any function, the ex-ante investment is controlled indirectly by contract variation rules and risk sharing rules.

3.3.4 Contingencies and contract variation rules

When the construction contract needs to be modified due to the occurrence of unforeseen contingencies, it is necessary to establish the rules to determine the content and procedures of the variation[26]. This is called contract variation rule. In GCW, modification of contract conditions is recognized when the actual condition is different from that in contract documents. However, there is no clause on contract variation and claim in GCW and the contractor is entitled for the right of renegotiation with the client for relevant matters. According to Clause 18 Change of Conditions, Clause 23 Change of Construction Period and Clause 24 Change of Contract Price, they stipulate that under the situation which satisfies the condition of contract variation, the case should be determined by negotiation between contracting parties. When the agreement cannot be reached, the dispute settlement shall be entrusted to a mediator who acts as a third party or Construction Disputes Committee for mediation or arbitration. In other words, there is a default premise in GCW that the client has enough abilities to make decisions on contract variation[26]. Therefore, since the client can decide the content of contract variation appropriately, necessity of the contractor's verification is no longer required. Consequently, basing on such precondition of the client, efficiency of contract variation in GCW can always be achieved without regulated procedure.

On the other hand, for international construction project, since the case that the client always possesses verifiability of contract variation is barely recognised, contract variation is normally in accordance with the rigorous procedures. Generally, since a change may also result in variations on cost and/or construction period, it is always accompanied by a claim. In FIDIC red book, both the client and the contractor are entitled to contract variation and claim. According to Clause 2.5, if the client thinks that he is entitled to some compensation on cost or extension of time, he or the engineer shall give notice to the contractor with detailed descriptions. The engineer shall give his determination. Compared with the process of the client's claims, there is a strict discipline of claim issue in the case of the contractor. According to Clause 20.1 of FIDIC red book, after the proposing of contract variation, the process starts at the time point when the contractor becomes aware of the claim event. He shall give notice to the Engineer in the first place and then submit a fully detailed claim report within 42 days. The claim report should include the specified clauses or other grounds of the claim issue. After receiving the report from the contractor, the engineer shall give his response within 42 days in accordance with Clause 3.5 Determinations. If the contractor dissatisfied with the claim result, then contracting parties may proceed to dispute resolution stage.

Nevertheless, both forms consent that construction contract is a legal binding agreement signed by contracting parties that the contractor undertakes the construction and maintenance work according to the client's requirement. Although construction contract is incomplete due to its complexities where contingencies are of common occurrence during implementation period, since the contractor is under an obligation to

complete the construction where cancellation offered by the contractor is not allowed, the client always owns absolute right of contract variation.

3.3.5 Functions of Dispute Board

Due to incompleteness of construction contract, when unforeseen contingency takes place with no relevant clauses, disputes may arise with respect to issues such as attribution of additional costs between the contracting parties[33)].

Although it is not necessarily inevitable, disputes are commonly observed in the majority of construction projects. Generally, parties will not rely on the procedures other than the contract, for example litigation or arbitration by the court, for dispute settlement, unless it is still not possible for contracting parties to reach a consensus through negotiation although they paid a lot of efforts. Contracting parties are bound by the arbitration result and are obligated to comply with it. However, litigation is usually not an optimum choice for contracting parties since it may cost a lot of time and money by miscellaneous procedures. Therefore, it is essential for the contract to provide a more appropriate procedure for dispute resolution[19)].

As indicated by Omoto et al. (2001)[33)], the old version of FIDIC form explicitly stipulates the dispute settlement procedure which starts from submission of claim issue by the contractor to the arbitration under the situation of disagreement. However, it has been observed in many international construction projects disputes have a tendency of long-term with high cost. Therefore, for the sake of efficient dispute settlement, dispute adjudication board has been established.

The Clause 20 Claim, Dispute and Arbitration in FIDIC red book provides detailed descriptions on a series of dispute settlement processes. When contracting parties cannot reach an agreement over the claim results given by the engineer even through amicable settlement, Dispute Adjudication Board (hereinafter referred to as DAB) will be set up for dispute settlement before proceed to arbitration. It is composed up to three members determined by contracting parties with appropriate qualifications and the cost shall be shared equally by both sides. After the acception of detailed information of dispute event submitted by contracting parties, DAB will make the adjudication within 84 days. The decision is binding on both parties with immediate effect.

On the other hand, in the former GCW, since the client is expected to play the leading role in dispute settlement, there is no clause on the contractor's claim. In order to respond to the internationalization of the construction market, it has become possible that the contractor is entitled to the right of claim from FY 1995[33)]. In addition, procedures of dispute settlement have also been stipulated in the contract. According to the contract, it the contracting parties cannot reach an agreement or the contractor is dissatisfied with the decisions, before arbitration by court, the client and the contractor can request the Adjustment Committee for construction disputes for mediation or conciliation.

Although they are named respectively in different contract forms, Dispute Board is

regarded as a generic term used to describe the various arrangements that contracting parties jointly designate one or more independent and impartial persons for dispute settlement[19]. The duties of DB members are identified both proactive and responsive. In order to achieve the most effective results, they are expected to proactively manage and organize the mechanisms and response the intentions of the contracting parties who are seeking for sustainable solution[18]. According to Chern (2015)[34], a considerable cost reduction could be brought by the Dispute Board since nearly all of the disputes could be settled without requiring expensive litigation or arbitration.

Such is the case, as summarized by Bunni (2013)[18], the following significant advantages bring the Dispute Board remarkable achievements. Firstly, comparing with multifarious judicial procedure such as arbitration, procedures of dispute resolution is simpler and less formal which may bring more efficiency. In addition, the response is more credible than that of arbitration since it is prepared more carefully and realistically. Since the DB members are selected by contracting parties by consensus, their integrity and ability are trusted with no doubt. Therefore, more meritorious claims will be accepted while frivolous claim can be restrained to a certain degree. Moreover, the existence of dispute board also plays an active role in promoting positive relationship between the client and the contractor. Since the contracting parties know that when dispute takes place, their previous behaviours will have an effect on the DB members' perception of themselves during dispute resolution process, both sides will adjust their behaviour with this in mind. As a consequence, attitudes is likely to remain positive not adversarial where the dispute board play a certain role of supervision.

3.4. Completeness of incomplete construction contract

3.4.1 The first best contract

Due to complexity of construction project, when the construction condition is different from the one predicted initially, contract variation will take place otherwise the value of infrastructure will loss under the previous condition. Generally, design is considered as the only variable to affect the value of infrastructure project. In addition, due to definition of construction contract, the client and the contractor sign a construction contract for completion of construction work and realization of its value. In other words, when the contract is signed, the contractor is strictly obligated to complete the construction work which is the essential difference between Hart's model and construction project. Because of the different contract type assumed in his model, the output variable is assumed to be strongly depends on the state of nature and also production decisions are also extremely difficult to be specified completely in an initial contract, which means that the output is non-contractible. However, on the contrary, in construction contract, the completion of construction work with specific value is the fundamental content of the contract. That is to say, output of construction work is

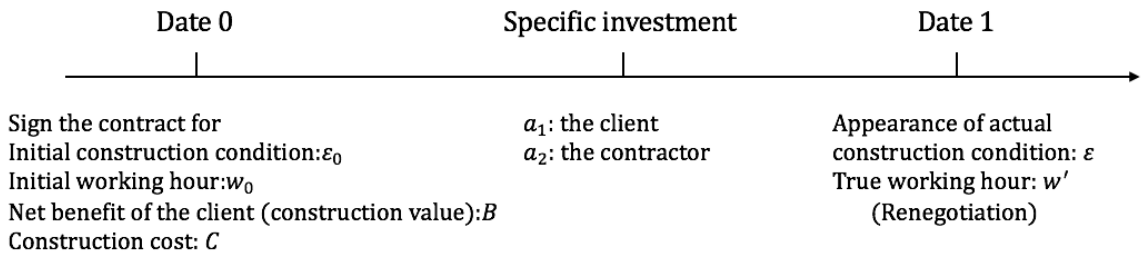

Figure 3.4 Timeline

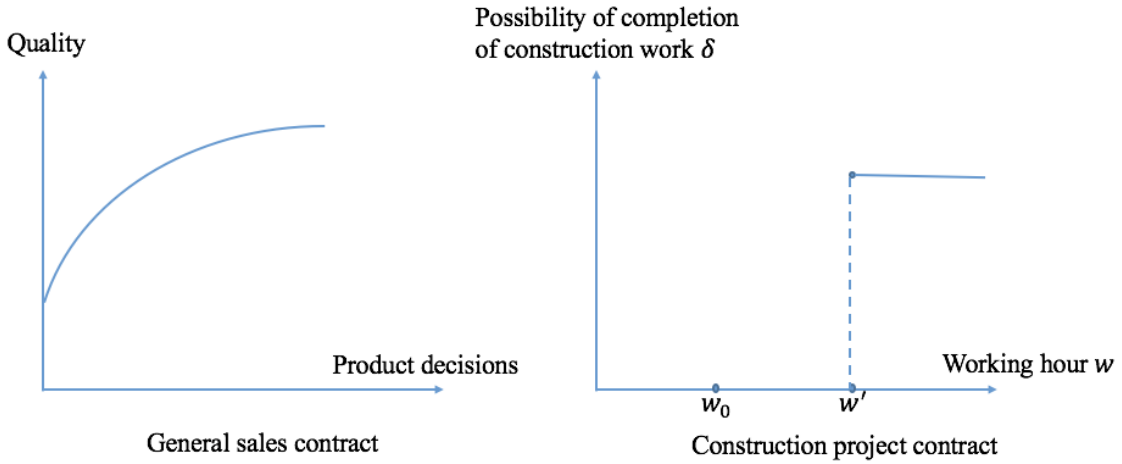

Figure 3.5 Nature of output in different contract types

contractible and observable and could be specified in the initial contract. For this reason, when unexpected condition appears, in order to guarantee the value and completion of the project, change of design is indispensable. Moreover, in construction project, when design change takes place, additional work by the contractor is always required. Nevertheless, additional working hours for example can be automatically determined at the time when appropriate design has been decided.

Let's first describe the model of hold-up problem. Timeline is shown in the **Figure 3.4**.

At date 0, the contracting parties sign the contract for an infrastructure work with utilization value B under the initial construction condition ε_0. The initial working hour for the contractor is decided to be w_0 and construction cost is accordingly assumed to be C. After the conclusion of the contract, both parties may make specific investment a_1 by the client and a_2 by the contractor for construction work. However, during construction period, unforeseen contingency ε takes place, for example appearance of actual construction condition. In order to guarantee specified utilization value of the infrastructure project, design change is strongly required by the client where additional working hours by the contractor is indispensable, so the true working hours are assumed to be w'.

As explained above, since construction contract is an agreement on completion of the

construction work while the sales contract mainly focuses on the process of procurement, the essential differences of the nature of output between the models are obvious when taking the contract type into consideration. The **Figure 3.5** demonstrates the respective characteristics of output in the two kinds of contract. As showing in the graph, for general type of contract such as sales contract, the output variable is assumed to be continues for example the quality. That is to say, even if the expected quality objectives have not been achieved due to unforeseen contingencies, the product still obtains some value. However, on the other hand, output is assumed to be discreteness in construction contract, since when the unforeseen contingency takes place, if the contractor refuses to make additional work for design change, there is no utilization value of the infrastructure project remains. In more detail, under the actual construction condition, the working hours stipulated in the initial contract cannot bring any construction value to the client. The utilization value can only be realized by design change where the real need of the contractor's minimum working hours is w'. In other words, under the situation of Hart's model, after realization of the state of nature, only production decision is contractible, that is to say, the level of quality cannot be verified by the third party. However, for construction contract, in fact, there is no unverifiable variable actually. Moreover, since whether the project has been completed is verifiable by the third party. In addition, for continuous and discreteness, compared with quality, if the project cannot be completed, there is no value of the infrastructure project. As shown here, after the realization of the contingency, the working hours taken by the contractor is insufficient, no construction value can be obtained by the client.

Let $\delta(w, \varepsilon, a_2)$ be the possibility of completion of construction work and it is supposed to be affected by the contractor's working hours, ex ante specific investment and construction condition. In accordance with the discreteness of the output of construction project, distribution of function δ is assumed to be

$$\delta(w, \varepsilon, a_2) = \begin{cases} 1 & if\ w \geq \overline{w}(\varepsilon, a_2) \\ 0 & if\ w < \overline{w}(\varepsilon, a_2) \end{cases} where \frac{\partial \overline{w}}{\partial a_2} < 0, \frac{\partial \overline{w}}{\partial \varepsilon} > 0\ . \tag{3.1}$$

$\overline{w}$ in above formula refers to minimum working hour rest with actual construction condition. And the actual working hours is assumed to be affected by the contractor's ex ante specific investment. For example, when the contractor invests high technical machines or skilled workers, his work efficiency will be significantly improved.

In actual construction project, since affecting factors and interactions among those factors on the construction value is very complex, therefore, in order to simplify the analysis, we assume that the construction value is only affected by ex ante specific investment by the client. Accordingly, net benefit of government can be defined as

$$V_G = B(a_1)\delta(w, \varepsilon, a_2) - a_1. \tag{3.2}$$

And in the case of contractor, the construction cost is assumed to be only affected by

the working hour

$$V_C = -C(w) - a_2. \tag{3.3}$$

In the first step, first-best situation will be figured out basing on the prerequisites of a complete contract situation. In addition, there is also symmetric information on specific investment of contracting parties where they both observable. Since the client stands for the maximizer of social welfare, the first-best is defined to be the one that maximize social welfare. The objective of the socially optimal contract model normatively seeks a desirable contract form that maximizes social welfare which is defined as the sum of the client surplus and the contractor surplus. Therefore, social welfare is

$$SW = V_G + V_C = B(a_1)\delta(w, \varepsilon, a_2) - C(w) - a_2 - a_1. \tag{3.4}$$

As explained above, when working hour by the contractor is insufficient, construction work cannot be completed where usage benefit of infrastructure cannot be realized as well. Therefore, optimal contract is also based on the premise of completion of the construction work where $w \geq \bar{w}(\varepsilon, a_2)$ and $\delta(w, \varepsilon, a_2) = 1$. So

$$max_{a_1,a_2}[B(a_1) - C(w) - a_2 - a_1] \; subject\ to\ w \geq \bar{w}(\varepsilon, a_2) \tag{3.5}$$

$$\Rightarrow \; \mathcal{L} = [B(a_1) - C(w) - a_2 - a_1] + \lambda[\bar{w}(\varepsilon, a_2) - w]$$

$$\begin{cases} \dfrac{\partial \mathcal{L}}{\partial a_1} = B'(a_1) - 1 = 0 \\ \dfrac{\partial \mathcal{L}}{\partial a_1} = \lambda \dfrac{\partial \bar{w}}{\partial a_2} - 1 = 0 \\ \bar{w}(\varepsilon, a_2) - w = 0. \end{cases} \tag{3.6}$$

Let a_1^* and a_2^* be the equilibrium level of ex ante specific investment by contracting parties. Therefore, social efficiency level of the client's ex ante specific investment is $B'(a_1^*) = 1$. For the contractor, it is defined as $\frac{\partial \bar{w}}{\partial a_2^*} = \frac{1}{\lambda}$ which depends on the value of lagrangian multiplier λ.

However, since construction contract is a typical incomplete contract, it cannot describe the contingency plans with regards to all the possible factors such as ground condition in initial contract. Accordingly, this model assumes that future construction condition is non-contractible. When such situation occurs, design change has to be taken to hold construction value. As the result of such incompleteness, hold-up behavior comes into existence as the situation of renegotiation.

3.4.2 Hold-up in construction contract

Due to incompleteness of contract, the contracting parties have to renegotiate on allocation of surplus where generate hold-up problem. Assuming contracting parties have to renegotiate to determine the content of contract variation, so, the generation of the hold-up problem is that when unforeseen contingencies take place, the initial contract may substantially turn to be invalidity where the contractor can terminate the contract without paying penalty. This is the source of the contractor's bargaining power. Especially the nature of output which is discreteness under the situation of construction project makes the problem more serious. As explained above, if the contractor refuses to continue the contract, the unfinished construction work is totally valueless for the client and so as the expected social welfare it should have brought. And accordingly, his relational specific investment may also become sunk in this case. So, this part is going to modelling the hold-up problem in construction project field. When the decision-making right of design change has not been appropriately distributed to the contracting parties in initial contract, in other words, both of them have the right to choose whether to change the design when contingency takes place, therefore accordingly consequences due to design change has to be renegotiated by both sides.

Under the situation that distribution of decision-making right on design change has not been stipulated in the initial contract, the contractor has the right to control his own resources – working hour. In other words, the contractor is entitled to terminate the contract when he is not satisfied with design change or just demanding for more profit. Therefore, this is saying that the contractor has the right to control δ. After the signature of contract and ex ante specific investment have been made by the contracting parties. On date 1, the unexpected condition ε occurs which has not been stated in the initial contract. Accordingly, in order to preserve the proper value of the project, design change is imperative which requires additional working hour by the contractor. So, under the true construction condition, the contractor's working hour increases from w_0 to w'. Generally, when the appropriate design has been decided due to true construction condition, additional working hour may also be determined accordingly which is supposed to be $w'(a_2, \varepsilon)$. Since the contractor owns the control right of his own resources, after required by the client for design change work, renegotiation may take place between contracting parties.

When renegotiation breaks down, since the construction project will lose it value without design change. Here in order to simplify the analysis, it is assumed that there is specific relationship between contracting parties that under the situation, only the contractor can do such design change.

Therefore, the break down profit of the client is

$$V_G^N = -a_1 \tag{3.7}$$

and the contractor obtains

$$V_C^N = -a_2. \tag{3.8}$$

Since the construction work cannot be completed due to negotiation break down. For the client, the benefit brought by infrastructure cannot be realized while his ex-ante specific investment is also sunk. For the contractor, besides no cost and payment by the client due to uncompleted work, his ex-ante specific investment is also sunk. In a word, break down of negotiation makes both sides suffer losses. In general, in construction market, ex ante specific investment made by the client is much larger than that of the contractor and makes more contributions to social welfare. So, under the situation of renegotiation break down, the loss suffered by the client is much greater than that of the contractor. On the other hand, for the infrastructure project, if it cannot be completed on time or even cannot be completed, compared with sunk cost of ex ante specific investment of the client, losing infrastructure value leads to more huge losses for the social welfare. Therefore, in order to avoid such worst case, the client may try his best to reach an agreement with the contractor.

On the other hand, assuming that contracting parties can reach an agreement on design change with a transfer payment p. Because we do not want to get into the details of contract renegotiation, we shall simply assume that the parties split the increase in total surplus 50:50 which is the Nash bargaining solution. Therefore, the client's earning from renegotiation is

$$V_G^A = B(a_1) - a_1. \tag{3.9}$$

The contractor's share is then

$$V_C^A = -C(w') - a_2 \tag{3.10}$$

where $w' = \bar{w}(\varepsilon, a_2)$and $\delta(w, \varepsilon, a_2) = 1$.

Therefore, the profit earned by each contracting party is defined as π_G and π_C.

$$\pi_G = -a_1 + \frac{1}{2}[B(a_1) - C(w')] \tag{3.11}$$

$$\pi_C = -a_2 + \frac{1}{2}[B(a_1) - C(w')] \tag{3.12}$$

Then we can get the transfer price which is regarded as contract price

$$p = \pi_C - V_C = \frac{1}{2}[B(a_1) - C(w')] + C(w') \tag{3.13}$$

$$= \frac{1}{2}[B(a_1) + C(w')].$$

When design change due to unforeseen contingency takes place, through renegotiation between contracting parties, the client has to pay p for design change, the final remuneration that can be obtained by the contractor is therefore

$$V_C^R = \frac{1}{2}[B(a_1) + C(w')] - a_2. \quad (3.14)$$

Accordingly, the surplus of the client after renegotiation is

$$V_G^R = B(a_1) - a_1 - \frac{1}{2}[B(a_1) + C(w')] \quad (3.15)$$

$$= \frac{1}{2}[B(a_1) - C(w')] - a_1$$

where $\delta(w, \varepsilon, a_2) = 1$.

Therefore, for the incentive of ex ante specific investment by the client, assuming specific investment a_1, a_2 are chosen non-cooperatively by contracting parties at date 0 and equilibrium investment level is a pair $\tilde{a}_i = (\tilde{a}_1, \tilde{a}_2)\ where\ i = 1,2$, the marginal specific investment level of the client is

$$\frac{\partial \pi_G}{\partial a_1} = -1 + \frac{1}{2}B'(a_1) = 0.$$

Then

$$B'(a_1) = 2. \quad (3.16)$$

Consequently, the result clearly presents the problem of hold-up behavior by the contractor. It is found that 50 percent weight on of the client's ex ante specific investment has been used to increase the contractor's benefit instead of social welfare, which generally may generally lead to ex ante inefficiency. It also shows that 50 percent of the client's benefit has been deprived by the contractor due to Nash bargaining solution. The client may eventually suffer losses due to such strategical behavior. When the existence of such risk can be entirely predicted by the client, there is a great possibility that the infrastructure construction project cannot be implemented. Even if the project should have been executed for the improvement of social welfare, in many cases, abandonment due to such hold-up issue could be observed which is considered to be the serious problem in infrastructure supply.

3.4.3 The optimal contract

However, since the causes of incomplete contract are extremely difficult to be avoided, the social efficiency level could be certainly unachieved under the situation of the incomplete contract. In response to this question, Hart (1995)[1)] designed the contract A and the mechanism guarantees that even if there is initially indescribable contingency, the initial contract may not be invalidity through definition of contract variation rules.

Contract A: the client designates the specification of the product on the first day. The client pays the price p_1, if the contractor agrees to supply the specified product or the contractor may obtain p_0. p_0 refers the payment from the client to the contractor when no transaction is established. It could be both positive and negative or even nothing. In the case of negative value, p_0 could be explained as a kind of compensation for

damage due to his default of delivery.

From this point of view, it is in common with the situation of construction contract. Recall the timeline given in the first part of this section, since the first day in Contract A could be considered as date 1 in construction model, the story therefore turns to be that the unforeseen contingency takes place at date 1 and the client requires design change on the same day. In accordance with Contract A, the contractor could choose whether to receive the design change work or not. If the contractor agrees with it, then the client will pay for price p_1. However, if it is refused by the contractor, then under the situation of construction contract, the contractor has to pay for a kind of default compensation p_0 for the client which is assumed to be negative. Since instead of specifically stipulating response to each contingency, contract A defines contract variation rule in advance that the client owns all rights of design change. This is actually consistent with the current construction contract that the client is entitled to make decision of design variation and the following analysis will show the effectiveness of such contract variation in avoiding hold-up problem and underinvestment of ex ante specific investment by the client.

The client has the right to change the inappropriate design when actual construction condition appears, the additional working hour is determined automatically when the appropriate design has been decided and the contractor has to obey the instruction of the client. There is no existence of renegotiation but the contractor is entitled to claim for compensation of such additional work. In addition, for the purpose of simplifying the analysis, we assume that there is no other opportunistic behavior during contract variation process and the verification by the contractor is costless. This ensures that the reasonable compensation due to additional work claimed by the contractor could be admitted and get paid without transaction cost.

Therefore, through stipulation of contract variation rules, surplus that the client can obtain after design change is

$$V_G^* = B(a_1) - C(w') - a_1.$$

And as a social welfare maximizer, the client's investment level is accordingly

$$\max_{a_1,a_2}[B(a_1) - p - C(w') - a_2 - a_1 + p]$$

$$B'(a_1^*) = 1. \tag{3.17}$$

Consequently, similar to the case of first-best, the client's ex ante specific investment can also reach social efficiency level. It is because that the client is endowed with full bargaining power by construction contract variation rule and thus there is no possibility to be held-up ex post. In other words, inefficiency generated from incomplete construction contract could be evaded through contract variation rules by replacing renegotiation which can be regarded as the completeness of incomplete construction contract. In a word, this result shows that the contract variation rule plays an effective

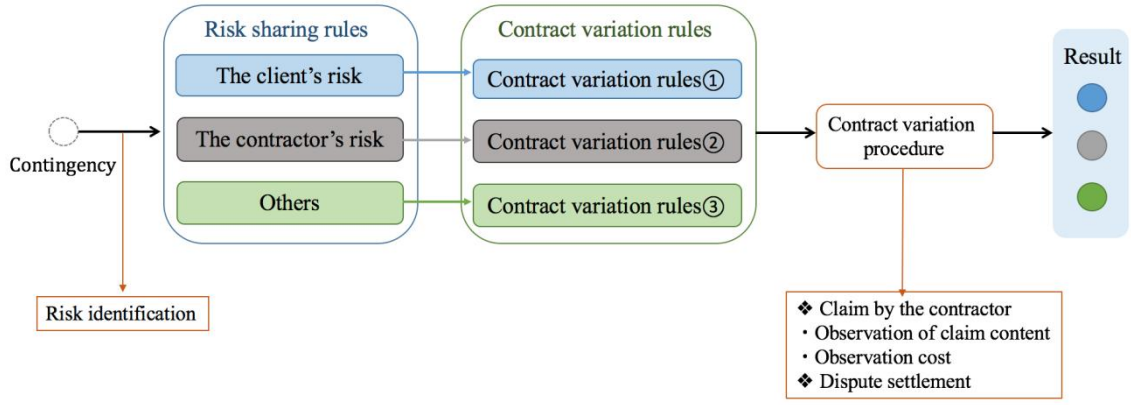

Figure 3.6 Contract variation procedures

role in mitigating losses brought by hold-up behaviour.

3.4.4 Insufficiencies

From the above analysis, stipulation of contract variation rules makes it feasible to avoid the hold-up problem and reduce losses due to underinvestment. The point is that by empowering the client to make decision on design change through contract variation rules, when the additional cost due to design change can be properly described and verified with no cost, the mechanism in contract A proposed by Hart (1995)[1)] can function effectively. So, it is obvious that the fundamental precondition of the effectiveness of Hart's consideration under the situation of construction contract is the compliance of contract variation rules. However, the reality is not always the case since there is no effective mechanism to guarantee the implementation of contract variation so far. Especially in the construction field, the case that the contractor ignores the contract variation rule is of common occurrence. That is, the contractor could refuse the requirement proposed by the client and renegotiate for a more favourable condition by threatening to quit the construction work. Then it will eventually cause the same problem again. Therefore, the remaining issue in Hart's model is the incentive to comply with the contract variation rules especially by the contractor which is also facing by construction project management.

However, since characteristics of construction project give rise to differences between construction contract model and the basic assumptions in contract A, even though the contract variation rule can be implemented by contracting parties, when taking the structure of construction contract rule and reality issues into consideration, there are some indispensable practical preconditions to guarantee the smooth implementation of the contract variation. In other words, it is quite difficult for the ideal situation under optimal contract model where the contract variation rule can be perfectly enforced to be achieved in reality.

3.5. Incompleteness of incomplete construction contract

3.5.1 Contract variation procedure in construction contract

From the above analysis, it is found that in construction contract, if the contracting parties are sufficiently motivated to comply with contract variation rules, contract A is indeed effective in preventing hold-up problem.

However, such conclusion seems not to be strict persuasive. As has been explained above, due to complexity of construction project, risk sharing rules, contract variation rules and dispute settlement rules have been stipulated in the contract for dealing with the occurrence of unforeseen contingencies. The whole process of contract variation is shown in the **Figure 3.6**.

It has been explained that for the construction contract, the consequence of unexpected contingency can be drawn without renegotiation through contract variation. When the contingency takes place as the grey dotted circle, before deciding which contract variation rule is applicable, the identification of nature of contingencies is necessary which is regarded as risk sharing rules. The risk sharing rules are used to tell the relevant responsible party due to the risk event in accordance with two risk sharing principles. The first principle is that the party who can assess and control the risk should bear it and the other one is that if none of the parties can assess or control the risk, the party who can bear it easier or procure the insurance from the market should bear it. Therefore, after nature of the contingency has been identified, the suitable contract variation rule can be correspondingly determined. In more detail, all possible contingencies can be categorized as possible with corresponding contract variation rules through risk sharing rules. Then, it will be preceded to the variation procedure where the either party may claim for compensation due to the nature of risk event. During variation procedure, the amount of compensation and/or extension of time will be determined in accordance of the result of verification provided by contracting parties. Although there may be some deviations of understanding between both parties which may lead to dispute, relatively fair and reasonable results will eventually be obtained while the consequence of unexpected contingency can be finally settled without renegotiation. In other words, sufficient observability and verifiability guarantee the implementation of contract variation.

Consequently, from this point of view, similar to the general incomplete contract, due to complexities of construction contract, the indescribability of unforeseen contingencies makes the construction contract incomplete. However, what is different from general theory is that there are risk sharing rules, contract variation rules and dispute settlement rules stated in construction contract for settlement of uncertainties instead of renegotiation.

3.5.2 Preconditions for the function of contract variation rule

As mentioned above, contract variation due to unforeseen contingencies is a set of complex process. Although the application of contract A is able to settle the matter of hold-up issue theoretically, in the field of construction project, there are several significant preconditions which are indispensable for the practical roles played by contract variation rules. In other words, when the following preconditions cannot be satisfied, even though the contractor can comply with the contract terms, it is also difficult to achieve the social efficiency.

In the first place, contracting parties have to identify the nature of the contingency in order to determine the risk responsibility and therefore adopt corresponding contract variation rules. In brief, which contract variation rule can be applied mainly depends on the category that the occurred event belongs to. After the responsibility party has been decided, in order to measure the additional cost due to design change, it assumes that such cost is observable by both contracting parties. Then they will proceed to contract variation procedure after they have reached an agreement on the additional cost. However, there exists a number of incompleteness during the pre-processing of contract variation.

In order to determine the responsibility party of unforeseen contingency, the essential condition is that the contracting parties should establish a common frame with common cognition on the categorization methods of contingent events. In other words, both contracting parties have sufficient common understandings on the causes of design change. They can exactly tell whether the design change is due to the change of utilization value by the client or infeasible construction method by the contractor. One of the reasons of occurrence of dispute is that they cannot reach an agreement on who should burden the additional cost due to contract variation. For example, when the contractor insists that the geological conditions that give rise to the change of construction method cannot be foreseen by an experienced contractor, then he may refuse to bear all the consequences due to change issue. Since dispute settlement incurs costs which hinder the achievement of social efficiency, contracting parties have to hold the same opinions on risk sharing. In consequence, the first precondition of effective function of contract variation rule is the common cognoscibility of contingency identification between contracting parties.

Secondly, although the research takes the assumption that the amount of additional cost is observable by contracting parties, it has to be emphasized that the observed results may not necessarily be the same. In other words, different result is normally observed due to different way of observation. Because of complexity of construction project and different roles played by both parties to the contract, it is practically difficult for them to have equal access to the information. For example, the contractor may be familiarly with geological conditions, suppliers and construction method while the client may know more on utilization value and the concept of design. Moreover, since contracting parties are motivated by rational choice, they tend to evaluate the additional

cost in a beneficial way to maximize their own profit. Therefore, the responsible party of the risk who has been determined in first step will try to force down the additional cost to the best of his ability where moral hazard likely takes place. Under the situation of the contractor, he may be more inclined to hide inconvenient facts. As a result, therefore, under the situation of asymmetric information there may be deviation of evaluated additional cost between contracting parties. On the other hand, the same situation may also occur in the case of symmetric information. Even if parties to the contract obtain the same relevant information, different measurement method or way of calculations may also lead to different outcomes. In consequence, the second precondition to guarantee the performance of Hart's mechanism is unanimous evaluation of additional cost by contracting parties.

The last indispensable precondition is costless observation and verification. In spite of the cost of verification during claim process, observation itself is not free as well. In the actual construction project, when evaluating the compensation amount of additional cost, the cost of labor, time and relevant measurement methods cannot be neglected. This can be considered as a kind of verification cost in a narrow sense. If such verification cost is taken into consideration in Hart's model, the implement of contract variation process will be more complicated. The issues such as the allocation of such verification fee and opportunistic behaviors of contracting parties thereof will certainly take place and bring negative effects on the consequence of contract variation. In the case where design change takes place, in order to determine a reasonable compensation scheme, as the above paragraph explained, observation and verification are indispensable. Generally, the bearing way of such cost can be summarized into 3 kinds: (1) paid by the party who claims, (2) undertook respectively and (3) being paid by the party who is responsible for the risk. Nevertheless, social efficiency level cannot be achieved because of the existence of such verification costs in each case.

3.5.3 The specificities of construction contract

As having been explained in this section, the idea of contract A from Hart (1995)[1)] is applicable to construction contract as contract variation mechanism which has been stated as contract terms currently. Generally speaking, Hart's model takes the general business contract as analytic target while construction contract is another type of contract with own characteristics. However, both contracts describe a similar transaction situation which is a kind of monopoly market with only one buyer and one supplier and specific investment will be made after concluding the contract. Since the contract is incomplete due to indescribability of the appropriate design, in order to achieve the first-best, contract A designs a mechanism that entitles the buyer to identify the specifications of the product and the seller may choose whether to accept it or not. This mechanism is also consistent with the stipulations in construction contract where the client is granted to the right of design determination. Therefore, in this sense, model background of these two kinds of contract can be considered as the same. However,

Table 3.2 Comparison between Hart's model and construction contract model

Items	Hart's model (Contract A)	Construction contract model
Application object	General business contract	Construction contract
Model background	The buyer specifies the unit and the seller could choose whether to accept or not	The client provides the specification and the contract has to complete the work
Determination method of price	Renegotiation	Contract variation rules
The contractor /seller' s choice	The seller is entitled to refuse the transaction by a price	The contractor cannot refuse the work required by the client.
First-best achievement	Fail to achieve first-best due to renegotiation	First-best can be achieved when the above preconditions are satisfied
Result	Only effective on short-term contract	Effective on long-term contract with satisfied preconditions

there are several differences between those two situations which have been showing in the **Table 3.2**.

Except the application object, in the first place, for the model background, although they both offer the buyer/the client the right to make decision on design which could be regarded as the similarity, in the condition of construction contract, since it has been explained that the contractor is not entitled to refuse the requirement from the client for design change and he is obligated to complete the construction work in all conditions. So, unlike Hart's model, the contractor has no idea but to accept the work. Secondly, after the work has been accepted by the supply side, the transaction price has to be determined. Under the situation of Hart's model, when there is some time before the production is carried out, the supplier will likely to reject the request and renegotiate for a more favourable treatment. On the other hand, since the contractor cannot reject the work and the additional cost due to design change will be determined through contract variation, renegotiation could not occur under the normal case. Therefore, for the short-term contract, the contract A in Hart's model is valid for hold-up issue. However, for long-term contract, if renegotiation turns to be possible, contract A in Hart's setting may not solve the problem and it also come to the conclusion that the equilibrium level of investment under long-term contracts is equivalent to the case where no contract is signed at all. Under the situation of construction contract which is a long-term contract, since contract variation replaces renegotiation, the first-best can be achieved with the mechanism of contract A. Nevertheless, the significant preconditions mentioned in the

above section should be satisfied in order to catch up with the reality.

Consequently, although mechanism described in contract A is applicable for the situation of construction contract, due to the different structures of contract type, while the contract A is only effective on short-term contract, contract variation rules are able to lead the construction contract to social efficiency level by restricting the contractor's right with satisfaction of the three preconditions.

3.6. Results and discussion

3.6.1 Results

Because of the complexity of construction project, construction contract is regarded to be a typical incomplete contract since it cannot describe all contingencies that may occur during contract execution period. When unforeseen contingency takes place, instead of renegotiation assumed in general incomplete contract theory, risk sharing rules, contract variation rules and dispute settlement rules are stipulated in construction contract for efficient implementation of the project. Moreover, as a unique feature of construction contract, the contractor is not entitled to refuse the client's requirement and is also obligated to complete the construction work in all conditions. Therefore, under the situation of construction contract, the client is entitled to obtain full decision-making right of design change which is consistent with the mechanism proposed in Hart (1995) by contract A. In the first place, this research follows the idea of contract A and models the situation in accordance with construction contract. The result shows that hold-up issue can also be solved in the case of long-term contract within the structure of construction contract. However, due to the incompleteness of construction contract, even though the mechanism is effective theoretically, there are several nonnegligible preconditions which are indispensable for the practical application of the mechanism. Otherwise, even if renegotiation does not take place, it is also unable to reach social efficiency level. The first precondition is the common cognoscibility of contingency identification between contracting parties. Since the corresponding risk sharing rule and the way of contract variation should be determined in accordance with the natural of the contingency, different opinions may lead to disputes which are obstacles to accomplish contract variation. In the next place, during the contract variation process, additional cost or/and extension of time are usually observed and claimed by contracting parties. However, because of the factors such as information asymmetry or different positions of the contractor and the client, deviations of observed result are likely to happen. Therefore, unanimous evaluation of the claim content must be guaranteed. Finally, although this is unrealistic in practice especially the construction project with a large scale, the last indispensable precondition is considered to be costless observation and verification which may have a great impact on the achievement on first-best level. But, it is important to note that the necessity of satisfaction of the above preconditions is

based on the fundamental premise that the contracting parties are able to fully comply with contract variation rules.

However, on the other hand, theoretical analysis is not always the case in practice, it is always observed that the contractor ignores the contract variation rules and try to renegotiate with the client by threatening to stop working. From this point, during the actual contract fulfilment process, even mechanism of contract A fails on solving the hold-up issue since renegotiation cannot be avoided. Therefore, other mechanisms other than contractual system should be taken into account.

3.6.2 Advanced functions of Dispute Board

The Dispute Board is known as a flexible mechanism for effective dispute resolution during construction period. It is recommended in all FIDIC forms that the disputes shall be adjudicated by the Dispute Board in the first place[19)].

There are mainly two forms of dispute board in FIDIC forms: standing DB and ad hoc DB. The standing DB is established at the beginning of the project before manifestation of any dispute event. It plays an active role throughout the whole project by visiting the site regularly[34)]. It is said that the active involvement of the DB in the construction project is conductive to resolve the potential disputes proactively before it turns to be an apparent one. Because the 'standing' DB could always be able to draw upon actual knowledge of conditions on the site and the contracting parties through frequent site visits and discussions at regular meetings. Moreover, since detailed and comprehensive information of the project could be collected continuously, decisions for disputes are able to be made promptly and then improve the efficiency of the whole project[19)]. The other type is 'Ad hoc' DB which is appointed only after a dispute has been caused. Therefore, it allows the parties to select the DB members with the particular expertise which is most suitable for specific dispute settlement[19)].

According to the special structure of construction contract, disputes usually take place at the stage of contract variation when the contracting parties hold different views. It has been point out that the standing DB has been taken as a standard approach for dispute settlement in the FIDIC red book for long-terms construction projects. The current functions of the dispute board can be summarized as two aspects. The most basic one is make decisions on disputes while the other one is nip the potential disputes in the bud by following up the project from the beginning.

In order to prevent the occurrence of hold-up behaviour, contract variation rules have been provided in construction contract. Nevertheless, for the sake of efficient implementation of the contract variation, some further functionalities of dispute board are expected. As mentioned above, cognitive deviations between contracting parties during pre-processing of contract variation procedure is one of the obstacles on the smooth operation. Therefore, at the first step, other than the awareness of potential disputes, recognition gaps with respect to the nature of the contingency should also be minimized even eliminated. When the unforeseen contingencies take place, members of

dispute board may cooperate with the engineer to help identifying the corresponding risk sharing rules as a mediator. The current condition is that if the contracting parties cannot reach an agreement on risk responsibility, the DB will intervene and prevent the generation of disputes or proceed to dispute settlement directly. However, different with the current approach, the dispute board is expected to be directly involved in the defining of the nature of the contingency in order to shorten the gap between the two sides in identifying the corresponding risk category. Then, the second precondition mentioned above is about the consistency of observation result on claim content. This could also be improved with the assistance of the dispute board. Since the standing DB is appointed at the time of the project commencement, they shall have a comprehensive understanding of the specific information on project condition such as the progress of the project and the behaviors taken by contracting parties. Through the coordination between both sides, this precondition is also likely to be satisfied. Finally, the last one is the issue of costly observation and verification. Although such cost cannot be completely avoided, a certain degree of reduction is still considered to be possible with the support of the dispute board during observation stage. Consequently, in order to alleviate the problems on efficient implementation of contract variation brought by incompleteness of construction contract, in addition to dispute settlement and dispute avoidance, the other expected functions of dispute board are the support for forming a unified opinion between contracting parties. Since it is possible for the dispute board members to accumulatively gain detailed knowledge of both the project and personnel, by periodical site visit and holding discussions, timely sharing information and communication should be beneficial to alleviate these incompleteness in construction project.

3.6.3 Suggestions on mitigation of hold-up problem

The dispute board has been expected to play an effective role in alleviating the issues brought by incompleteness of construction contract during the implementation process of contract variation. However, it has to be emphasizes that the further functionalities expected of the dispute board is basing on the premise that contract variation can be executed by contracting parties. When the contractor ignores the contract variation rules and tries to initiate renegotiation with the client, the dispute board has no effect in mitigating hold-up issue. Therefore, basing on such realistic considerations, other mechanisms are required where hold-up cannot be circumvented eventually.

Generally, pattern of payment varies from different contract forms. The FIDIC red book takes progress payment as the standard pattern for international projects while GCW applies lump-sum payment. The progress payment, as the name implies, payment will be made according to progress of works and workload regardless of working hours. On the other hand, lump-sum payment in GCW stipulates that the contractor will not be paid until they complete the construction work. These two types of payment patters make great difference on mitigating hold-up issue. Under the situation of progress

payment, when more than a half of the projected workloads have been completed, if the client requires design change at this time, the contractor is likely to break the contract variation rules and initiate renegotiation by threatening to refuse to continue the remaining work. This is because that, by progress payment, most of his revenue has been guaranteed. However, for the client, if the contractor really refuses to continue working, then the loss due to semi-complete project will be quite significant. Therefore, to this point, the contractor's threat is effective and hold-up behaviour will undoubtedly take place. Accordingly, the progress payment pattern is easier to cause hold-up problem. On the other hand, for the lump-sum payment in GCW, if the contractor refuses to complete the construction work in the half way, he won't get any rewards even if he has already done some work. Especially in the later stages of the project, instead of running the risk of gaining nothing for the benefit of hold-up, it is advisable for the contractor to carefully fulfil his own duties and get fully paid. As a consequence, lump-sum payment stipulated in the GCW plays a significant role in warding off the hold-up.

Moreover, in addition to the pattern of payment, timing of design change also has an impact on occurrence of hold-up behaviour. Under the situation of progress payment, the later the contract variation is proposed, the easier the client is to be held-up by the contractor. In addition, when the design change is proposed during later construction, demanded additional cost and extension of time are likely to be much more than in the early days. Therefore, it is better to make design change sooner than later especially for those caused by the client. This requires the client to put more effort on the appropriateness and practical operability of initial design. However, in practice, since the designer and the client may be lack of practical experience, the Early Contractor Involvement has been considered to be one of the effective methods which enable contractor's construction knowledge to be integrated into design process[35)-37)]. According to the definition given by early contractor involvement clauses published by NEC, the contractor can be assigned before the details of construction project have been fully specified and priced which enables the contractor to participate in the design and planning stages of the project. Along with improving team working, innovation and planning, such cooperation can also reduce the possibility of design changes during construction period to some extent.

In conclusion, when the main cause of hold-up behaviour in construction project is nonobservance of contract variation rules, other than contractual system, incentive mechanisms that is capable to motivate the compliance of contract variation rule should be paid more attention.

3.6.4 Limitations

This research firstly verifies the applicability and effectiveness of Hart's idea under the situation of construction project. It emphasizes on the significance of the client's ex ante specific investment and mainly focuses on the underinvestment issue of the client. It is obvious in the model that the contractor's ex ante investment is an optional variable.

However, it may be more reasonable if we treat the significance of the contractor's investment as much as that of the client. And moreover, there may be some correlations between these two kinds of specific investment. For example, the degree of investment will affect each other's behaviour. So, the model may, to a certain extent, weaken the effect of contractor's investment on the construction project.

After that, it points out the limitations of the theoretical mechanism from a practical standpoint that costly verification is possible in construction field practically. Therefore, in order to accurately analyse the real-life situation, such factor should be taken into account.

3.7 Conclusion

With the inseparable position of infrastructure in people's daily life, issues on efficiency improvement of construction project has always attracted the attention of many researchers. On the other hand, in the field of economics, researches on mitigating hold-up problem within incomplete contracts is also making progress. As a kind of contract with specific features, institutional design of construction contract has been considered to be an effective means to enhance the overall efficiency of the project, and then improve the social welfare. In the current construction project, hold-up problem caused by the contractor still remains as primary reason that affects the utility of the project. Therefore, the measures consistent with the practice to address the problem should be analyzed and devised.

This research combines Hart's idea with the situation of construction project and then shows the effectiveness of current contract variation rules stated in construction contract on mitigating hold-up problem theoretically. Moreover, in accordance with the structure of construction contract, it has pointed out that due to incompleteness of incomplete contract, there are three nonnegligible preconditions that guarantee the perfect implementation of contract variation rule and the achievement of social efficiency in the field of construction project. The first one of the preconditions without taking into account is the common cognoscibility of contingency identification between contracting parties. The next one is unanimous evaluation of claim content and the last point is costless observation and verification. Furthermore, the paper also concludes that the dispute board plays a significant role in alleviating the above deviations. On the other hand, this article indicates that hold-up issue is unable to be avoided since it is mainly attributed to non-compliance of contract variation rules by the contractor in actual construction projects. In a word, although the contract variation rule has been proved to have mitigative effect on hold-up issue by evading the occurrence of renegotiation and lead to the achievement of social efficiency level, due to the incompleteness of incomplete construction contract, it is still impossible to realize the first-best. Accordingly, other governance mechanisms other than the dispute board should be figured out while this research gives the ideas of appropriate payment pattern and

timeliness of proposing design change.

This study discusses hold-up issue in construction project from and gives opinions on both theoretical and practical aspects. However, detailed design on incentive mechanisms and governance has not been involved in the research. In addition, modeling analysis is established on costless verification which is discrepant from the reality. These will be treated as future research objects.

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4. Endogeneity of contract incompleteness and the choice of contract scheme

4.1 Introduction

As the foundation of the normal operation of the main facilities of the city, construction project therefore has a great effect on economic and social development. However, due to the characteristics of construction project such as complexity and high degree of uncertainty, changes are normally observed during construction period due to a variety of reasons[1),2)]. In construction projects, a change is normally considered as modification of initial design, adjustment of the scope of works, change of construction method and project schedule, etc. Many claims and disputes around time extensions, compensation for over-expenditure, quality defects of building works or even termination of contract can be ascribed to a variety of change issues during all phases of a project[3)-6)]. One of the most influential factors that may lead to the change issue is said to be design change[7)]. The essential factors of the occurrence of design change can be attributed to the incompleteness of construction contract due to bounded rationality of human beings since there are contingencies which cannot be foreseen in advance. As pointed out by Ross et al. (2005)[8)], problems generally arise from our unawareness due to imperfect information or uncontrollable. From this point of view, Tirole (2009)[9)] establishes a theoretical model involving the bounded rationality approach by taking account of cognitive limitations of human beings and rational choice approach. He introduces the concept of cognitive effort and analyzes the efficiency of sales contract under the situation of design changes basing on the idea that parties are unaware, but aware that they are unaware. On the other hand, in construction contract, consequences of those changes could be settled by contract variations rules stated in the construction contract. However, due to the incompleteness of incomplete construction indicated in the previous chapter, when the contract variation rules cannot be perfectly enforced, it may also give rise to the occurrence of opportunistic behaviors of contracting parties.

This study follows Tirole's idea and tries to analyse the conditions under construction contract. Construction contract is regarded as a typical incomplete contract since it cannot describe the possibility of contract variation with detail at the time of contracting. In this research, contract incompleteness mainly regards to the occurrence possibility of design change ex post. In more details, if the initial design is not an appropriate one with high likelihood and hence has to be changed during construction period, the contract is regarded to be incomplete since there is a high probability of the occurrence of contract variation which may lead to inefficiency issues. Nevertheless, people may aware of their incapacity of full awareness. In other words, people know that they may be unable to aware the appropriate design initially, so in order to avoid the unnecessary

expenses ex post, they may exert themselves by cognitive effort to find the appropriate one. If they fail to contract on the appropriate design, ex post design change with adjustment cost will take place since the inappropriate one may result in reduction of construction value and the client's utility. However, it is worth noting that unlike sales contract, in construction contract, there is no binding power of the initial contract since the client is entitled of full right of determining the change of design. That is to say, design change required by the client is always contractually acceptable. In addition, when design change takes place, there is also no choice for the contractor but to claim for compensation of adjustment cost in accordance with the client's requirement.

Therefore, as a result of the situation of conventional contract, on one hand, due to the stronger position of the client, the expropriation of the contractor's adjustment cost which is regarded as strategic behaviour by the client in this research is hard to be avoided. On the other hand, following the practical issue pointed out in the previous chapter, it is also possible for the contractor to hold up the client through conducting the renegotiation by threatening the client to quite the work which is regarded to be non-enforceability of contract variation rule. As a consequence, social efficiency level of cognitive effort may hardly to be achieved. For the sake of avoiding the inefficiency caused by the above two cases, the appropriateness of initial design should be guaranteed to the maximum extent. In addition, in construction field, it is known that the contractor is more experienced with technological knowhow than the client. They may be more capable of finding the appropriate design to the extent. Therefore, besides the conventional contract, design-build contract is also treated as a popular contract scheme of construction project.

This research analyzes incentives of contracting parties to reduce negative effects brought by contract incompleteness by introducing cognitive effort under the situation of two types of contracting mode and theoretically clarify the optimal contract scheme for solving the issues caused by design change ex post. The rest of this paper is organized as follows: In order to show the basic philosophy of this study, section 4.2 summarizes the theoretical background on construction contract as incomplete contract and explains cognitive effort in this research. In section 4.3 to section 4.5, we develop the framework and build the cognition models of different types of construction contracts. Section 4.3 and section 4.4 focus on one-sided cognition in the case of conventional contract and design-build contract. Section 4.3 discusses the situations of both imperfect-enforceability of contract variation rules and non-enforceability where renegotiation takes place. Section 4.4 analyzes the case of design-build contract. In section 4.5, comparative analysis has been conducted for ascertaining the optimal contract scheme. The last section 4.6 includes discussion, summarization of conclusions and also envisages the future research directions.

4.2 Basic idea

4.2.1 Literature review

The research is mainly based on the idea of the founder paper proposed by Tirole (2009)[9]. According to Halonen-Akatwijuka and Hart (2013)[10], the main insight of this paper is that: the level of cognitive efforts exerted by contracting parties has a close relation to incompleteness of the contract. Trade-off between transaction cost of cognitive effort and ajustment cost due to design change is focused. In additon to incompeletness due to high probability of occurance of renegotiation caused by low cognitive investment, the contract may also be too complete if too many cognitive efforts are spent on search in order to avoid a vulnerable status in renegotiation. The originality of the paper is that it introduces the concept of cognition which makes the incompleteness of incomplete contract become endogenous. Since transaction costs cannot be avoided when thinking about the contingencies while drafting the contract, moreover, according to bounded rationality approach, there exists cognitive limitation among human beings. On the other hand, in term of rational choice approach, people tend to adopt the best strategy to minimize the cost for maximizing their profit which can be described as objective optimization or utility maximization. Tirole combines the mainstream contract theory and bounded rationality approach and proposes that parties are unaware, but aware that they are unaware which means that human beings have cognition limitations, and they know the existence of their inherent cognition limitations as well. Since his paper mainly applies for the condition of sales contract where renegotiation takes place at the time of design change, there exists a cut-off value of the seller's bargaining power which is the boundary of negotiation break down and excessive completeness. He also insists that ex ante competition makes no difference on reduction of transaction costs. In addition, relational contracting and vertical integration are considered to be effective in lowering the completeness of contract due to governance mechanism.

In addition to Tirole's paper, Shi et al. (2010)[11] theoretically investigates the optimal procurement contract between the owners in developing countries in terms of double moral hazard issue. Omoto, Kobayashi and Wako (2001)[12] make comparative study between the GCW forms and the FIDIC forms. They clarify there exist considerable differences of endogenous risks between those two contracts and the primary cause is the different scenario on the client's ability of verification. Kobayashi et al. (2001)[13] provides theoretical analysis of efficiency and the social optimal form of Japanese construction contract, but assumes that parties continue the transaction according to the content of initial contract when renegotiation breaks down. Moreover, Zhang and He (2003)[14] summarize international cutting-edge research on the design-build delivery systems and also discuss its feasibility in China.

However, those literature on construction field have not taken the consideration of

cognitive effort into account. In addition, theoretical analyses on ex ante efficiency in the case of conventional contract, design-build contract are also vacant as well. In addition, the contextualization of this research also has not been involved so far. This paper takes cognitive effort into account and analyses the ex-ante efficiency of the conventional contract and design-build contract under the situation of design change and finally theoretically proves the active role of the design-change contract on guaranteeing efficiency of construction project.

4.2.2 Incomplete contract and cognitive effort

Construction work is generally large in scale and with high complexity. Therefore, the number of contract documents is enormous which makes it impossible or prohibitively costly to consistent with all the contents such as drawings, specifications, contract terms, etc. Moreover, construction work is also susceptible to some exogenous factors such as revision or abolition of law, geological and natural conditions, changes of contractual environment etc. In a word, there are unforeseeable risks faced by the contracting parties and it is impossible to control all of them[15]. Such contract which cannot specifically describe all the contingencies that may arise in the future is called incomplete contract[16)-18)]. Omoto, Kobayashi and Onishi (2001)[15), 19)] have pointed out that the construction contract is a typical incomplete contract. In this case, when contingency has occurred, contracting parties have no choice but revise the contract content.

Incomplete contract theory has been gradually developed with the starting point of Grossman and Hart (1986)[20)] and has also accumulated findings of desirable contractual mechanism and institutional design. In practice, changes are normally observed during the construction process, due to complexity of construction work, they ineluctably can have a great influence on labour productivity[21)] and may also lead to an adjustment to the contract price or extension of time[22)]. According to numerous related studies, design change is regarded to be one of the significant factors by many scholars[23)-27)]. Based on incomplete contract theory, generally when contingency occurs, contracting parties have to determine the terms of the agreement through contract variation by renegotiation. However, during renegotiation process, since parties may make use of their advantageous position, misconduct is normally observed.

On the other side, cognition in this research refers to the process of learning the appropriate design. Cognitive effort therefore is considered as contracting parties' endeavour for acquiring and processing relative information for design. It may also be regard as the ability that contracting parties can realize or investigate the inappropriateness of initial design using heuristics. In more detail, designing for construction project requires adequate information such as geological condition, humanities in the surrounding and so on. Moreover, factors such as technological level, budget constrain, owner's specifications should also be taken into account. The certain amount of manpower, time and resources consumed by such workload are defined as

cognitive cost by contracting parties.

The contracting parties may initially contract on an available design which may be the best one under their existing knowledge. After a period of time, either or both of contracting parties may realize that the initial design may not be the appropriate one and should be modified. When ex post design change becomes inevitable, along with the reduction of social welfare and construction efficiency, there also exists a kind of regret. If contracting parties are able to exert a massive effort, it may be more likely for them to find the appropriate design before contracting or the time that may cause losses. When the appropriate design can be contracted ex ante, ex post design change can be avoided as well as adjustment cost. Therefore, the inefficiency caused by design change could be improved by guaranteeing precontractual efficiency.

4.2.3 Variation rules in FIDIC form

In construction contract, contract variation rules have been established for determining the content and procedures of variation when the contract needs to be modified due to some unforeseen contingencies. The FIDIC form (1999)[28)] is regarded as the international standard form of construction contract which is formulated by authoritative experts from International Consulting Engineer Federation. The contract variation procedure stipulated in the FIDIC red book starts from the time-point when the contractor became aware, or should have become aware of the claim events or circumstances. According to the Clause 20.1 of FIDIC form, after the awareness of the event, the contractor shall give the notice to the engineer which should describe the event that caused the claim. And then after a certain period, the contractor is required to submit to the engineer a fully detailed claim report which includes the compensation matters such as the amount of additional cost. After receiving the claim report, detailed comments by the engineer shall be responded with either approval or disapproval. In the case of design change, when adjustment cost of design changing occurs, the contractor is entitled to claim for the compensation through engineer. If the parties cannot reach an agreement on the amount of compensation, then they will proceed to dispute resolution.

Since construction contract is a legal binding agreement signed by contracting parties that the contractor undertakes the construction and maintenance work according to the client's requirement with labors, materials and equipment. It is a kind of promise that the contractor completes project construction, where the client pays the price[29)]. Therefore, the contractor is under an obligation to complete the construction, so construction contract does not allow cancellation offered by the contractor[12)].

However, the model described in Tirole's paper is mainly applied to sales contract. The setting in his paper describes a pure transaction sale which is based on cash on delivery and realization of inappropriate design usually happens after the buyer took possession of the good. Under such situation, after delivery of the good on initial design by the seller, even if the buyer finds out that the initial design is not appropriate, as long as the seller refuse to do the adjustment of the product, the buyer has no idea but to

purchase the undesirable good. In other words, although there are contract variation clauses in sales contract, initial contract still has binding effect on contracting parties as status quo.

Above preconditions generate the essential differences between Tirole's work and ours according to the following three points. The first one is the renegotiation procedure, in sales contract, after realization of the inappropriateness, the buyer will propose requirement of adjustment work to the seller, and then, the seller will decide whether to accept it or not. If the seller refuses the work where renegotiation breaks down, there remains execution of initial contract. However, in construction contract, the condition changes, after required by the client, the contractor is entitled to claim for compensation of adjustment cost since he is obligated to answer the client's requirement. Then the engineer will make his decision on contractor's claim. The second difference is consequences of renegotiation. In sales contract, excepting the condition of agreement, the initial contract is always binding on both parties to the contract. Under the situation of construction contract, since such changes are hard to be avoided completely under the situation of incomplete contract, if the contractor agrees with the engineer's decision, then everything goes smoothly, otherwise, the contracting party have to proceed to dispute resolution process since the compensation amount due to additional work is largely dependent on bargaining power of contracting parties and standpoint of the engineer[30)]. At the same time however, the contractor has to start adjustment work required by the client. Therefore, the initial construction contract has no binding power when change issue takes place. The last one is surplus of renegotiation, in Tirole's paper, it is assumed to be the differences between the increment of value and adjustment cost due to design change. In construction field, since the adjustment work has already been done by the contractor without payment before dispute settlement, the client always has stronger bargaining power than the contractor. Therefore, this gives the client a chance to hold up the contractor where the actual compensation may be less than reasonable cost.

In addition to the case of the client's strategic behaviour, similar to the settings in Tirole's work, it is also possible for the contractor to hold up the client. However, while the seller requires more shares of increment value due to design change, the contractor may want to expropriate more compensation amounts of additional cost.

4.2.4 Design-build contract

According to Song et al. (2009)[31)], in traditional design-bid-build contracting mode which is regarded as conventional contract in this research, generally, the designer will closely cooperate with the client during design stage in order to meet his expectation and specification, whereas since contractors are determined through competitive bidding which is normally conducted after the basic design has been determined. Such separation of design and construction process hinders the utilization of related knowledge and experience owned by the contractors and accordingly reduces the

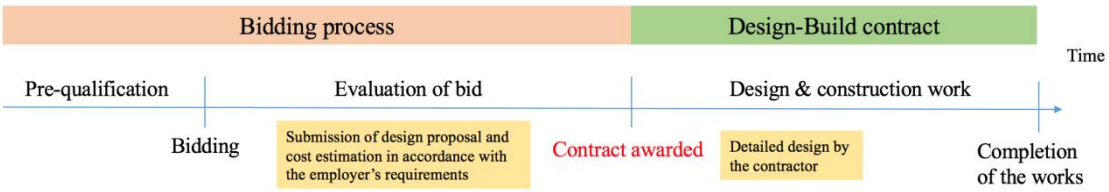

Figure 4.1 Timeline of Design-build contract

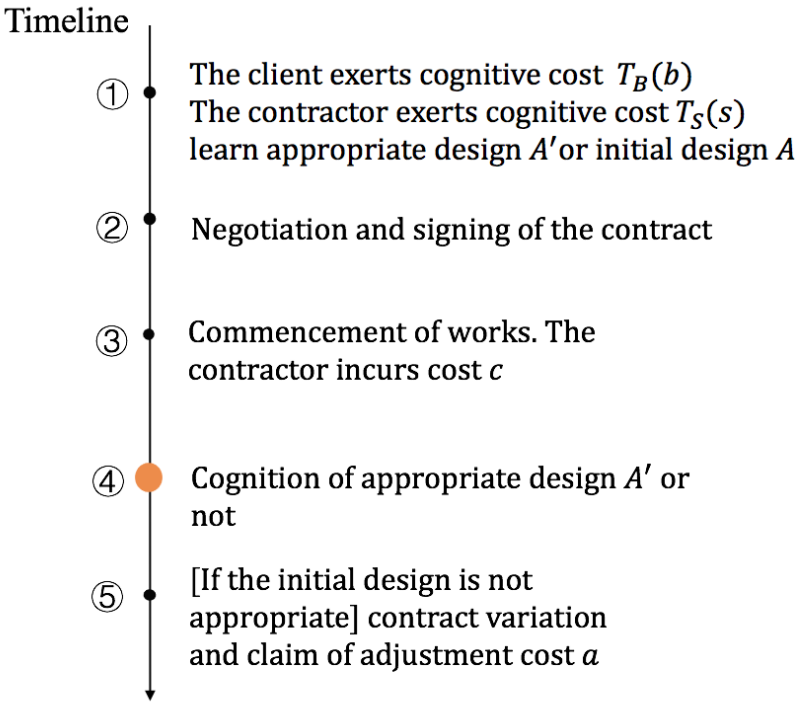

Figure 4.2 Timeline of one-sided cognition model

opportunity for them to affect design decisions. However, the fact that the contractors have better know-how than the client both in practice and design experience has been widely accepted[32), 33)]. Moreover, since design work is delivered by designing institute appointed by the client, disputes become a common occurrence due to misunderstanding of the design and its low practical operability for the contractor. In addition, in order to recover losses caused by low price bidding, claims also arise frequently against the client from the contractor. Moreover, considerable issues such as the client's inadequate control ability for budget and construction period, responsibility prevarication between the designer and the contractor and inefficiency interface among main sectors are often observed in conventional contract mode[14)]. Therefore, inefficiency of the project is severely impacted under the situation of conventional contract. However, it promotes the process of shifting to design-build contract scheme.

Design-build is the construction project delivery system that the client signs a

comprehensive contract with only one contractor. The contractor is response for both design and construction work within given budget while the client dispatches his own project management team as his representative to manage the contractor. Flow chart of the system is shown as **Figure 4.1**. The whole process can be divided into bidding process part and design-build contract part. After pre-qualification of bidders who are interested in the project, qualified candidates have to submit their design proposal and cost estimation in accordance with the client's requirements. When the most suitable candidate is chosen after circumspect evaluations, design-build contract will be awarded. In order to lighten the burden of the client, fixed price contract is mostly common used, that is, in other words, once a contract is signed, its price is basically determined and does not vary with the changes in the construction work, therefore, as an investor, the client can basically determine the price of the project at the time of contract awarding. For the contractor, contract price includes his cognitive cost for design proposal and detailed design proposal in bidding process, construction cost and risk cost. Since design in this research mainly refers to detailed design, the contractor's cognitive effort exerted is only for detailed design after the contract has been awarded. Therefore, his cognitive effort level is also constrained by the budget.

4.3 One-sided cognition model

In this part, we try to analyze the situation of one-sided cognition. In construction market, in order to manage an efficiency project, while the responsibility of the client plays a decisive role in conventional mode, design-build contract emphasizes the utilization of the contractor's knowhow. Therefore, this section will analyze the condition of one-sided cognition when only the client or the contractor is able to learn about the appropriate design.

Firstly, I will describe the general settings of the one-sided cognition model. As showing in the **Figure 4.2**, in the first place, both of contracting parties, the client (B) and the contractor (S) can exert cognitive effort to investigate the appropriate design and incur cognition costs $T_B(b)$ for the client and $T_S(s)$ for the contractor. We assume that the functions T_i (for $\in \{B, S\}$) are smooth, increasing, and convex functions. b and s denotes the level of their cognitive effort respectively and it can also refer to the probability of awareness. The probability that they can learn design A' initially where A' is the appropriate one is b and s respectively, by contrast, they learn nothing with probability $1-b$ and $1-s$. Moreover, the probability that the initial design A is the appropriate design is common knowledge for contracting parties which is $1-\rho$ and it delivers utility v to the client. Meanwhile, with the probability ρ the appropriate design is A' and delivers utility v to the client while the design A can only delivers $v-\Delta$. If A is the appropriate design, even if they exert enough cognitive effort, nothing will be investigated. After that, they conclude the contract on the initial design. Next step is commencement of works which costs the contractor c for

construction. During construction period, either party may realize that whether the initial design is the appropriate one or not. If the initial design is inappropriate, in order to obtain expected utility, design change work has to be conducted with additional adjustment cost a. Here has to be emphasized that different from the definition of design in sales contract, design change in this research refers to the situation that the pre-existing design cannot respond to the current situation and therefore change of design is needful. It can be considered in the way that the inappropriate design can only response to some specific situations and therefore it is vulnerable to uncertainties. If the initial design can be devised to be able to deal with more situations, then the possibility of design change ex post can accordingly be reduced.

4.3.1 Conventional contract model — benchmark model

Under the situation of conventional contract, the client first exerts cognitive effort and incurs cognition cost to investigate and find out the initial design. It is notable that the client is considered to be more concerned about the realization of his own needs in terms of design, since only the client himself knows what he exactly wants. Then the client concludes a construction project contract with the contractor on the initial design through open tender. The completion of this construction work of initial design costs the contractor c. According to peculiarity of construction contract that the contractor is prohibited from proposing contract termination except special circumstances stipulated in the contract. In addition, since the investment amount of construction project is enormous, and both contracting parties have to make relational specific investment initially which is different from other kinds of projects. Therefore, we assume that after signature of the contract, both contracting parties are bound within the transaction. If the contracting parties contract on appropriate design A' initially, then the total cost of the construction project is c and delivers utility v to the client. There is no adjustment cost and renegotiation will not occur either. By contrast, if the client contracts on design A ex ante but finds out that the appropriate design A' during the process of construction, he can apply for the adjustment of A' to the contractor. If design change is feasible, it takes the contractor adjustment cost a of such modification. Therefore, contract variation due to design change takes place and compensation of adjustment cost of such change has to be determined through claim. Such adjustment cost can be interpreted in the construction field in the following ways. First, the labor force of the contractor. When the conversion takes the place, there are addition works for build labors, so not only the labor cost, but also utility expenses such as water and electricity. Second, additional building materials may be needed for conversion work, so the contractor has to arrange procurement and logistics as well as correlative charges. Furthermore, in most of the construction contract, variation of design needs to go through a set of complicated process. In addition, the contractor has to learn about the new design. Therefore, adjustment cost a can also be treated as such time cost.

Design change may lead to contract variation. Since the contractor is obliged to follow

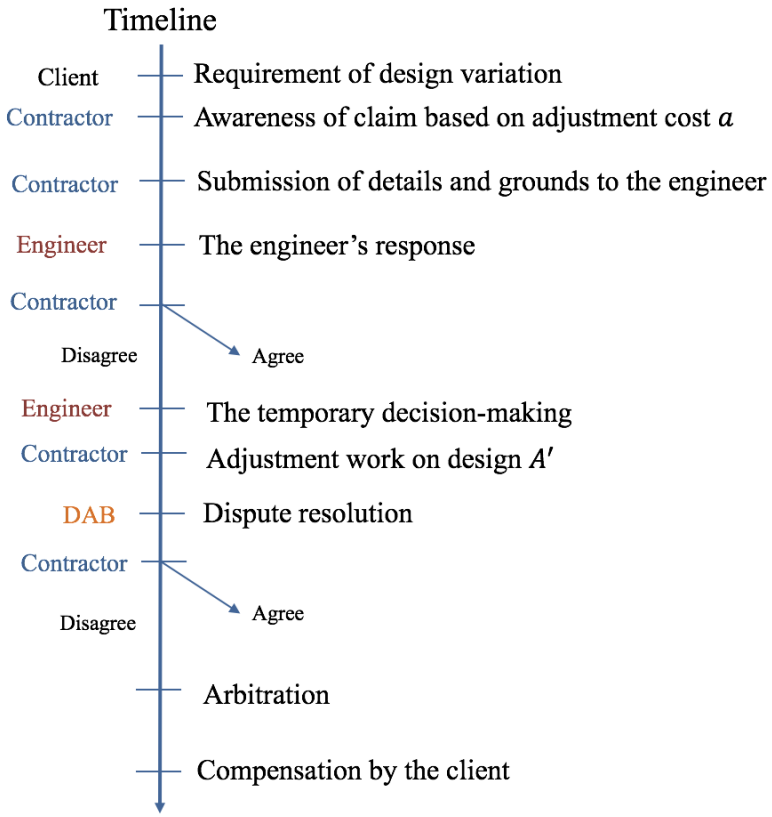

Figure 4.3 Contract variation process in accordance with FIDIC form

the client's instructions, when design change takes place, he is entitled to claim for extra cost or extension of time. Then, the engineer will make his decision on the claim issue. If a final agreement cannot be achieved, they will proceed to dispute resolution or arbitration.

Contract variation— if the client has learned about the appropriate design A', there is no necessity of design change ex post. After concluding the contract with specification on design A', the contractor incurs the cost c to accomplish the construction work and get paid. By contrast, when the client has not learned the appropriate design initially thus contracts on design A. Therefore, during the construction period, when the client realizes that the appropriate one should be A', he will require the contractor to adjust the inappropriate design.

Figure 4.3 describes renegotiation process stipulated in FIDIC form. It shows that the client should make a request of design change to the contractor when the inappropriate design A' is realized. After receipt of the client's requirement, the contractor is entitled to claim for the reasonable adjustment cost a by submitting details and grounds of this claim issue to the engineer and start the adjustment work at the same time. Then, the engineer will come to a decision. If the contractor is not satisfied with this response, contracting parties will enter into dispute resolution process or even arbitration. However, even if the contractor disagrees with the engineer's decision on compensation

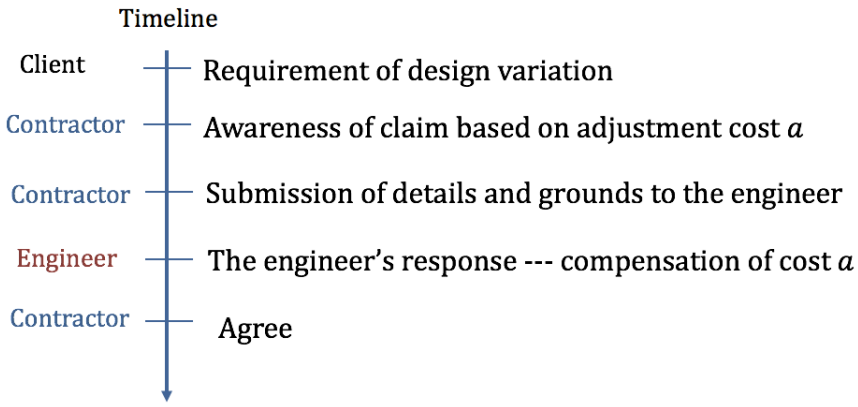

Figure 4.4 Contract variation process under neutral engineer situation

of adjustment cost, the adjustment work on design A' required by the client cannot be set aside while the engineer makes a temporary decision. At the same time, the contracting parties proceed to dispute resolution.

(1) First best

First-best is considered basing on the prerequisites of a complete contract where contract variation will be conducted without renegotiation. When only the client is able to exert cognitive effort with cognition cost $T_B(b)$, the social efficient level of cognition cost only concerns with $T_B(b)$ and adjustment cost a, which is:

$$min_b[\rho(1-b)a + T_B(b)]. \tag{4.1}$$

Therefore, the social efficient level of cognition $\bar{b}$ is:

$$T_B'(\bar{b}) = \rho a. \tag{4.2}$$

(2) Benchmark model

Assuming that the engineer is neutral and therefore reasonable judgment can be made according to details and grounds submitted by the contractor. Under this situation, the contractor may certainly agree with the engineer's decision and there is nonexistent of following dispute resolution procedures. The timeline is shown as **Figure 4.4**.

— Cognitive effort by the client

First, under specified situation, if the client finds out that design A' is appropriate, he will rationally disclose it and specify the delivery of design A'. Because the ex ante price always equals to the cost in competitive marketing environment, moreover, renegotiation is nonexistent under obedient client model, if the client conceals design A', he will wastefully suffer the losses due to adjustment cost a even if there exists hold-up. When the client trades even having learned nothing, his profit solves

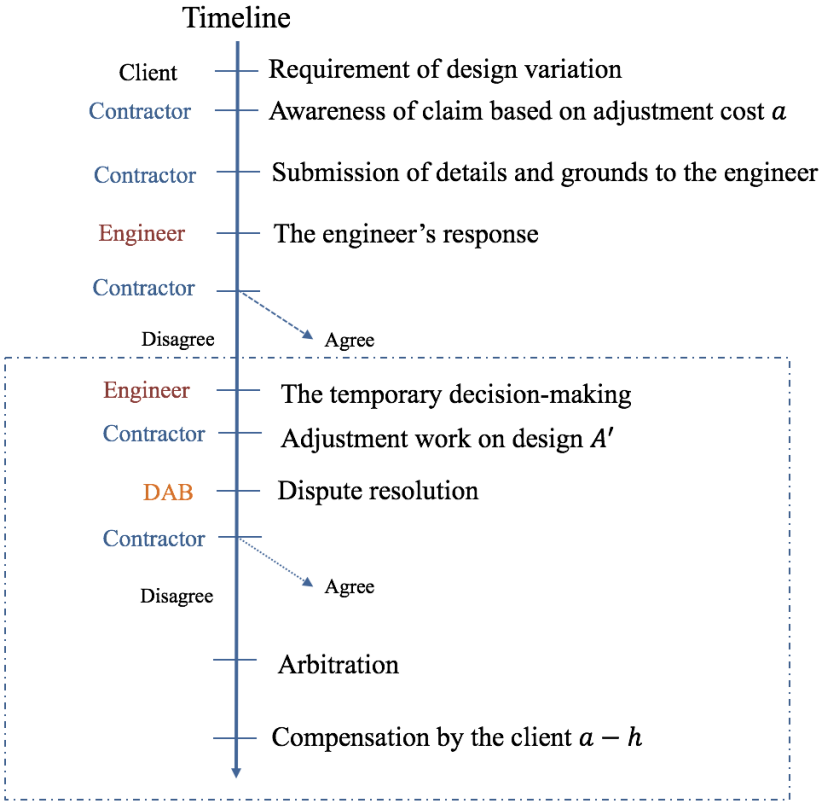

Figure 4.5 Contract variation process in the case of the client's strategical behavior

$$\max_{b}[\rho b(v-c)+(1-\rho)(v-c)+\rho(1-b)(v-a-c)-T_B(b)].$$

Differentiating the equation yields first-order condition we can get the following function which is the same as the social efficient level:

$$T_B'(b^*)=\rho a. \tag{4.3}$$

It shows that when neutral engineer can verify adjustment costs, both adjustment cost and effort costs can be internalized. Therefore, we can put forward proposition 1.

Proposition 1:

When the engineer takes neutral behavior to make decision on adjustment cost claimed by the contractor, the social efficiency level of cognitive effort can always be achieved.

4.3.2 Conventional contract model

(1) Strategic behaviour taken by the client

It has been verified that when the engineer behaves neutrally, reasonable judgment can be made and therefore social efficiency level of cognitive effort can be achieved.

However, the reality is not always the case. In construction field, as competition intensified due to a decrease in construction investment, the client become more aggressive, the construction industry is definitely a buyer's market, the status of the client is unilaterally superior to that of the contractor[33]. Moreover, since FIDIC form stipulates that the contractor is responsible for verification when he makes claim, when verification is no longer costless, if the transaction cost of verification is too large to be afforded, the contractor will be more vulnerable during contract variation process. Therefore, when the contractor agrees with the decision on compensation of adjustment cost made by the engineer, he will get paid after accomplishment of design adjustment work. However, taking into account that the engineer is employed by the client in reality, the decision of the engineer, to a large extent, reflects the intention of the client. Therefore, under such situation, the case may turn to be that the contractor is likely to be dissatisfied with the unneutral engineer's decision and contracting parties have to proceed to dispute resolution process. Nevertheless, since requirement by the client cannot be denied, the contractor has to continue the design adjustment work at the same time. It is usually the case that before the settlement of dispute, adjustment work has already been delivered to the client by the contractor without payment. Therefore, the client has a chance to take advantages of the contractor by delay in payment, so the actual payment of adjustment cost may be less than the exact amount. In order to get paid as early as possible, the contractor may reluctantly accept it in general. Therefore, in this case, the engineer may not take neutral behavior and the client may likely behave strategically during contract variation process. Accordingly, under strategic client model, the case turns to be that since the engineer is not neutral anymore, the contractor may not agree with his decision. The process is shown as **Figure 4.5**.

Under the situation of disagreement, the engineer will make a temporary decision while the contractor has to start working on design adjustment work. At the same time, contracting parties enter dispute resolution process. Generally, in the actual situation, since before settlement of dispute, the adjustment work has already been delivered to the client, in order to simplify the analysis, we assume that discount ratio of the client is 0. Due to ex ante fierce competition among contractors and the delivery of adjustment work without payment, the client may always be in a stronger position than the contractor. Therefore, as long as the client does not pay for design adjustment work, the contractor has little recourse. Finally, in order to get paid as soon as possible, the actual payment made by the client may be less than the sum of claim which is assumed to be $a-h$. h here refers to the compensation amount expropriated by the client. In the end, the contractor can receive only $a-h$ while the exact adjustment cost is a.

— Incentive for disclosure

When learns nothing, the posterior probability that conditional on cognitive intensity b and unawareness of A' is showing as follows

$$\hat{\rho}(b) \equiv \frac{(1-b)\rho}{1-\rho b}.$$

On the equilibrium path, since both contracting parties expect ex ante strategic behavior taken by the client with the amount of h. The contract price then accounts for the possible expropriation which is regarded as a kind of risk premium. In addition, competitive price is considered generally in construction field, therefore,

$$p(b^*) - c - \hat{\rho}(b^*)h = 0.$$

Or

$$p(b^*) = c + \hat{\rho}(b^*)h.$$

When the client learns nothing, then his utility solves as

$$v - \hat{\rho}(b^*)(a-h) - p(b^*) - T_B(b).$$

Suppose that the client finds out design A' is appropriate, by concealing it, he receives

$$v - (a-h) - p(b^*).$$

By disclosing design A', the client's profit is:

$$v - c.$$

Therefore, disclosing the appropriate design increases the client's utility by

$$\begin{aligned}\Delta U_B &= v - c - [v - (a-h) - p(b^*)] \\ &= a - [1 - \hat{\rho}(b^*)]h. \end{aligned} \tag{4.4}$$

Since the expropriation amount cannot be larger than adjustment cost, ΔU_B is always positive. The increment of the client's utility by disclosing the appropriate design A' is composed of occurrence of ex post adjustment cost and losses due to the contractor's expectation of expropriated amount. Accordingly, since compensation of adjustment cost by the client cannot be avoided when design change takes place, the client always has incentive to disclose the appropriate design when he becomes aware of it.

— Cognitive effort by the client

According to contract form, in construction field, since the contractor has no right to refuse the client's requirement, the client may trade even when having learned nothing, his utility solves

$$-T_B(b) + \rho b(v-c) + (1-\rho)(v-c) + \rho(1-b)[v - (a-h) - p(b^*)].$$

With the probability ρb, the client is aware of the appropriate design A' ex ante and his profit is $v - c$. With probability $1 - \rho b$, the contracting parties contract on design A with competitive price c. With probability$1 - \rho$, A is the appropriate design and the client can also obtain $v - c$. With probability $\rho(1 - b)$, the appropriate design is A' but the client fails to find out it initially, therefore, the contracting parties contract on design A first and then renegotiate for design change. Since the client in practice wants to achieve the maximum value of the construction project, therefore,

$$\max_{b}\{-T_B(b) + \rho b(v - c) + (1 - \rho)(v - c) + \rho(1 - b)[v - (a - h) - p(b^*)]\}.$$

By differentiating the above equation, first-order condition solves as:

$$T_B'(b^*) = \rho a - \rho h[1 - \hat{\rho}(b^*)]. \quad (4.5)$$

Since the second cannot be negative, the result shows that marginal cognition cost of the client is obviously lower than social efficiency level.

Proposition 2:

Due to strategic behaviour taken by the client, under-investment of cognitive effort will always take place.

(2) Hold-up behaviour taken by the contractor

On the other hand, although there are contract variation rules stipulated in the contract and termination by the contractor is forbidden, in practice, the contractor can still hold-up the client at the time of design change by threatening to quit the work and carry out renegotiation instead of contract variation process which is considered to be the non-enforceability of contract variation rule. Since the utility brought by the completed project is immeasurable for the client and delays can also be costly, hold-up behavior taken by the contractor is also considered to be conceivable in construction project. In this case, the procedure of contract variation described in **Figure 4.3** will no longer stand anymore since it will not happen. Therefore, in this case, the contractor will expropriate a portion of the client's utility conversely, so h consisted in the client's compensation turns to be a negative value. In other words, in addition to the adjustment cost, some extra profit should also be paid by the client to the contractor as a hold-up amount.

— Incentive for disclosure

When the client is held up by the contractor by the amount of h, then whether the client is still willing to disclosure the appropriate design when he becomes aware of it has to be investigated in the first place. Therefore, similar to the case of the client's

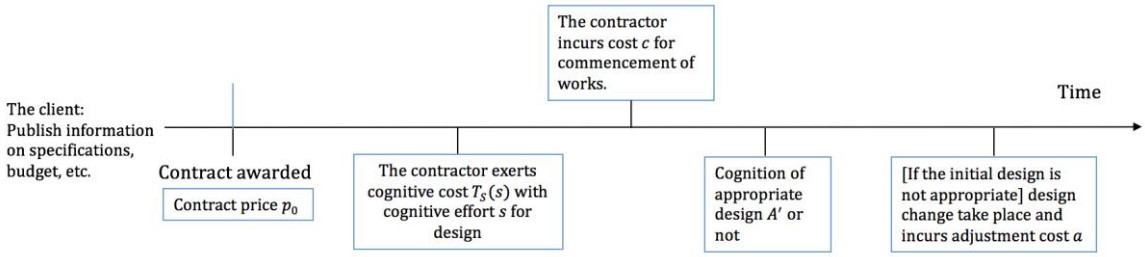

Figure 4.6 Timeline of design-build model

strategic behaviour, the increment of the client's utility through disclosing the appropriate design is described by formula (4.4).

In this case, the amount of h should turn to be negative since it represents the losses of the client due to the renegotiation carried out by the contractor. Therefore, the result obviously shows that ΔU_B is a positive number. Since it is predictable for the client that he may be held up by the contractor ex post, in order to avoid such unnecessary losses, the client may certainly disclose the appropriate design when he becomes aware of it.

— Cognitive effort by the client

Since the time limit for a construction project is closely related to realization of the value of construction work, and it is also documented that the client is entitled to change the inappropriate design at any time, therefore, even if under the situation of likely being held-up, the client will still choose to start the construction.

According to the result shown by formula (4.5), when the amount of h is negative, different from the proposition 2, the situation of the cognitive effort exerted by the client will turn to be overinvestment, because $1 - \hat{\rho}(b^*)$ will never smaller than 0.

Proposition 3:

Due to hold-up problem caused by the contractor during contract variation process, overinvestment of cognitive effort by the client will take place since he may want to avert the possibility of being held up by the contractor.

4.3.3 Design-build model

From the above analysis, it is found that inefficient investment of cognition caused by strategic behaviours of contracting parties is likely to take place in conventional contract model when only the client is able to exert cognitive effort for appropriate design. Since design-build contract is used to solve the inefficiency problems brought by conventional contract, this section is going to analyse the choices of cognitive effort under the situation of design-build contract. It has to be emphasized that the definition of design change under the situation of design-build contract may be different from that in convention contract. As the supply side, the contractor may be more experienced than

the client in the aspect of technology during construction process, so design change conducted by the contractor should be the issue which is determined by the technical requirement. In more detail, in accordance with characteristics of construction project, construction method is heavily depended on geological conditions, climatic environment and some other uncertain factors which are difficult to forecast before contracting. Therefore, design change in this case can be considered as the change of construction method. For example, based on the existing knowledge of parties at the time of contracting, they can only find the design A of construction method, however during construction period, some of the construction environment changes which make the initial construction method impossible to continue, and contracting parties become aware of the appropriate design A'.

Since the client signs an overall contract with the qualified contractor, the contractor is response for both design and construction work. Therefore, in design-build model, we assume that only the contractor has to exert cognitive effort. Its timeline is showing as **Figure 4.6**. After the bidding process, the contracting parties sign the contract with a lump-sum contract price p_0. Assuming that it was a competitive tender, and therefore the contract price p_0 is competitive price which is consist of construction cost and cost of cognitive effort by the contractor

$$p_o = c + T_S(s).$$

Then, the contractor starts with construction work including detailed design of the project where he exerts cognitive effort s which costs $T_S(s)$. Completion of construction works costs the contractor c. As with conventional contract, under the situation of lump-sum contract, when the contractor realized that the initial design is not appropriate, he has no idea but disclose it and adjustment cost due to design change has to be burdened by himself. Consequently, strategic behavior by the client is no existence.

(1) First-best

First-best in design-build model is similar to that in conventional contract model. When only the contractor, not the client is able to exert cognitive effort and incur cognition cost $T_S(s)$, the social efficient level of cognition cost only concerns with $T_S(s)$ and adjustment cost a, which is:

$$min_s[\rho(1-s)a + T_s(s)]\,. \tag{4.6}$$

Therefore, the social efficient level of cognition $\bar{s}$ is:

$$T_S'(\bar{s}) = \rho a. \tag{4.7}$$

(2) Cognitive effort by the contractor

Design-build contract is a lump-sum contract, so cost of the contractor's cognitive effort is also included in contract price, it is likely that the contractor may choose to trade even when having learned nothing. His profit solves as

$$p_0 - T_S(s) - c - \rho(1-s)a.$$

Since the contractor acts as a self-profit maximizer, the above formula turns to be

$$max_b[p_0 - T_S(s) - c - \rho(1-s)a].$$

We can get the contractor's marginal cognitive cost

$$T_S'(s^*) = \rho a. \tag{4.8}$$

As a result, under the situation of design-build contract, social efficiency can be achieved when only the contractor is able to exert cognitive effort. Because of lump-sum contract mode, adjustment cost due to design change has been endogenized by the contractor. In addition, there is no opportunity for opportunistic behaviors, so extra cost of h can be saved which is also a main factor of the achievement of first-best.

Proposition 4:

Under the situation of design-build contract model, social efficiency level can always be achieved since there is no occurrence of opportunistic behaviors and design change risk is burdened by the contractor.

4.3.4 Summary of results

To summarize, when only one party is able to exert cognitive effort, in the case of conventional contract, under the situation of well-behaved contracting party, social efficiency can always be achieved through impartial contract variation. Moreover, in the situation of design-build contract, as a result of fixed price, the contractor has to undertake all the risks that generated during construction period, social efficiency level of cognitive effort may also be achieved. The reason is that the behavior agent of cognitive effort in both contract modes is in full charge of design change risk which means that adjustment cost due to design change is endogenized. Therefore, no opportunistic behaviors will take place.

However, in the case of conventional contract, when the contracting parties behave strategically, inefficiency investment by the client is inevitable. When the client behaves strategically where expropriation of the compensation of adjustment cost occurs, it results in underinvestment of cognitive effort. This can be considered as a kind of transfer of design change risk to the contractor due to ex ante unawareness by the client. In other word, since there is no need for the client to be fully responsible for his unawareness, underinvestment of ex ante cognitive effort is conceivable. On the other side, when the hold-up behavior is taken by the contractor where the client may suffer

losses due to design change since renegotiation may be conducted by the contractor instead of contract variation. Under such situation, contrary to the results of the previous case, overinvestment of cognitive effort exerted by the client will take place. Because the client wants to avoid the losses due to being held up, he will exert more cognitive effort ex ante in order to reduce the possibility of occurrence of design change.

4.4 Comparative analysis between conventional contract and design-build contract

Analysis in the previous sections clearly demonstrate that when the strategic behaviours taken by the contracting parties is difficult to be avoided, under the situation of conventional contract where only the client is able to exert cognitive effort for investigation of initial design, the social efficiency cannot be achieved due to the additional losses arisen during the design change process. On the other hand, when the design-change contract is applied, since the contractor is responsible for both design and construction work, negative effects brought by design change can be contained from the source and therefore the social efficiency level of cognitive effort can be achieved.

However, the results of the above analysis are derived from their respective context. In order to identify the effective party in terms of investment of cognitive effort, that is, which type of the contract may bring more social welfare, comparative analysis between these two types of contract should be conducted within the same context.

4.4.1 Comparison of social welfare

According to the analysis in the above sections, the social efficiency level of cognitive effort is derived by minimizing the total cost of both adjustment cost and transaction cost of cognition in both situations. Therefore, the situation of conventional contract is described by formula (4.1) and the situation of design-build contract is represented by formula (4.6).

Accordingly, the social marginal cost under the situation of conventional contract is as follows which is represented by $V_B'(b)$

$$V_B'(b) = T_B'(b) - \rho a. \tag{4.9}$$

And similarly, the social marginal cost under the situation of design-build contract is therefore,

$$V_S'(s) = T_S'(s) - \rho a. \tag{4.10}$$

Moreover, we had already figured out the marginal cognitive cost under the equilibrium of both contract types where $T_B'(b^*)$ is denoted by formula (4.5) where the amount of h could be both positive and negative: $h < a\ but\ \neq 0$. And similarly, the

equilibrium level of marginal cognitive cost of the contract under the situation of design-build contract is calculated by formula (4.8)

With the above conditions, social marginal cost can be transformed by plugging corresponding formula respectively. Therefore,

$$V_B'(b^*) = \rho a - \rho h[1 - \hat{\rho}(b^*)] - \rho a$$

$$= -\rho h[1 - \hat{\rho}(b^*)] \; where \; h < a \; but \; h \neq 0. \tag{4.11}$$

And

$$V_S'(s^*) = \rho a - \rho a$$

$$= 0. \tag{4.12}$$

The results show that social marginal cost under the situation of design-build contract where the cognitive effort is exerted by the contractor is 0. On the other hand, the amount of $V_B'(b^*)$ is impossible to be 0 to some extent and the determinant of its plus minus is also closely related to the signature of h.

4.4.2 Comparative results and discussion

By introducing the cognitive effort for initial design, it becomes a determining factor of possibility of design change occurrence ex post. If the cognitive effort exerted by contracting parties is efficient, in addition to the optimal trade-off between additional cost and cognition cost, the total cost of the construction project can also come to an ideal state.

Under the situation of conventional contract, since the client is most concerned with the utility of construction project, the cognitive effort level will be chosen to maximize his utility which is derived as formula (4.5). However, if design change ex post takes place where gives chances to some strategic behaviours, it is hard for the client to exert efficient level of cognitive effort either because lack of incentive or he is afraid of being held-up. Therefore, it is thinkable that such results may naturally have an effect on the total cost of the project. As the formula (4.9) shown, when the client is the actor of strategic behaviour, then due to his slackness where h serves as a positive value, insufficient cognitive effort has been exerted. Accordingly, under such situation, social marginal cost is negative which means that the total cost on the social level is decreasing with the increase of the client's cognitive effort. In other words, the total cost should have been lowered if the initial design can be taken more seriously by the client. Another case is that the client is held up by the contractor where the amount of h is less than zero. Similarly, the social marginal cost conversely turns to be positive. Due to self-protection awareness of the client, excessive investment of cognition has caused a lot of unnecessary costs. So, in summary, it is hard to say that the conventional contract could produce high social efficiency.

On the other hand, since the contractor is in full charge of the design and construction

work, if the design change due to technical issue takes place, the contractor has to take this responsibility. Therefore, no contract variation or even renegotiation will be incurred which guarantees the efficiency of the contractor's cognitive effort investment. As shown in formula (4.10), social marginal cost is 0 in this case. This would imply that the increase in any unit of cognitive effort will not cause any change in total cost. That is to say, the current situation is the most ideal one where profit maximization can be obtained.

For the possible reasons, in addition to the one that there is no contract variation since the contractor is fully obligated to the risk of design change, the capacity of the client is also considerable. In-house engineer was a common existence as technical consultant on the side of the client. However, currently, in order to reduce the cost, in-house engineers are steadily decreased and even being abolished. Accordingly, the design capacity of the client will also be reduced. Moreover, due to the high incompleteness of construction project caused by the complex external and internal environment, the client may have no sufficient ability to determine what kind of the design is exactly the appropriate one. From this point of view, rather than the client, the contractor may be more efficient in design work. Consequently, in the case where the factors such as technical capabilities, cognitive abilities and costs of both contracting parties are the same, design-build contract is preferable than conventional contract. The conclusion also conforms to the original intention of introducing the design-build contract.

In conclusion, the comparative analysis makes it clear that the design-build contract may be more efficiency in solving the inefficiency caused by the design change ex post.

4.5 Results and discussion

4.5.1 Results

This research follows Tirole's idea of the introduction of cognitive effort and analyses the situation of design change in construction field where the contract variation rule cannot be perfectly enforced. Because of bounded rational of human being, it is quite difficult for contracting parties to aware the appropriate design before contracting, due to such cognitive limitations, design change is normally observed in construction projects. In addition, as people may be aware of their cognitive limitations, they may exert themselves to find the appropriate design. Nevertheless, if the initial design is likely to be inappropriate, the variation of contract due to design change also probably occurs where the contract is regarded to be incomplete. In addition, since adjustment cost due to design change is always coincident with contract variation and has to be determined by contracting parties, this may also give rise to the opportunistic behaviors of contracting parties.

Under the situation of one-sided cognition where only the client is able to exert cognitive effort which is consistent with conventional contract, it shows that when the

engineer is neutral, both adjustment cost and effort costs can be internalized, the social efficiency level of cognitive effort can always be achieved. However, when the engineer behaves unneutrally as actual situation, due to the imperfect enforceability of contract variation where verification cost for the contractor is not free, strategic behaviour will be probably taken by the client, under-investment of cognitive effort will always take place. On the other hand, since hold-up behaviour taken by the contractor is also conceivable in construction project where there is no enforceability of contract variation rule, in this case, over-investment of cognitive effort will be made by the client since he intends to prevent himself from being held up. By contrast, in the case of design-build contract where only the contractor needs to exert cognitive effort, since the contractor is responsible for the design change risk within lump-sum framework, social efficiency level of cognitive effort is able to be achieved. Moreover, through comparative analysis in terms of total construction cost from the perspective of social benefits, the result shows that both of the two contract types are efficient while design-build contract performs better in solving the inefficiency caused by the design change ex post.

Although the modelling in this study has been made on the basis of Tirole's work, such contextualization has not been applied in the construction field for investigate the optimal contract scheme in dealing with design change issue, since the construction contract is specially featured which is different with other business contract types. Therefore, this research can be regarded as novelty by interpreting the concept of cognition within the field of construction contract.

4.5.2 Application of Early Contractor Involvement

It has been verified in this study design-change contract plays an effective role in dealing with the issue of design change since it enables the contractor to take full charge of the design change risk. However, there are still some critical voices that although the design and construction collective ordering method was used to unify responsibility for design and construction, there is criticism that the risks are excessively transferred to the contractor[32]. Moreover, the contractor's opportunistic behavior such as cheating on workmanship and materials due to egoism are equally worrying.

In addition, since the capabilities of both contracting parties are different as defined in this study, the client may be better to understand his needs while the contractor is more advantaged in terms of technical and practical experience. However, for a successful construction project, these two aspects are indispensable for an appropriate initial design due to incompleteness of construction contract. Therefore, a mechanism for initial design which could involve cognitive effort of both contracting parties is considered to be desirable.

It is acknowledged that New Engineering Contract (short for NEC) [34] for construction work is rapidly spreading in the UK and it has been implemented successfully. Different

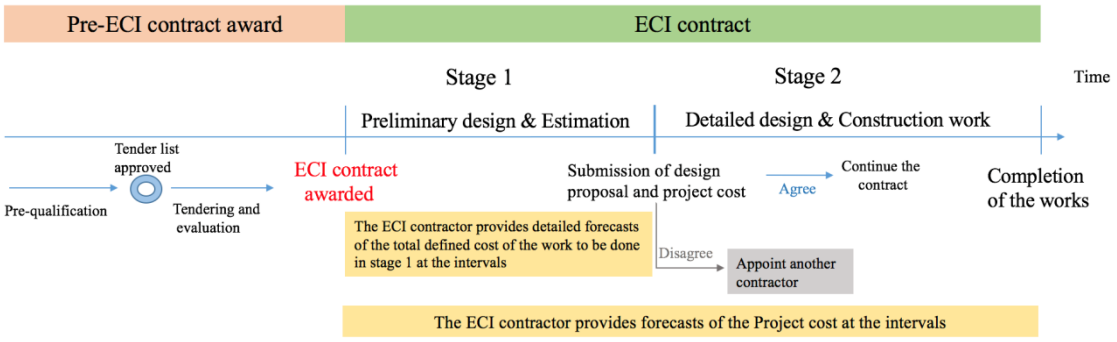

Figure 4.7 Timeline of Early Contractor Involvement
(Adopted from High Speed Two (HS2) Limited (2014)[38])

from the FIDIC form which is widely used as a standard contract form in international construction project recently, NEC emphasizes partnering between contracting parties and there are also some special provisions are stipulated. In order to solve the divergence between conventional contract and design-build contract and so as the negative effects brought by the design-build contract, Early Contractor Involvement (ECI)[35] has been introduced and considered to be one of the effective methods which can incorporate contractor's construction knowledge into design process[36),37]. It was introduced with the aim of constructing a strong team of contracting parties[32]. According to the early contractor involvement clauses published by NEC[35], it allows the contractor to be appointed before details of what is to be constructed have been fully developed and priced which enables the contractor to take part in the design development and construction planning stage of a project. ECI approach supports improved team working, innovation and planning and is widely recognized as beneficial. As shown in the **Figure 4.7**, the ECI contractor is selected through pre-qualification process. After an ECI contract has been awarded, the contractor has to cooperate with the client for preliminary design work and get paid for his cognitive effort in form of progress payment. At the end of stage 1, the contractor has to submit his design proposal and estimation of the cost of construction work in accordance with the initial design. When contracting parties can reach an agreement on it, then the contractor may continue his construction work in next stage without secondary tender process which is considered to be effective since it saves time.

Although in both design-build contract and ECI contract, the contractor is allowed to participate in design stage, there are mainly two essential differences between them. The first one is contract price. In design-build mode, lump-sum contract is normally used and contract price has been decided at the time of contract conclusion. Therefore, within the contracted budget, in addition to the cost of design investigation and construction cost, the contractor has to burden all the risks during construction period.

For the ECI contract, contract price of stage 1 will not be determined when concluding the contract since the payment of the cost of contractor's cognition work is made

monthly by the client instead. In addition, unlike design-build contract, before entering stage 2, contracting parties have to estimate a target cost of construction work. After completion of construction work, the difference between the target cost and actual cost are shared by both sides. In brief, even though contractor's cognitive cost is paid by the client in both contracting mode, since the price is fixed in design-build contract, the degree of cognitive effort that the contractor can make is also constrained. While in ECI contract, the contractor is paid according to his workload, although there is upper limit of payment, the contractor's effort will be easier to play its role. Another difference is behavioral subject of cognitive effort. In design-build contract, the contractor has to take full charge of design work. During the bidding process, he has to exert his cognitive effort in making design proposal in order to win project bid. In this case, the only work for the client is to publish information on specifications, budget and evaluate of bids, so only the contractor needs to exert cognitive effort in design-build mode. On the other hand, since ECI contract emphasizes teamwork and cooperation between contracting parties and the contractor is involved when details of what is to be constructed have been fully developed and priced, the client and the contractor have to work together for designing.

4.5.3 Limitations

This research is no more than a theoretical demonstration of the endogenous of the incompleteness of incomplete contract by introducing cognitive effort under the situation of design change. In order to simplify the analysis, we did not take discount ratio and bargaining power of contracting parties into consideration. Moreover, this research follows the dispute resolution process stipulated in FIDIC form. However, in order to cater to the domestic market environment, domestic standard contract terms have been developed as a model of construction con-tract concluded in many countries. A country's standard contract terms are normally applied to the general construction work intended for the domestic construction market, so the standard contract terms of individual countries may not be the same with that in other countries.

For the comparative analysis part, conclusions are drawn only by comparing the social marginal cost. However, due to the different field of cognitive efforts exerted by contracting parties, for the degree of cognitive effort, it is a little far-fetched to put them in the same sense to judge the significance of them. Since b and s are affected by various complicated factors such as capacity of both parties, although it should be considered, the examination of the relationship between them goes beyond the scope of this particular study.

4.6 Conclusion

As an important part of social development, the efficiency of construction project, especially infrastructure has attracted more and more attention. However, due to

bounded rational of human being, contract variations caused by inappropriate initial design are commonly observed which may bring a lot of unnecessary losses and result in inefficiency investment. As a fundamental link of the whole project lifecycle, efficiency improvement which starts from reducing negative effects brought by inappropriateness of initial design is considerable.

This research follows Tirole (2009)[9)]'s work of the introduction of cognitive effort for initial design and takes it into the field of construction contract. It firstly verifies the incentive on exerting cognitive effort of contracting parties under the situation of both conventional contract and design-change contract through one-side cognition modelling. And then it makes a comparative analysis between the both contract forms in order to examine the optimal contract type in solving the issue of inefficiency due to ex post design change. The result shows that, in the context of imperfect enforceability of contract variation rule, under the situation of conventional contract where only the client is able to exert cognitive effort, when the engineer plays a neutral role, the cognitive level of the client can reach social efficiency level since there is no existence of opportunistic behaviour. However, if the engineer behaves unneutrally which gives the chance of strategic behaviour during design change procedure, it is impossible for the client to exert cognitive effort with the degree of social efficiency. When the verification cost expended by the contractor during contract variation process turns to be more and more expensive, there will generate the chance of the client's strategic behavior. In this case, then underinvestment will take place. Since some of the adjustment cost of ex post design change will be transferred to the contractor, there is no incentive for the client to exert sufficient cognitive effort. Conversely, in the case of being held up where non-enforceability of contract variation rule, the situation turns to be overinvestment for avoiding risk.

Under the situation of design-build contract, since the contractor is in full charge of design and construction work, when the initial design is inappropriate, he has to be responsible for such risk so as the adjustment cost. Therefore, thanks to the no existence of contract variation, no strategic behaviour will be taken and social efficiency level of cognitive effort can be achieved by the contractor. Moreover, through comparative analysis, it is also found that the design-build contract indeed plays an effective role in improving the utility of construction project.

However, this research mainly focuses on one-sided cognition by either the client or the contractor in two types of construction contract. When taking Early Contractor Involvement into consideration, in order to clarify its performance in dealing with the inefficiency issue caused by design change, analysis on two-sided cognition is necessary which can be regarded as further research.

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5. The structure of governance for construction contract in China: based on the comparative study with FIDIC form

5.1 Introduction

As symbolized by the establishment of AIIB (Asian Infrastructure Investment Bank), China has been playing a significant role in international infrastructure projects. In order to make contributions to the overseas infrastructure project, it is necessary for Japanese construction companies to focus and expand the business in China. Hence, for the coming era, Japanese contractors may be required to accumulate the knowledge on the Chinese style of construction contracting governance as a background of the extensive role of Chinese contractors in international markets for infrastructure development.

In many countries, standard contract terms have been formulated as a model of construction contract concluded between the employer and the contractor for public construction projects. A country's standard contract terms are normally applied to the general construction work intended for the domestic construction market, so the standard contract terms of individual countries may not be the same with that in other countries. For example, Omoto et al. (2001)[1)] have compared Japanese construction contract (GCW)[2)] with Federation Internationale Des Ingeniers Conseils (FIDIC)[3)], the results show that there are essential differences between two contracts in term of contract variation rules. And they also point out that the cause of such difference is whether there is good faith between the contracting parties. Accordingly, same situations may also exist in the other countries, in many cases, standard contract terms reflect the contractual customs that have been historically developed in the country. As claimed by Aoki (2001)[4)], the existence of institutional diversity in such contractual customs makes the content of standard contract terms different from countries and regions.

Generally speaking, there is a tendency that along with the internationalization of the construction market, transaction opportunities for overseas construction projects will gradually increase through the formation of joint venture with foreign construction companies. In overseas construction projects, there are cases of applying the local standard contract form as a construction project contract since conforming the local contractual customs is considered to be more efficient.

This study takes Chinese construction Contract for Construction Project Model Form (hereafter called Chinese Construction Contract)[5)] as the research object and reveals the structure of contractual customs in Chinese construction market. Meanwhile, in order to reveal the characteristics of Chinese construction contract and its contractual customs, this study takes FIDIC form which is widely used in international construction projects as the benchmark of comparative analysis. FIDIC form is based on the opinions of

experienced experts in International Consulting Engineer Federation. It was published in 1999 and has been widely used in internationally. China has also accelerated the international standardization process of construction contract after joined the WTO. The first edition of Chinese Construction Contract was published in 1999 and released a new revised edition in 2013, which is regarded as legitimacy in the Chinese construction industry. However, there still remain discussions on the irrationality of Chinese construction contract in China.

In view of the comparative institutional analysis, institution can be considered as the shared beliefs of the way that people behave in society. Social system is a mixture of institutions. Each institution is not independent but functions to strengthen the effectiveness of each other. Such complementary and dependent relationship among variety of institutions is one of the causes which form the steady institutional system. For the particularity of Chinese Construction contract (if it exists), it can be interpreted that Chinese construction contract reflects the institutional complementarily and contractual customs in Chinese construction market.

By comparing the risk sharing rules of FIDIC form and Chinese construction contract, this study investigates and analyzes the differences between the two contract forms. In addition, by analyzing the essential differences between the two contracts, it points out that FIDIC form may not effectively play its role in China. Moreover, this study also theoretically indicates that there is institutional complementarily between contracting parties in China, which is different from the international contract environment.

The rest of this paper is organized as follows. In order to show the basic philosophy of this study, section 5.2 summarizes the theoretical background on relations between contract mechanism and its basic structure, contract rules and business practice. In section 5.3 to section 5.5, we analyze the differences in contract rules between Chinese construction contract and FIDIC form. Section 3 focuses on risk sharing rules of exogenous risk. Section 5.4 analyzes the differences in contract variation rules while section 5.5 verifies the differences in dispute settlement rules. In section 5.6, we sum up the essential differences between the two contracts and discuss the theoretical background of those differences. The last section 5.7 summarizes the results of this study and envisages the future research direction.

5.2 Methodology

5.2.1 Literature review

One of the basic functions of contract is to allocate profits or expenses when contingencies take place[6]. Law, economics, and engineering management field have accumulated a lot of insights on normative principle of allocating the extra cost due to the occurrence of the risk events between subjects of the contract[7), 8)]. Omoto et al. (2001)[1)] has summarized the risk-sharing principle of construction contract on the basis

of the accumulative research results of normative principle of risk sharing. According to normative principle of risk sharing, risk sharing rule should be decided with the considerations of risk-bearing capacity and risk management capacity of contracting parties. Accordingly, for the sake of establishing the specific methodology of risk sharing analysis, the concept of risk sharing based on quantitative method has been presented[9].

Omoto et al. (2001)[1] have pointed out that the construction contract is a typical incomplete contract[10)-12)] composed of the risk-sharing rule, contract variation rule and dispute resolution rule. Moreover, from this point of view, comparative analysis between international standard contract FIDIC form and Japanese standard contract GCW has been conducted. It indicates that there is no essential difference between the two contracts in accordance with sharing risk principle. However, for application of risk sharing rules in the field, it reflects the Japanese contractual customs are premised on the existence of good faith where generates a considerable difference between these two contracts. On the other hand, Chinese academics have accumulated a lot of researches on the characteristics of Chinese construction contract. Liang (2012)[13] states that the contractual governance and relational governance are both indispensable parts in the governance structure of construction projects in China. Su et al. (2013)[14] discuss the characteristics and main achievements of the Chinese construction contract 2013 version. Lou et al. (2016) [15] point out that Chinese construction contract 2013 version can improve contract flexibility from the perspective of grounded theory[16]. In addition, Lu et al. (2015)[17] indicate that there is complementarity in contractual governance and relational governance in China. It will improve the performance of the construction project when both governance mechanisms function in harmony. However, on the other hand, none of these previous studies was based on the support of theoretical background and in-depth comparative analysis with the international standard contract terms. The creativity of this paper is that this study is basing on the theory of incomplete contracts, and clearly analyzes the characteristics of Chinese construction contracts through comparative study with FIDIC form.

5.2.2 The structure of construction contract

In order to give perspective of comparative analysis, this part will firstly reveal the structure of construction contract from the standpoint of incomplete contract theory. From an economic point of view, the contract can be considered as a kind of agreement, which is a bilateral commitment to the actions of the two parties[18]. That is to say, the contract is a kind of rule formed by consensus between the two sides. When a certain transaction time is required, a variety of contingencies may occur from contract conclusion to implementation. Cooter and Ulen (1988)[6] insists that due to the transaction time from contract conclusion to implementation, 1) responsibility assignment of contingencies between the contracting parties, and 2) improvement of information exchange should be regarded as important issues. In terms of construction

contract, Flaganan and Norman (1993)[19] point out that the important function of the contract is 'account for all of the risk factors that may occur during the execution of the project and the method of sharing the resulting losses'. In other words, the fundamental role of the contract is to jointly confirm the preconceived risk events, and reach a consensus on risk sharing method of each risk event.

There is a wide range of risks existing in construction projects. It includes natural factors such as geological conditions and weather as well as socio-economic factors such as material and labor costs. However, even if the causes of risk factors can be enumerated, it is impossible for the contract to describe all matters that may occur in the future. Such contract which cannot specifically describe all the contingencies that may arise in the future is called incomplete contract[10)-12)]. In incomplete contract, when contingency takes place, after observing the generated result, contracting parties have no choice but revise the contract content by renegotiation. In this case, it is necessary to determine the rule of contract variation. According to Clause 13 in FIDIC form, each variation may include changes to the quantities, quality and other characteristics of any item of work, changes to the levels, positions and/or dimensions of any part of the works, omission of any work or any additional work, changes to the sequence or timing of the execution of the works.

Incomplete contract theory has been gradually developed by the starting point of Grossman and Hart (1986)[20] and has also accumulated findings of desirable contract design and institutional design on the premise of incomplete contract. Based on the incomplete contract theory, when the contingency occurs, contracting parties have to determine the terms of revised contract by ex post renegotiation. In the process of renegotiation, the parties may take advantages of position changes or information asymmetry to redistribute the project surplus decided in the initial contract. When the parties believe that the initial contract is likely to be modified ex post, in order to ensure the bargaining power of renegotiation, they will try to suppress the investment in the early stages of the project. Such underinvestment is known as the hold-up problem. Therefore, in incomplete contract, contract variation rules which can inhibit hold-up problem are indispensable.

Generally, contract variation is based on consensuses reached by contracting parties. In the case of construction contract, since project contracts do not allow cancellation offered by the contractor, if it is difficult for two parties to reach a consensus with regard to contract variation, then it is necessary to provide a mechanism for resolving disputes between the contracting parties. This mechanism is known as dispute settlement rule.

Consequently, as a typical incomplete contract, risk sharing rule, contract variation rule and dispute settlement rule are necessary to construction contract. Any construction contracts have to be equipped with the above three rules. However, specific desirable rules are different in various countries and regions. Theoretical background of the generation of such diversity will be discussed in the following section.

5.2.3 Overview of Chinese Construction Contract

Chinese legal system belongs to civil law system. Construction contract originally belonged to the typical work contracts. After that, the Chinese Contract Law has positioned the construction contract as an independent typical contract. Chinese Contract Law Article 269 defines construction contract as 'an agreement that the contractor completes project construction work, where the employer pays the price'. It includes engineering survey, design and engineering construction contract. In the Chinese civil law, construction contract is treated as a typical kind of contract which is different from general work contract. However, there is a strong correlation between the construction contract and work contract. Under Article 287 of Chinese Contract Law, if there are no relevant provisions in construction contract, the relevant provisions of the work contract can be taken as references. Therefore, the construction contract is also considered to be a kind of work contract. Not only civil law, building law and bidding law also explicitly stipulates legal rules of construction contract such as characteristics of construction contract, method of concluding the contract, bidding process and supervision system.

Chinese construction contract was issued in 1991, as a construction contract model text formulated by the National Ministry of Construction and Industry and Business Administration Bureau. In the market economy, especially after joining the WTO, Chinese construction market has developed rapidly. Against this background, from 1997, old contract terms had begun to be amended. A new construction contract has been implemented in 1999. In addition, a series of regulatory laws and regulations and construction contract including survey, design contract were also established. In 2013, based on relevant laws and regulations, Ministry of Housing Urban-Rural Development and State Administration for Industry and Commerce took current situation and the international convention of the construction field into account and formulated Construction Contract for Construction Projects (Model text) which has been widely used in China.

However, the use of Chinese construction contract is optional. It is just a model which stipulates obligations and rights of contracting parties in the form of integrating relevant laws and regulations[21)]. Therefore, as long as the parties reach a consensus, they can also sign a contract without regarding the model text. In other words, the role of Chinese construction contract is to provide a reference point for both parties to seek for common ground. However, Since Chinese construction contract covers a wide range of laws and regulations, once the agreement violates these laws and regulations, and then the contract will be null and void. Thus, the room for contracting party to establish an agreement autonomously is relatively small[22)]. In reality, cases that the agreement divorcing from Chinese construction contract may rarely occurs.

5.2.4 Theoretical background of comparative analysis

The function of contract is rule-making in order to adjust the interests in the trading of

goods and services and restrain the opportunistic behavior of the contracting parties. The agreed rules shall be abided by the parties to the contract. However, if either party fails to comply with rules, eventually it will be enforced through the courts. In other words, the effective role of contract that regulates the behavior of both parties is guaranteed by legal binding force brought by the third-party, such as court or arbitration organization.

Contract expressly provides the content of the agreement between the parties. If the contract is not abided, the rights are also able to be protected by the force of the third party. When the enforcement function of the law can make its role, the opportunistic behavior of the contract parties can be restrained by contract rules.

However, in the case of repeated transactions between the contracting parties, if any party takes the opportunistic behavior, then the other party may be able to punish them by refusing to cooperate in the next transaction. If repeated trading opportunities exist between the parties, even if there is no third party to enforce the contract, the effectiveness of the contract can also be safeguarded. The mechanism that ensures effectiveness of the contract may depend on the relationship between the contracting parties [4)].

The application environment of the FIDIC form is assumed to be international construction market. Especially in construction market for infrastructure, unlike domestic construction project, there is barely high transaction frequency between the employer and the contractor. So, the international construction market is based on the one-shot relationship between the two parties. In other words, the contracting parties may try their best to pursue the interests of the project without considering a long-term relationship. As a precondition of the standard contract subject under the international market environment, FIDIC form make regulations in order to restrain opportunistic behavior of the contract subject and establish effective order. However, the general situation of the domestic construction market is that it is conceivable for contractor to repeatedly sign projects contracts with the same public institution. The establishments of the trade relations between the employer and contractor may be consist with social norms shared in domestic market environment which is different from the rules of contracts and laws. Thus, in the domestic construction market, unlike one-shot relationship assumed in FIDIC form, transaction order can also be set up under different social norms. Under the situation of different social norms, the content of FIDIC form is not necessarily desirable. There may be different content of the contract.

5.3 Comparative analysis of risk sharing rule

5.3.1 Exogenous risk and risk sharing rule

Based on pioneer study conducted by Posner and Rosenfield (1977)[7)] and Omoto et al. (2001)[1)] , two risk sharing principles have been summarized. First, after evaluating the

Table 5.1 The comparison results of Chinese construction contract and FIDIC form

Risk event	RP	Chinese Construction Contract (2013)			FIDIC Red book (1999)		
		V	R	Relevant provisions	V	R	Relevant provisions
Changes of upper plan	2	△	△	7.5.1 Delay Caused by the Employer 7.8.1 Suspension of work caused by the Employer 10 Variation 16.1.2 Default of the Employer	○	P	8. Commencement, Delays and Suspension 8.5 Delays caused by Authorities 13.Variations and Adjustments 15. Termination by Employer 19.7 Release from Performance under the Law
Changes of laws	2	○	P	11.2 Adjustments for Changes in Legislation	○	P	13.7 Adjustment for Changes in Legislation 19.7 Release from Performance under the Law
Changes of taxation rules	2	○	P	11.2 Adjustments for Changes in Legislation	○	P	13.7 Adjustment for Changes in Legislation 14.1 Contract Price and Payment (b)
Approval and licenses	1	○	△	1.10.1 Right of access to the site 1.10.4 Transport of oversize and overweight parts 2.1 Permits or Approvals 16.3 Default caused by Third Party	○	△	8.5 Delays caused by Authorities
Change of cost	2	—	N/A	11.1 Adjustments for Price Fluctuation	×	A	13.8 Adjustments for changes in cost
Change of currency exchange rate	2	△	△	No provision for domestic use	△	△	14.5 Currencies of payment
Academic discovery	1	—	N/A	1.9 Fossil and Historical Relics	△	△	4.24 Fossils
Pollution	△	○	P	7.6 Adverse Physical Conditions 6.3 Environmental Protection	○	P	4.12 Unforeseeable Physical Conditions 4.18 Protection of the Environment
Protest	1	△	△	N/A	○	△	4.1 Contractor's General Obligations 17.3 Employer's Risks
Land acquisition	1	△	△	1.10.1 Right of access to the site 2.4 Provision of the Site, Facilitation and Basic Information	○	△	2.1 Right of Access to the Site
Natural catastrophes	2	△	△	17.3 Force Majeure	○	P	19 Force Majeure

(Continued)

Climatic conditions	2	—	N / A	7.7 Exceptionally Adverse Climatic Conditions 17.3 Force Majeure	○	P	8.4 Extension of Time for Completion (c)
War	2	○	P	17.3 Force Majeure	○	P	19 Force Majeure
General strike	2	△	△		△	△	19 Force Majeure
APC	1	△	△	7.6 Adverse Physical Conditions	△	△	4.12 Unforeseeable Physical Conditions
Contract documents	△	○	P	1.5 Priority of Contract Documents 1.6 Drawings and Contractor's Documents 1.13 Correction of Errors in the Bill of Quantities 2.4.4 Liability of overdue	○	P	1.5 Priority of Document 8.4 Extension of Time for Completion 13 Variation
Site data, survey information mistake provided by the Employer	1	○	P	1.6.2 Errors in drawings 1.10.1 Right of access to the site 3.4 Site Inspection by the Contractor	○	P	4.10 Site data 4.7 Setting out 13 Variation
Delay or errors of instructions and/or issuance of necessary documents including drawings and specifications	1	○	P	4.3 Instructions of the Engineer	○	P	1.9 Delayed Drawing or Instructions
Quantitative change and additions	1	○	P	10 Variation	○	P	13 Variation
Delay of payment	1	×	A	12 Contract Price, Measurement and Payment 14.4.2 Final Clearance Certificate and Payment	×	A	14.8 Delayed Payment
Bankruptcy (P)	1	×	△	16.1 Default by the Employer	×	△	16.2 Termination by Contractor
Building damage	1	×	A	3.6 Care of the Works and Protection of Finished and Semi-finished Works	×	A	4.1 Contractor's General Obligations
Performance and quality	1	×	A	5 Quality of Work	×	A	4.1 Contractor's General Obligations
Defect liability	1	×	△	3.1 Contractor's General Obligations 15. Defects Liability and Quality Warranty	×	△	4.1 Contractor's General Obligations 11. Defects liability
Management	1	×	A	3.1 Contractor's General Obligations	×	A	4.1 Contractor's General Obligations
Other facility damage & third party damage	1	△	△	3.1 Contractor's General Obligations	○	P	4. 1 Contractor's General Obligations 17.1 Indemnities

(Continued)

Labor accidents	1	◯	P	3.1 Contractor's General Obligations 6.2.1 labor protection	◯	P	4.1 Contractor's General Obligations 17.1 Indemnities
Funding	1	×	A	3.1 Contractor's General Obligations 16.2 Default by the Contractor	×	A	4.1 Contractor's General Obligations 15.2 Termination by Employer
Bankruptcy(A)	1	×	∆	16.2 Default by the Contractor	×	∆	15.2 Termination by Employer
Interference by other contractors	1	—	A	16.3 Default caused by Third Party	∆	∆	8.4 Extension of Time for Completion
Subcontractor bankruptcy	1	×	A	3.5 Subcontractors	×	A	4.4 Subcontractors
Copyright infringement	1	∆	∆	1.11 Intellectual Property	◯	∆	17.5 Intellectual and Industrial Property Rights

Note 1) "RP" shows the applicable risk sharing principle for each risk event. "1" is the first risk sharing principle, "2" is the second risk sharing principle. "∆" means depending on risk event.

Note 2) "V" shows whether or not contract variation is permitted. "○" means permission. "×" means unpermitted. "—" means that there is no specific prevision. "∆" means depending on risk event.

Note 3) "R" shows the risk-taking party. "P" is the client while "A" is the contractor. "—" means that there is no specific prevision. "∆" means depending on risk event.

size and occurrence probability of the risk, the party who can assess or control the risk should bear it. This is called the first risk sharing principle. Second, if neither of the parties can assess or control the risk, the party who can bears it easier or procure the insurance from market should bear it. This is called the principle of risk-sharing second. Especially, in the case that the employer is a public sector, it has usually more capability for bearing the risk and is expected to play the role as a deep pocket.

Table 5.1 shows the comparison results of Chinese construction contract and FIDIC form. It includes risk sharing rules for main risk matters, contract variation rules, and applicable risk sharing principle. According to **Table 5.1**, it is found that risk sharing rules of both forms are in accordance with the risk sharing principles. However, there are also some risks specified in FIDIC form as the employer's risk but not expressly stated in Chinese construction contract. This will be discussed in the next section.

5.3.2 Differences of risk sharing rules

Through comparative analysis between FIDIC and Chinese construction contract, some difference in risk sharing rules between both forms are found as follows.

1) Approval and licenses

Approval and licenses risk is the occurrences of unplanned situations during approval

procedure of project implementation caused by the government. It may arise from both the employer such as delay caused by authorities and contractor such as delay in obtaining approval application.

According to Clause 2.2 and 4.13 in FIDIC form, the responsibility for obtaining the relevant approval and license belongs to contractor, while the employer shall provide reasonable assistance to the contractor at the request of the contractor. If the risk is caused by authorities, then, under the Clause 8.5, the contractor can entitle extension of time. In addition, there is no statement about the compensation of the associated cost because it would depend upon the particular circumstances.

In Chinese construction contract, the responsibility of approval and licenses should be taken by both the employer and contractor. For example, in the clauses of 1.10.1, the employer has to obtain the approvals required for the construction work carried out in the field. Clause 2.1 also provides that the employer shall abide by the law and take the responsibility of obtaining relevant approvals and permits required by administration. On the other hand, the Clause 1.10.1 also clearly states that the contractor is obliged to give the employer necessary assistance. Clause 1.10.4 specifies that the contractor is responsible for the transport of oversize or overweight parts and applying approval from the traffic management department. The employer is also obliged to provide the necessary assistance.

However, if the delay of those approval and license is caused by authorities and has led to additional cost and delay, since Clause 2.1 clearly recognizes that the responsibility of this risk belongs to the employer, according to Clause 7.5.1, the contractor can entitle extension of time and compensation of additional cost. Therefore, in FIDIC form, the compensation of additional costs is determined case by case while Chinese construction contract clearly expresses the claim right of additional cost. However, if the risk is caused by a third party, then according to Clause 16.3 Default caused by Third Party in Chinese construction contract is applicable to this case. The risk sharing rules of risk caused by the third party will be described detailedly in following section d). During execution of contract, even if the breach of contract is caused by the third party, the contractor has to in charge of liability for damages. Disputes between the contractor and the third party shall be settled in accordance with the law or their agreement. Thus, in the case that Clause 16.3 is applicable, when the risk consequence has been identified as breach of contract, it must be borne by the responsible party.

2) Force majeure

Force majeure risk is the risk events such as earthquake, flood, weather, war or terrorism which cannot be assessed or controlled by both contracting parties. Therefore, normative risk sharing rules of force majeure should be based on the second risk sharing principle. According to the principle of risk sharing, it is desirable for the force majeure risk to be hedge by the market insurance, or taken by the employer as deep pocket [1)].

In both FIDIC form and Chinese construction contract, contractor has the right to claim for extension of time or terminate the contract at the time of the occurrence of

force majeure risk. It means that the employer shall shoulder the force majeure risk. Clause 19 of FIDIC form stipulates that the employer is responsible for the delays and additional cost caused by the event of force majeure other than natural disasters. For natural disasters, contractor also shall bear part of the additional cost according to the FIDIC form. The impact of natural disasters can be reduced through the pre-disaster prevention training. Bearing part of losses by the contractor can effectively encourage the contractor to take appropriate measures for disaster prevention.

On the other hand, the Clause 17.3 of Chinese construction contract stipulates that casualties, property losses and additional cost and other consequences caused by the force majeure should be borne by the parties in accordance with the law and the contract agreement. Specifically, the permanent works, the damage of materials and engineering equipment which have been transported to the construction site, and casualties of third party, property losses caused by the damage of the project should be borne by the employer. The contractor shall bear the damage to the contractor's construction equipment. The employer and the contractor shall bear the casualties and losses of their respective personnel and property. If the contractor requires to stop work or to terminate the contract, the losses are borne by both the employer and the contractor.

3) Change of upper planning

Upper planning risk refers to the change of circumstances resulting from the change of the higher-level plan such as the government policy or the city plan. The upper planning risk is beyond the responsibility of the employer, and it is difficult to control for both contracting parties, so it is applicable to the second principles of risk sharing. Therefore, the employer shall bear the risk. Common law system regards the upper planning risk as force majeure risk[23)]. In FIDIC form, which is based on the common law system, according to the Clause 19.7 and 8.5, contractor can entitle contract variation or compensation of additional cost, and it also clarifies the risk-taking responsibility of the employer.

On the other hand, there is no risk sharing rule for the upper planning risk in Chinese construction contract. However, according to the Clause 7.5.1 Delay caused by the Employer (Clause 7.8.1 Suspension caused by the Employer), if delay and suspension of work is considered to be caused by the employer, then the employer should bear the risk. When change of the upper plan is considered to be caused by the delay of the employer, the risk shall be borne by the employer in accordance with the provisions of this clause.

4) Interference by other contractors

In the construction project, the situation that a number of contractors carry out the construction at the same time is very common. As a result, there is a risk of delay or additional costs due to interference or obstruction by the other contractors. In this case, the contractor has the right to claim for the extension of time according to the Clause 8.4 of FIDIC form. However, there is no relevant provision that which contracting party

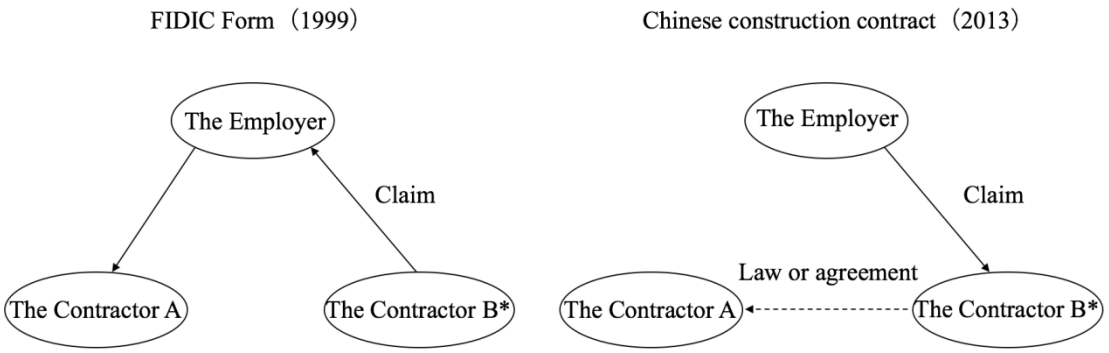

Figure 5.1 The structure of the risk sharing of interference of other contractors' risk

should bear the additional cost caused by this risk. Clause 3.1 Contractor's General Obligations of Chinese construction contract stipulates that the contractor shall not interfere with the work of the other contractors, and has the obligation to provide convenience for others. When the risk caused by the interference of the other contractors occurs, compensation may be made in respect of the losses caused by the risk according to the Clause 16.3 Default caused by Third Party. Clause 16.3 stipulates that during the execution of contract, if a party breaches the contract due to the third party, the party has to be liable for breach of contract to the other party. The dispute between this party and the third party shall be settled in accordance with the law or agreement.

Figure 5.1 shows the structure of the risk sharing of this risk matter. The contractor A is the interfering party, and the contractor B is the disturbed party. The interference of contractor A leads contractor B to the breach of contract. FIDIC form and Chinese construction contract clearly indicate that the final loss should be borne by the interfering party. In FIDIC form, the employer makes the claim to the contractor A. But in China construction contract, the disturbed party contractor B claims the compensation to the interfering party.

The differences between the FIDIC form and Chinese construction contract in the risk sharing rules were described above. Since the two contracts generally follow the two principles of risk sharing, they both have certain rationality.

5.4 Comparative analysis of contract variation rule

5.4.1 Contract variation rule

Since construction contract is a typical incomplete contract, it is impossible to specify all the situations that may occur in the future in advance. Therefore, when the construction contract needs to be modified ex post, it is necessary to establish the rules

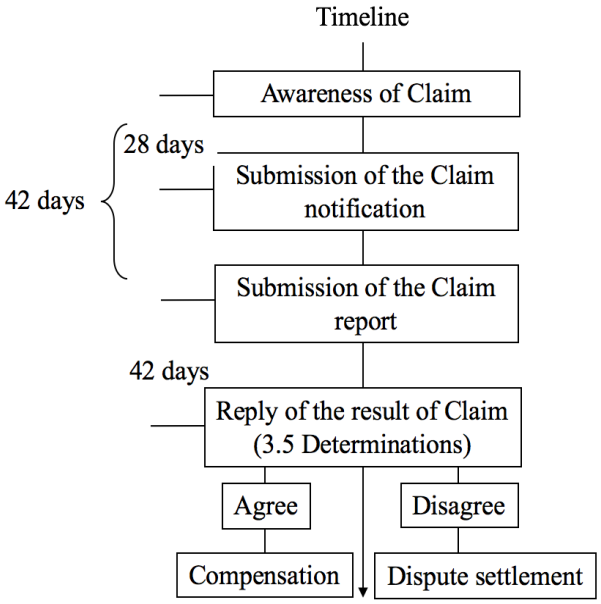

Figure 5.2 The contract variation rule of FIDIC form

to determine the content and process of variation. This is called contract variation rule. The design of contract variation rule should aims at reducing or avoiding the transaction cost caused by moral hazard and hold-up problem with the considerations of the opportunistic behaviors taken by contracting parties through contract variation. As discussed below, by comparing FIDIC form and Chinese construction contract, it is found that except the slight differences on the time limit, the two contracts have the same contract variation procedures.

5.4.2 Contract variation rule of FIDIC form

The contract variation rule of FIDIC form is shown in **Figure 5.2**. The procedure starts from the time-point when the contractor became aware, or should have become aware of the event or circumstance. According to the Clause 20.1 of FIDIC form, the contractor shall give notice to the engineer within 28 days after the awareness of the event. The notice should describe the event or circumstance giving rise to the claim. And within 42 days after the awareness, the contractor is required to submit a fully detailed claim report to the engineer. Within 42 days after receiving the claim report, the engineer shall respond with approval, or with disapproval and detailed comments. If both the employer and contractor agree with engineer's decision, contract can be modified with this content. If either or both parties disagree with the decision, then it will proceed to the dispute settlement. However, taking into account that the engineer is employed by the employer, the decision of the engineer, to a large extent, reflects the intention of the employer. Therefore, the party who often opposes engineer's decision is generally the

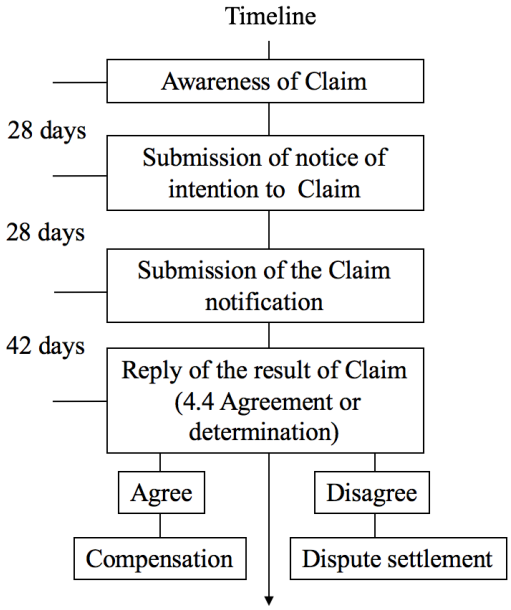

Figure 5.3 The contract variation rule of Chinese construction contract

contractor.

5.4.3 Contract variation rule of Chinese construction contract

Contract variation rule of Chinese construction contract is shown in **Figure 5.3**. There is no significant difference in the basic procedures with the FIDIC form. According to the Clause 23, the Contractor shall, within 28 days after become aware or have become aware the claim event, submit a notice of claim intention to the supervisor, which includes description of the event. Otherwise, the contractor will lose the right to ask for additional payment and (or) extension of time. The Contractor shall formally submit a claim report to the supervisor within 28 days after the notice of claim intention. The claim report shall specify in detail the reasons for the claim and the amount of payment and (or) extension of the time, and the necessary records and certificates should be also attached. Within 42 days after receiving the claim report made by the contractor, the supervisor has to respond to the contractor with the results of the claims according to Clause 4.4. If the contractor does not accept the results of the claim, the dispute should be resolved in accordance with Clause 20.

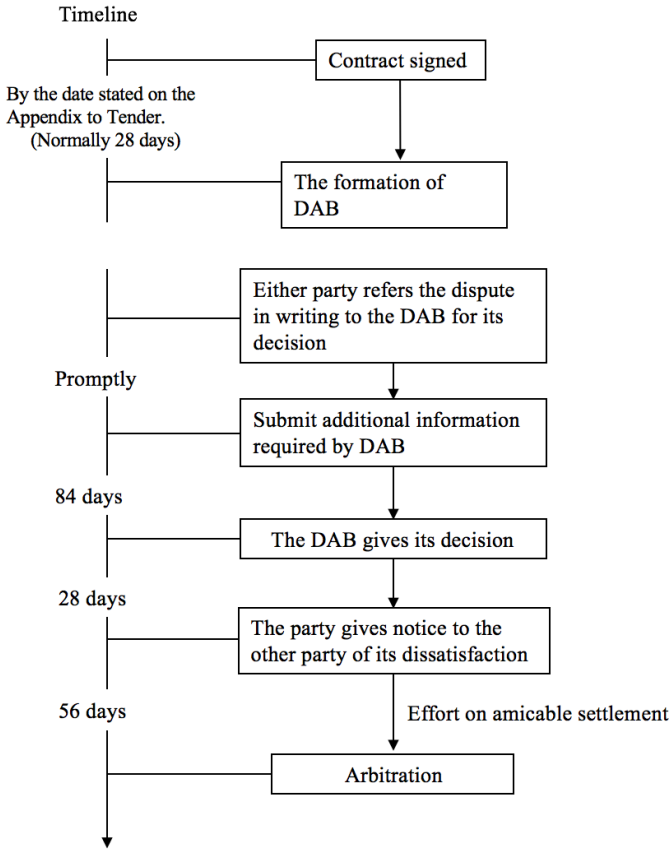

Figure 5.4 The dispute resolution rule of FIDIC form

5.5 Comparative analysis of dispute resolution rule

5.5.1 Dispute resolution rule

In the process of contract variation, if the two sides of the contract are unable to reach an agreement on the engineer's decision, this situation is referred to as the dispute. The dispute resolution rule is a dispute resolution procedure. In the dispute resolution procedure, there are obvious differences between the FIDIC form and Chinese construction contract.

5.5.2 Dispute resolution rule of FIDIC form

The dispute resolution rule of FIDIC form is shown in **Figure 5.4**. The Clause 20 in the FIDIC form describes in detail the settlement method when the two sides of the contract have not reached a consensus on the decision of the engineer. FIDIC form stipulates that before the formal dispute resolution process, the two parties to the contract have a chance to thrash out a settlement. If it is unable to reach a settlement, Dispute Adjudication Board (hereinafter referred to as DAB) has been set up to make

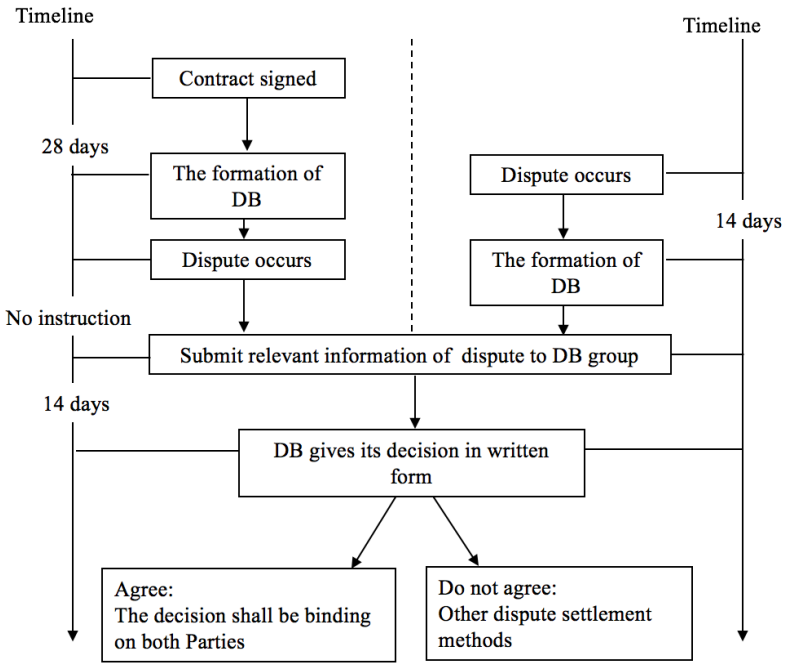

Figure 5.5 The dispute resolution rule of Chinese construction contract

adjudication on the dispute case based on the agreement of contracting parties. DAB shall be composed of members with appropriate qualifications. The number of members may be one or three, determined by the two parties to the contract. The cost of DAB shall be divided equally between the parties. After the establishment of DAB, the parties to the contract should submit the information related to the dispute event to DAB as soon as possible. After receiving the dispute event, DAB should make adjudication within 48 days. The adjudication has legally binding on both parties. So, even if the adjudication is not satisfactory, the contract parties have a legal obligation to comply with the DAB adjudication without arbitration.

If either party is dissatisfied with the DAB's decision, then either party may, within 28 days after receiving the decision, give notice to the other party of its dissatisfaction. Otherwise, the decision will be considered as the final decision, and it has legally binding on both parties. If one or both of the parties are not satisfied with the DAB adjudication, they may seek the final decision from the arbitration institution. However, the parties should try their best to settle the dispute in a friendly way before arbitration starts. If no settlement can be reached within 56 days after the notice of dissatisfaction, then the contracting parties will proceed to the arbitration procedure.

5.5.3 Dispute resolution rule of Chinese construction contract

According to the Clause 20 of Chinese construction contract, the dispute resolution rule is shown in **Figure 5.5**. The basic dispute resolution process is mainly the same with the FIDIC form. In Chinese construction contract, the contracting parties cannot

reach agreement on the decision of the supervisor is considered as a dispute. Dispute Board (hereinafter referred to as DB) has been set up to make an adjudication based on the agreement of the two parties to the contract. According to the Clause 20.3, within 28 days after signing the contract, or within 14 days after the occurrence of the dispute, the parties of the contract shall select the members and set up dispute review team. In other words, DB is divided into two cases. One is permanent DB established after signing the contract and before the occurrence of the dispute. The other is ad hoc DB established after the specific dispute. The establishment procedure of permanent DB is on the left side of **Figure 5.5** and the right side is for the ad hoc DB.

The same with FIDIC form, Chinese construction contract stipulates that before the formal dispute solution procedures, the contracting parties should try to resolve the dispute in a friendly way. Or, in the previous stage of the DB, the parties may request the third party to mediate the dispute. When the reconciliation or mediation fails, the parties need to submit a dispute resolution request notice to DB. At the same time, details of the dispute event as well as the relevant information also need to be submitted to DB. After receiving the detailed information, DB should follow the principles of impartiality, fairness and objectiveness, fully listen to the views of the parties to the contract, make a written decision on the basis of the relevant laws, regulations, standards, case experience and business practices, and explain the reasons. Compared to the 84 days of FIDIC form, only 14 days of review time is given by the Chinese construction contract.

In addition, according to the Chinese construction contract, in the case that either party does not accept the decision or not to perform the decision of the dispute review team, the two parties can choose other ways to resolve the dispute. In FIDIC form, when either party is dissatisfied with the DAB's decision and gives notice to the other party of its dissatisfaction, as long as they do not proceed to arbitration within 56 days, the decision has legally binding force on both parties. However, different from the FIDIC form, after DB made his adjudication, if the parties to the contract cannot reach a consensus, they can also seek for other methods to resolve the dispute. For the legally binding force of the adjudication made by DB, the relevant provisions are also vague. That means the adjudication made by DB has a weaker binding force on both parties compared with DAB. In combination with the time limit of negotiations between the contracting parties, it is considered that there is an intention to promote reconciliation between the two parties.

As shown in **Figure 5.4** and **Figure 5.5**, there are differences in the dispute resolution process between the Chinese construction contract and FIDIC form. DAB is set up at the time of signing the contract according to the FIDIC form. In Chinese construction contract, there are two situations to choose: permanent DB and special DB. In addition, there is also stipulation of ad hoc DB in FIDIC Conditions of Contract for Plant and Design-Build which is FIDIC Yellow book and Conditions of Contract for EPC/Turnkey Projects which is FIDIC Silver book.

5.6 Contractual customs of Chinese construction project

5.6.1 Results of comparative analysis

The followings are the results of comparative analysis between the FIDIC form and Chinese construction contract. There are some differences in risk sharing rules of approval and licenses risk, force majeure, upper planning risk and risk of the interference by other contractors. The risk sharing rule of approval and licenses risk, force majeure and upper planning risk which are caused by the employer, are not clearly described. For the risk of interference by other contractors, compared with the FIDIC form, the contractor is responsible for claiming for compensation against the third party under the situation of Chinese construction contract, so the contractor may be burdened with a greater risk. However, since risk sharing rules stipulated in both contracts are based on the principle of risk sharing, there is no essential difference between the two contracts in terms of the risk sharing rule.

In the case of the contract variation rule, it shows that the FIDIC form and Chinese construction contract have the same process. Although there are some slight differences in the processing time of each stage, the rules do not have much difference.

Finally, there exist significant differences between the FIDIC form and Chinese construction contract in the dispute resolution rule. DAB plays the same role in both the FIDIC form and DB in Chinese construction contract under the same dispute resolution procedures. However, compared with 84 days given by the FIDIC form for DAB to make adjudication, Chinese construction contract only gives DB 14 days. When taking the consideration of the complexity of construction project and the contract, in order to make reasonable judgment of the dispute, it is necessary to give the sufficient time. As a result, 14 days are far from enough to make a logical and persuasive conclusion for a complex dispute case.

Through the above analysis, the structures of risk sharing rule, contract variation rule and dispute resolution rule of Chinese construction contract are the same with FIDIC form. However, in terms of the dispute resolution rule, there is a significant difference in time limit for making a judgment which is closely related to the quality of DB's adjudication.

5.6.2 Implication of contractual customs

From the comparative analysis with the FIDIC form, it is found that one of the characteristics of Chinese construction contract is the shorter time of dispute resolution. Although there is no specific standard of how long it should take to resolve the dispute, it could be concluded that the longer the time is given to the DAB/DB, the more likely it is able to draw a logical conclusion with high quality. However, on the other hand, along with the longer time it takes, it is not only related to more direct costs of dispute resolution, the decision to be retained before the adjudication will also lead to the

occurrence of loss.

As mentioned above, FIDIC form is based on the premise of the one-shot relationship where the two parties have only one transaction opportunity. Therefore, the disciplined actions and the allocation of loss between the contracting parties are only determined by contractual provisions and legal provisions. In this case, the decision must be able to convince the contracting party. For this reason, the solution of the dispute case requires fully logical consideration.

If the contracting parties can get more benefits through the arbitration or litigation than following the adjudication of DAB/DB, they will not comply with the adjudication of DAB/DB. Therefore, if the adjudication of DAB/DB is likely to be the same with the expected judgment given by arbitration or litigation, the possibility to overturn the adjudication will be low, so DAB/DB can help to improve the efficiency of the dispute settlement[24]. In order to reduce the possibility of DAB/DB's decision to be overturned by arbitration or litigation, it is necessary to fully consider the judgment standard of the arbitration and litigation during the DAB/DB stage. In the hypothetical situation of FIDIC form, the judgment made by the arbitration or litigation is based on the detailed information and evidence, which has strong logical rationality. In this case, in order to improve the efficiency of the dispute resolution, DAB/DB needs to ensure the logical rigor of the adjudication. Otherwise, since the adjudication of DAB/DB may be frequently overturned, alternative dispute solution will gradually lose its role. Since sufficient time is required to fully consider the dispute event in order to make a reasonable adjudication with logical rigor, the FIDIC form gives DAB 84 days to make adjudication. In the relationship of one-shot, the cooperation is also one-off, so the controversial parties will fight to safeguard the legitimacy of their claims. However, in this case, since the two parties and the adjudicators need a considerable period of time and cost to improve their own theory, this dispute resolution is not necessarily an efficient method.

On the other hand, as mentioned above, DB is required to make adjudication within 14 days after receiving all the information according to the Chinese construction contract. In order to make adjudication with logical rigor, 14 days is practically not enough when taking the complexity of the construction project into account. Therefore, if DB in Chinese Construction Contract also plays a role as an alternative dispute solution, then it can be inferred that there should be other requirements of appropriateness which is different from the logical rigor.

Supposing the situation that even if the adjudication is lack of certain logical rigor and persuasion, the contracting parties are still willing to follow, and although all parties have acknowledged the existence of fuzzy logic, the standard which includes the fuzziness is also indispensable for the achievement of agreement. For example, in the relationship of one-shot type, even if the two parties vehemently argue about the sufficiency of the evidence, when there is a chance for repeated transaction, compared with the cost and time expensed on arguing, even the adjudication lacks logical rigor, it is also conceivable for them to accept it since the way to reach a consensus through

intuitive judgment may be more economical. Such standards may also be established.

In reality, it is commonly observed that the employer and the contractor can reach an agreement though negotiation before the event evolving into a dispute. It is believed that this reflects the phenomenon of 'relation society' in China. If the event turns to be a dispute, no matter whether the dispute is resolved by DB or litigation, it will damage the relationship between the parties to the contract. For this reason, the contracting parties, especially the contractor, will pay more attention to the long-term relationship and try to choose a reconciliation way to solve the problems. In addition, since the employer has a relatively strong bargaining power in Chinese construction field, it is difficult to develop into a dispute as well. The above views can theoretically explain the reason why formal dispute resolution ways such as DB, arbitration and litigation in Chinese construction contract have very simple rules.

As stated in previous studies, there are researches on the significance of relational governance in Chinese construction market. Through the comparison of the two contracts, it is found that significant difference between dispute resolution rules is due to the different premises of relationship between the contracting parties in the FIDIC form and Chinese construction contract. And according to the comparative analysis in this research, one point of relational governance in China is that 'there is a standard to reach an agreement which includes the vagueness of adjudication without pursuing the logical rigor.' If the contracting parties can establish such a standard, it may be more efficient than the dispute resolution way stipulated in the FIDIC form.

5.6.3 Notes

The conclusion of this study is based on a number of important premises. First of all, one of the important premises of this research is that the dispute resolution rule in Chinese construction contract functions effectively. If the adjudication made by DB is frequently overturned, and finally submitted to the arbitration, the results of the hypothesis made by this study will lose its appropriateness. Secondly, another premise of the research conclusion is that the two parties to contract comply with Chinese construction contract strictly in practice. For example, even if the time for adjudication given by Chinese construction contract is 14 days, the contracting parties can also modify the time limit through negotiation. The premise of this study is that the 14 days given by Chinese construction contract has its legitimacy.

Finally, there is also the situation that the rules in the contract are just treated as a kind of formalism where contracting parties are bound by a side contract. For example, in Japan, the situation that the parties resolve the dispute in accordance with the contract is extremely rare. Although the conclusion of this study has played an important role in the derivation of the logical expansion, it does not fully consider the appropriateness of the premises. In spite of this, the significance of this study is to put forward a new hypothesis of the form of Chinese relational governance.

5.7 Conclusion

In recent years, China has played an increasingly important role in international infrastructure projects. In order to contribute to the construction of overseas infrastructure in the future, Japanese contractors have to take China as the center and expand the business scope. Therefore, even in the field of construction management in Japan, it is needed to prepare for the upcoming era, and constantly accumulate knowledge of Chinese construction contract governance.

This study aims at explicating structure of contractual customs in Chinese construction market by analyzing Construction Contract for Construction Project Model Form compared with FIDIC form, the international standard form of construction contract. It is found that the structure of the risk sharing rule, contract variation rule and dispute resolution rule of the Chinese construction contract are approximately the same as that of FIDIC form. However, in terms of the dispute resolution procedures, compared with the DAB's 84 days stipulated in FIDIC form, Chinese construction contract only gives DB 14 days to make adjudication. This paper also theoretically explains that the significant difference in dispute resolution rule is caused by the different relationship premise between the contracting parties in the FIDIC form and Chinese construction contract. Moreover, it also points out that there is a kind of standard for consensus between contracting parties which includes the vagueness of adjudication without pursuing the logical rigor of adjudication made by DB in Chinese construction contract. This study only points out that there exists relational governance in the above form within the dispute solution procedure in Chinese construction contract. The mechanism of relational governance in Chinese construction contract will be studied in the future.

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6. Conclusion

6.1 Summary

Along with the development of urban and social development, construction projects, especially the infrastructures are playing an increasing significant role by providing the fundamental support of the functionality of cities and people's daily life. However, at the time of high-speed development of economic, the efficiency of construction project is still a topic of concern. It is acknowledged that large scale of construction project is extremely complicated and susceptible to a variety of uncertainties. As the fundamental way of project management, construction contract has been paid a lot of attentions. However, due to the existence of unforeseen contingencies, the construction contract is considered to be a typical incomplete contract since it cannot specify all the future states that may happen during the construction period. Therefore, the incompleteness of construction contract gives a chance of opportunistic behaviours taken by contracting parties which may lead to inefficiency issues. On the other hand, different from general framework of incomplete contract theory, construction contract is a kind of special form of contract with unique structure. This research focuses on solving the inefficiency issue of construction project in terms of construction contract. The main content and conclusions of each chapter are summarized as follows.

Chapter 1 gives an overview of this research. Followed by the introduction of the background and problem consciousness of this study, the expected contributions and the scope of this research are also encompassed. The organization of this thesis and the synopsis of each chapter are given at the end of this section. Chapter 2 conducts a literature review from the perspective of contract theory and construction project. In the first part of this chapter, introduction of contract theory starts from the origin and concept of contract. And then incomplete contract is followed by the concise explanation of complete contract theory. Papers with outstanding contributions and the latest researches within this field are also summarized. The second part is mainly in connection with the issues related to construction field which firstly gives a view of the features of construction project and construction contract through related literature. Finally, it highlights the applicable issue of the mainstream management theory to construction project management. The concept of construction governance is also mentioned.

In chapter 3, the research in first place demonstrates that by replacing renegotiation and endowed the client with full bargaining power, construction variation rules are theoretically contributing to mitigating the inefficient investment issues through illuminating models proposed by Hart (1995). However, by taking the structure of construction contract and practical issues into consideration, there are nonnegligible preconditions for the achievement of the effectiveness of contract variation which are considered to be the incompleteness of incomplete construction contract. The first one is

the common cognoscibility of contingency identification between contracting parties. This ensures that both parties may not hold different opinions on the responsible party of the risk. The second precondition is unanimous evaluation of the effects of the risk such as the amount of additional cost or the duration of extension of time. The last precondition is costless verification and observation. However, those preconditions are extremely difficult to be satisfied during the practice. In other words, incompleteness of incomplete construction contract still cannot be completed. Therefore, hold-up issue is still cannot be completely eliminated where the social efficiency also cannot be achieved. On the other hand, in practice, it is the case that the contractor always ignores the contract variation rules and conducting renegotiation with the client by threatening to quit the work where contract variation rule is considered to be non-enforceability. Since the in-time delivery of construction work is all-important both for the client and the realization of the utility of the project, the hold-up behaviour is uncontrollable by contractual mechanism sometimes.

As chapter 3 has pointed out that hold-up behaviour is barely mitigated under the situation of an incomplete construction contract due to imperfect enforcement of the contract variation rule. Inspired by Tirole's idea of cognitive effort, chapter 4 tries to solve the problem from the perspective of precontractual efficiency. The appropriate design may likely to be found if sufficient cognitive effort has been exerted by contracting parties. However, since cognitive effort is not costless, there is a trade-off between such transaction cost and ex post losses due to contract variation. This part analyses conventional contract and design-build contract under the situation of one-sided cognition with the consideration of the opportunistic behaviours taken by both contracting parties. It finds out that design-build contract is more desirable since there is no occurrence of contract variation while conventional contract may lead to the inefficiency investment of cognitive effort since the contract variation rule cannot be perfectly implemented and therefore lessen social welfare.

During contract variation process, when there are cognitive distortions between contracting parties, dispute settlement has to be conducted. In relation to this content, chapter 5 conducts a case study on the structure of governance for construction contract in China through a comparative analysis between Chinese construction contract and the FIDIC form. The study clarifies that there exists a significant difference in dispute resolution rules between both contract forms and it is due to the different premises of relationship between contracting parties. It indicates that one point of relational governance in China is that there is a standard to reach an agreement which includes the logical ambiguity of judgement without pursuing the logical stringency. If contracting parties can establish such a standard, it may be more efficient than the dispute resolution way in the FIDIC form.

This research theoretically analyses the inefficiency issue and effective governance mechanism thereof in the construction project from the perspective of incompleteness of incomplete construction contract. It is expected that the conclusions of this research may bring some useful inspirations for the development in the field of construction.

6.2 Directions for future research

Since the dissertation only focuses on several aspects of construction field, there are still some problems and limitations left. Therefore, this section will provide some suggestions on directions for future research.

The first one is concerned with the content of chapter 3. It has indicated that one of the preconditions is costless verification and observation. However, in practice, the transaction cost of verification should not be neglected. Especially for the construction project, since the amount of funds involved in construction projects is huge, losses caused by opportunistic behaviour is also considerable. Moreover, since costly verification is considered to be achievable in the construction field and usually has to be paid by the contractor, it may always give rise to the inequality between contracting parties. Accordingly, for the future research, the factor of costly verification should be necessarily taken into account. In addition, as suggested in chapter 4, the functionalities of Early Contractor Involvement are worth expecting in reducing the possibility of the occurrence of design change. However, since there is no relevant theoretical analysis up to now, two-sided cognition model basing on the structure of ECI is essential, so as the comparative analysis with both conventional contract and design-build contact. And the last topic is concern with the governance mechanism. Since the structure and mechanisms of project governance is diverse in different regions, as a more flexible and effective mode for efficiency improvement of construction project, specific mechanisms in different counties are expected to be clarified.

On the other hand, from the whole view of the conception of the thesis, the research mainly considers the situation that both contracting parties are capable to obtain sufficient information and smart enough to make reasonable decisions. In other words, the conclusions obtained in this research are only able to cope with the inefficiency condition where both contracting parties are competent to take opportunistic behaviours in order to maximize their own benefits. However, in reality, such kind of contracting parties are extremely rare. There is also another kind of nature of contracting parties which could be regarded as incapable. Incapable contracting man means that they don’t have sufficient ability to make the right decisions even if they intend to take interest-driven behaviour. In this case, the governance mechanisms discussed in this thesis are not effective anymore. Therefore, the case that edge closer to reality with the consideration of incapable contracting parties is worth analyzing.