THE UNIVERSITY OF HULL

An exploration of *ex post* contract adjustment under Public Private Partnership with special investigation of the transportation industry

being a Thesis submitted for the Degree of Philosophy in Economics

in the University of Hull

by

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February 2014

Abstract

This research focuses on *ex post* Contract Adjustment (CA) under Public Private Partnership (PPP) program. It includes theoretical exploration and empirical investigation. The former has one model while the latter finishes two sets of regression with a simple simulation. The research question is 'what are the reason for and consequence of *ex post* Contract Adjustment (expressed by CA only in following) under PPP?'.

PPP has been applied increasingly in developing and developed countries. However, the potential problems surrounding CA under PPP is explored or investigated inadequately by scholars. For one thing, most of literatures in PPP focus on *ex ante* contract design instead of *ex post* problems. For another, *ex post* CA, this topic that should be in New Institutional Economics (NIE) is unfortunately overlooked by NIE. Even some works relate to CA with the focus on some similar topic, e.g. contract renegotiation; CA is treated as a condition instead of process.

Considering the inherent incentive of government to rescue firm under *ex post* risk to keep PPP program going, our model figure out the specific situation when takeover policy of government has be adopted. The basic conclusion of modelling is that holdup problem or uncontrollable *ex post* CA(s) could force government to terminate PPP in the end.

For investigating the compensation effect under *ex post* CA, author creates data after thirty-two PPP case study. It could be found that *ex ante* contract and the way of *ex post* adjustment is meaningful as predicted while *ex post* risk is not as expected for *ex post* CA. Based on regression, policy suggestions are given for *ex post* CA under PPP. Moreover, data are also used for simulation, the corresponding conclusion coincides the conclusion of modelling.

Acknowledge

Firstly I would like to thank my first supervisor, Dr Stephen Trotter for guidance, advice and supervision of the study. Without his support, my thesis would not have been mature.

Secondly I wish to express my appreciation to Professor Antony Dnes. As my former first supervisor, he gives me valuable guidance for my preliminary work. Moreover, I also need thank Mr Christopher Hammond that is my former second supervisor; he gives me a clear picture for my thesis. In addition, Dr Kashab Bhattarai suggests some good idea for my thesis before submission, as my current second supervisor.

I am grateful to the participants from the seminar held by the Department of Economics, University of Hull for their comments and discussions. I am indebted to Dr Mike Nolan for his useful suggestions.

I am also grateful to many of my friends and brothers. Special thanks must go to Yarui Zhou, Bo Wang, Limin Qu, Chenghang Zhang, Fang Hou, Kun Yang, Zhiyong Huang, Yajun Cao, Zhumin Chang and Guifang Xie for their help. At the same time, during more than three years, my landlord, Ying Gao and her family, give me and my wife continuous support.

I owe my deepest gratitude to my parents, my parents-in-law, and my wife, Zhongmei Wei, for their tremendous moral support and without whom this thesis would not have been completed.

Finally, I must thank my government and Hull University, without the scholarship supplied by those, I would never get any chance to finish this research in UK.

DECLARATION

The material in this thesis has not been submitted for a degree in this university or other university. Furthermore, I must declare that Taiwan is one part of China. When I talk about Taiwan case in this thesis, I always specially use double quotation marks in relevant phrases. I do not mean Taiwan is a country in any place of this thesis. If there is some mistake, it must derives from an honest mistake. I hope any person reading my paper should not blame me for the political element. This is just an economic thesis.

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Chapter 1 Introduction

This research focuses on *ex post* Contract Adjustment (CA) under Public Private Partnership (PPP). It includes two parts, theoretical exploration and empirical investigation. The former explores behavior of firm and government under *ex post* CA for PPP program with one model while the latter investigates quantitative relationship through two sets of regression between relevant economic variables.

This chapter has seven sections in following. It starts the story of PPP programs under *ex post* CA(s) in reality and then the motivation of this research is explicitly illustrated. Thirdly, the significance of research is reflected by showing the current context of PPP and the literature gap after reviewing the definition of PPP. Fourthly, the summary of research will be especially clarified. The contribution of this research is listed in fifth section. The special design of this research will be illustrated in section 1.6. The framework of this research is given in the end.

1.1 The reality of PPP programs under *ex post* CA(s)

We study thirty-two real PPP programs under *ex post* CA(s) in this thesis, those programs are studied and then measured in Chapter 5. In spite of country and sector, three *ex ante* variables involving original contract and four indicators related to *ex post* CA are evaluated especially in Table 1-1 and Table 1-2, respectively.

Firstly, *ex post* CA of PPP programs does not happen in specific country or sector. Seen from Table 1, PPP programs get *ex post* CA in developed and developing countries, for example, Thailand and UK, respectively. At the same time, *ex post* CA takes place for PPP programs in High Speed Rail (HSR) sector, rail sector, highway sector, bridge sector, tunnel sector, airport sector and facility sector, which could be seen in Table 1-2.

In addition, author finds that PPP programs under *ex post* CA(s) have *ex post* risk in reality. For illustrating this property of PPP programs under *ex post* CA(s) in realty, we describes the expected situation and then real one (with *ex post* risk) in following subsections. Based on the connection of PPP programs under *ex post* CA(s) with *ex post*

Table 1-1: *ex ante* variables of PPP programs in plan					
	case	**Cost (million Pound)**	**Time target***	**Program duration**	**Country**
1	Taiwan High Speed Rail	9239.4	87	420	China
2	CTRL	7363.7	94	1080	UK
3	Channel Tunnel	6007	70	1187	France†
4	Perpignan–Figueres	646.1234	60	718	Spain†
5	HSL-Zuid	763.2431	70	360	Netherland†
6	Treno Alta Velocita	6922.75	194	600	Italian
7	Sydney ARL	96.2305	60**	419	Australia
8	Seoul ARL	1717.815	137	509	Korea
9	Southern Cross Station	135.541	45	420	Australia
10	Reliance Rail	1037.988	48	415	Australia
11	Tagus South LRS	219.848	40	360	Portugal
12	STAR LRTS	722.022	NA	720	Malaysia
13	PUTRA LRTS	1139.103	NA	720	Malaysia
14	KL Monorail	300.9059	62	480	Malaysia
15	Metronet	8700	NA#	360	UK
16	Tube Lines	2218	NA#	360	UK
17	MRT-3 project	400.1028	NA	335	Philippines
18	M1/M15 Motorway	213.2218	56	420	Hungry
19	M5 Motorway	277.9541	115	440	Hungry
20	M2 Motorway	236.9447	40	621	Australia
21	Don Muang Tollway	248.7584~	NA	300	Thailand
22	M6 Tollway	959.0445	36	636	UK
23	A4 Motorway	53.7522~	NA#	361	Poland
24	Delhi Noida Bridge	68.6348	29	360	India
25	Vasco da Gama Bridge	673.8510~	NA	396	Portugal
26	Lane Cove Tunnel	673.9807	39	397	Australia
27	Cross City Tunnel	246.4381	34	396	Australia
28	NATS	1486.275	no	300	UK
29	Stadium Australia	332.2922	45**	411	Australia
30	Orange Health Project	106.9597	32	336	Australia
31	NNUH	81.2535	48	475	Australia
32	RAM	42.6	27	720	UK

CTRL: Channel Tunnel Rail Link. NATS: National Air Traffic Service; NNUH: Norfolk and Norwich University Hospital; RAM: Royal Armouries Museum.
*measured in months; **the time target is soft, this is just the biggest time for construction; #the building is not finished under PPP; †the project is extended into UK, France and Belgian, respectively; ~The growth rates of GDP of EU during 1995 to 1999 are 2.70%, 1.90%, 2.76%, 2.94%, 2.98%.

risk, we explain especially the relevance of thirty-two cases though there are difference between those cases.

1.1.1 The expected situation of thirty-two cases

Table 1-1 give a picture about expected situation of PPP programs under original contract in reality. Cost of program, time target of building project and the duration of PPP programs are especially listed. In particular, the cost in original contract is actually represented by project fund (measured in Chapter 5). Considering project fund is in different currency, original amounts are exchanged into British Pound with help of Ozforex (2013). As for three cases (marked by "~") involves Euro before 1999, Index Mundi (2012) are referred for the percentage of GDP growth. The project fund of those three cases is exchanged into the one with Euro in 1999 and then we use the exchange rate between Euro and British Pound in 1999 to get the cost in pound. Considering Table 1-1 does not need compare those PPP programs in detail, all cost in Table 1-1 is only exchanged into pound in its own year.

Seen from Table 1-1, from the column of cost, it could be seen that most of PPP programs cost at least in hundreds of millions of pound in those years, among which some spend billions of pound. In the column of time target Table 1-1, two cases has only approximated values since those two cases has no clear time target except a hard deadline for Olympic game in 2000. Five cases cannot measure the time target in original contract. Three of those give cases have not finished the building job under PPP while the other two has no building stage. From this column of time target in Table 1-1, the building target is always at tens of months while few cases need reach one hundred of months. As for the duration of PPP programs, all of cases except two cases that have 1187 months and 1080 months need last at least 300 months (namely, 25 years).

1.1.2 The real situation of thirty-two cases

Table 1-2 gives precise values for *ex post* variable for PPP programs. Only five cells for demand shrinkage have no value due to information unavailability, all of others have precise values.

Table 1-2: *ex post* variables for PPP programs for reality					
Case (as before)	**Cost overrun**	**Time overrun**	**Demand shrinkage**	**No. of *ex post* CA**	**Sector**
1	1.4223	1.1724	0.2778	4	HSR
2	1.3123	1.5106	0.3958	3	HSR
3	2.3541	1.1714	0.1824	8	HSR
4	1.1348	1.1667	0	1	HSR
5	1.2444	1.4143	0	1	HSR
6	1.6078	1.1392	1	1	HSR
7	1.5220	1	NA	2	Rail
8	1.1413	1.1752	0.0696	3	Rail
9	1.3556	1.3333	1	1	Rail
10	1.0540	1.1458	1	1	Rail
11	1.178	1.8500	0.4375	1	Rail
12	1.8286	1	0.3881	1	Rail
13	1.4995	1	0.3333	1	Rail
14	1.4746	1.3226	0.1571	1	Rail
15	1.2069	1.2500	1	1	Rail
16	1.2049	1	1	3	Rail
17	1.3939	1	0.0556	2	Rail
18	1.18	1.125	0.5500	1	Highway
19	3.4324	1.2348	0.6250	1	Highway
20	1.8649	0.825	0.7352	5	Highway
21	1.5135	1	0.3333	1	Highway
22	1.6552	1.0278	NA	1	Highway
23	2.3256	1	NA	2	Highway
24	1.4987	0.8621	0.37	1	Bridge
25	1.6805	1	NA	6	Bridge
26	1.0425	1.2821	0.63	7	Tunnel
27	1.2956	0.9412	0.3371	2	Tunnel
28	1.1077	1	NA	1	Airport
29	1.3314	1	0.3140	2	Facility
30	1.1605	1.3438	1	1	Facility
31	2.0421	0.8958	1	3	Facility
32	1.2958	1	0.0412	1	Facility
NA: information is not available.					

For showing *ex post* risk of these PPP programs under *ex post* CA(s), we illustrates *ex post* situation briefly. The evidence or detail could be seen in Chapter 5. Seen from Table 1-2, the first six cases are in HSR sector. Channel Tunnel, Perpignan–Figueres and HSL-Zuid are built between two countries, but the main program initiators are France, Spain and Netherland, respectively. The other three are built in the inner side of Taiwan, UK and Italian, respectively. Among these six HSR programs, the first five get hit by *ex post* severe demand risk while the final one witnesses from the withdrawal of private partner so that government of Italian has to terminate PPP mechanism in advance. Among eleven rail program in Table 1-2, two airport rail links (Seoul ARL in Korea and Sydney ARL in Australia) get complicated original contracts and then *ex post* packages. The former gets twice refinanced while the latter gets compensated with a new price scheme. Southern Cross Station gets revised by government of New South Wales (NSW) in Australia. Reliance Rail gets financial crisis in 2008 and then NSW has to rescue it directly. Four light rail systems in Malaysia (Tagus South LRS in Portugal, STAR LRS, PUTARLRS and KL Monorail) gets bailed out under bankrupt problem. Two sets of underground lines in London (Metronet and Tube Line) experience *ex post* disputation with government; even the former case get terminated in advance. MRT-3 project in Philippines get buyout packages indirectly and directly after continuous demand risk.

In addition, among six highway cases, two highways in Hungry (M1/M15 and M5) get *ex post* severe demand risk and then bailed out by government. M2 Motorway in Sydney gets several revises, all of which are undertaken by government, Don Muang Tollway in Thailand experiences a severe default of government and then bailed out by government. M6 Tollway in Birmingham gets long local opposition for project. A4 motorway in Poland gets supported by Europe Bank of Reconstruction Development (EBRD) for original contract and *ex post* rescue packages directly and indirectly. Comparing with those highway cases, the other cases in transportation industry gets more severe problems. The Delhi Noida Bridge is the one of projects developed under PPP in India; it gets *ex post* debt restructure and equity issuing. Vasco da Gama Bridge in Portugal gets repeated disputation with government. The Lane Cove Tunnel and The Cross City Tunnel in Australia are labelled as failure; both experience *ex post* demand risk and severe accidents so that government cannot bail them out any more. The National Air Traffic Service is a special PPP program in which government maintains some share; it gets *ex post* severe demand risk due to September 11th, Severe Acute Respiratory Syndrome (SARS) or the second Gulf War.

Facility projects of PPP under *ex post* CA(s) face similar situation as before cases. Stadium Australia is launched for the Olympic Game in Sydney; its idiosyncratic arrangement in original contract leads to *ex post* demand deflation and then government approves its CA. Orange and associated health service PPP project gets *ex post* package due to the upgrade projects. Norfolk and Norwich University Hospital (NNUH) and Royal Armouries Museum experience *ex post* refinance; the former relates to project revise while the latter derives from *ex post* extreme demand risk.

Seen from Table 1-2, every case has cost overrun and at least one *ex post* CA; most of cases have construction delay or demand shrinkage. Cost overrun, time overrun and demand overestimation seem to be related to *ex post* CA. Seen from Figure 1-1, the quantities for the number of *ex post* CA (represented by N_{CA}) has a positive relationship with the empirical quantiles of other indicators (R_c for cost overrun, R_t for time overrun and R_q for demand shrinkage).

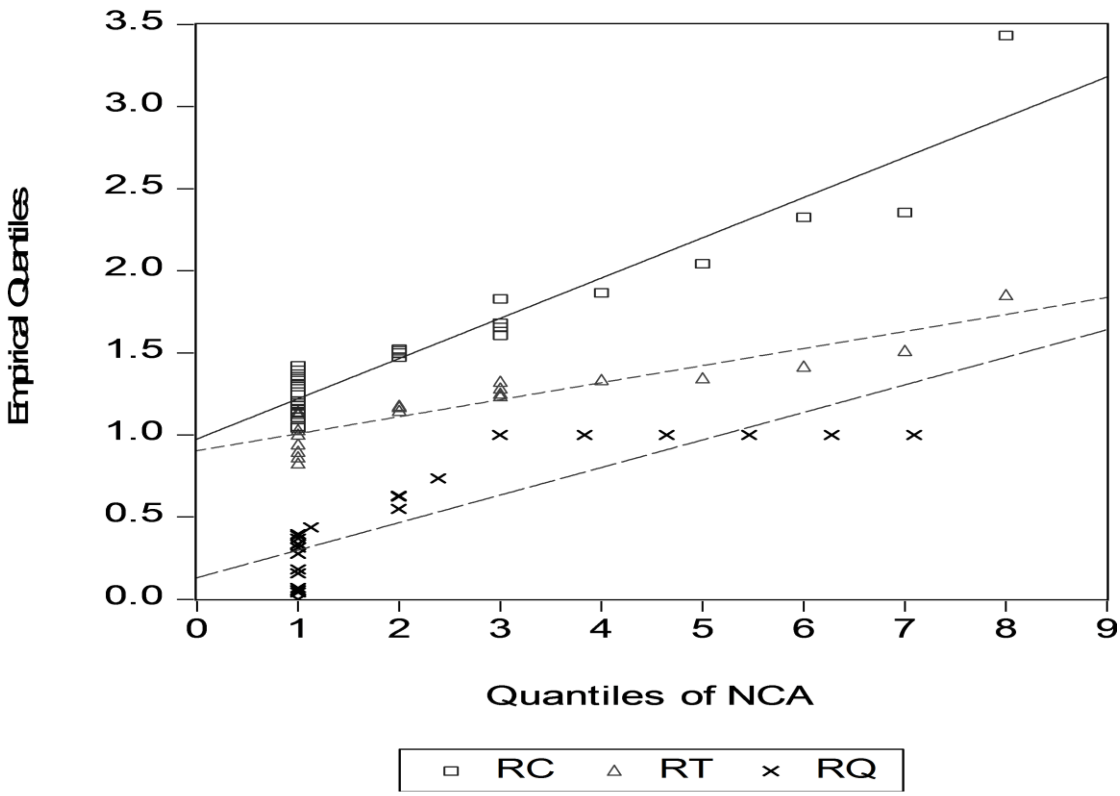


Figure 1-1: relationship between NCA and *ex post* risks

1.1.3 The relevance and difference of thirty-two cases

Seen from section 1.1.1, all thirty-two PPP programs with *ex post* CA(s) reach a high level of scale since the start for the project cost, construction time or the length of contract. Meanwhile, section 1.1.2 shows that all of those cases have *ex post* economic risk, including time overrun, cost overrun, demand shrinkage and *ex post* CA. Our cases are relevant because of these two above common characteristics of PPP program (seen in section 1.1.1 and 1.1.2). In particular, we study the general economic property of PPP program in all of these cases, precisely, the relationship between private firm and government under PPP with *ex post* CA(s). Either in later theoretical exploration or empirical investigation, the contribution from government for PPP program is the objective of analysis. The consideration of government contribution under *ex post* CA could represent well the common economic characteristic of PPP under *ex post* CA. All of other relevant variables in modelling or indicators in measurement must involve the economic relationship between firm and government. Therefore, our cases should be relevant though some differences between cases exist objectively.

The differences of our thirty-two cases are realized and controlled as following. At firstly, some differences are especially directly or indirectly measured. For example, some cases are expired, some are still going on. For telling contracts at different stage, hence, t_{CA}, the ratio of the *ex post* CA period relative to the whole PPP program, is designed to tell CA under the different stages of PPP program. Some difference cannot be measured directly, but the final evaluation of data considers the difference. For instance, our cases involve different contract types, i.e. some cases use concession contract while others have no demand risk, we evaluate the demand risk indicator as one when the contract transfer no demand risk to private firm while concession contract under PPP has the indicator value less than one due to *ex post* demand risk undertaken by the firm. Secondly, some difference is controlled by research design. For example, considering the scale of case is much different between some sectors, author specially uses the ratio indicators instead of absolute value for data form. Thirdly, some differences that cannot be controlled are avoided. For example, considering cases from different countries that could be developing or developed, we are very cautious about our conclusions. As mentioned above, only the general aspects of PPP program are measured and investigated. Especially, any analysis and corresponding finding or conclusion in this thesis does not go beyond the PPP itself for *ex post* CA. Considering the above design for measuring difference, controlling difference, avoiding difference with focus on the common aspects of PPP program under *ex post* CA(s), the adverse effect of difference could be tolerated.

1.2 The motivation of this research

This section explains why author is motivated to explore and investigate *ex post* CA (in this thesis, especially under PPP). Author follows on the academic spirit of Cheung (1969a), focusing on and explaining the reality. The preliminary motivation is to explain *ex post* CA under reality. To keep close distance with reality, author study *ex post* CA especially under PPP because ⑴*ex post* CA under PPP gets exposed better, ⑵PPP has a long-term contract for huge projects and then *ex post* CAs happens relatively more times.

The intuitive motivation is that author hope to give policy suggestion for PPP, which has been applied increasingly (see section 1.3.2). Our study not only involves the behaviour of firm and government under PPP, but also uncovers some property of PPP program or PPP contract. This consideration could be reflected in policy suggestion in Chapter 7.

In spite of above reason, fundamentally, the departure between theory and reality and the characteristics of *ex post* CA motivate author to make this research. These two reasons for motivation could be seen in following.

1.2.1 The departure between the theory and reality

The departure between the theoretical vision and real situation motivates author to give a picture for *ex post* CA. Too many scholars explores *ex ante* contract design or general contracting, from which it seems all future problems could be avoided or solved *ex ante*. However, *ex ante* design cannot estimate *ex post* problems as good as expected since transacting parties will face different situations relative to the original expectation. Information incompleteness in Mechanism Design Theory (MDT) and New Institutional Economics (NIE) and human irrationality in NIE tell *ex ante* design could be vulnerable. For example, the basic opinion of MDT is that *ex post* efficiency is better than *ex ante* efficiency (Holmström and Myerson 1983); then *ex ante* design seems not able to guide *ex post* settlement. As for human irrationality, it denies the probability of solving *ex post* problem by *ex ante* decision-making. In fact, the vulnerability of *ex ante* contract design under *ex post* CA is very general. Most of cases under *ex post* CA(s) do not use *ex ante* design for CA. For example, in HS1 case, an *ex post* crisis of raising project fund take program into different (absolutely unexpected) situation with complicated package (more detail could be seen in Chapter 5).

Moreover, even if *ex ante* design has a perfect version for *ex post* problems, it is vague for *ex post* implementation. For example, two London underground programs in our cases have *ex ante* design for potential crisis; *ex post* disputation is stipulated to settle by the third party. However, after a long negotiation and judgement, government realizes the disputation is far always from the expectation and the relevant *ex ante* stipulation is not practically meaningful. Government has to terminate one of PPP programs in advance. More details about these two cases could be seen in Chapter 5.

Seen from above, either *ex ante* design is vulnerable at *ex post* CA or vague for *ex post* settlement. Hence, the literature focusing on *ex ante* contract design cannot explain the reality under *ex post* CA. Moreover, the literature related to the topics similar to *ex post* CA, renegotiation, does not analyse the practical problems under reality. Simply speaking, most of those works treat renegotiation and some similar behaviour as (exogenous) element, so the process of *ex post* CA gets overlooked. Precisely, some relevant works focus on the determinants of renegotiation. For example, Brux (2011) and Brux et al (2011) study empirical elements of renegotiation and then explore theoretically the effect of renegotiation over efficiency; but the process of CA is not analysed. Similarly, CA is treated as an element when Tsai (2007) analyses alternative instruments (debt and internal equity) for *ex post* improvement. Some other literature studies the consequence of renegotiation under PPP. For example, Estache (2006) points out the relationship between the subsidy and rate of renegotiation under PPP. Engel et al (2011) find contract renegotiations have resulted in excessive costs for taxpayers or losses for private firms.

More practically, *ex post* CA cannot be overlooked under PPP. According to Pablo (2008), the public contract (such as PPP) must rely on formalized contract rather than the relational contract due to the governmental opportunism and the third party opportunism.

With more formalized contract, *ex post* adjustment is more probable to happen. Furthermore, the transportation infrastructure projects get always inaccuracy of demand and cost (Skamris and Flyvbjerg 1997); PPP is always used for transportation infrastructure projects. Namely, PPP is always under *ex post* risk and then *ex post* CA is more probable due to *ex post* risk. Therefore, it is easy to understand why Bajari and Tadelis (2001) suggest that the contract itself should consider about *ex post* adaption for complicated program such as PPP.

1.2.2 The two-fold characteristic of ex post CA

Ex post CA is special; it might be efficient for implementing contract under *ex post* risk while it is expected to be inefficient for *ex ante* arrangement. This two-fold characteristic motivates author to study economic behaviour under *ex post* CA.

The *ex post* package is efficient to keep contract going. Contract implementation hinges on *ex post* situation instead of *ex ante* design. Any contract has 'specific rights' and 'residual rights' (Grossman and Hart 1986: 692). The specified rights are always changed to avoid the failure of transaction, especially for the complicated contract under PPP. That is why government should adopt PPP when service provision is easier to specify than building provision (Hart 2003). In spite of the change on specific rights, contract could be *ex post* adapted with the reallocation of residual rights under new contractual relationships for *ex post* efficiency (Grossman and Hart 1986). In fact, even when Williamson (1976: 103) focuses on the disputation due to *ex post* adaptation, he must also admit that 'in principle and sometimes in fact, adaptations to changing circumstances are introduced in a low cost, nonacrimonious way'; in other words, *ex post* adaptation could be promoted for efficiency.

At the same time, *ex post* CA spoils *ex ante* efficiency and generates unexpected transaction cost. As contract theory claims, *ex post* CA spoils *ex ante* efficiency since it changes *ex ante* contract specification (Gagnepain et al 2010). Every *ex post* CA must go through renegotiation. When there is no specific design for potential renegotiation and then the distribution of unexpected gain (or loss), the adaption would incentivize transacting parties for its own interest (Williamson 1976), thereby generating *ex post* disputation. As for the unexpected transaction cost due to *ex post* CA, Bajari and Tadelis

(2014) found that economizing on the cost of *ex post* adaptation is an important source of cost-savings. In spite of adverse effect, importantly, *ex post* CA is difficult to control or avoid. This point is actually reflected by the literature focusing on renegotiation. There are a number of elements generating *ex post* CA, for example, the political institutional issue (Guasch et al 2004), relational-specific investment (Joskow 1987), regulatory policy (Estache et al 2009, Guasch et al 2006 and Guasch et al 2008), economic shock (Guasch et al 2006 and Guasch et al 2008) and so on.

To sum up section 1.2, both the departure between the theory and reality and the two-fold effect of *ex post* CA for transaction motivate author to give a specific research for *ex post* CA (under PPP). In particular, author is motivated to give study on the process of CA (instead of obsessing *ex ante* design or efficiency itself) in order to give more sufficient explanation over reality.

1.3 The significance of research

This section will illustrate the significance of research. To prove the significance, the definition of PPP will be introduced firstly, then the current context of PPP will be given; literature gap of *ex post* CA under PPP will be figured out in the end.

1.3.1 The definition of PPP

The definition of PPP has no clear definition since PPP has no uniform standard for its forms. Some PPP programs are labelled as PFI in UK. Every type of PPP might involve different forms and names in different countries/areas (European Commission 2003). In fact, this lack of definition exists in legality and there is not mature institutional system for PPP, at least, in EU (Tvarnø 2012). Maybe because of the lack of precise definition, some scholars such as Iossa et al. (2007) and Carnona (2010) define PPP via targeting specific characteristics.

Fortunately, the generality property of PPP gets uncovered without precise definition. As discovered by Hoppe et al (2013) after revealing literature, PPP awards two series of building contract and operation contract to the same private party, which is different from traditional procurement. This opinion gives a clear picture upon the property of PPP though the definition is overlooked.

In fact, the difference between contracts under traditional procurement and under PPP is very meaningful. The former corresponds to general transaction, the private parties as a producer 'supplies' a project for government. However, the latter awards contract right and relevant risk to the private firm. Firm under PPP gets the contract right, which is actually equal to the ownership in duration for management and operation[1]. Firm is co-operator with government under PPP. In the term of Economics of Contract (EoC), PPP is a mechanism that constrains government and firm under an ex ante contract relationship. In the item of Transaction Cost Economics (TCE), PPP is a mechanism under intermediate governance structure.

1.3.2 The current context of PPP

PPP could trace back towards 'early cooperative forms of partnership' (Hodge and Greve 2007). Just as said by Tang et al (2010: 683),

> 'Though the PPP approach was widely implemented in the late 1990s, private investment in public infrastructure can be traced back to the 18th century in European countries.'

The first project of PPP is launched in UK in 1992 (Li et al 2005). After that, the success of PPP in UK leads a spread towards the all countries. PPP includes multiple cooperative forms so that most of countries witness or will witnesses the application of PPP.

The prevalence of PPP for large projects is obvious in recent decades, especially in countries with constraint on public budget (EIB 2004). In fact, the developing countries is actively constructing the institutional system and applied PPP upon projects in small scale (Taylor 2005).

The rising tendency could be seen in Figure 1-2 to Figure 1-5. Figure 1-2 shows the number of PPP program in six regions. The regions could be seen in figures, the names and corresponding data come from World Bank (2012). All PPP programs in this figure come from countries whose incomes are at the low or middle level according to the standard of United Nations. Considering there is no available data for developed countries,

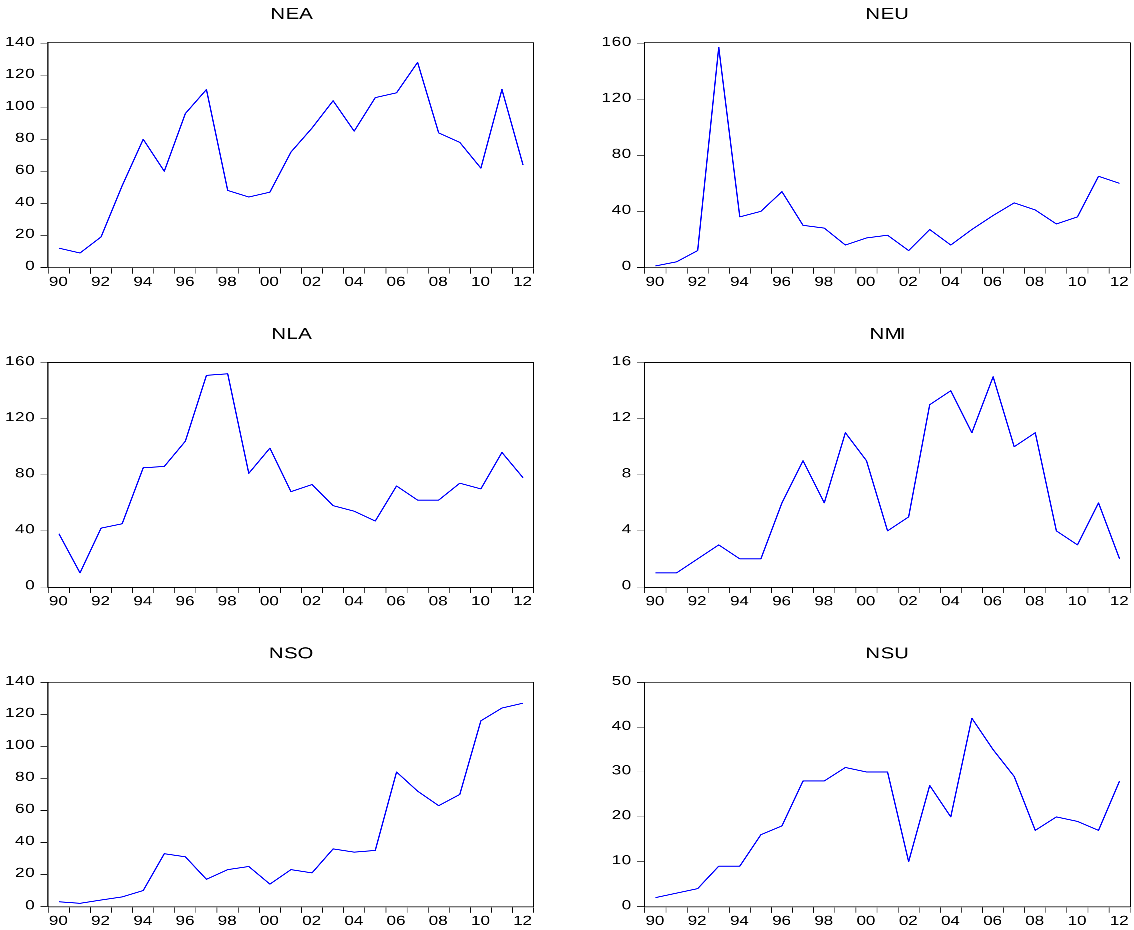
[1] However, it is not really equal to ownership in law since firm has no transfer right over the project.

the number of PPP program in European Union (EU) is used as the example of developed countries; it could be seen in Figure 1-3. The data about PPP program in EU is from European Investment Bank (EIB) (2010); this data is the newest one available. As for the tendency of rising in investment amount, it could be seen in Figure 1-4 and Figure 1-5. The former is for the developing countries while the latter is for EU.

Though some countries in EU are used as the examples of developing countries (in Figure 1-2 and Figure 1-4) and the ones of developed countries (in Figure 1-3 and Figure 1-5), the overlap of using same examples in those four figures is not a big issue. Just as said by EIB (2010), PPP programs in EU have been mainly from UK during the period between 1990 and 2009. So the figures about PPP programs in EU (Figure 1-3 and 1-5) reflect mainly the situation of UK, which represents a developed country. The trend in Figure 1-3 and 1-5 has only a little of noise.

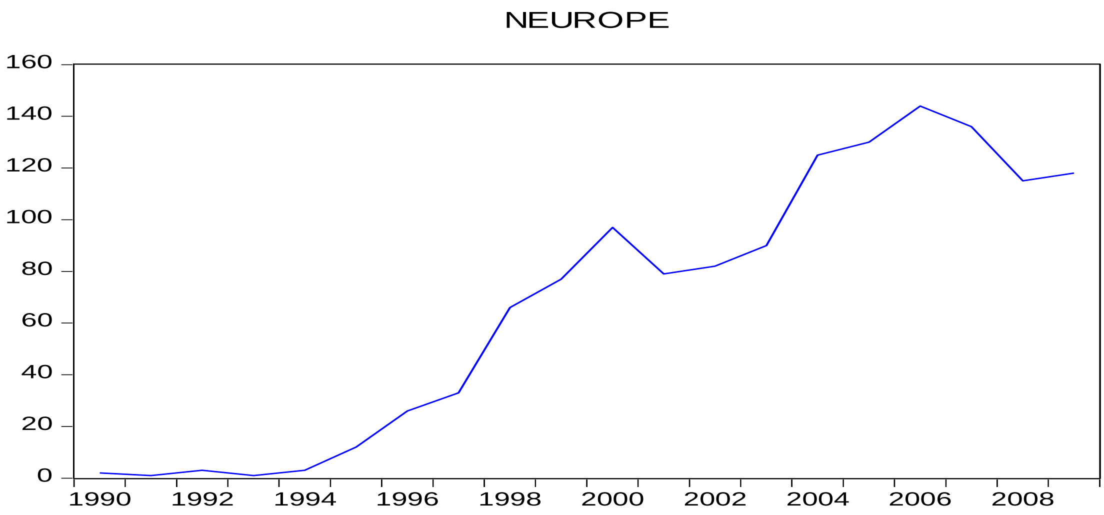
As for the number of PPP program, seen in Figure 1-2, five regions keep increase while the Middle East and North Africa has a decrease tide in the recent six years after a rising tendency. It could be concluded that there is a rising tendency in developing countries, basically. At the same time, from Figure 1-3, it is very clearly there is a rising tendency of applying PPP in EU. With regards to the investment of PPP program, the rising tendency will be clearer in developing and developed countries. From Figure 1-4, there is clear rising tendency of PPP program in developing countries. From Figure 1-5, EU has a clearly rising tide except final two years. Combining above conclusions, it could found that PPP has been applied in developing countries and developed countries with a basically (for the safety of conclusion) rising tendency.

It has been found from above illustration, PPP as specific mechanism between government and firm has been applied generally. However, recalling there is no precise definition of PPP (not to mentioned problem else in essence); under this situation, it is not surprised that PPP gets explored seldom about its potential problems. More details about literature gap upon *ex post* CA under PPP in this dissertation are exposed in following.



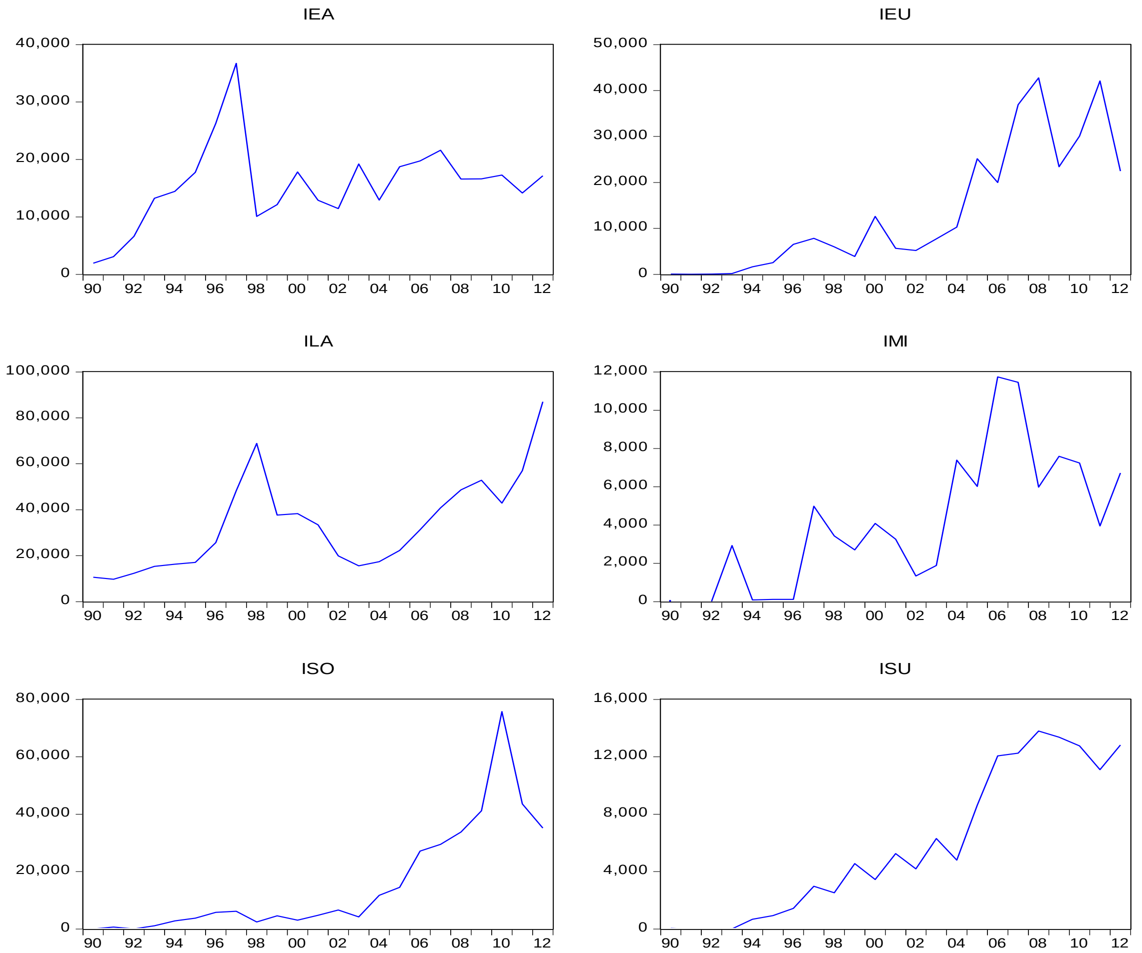
NEA: The number at East Asia and Pacific
NEU: The number at Europe and Central Asia
NLA: The number at Latin America and Caribbean
NMI: The number at Middle East and North Africa
NSO: The number at South Africa
NSU: The number at Sub-Saharan Africa

Figure 1-2: PPP number in developing countries



NEUROPE: The number of EU

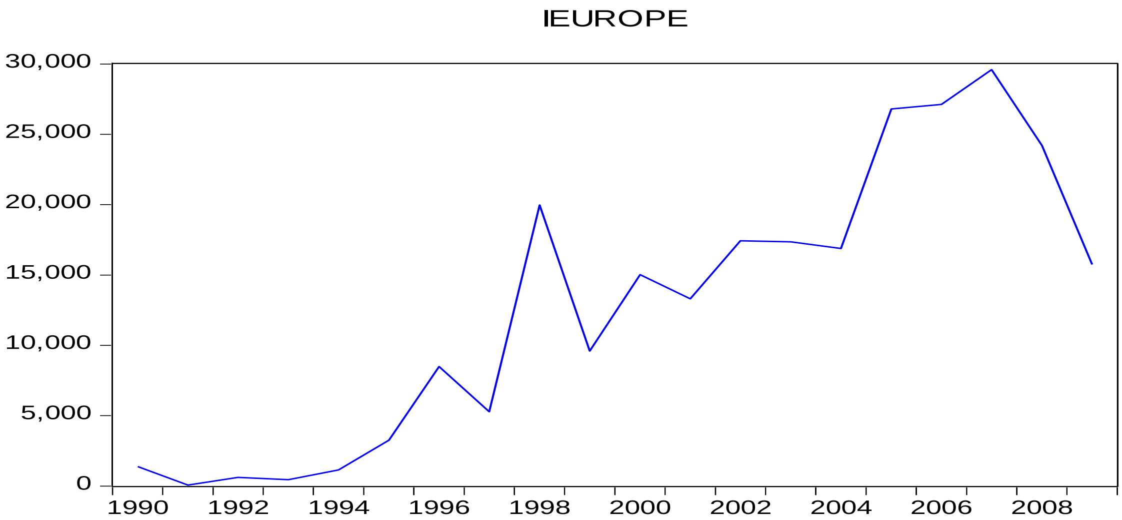
Figure 1-3: PPP number in developed countries



IEA: The investment at East Asia and Pacific
IEU: The investment at Europe and Central Asia
ILA: The investment at Latin America and Caribbean

IMI: The investment at Middle East and North Africa
ISO: The investment at South Africa
ISU: The investment at Sub-Saharan Africa

Figure 1-4: PPP investment amounts in developing countries



IEUROPE: The investment of EU

Figure 1-5: PPP investment amounts in developed countries

1.3.3 The literature gap in the field

After several cases study about PPP program, author finds immediately that *ex ante* contract may be vulnerable to *ex post* risk. A series of incentive and corresponding behaviours emerge under *ex post* expectation. More importantly, after revealing literature, the potential problems surrounding *ex post* CA (not to mention *ex post* CA under PPP), is explored or investigated scarcely by scholars. The following will show how literature overlooks the theme of *ex post* CA under PPP.

There are a series of literatures focusing on pros and cons of PPP. The main advantages get emphasized clearly: better incentive, better risk allocation, introduced resource and subordinate benefits such as added economic value and so on (Geest and Jorge 2011, Bettignies and Ross 2004 and Saussier at el. 2009). PPP is even regarded as a miraculous solution (Carnona 2010). The challenges are also mentioned such as renegotiation, potential extra costs and so on (Geest and Jorge 2011). However, potential problems (responding to above challenges) are more influential than expectation. For example, the added economic value hinges on the strong pursuit of government (Carnona 2010). Government is not only regulator on economic efficiency and also political decision maker; the decision of government is not pure economic. As an attractive mechanism, the fundamental driver of PPP is actually the limited public fund (Geest and Jorge 2011, Saussier 2013) instead of its advantages. PPP may just delay the public spending; it could be over-advocated by the politicians (Parker and Hartley 2003). In fact, a new European directive has been proposed to avoid potential failure of PPP in 2011 (Saussier 2013).

There are actually not enough works done for PPP, though the theoretical framework is given (Saussier 2013). It is noted that some literatures involve problems of PPP, but those have mainly focused *ex ante* contract design (for example, see Cheng 2010), not *ex post* problems. Among literature of PPP, *ex ante* risk gets emphasized (see Ng and Loosemore 2006) as determining factor. It has actually been explored under PPP from qualitative analysis (see Geest and Jorge 2011, European Commission 2003, Iossa et al 2007) or quantitative one (see Geest and Jorge 2011); however, the exploration on *ex post* risk is neglected. Even when *ex post* risk is mentioned; it always only emerges in the section about future research in papers (for example, Demirag et al 2011). This shortage of study on *ex post* risk results into an overlook upon *ex post* CA. Similarly, Auriol and Picard (2013) only confirms PPP reduce the consumer surplus, but PPP failure gets no analysed.

In addition to no literature upon the specific theme, *ex post* CA under PPP, the relevant works overlooks also the behaviours under *ex post* CA. Namely, the phenomenon of *ex post* CA get involved, but the process gets no explored. At first, Wernerfelt (2004) explores explicitly CA by creating "adjustment-cost theory". However, the process of CA is not analysed and even Wernerfelt (2004: 21) has to admit that "the work is embryonic; many more games form can be looked at and other sources of inefficiency can be introduced". In addition, Holden et al (2010) explore bilateral relationship under *ex post* adjustment but those treat CA as exogenous element. With similar attitude towards CA, Bitran et al (2013) analyse the legal framework, institutional design and concession type of PPP while use novel data for renegotiation, but the process of CA get overlooked.

Besides above theories, Dnes (1995) and Miceli (1995) study contract modification in law economics; Danziger (1995), Andersen and Christensen (2002) and Dixit (1991) analyse contract reopening/renewal; Brown et al (1995) and Barraclough et al (2012) dissect CA at stock market; however, those neglect the process of CA and then do not focus on behaviours under *ex post* CA.

Some issues related to *ex post* CA have been explored, but most of those are not developed to reveal the process of CA. The issue of intervening contract relates to the contract adjusted by government for the political consideration, but it is always analysed on the bad effect over economic efficiency (see Boyer 2009). As for hold-up issue, it reveals the lock-in effect (transacting party cannot withdraw easily from investment or assignment contract) and exhibits some behaviours related to *ex post* CA. However, holdup problem is limited for the insight over *ex post* CA, so the process under *ex post* CA gets overlooked. Klein (1996) creates the theory of private enforcement capital while Hart and Moore (2008) constitute a theory of contractual reference points, respectively; but the process of *ex post* CA is not discussed. Gow and Swinnen (2001) investigate phenomenon related to CA, but the CA itself (as process instead of element) is not explored. Similarly, the same limitation happens in the issue of SBC. Bailing-out is involved, but most of scholars focus on the performance due to the phenomenon of SBC while the process related to *ex post* CA gets overlooked. For example, Dahlberg and Petterson-Lidblom (2002) investigate bail-out problem while Gao and Scheffer (1998) study empirically the SBC issue in China and other transition countries, but the potential incentive or effect of *ex post* CA gets overlooked by those scholars. The issue of holdup and SBC could be seen more in Chapter 2. All these literatures could give guidance for the exploration on *ex post* CA, but it cannot give direct and clear picture about behaviours under *ex post* CA.

Finally, as an outstanding economist in EoC, Cheung (1969, 1970 and 1974) has actually explored the general CA (not *ex post* CA). Cheung explores behaviours when income right is needed to update. The change of income right corresponds to the adjustment over original contract relationship. However, it is very unfortunate that his theory does not get developed systematically. At the same time, Cheung's theory focuses on general CA, so the CA due to *ex post* risk is not explored specially. Furthermore, Cheung's theory focuses on the behaviours of private parties after the change; hence the behaviours involving firm and government get no involvement. Cheung's theory give a very meaningful start about restructure of contract, but it gets no development by Cheung itself and following scholars. The reason for no development about CA, for one thing, is Cheung keeps originality of research and study nothing systematically. For another, later scholars do not follow Cheung's findings, though the Nobel Prize winners including Ronald Coase, Joseph E. Stiglitz and Milton Friedman specially acknowledge Cheung's contribution.

In fact, the insufficiency of research on the topic of *ex post* CA could be understood. *Ex post* CA, this topic in economics, definitely should go along NIE. However, EoC focuses on *ex ante* contract design without sufficient investigation on *ex post* contract relationship (including adjustment); TCE focuses on *ex post* governance structure overlooking *ex post* contract adjustment. That is why NIE (mainly EoC and TCE) overlooks the topic, though it should be relevant. Moreover, neoclassic economics focuses on initial situation and final equilibrium (Manicas 2008). *Ex post* contract adjustment with focus on an adaption process is definitely overlooked by neoclassic economics.

To sum up, PPP gets no clear picture about *ex post* CA, though it attracts sufficient attention to be a popular mechanism in current and future ages. Most of relevant literatures are limited at the implication for *ex post* CA under PPP, the significance of this research seems clear.

1.4 An overall summary of research

For the convenience of illustrating this research, Table 1-3 is given especially. The theme of this thesis is *ex post* CA (namely, CA that takes place after contract stipulation, this will be followed since then[2]) under PPP. The research question is 'What are the process and consequence of *ex post* Contract Adjustment (CA) under PPP?'. This research involves mainly the issue of Contract Restructure (CR) and Soft Budget Constraint (SBC).

As for CR issue, it involves different policy and different packages. The former include rescue policy and takeover policy. The latter includes *ex post* risk transfer (for example, *ex post* risk guarantee for debt borrowing of firm), property rights reallocation and the combination. These packages will be adopted under different situations related to no/definite/potential bankruptcy problem.

With respect to SBC issue, it witnesses actually a compensation effect under *ex post* risk. The compensation effect is reflected by *ex post* contribution from government to firm; the budget constraint of PPP program is softened inevitably. Every *ex post* CA between firm and government is actually one chance of firm to soften budget constraint behind previous contract relationship. Therefore, SBC issue could give a suitable framework for research. At the qualitative aspect, it relates to the moral hazard of firm under the expectation of government's *ex post* bailing-out. At the quantitative aspect, it means PPP program must be the public utility when the number of CA reaches some value (as the limit). Different from literature, author focuses on the contract relationship to explain the reality, hence the research target is *ex post* CA under PPP instead of SBC phenomenon.The following will introduce the main contents of this research; namely, the lower-part of Table 1-3 will be illustrated. During the illustration, some important concepts in this research will be also introduced. More details about modelling and regression/simulation could be seen in

[2] More details about *ex ante* or *ex post* will be given in the end of this section.

later chapters.

<table>
<tr><th colspan="5">Table 1-3: the summary of hierarchy levels for this research</th></tr>
<tr><td>Research theme</td><td colspan="4">ex post CA under PPP</td></tr>
<tr><td>Research question</td><td colspan="4">What are the process and consequence of ex post CA under PPP?</td></tr>
<tr><td>CR issue</td><td colspan="4">different policy & packages of government to keep PPP program going</td></tr>
<tr><td>SBC issue</td><td colspan="4">compensation effect from government to firm under ex post risk</td></tr>
<tr><td>Part</td><td>Sub-question</td><td colspan="2">Main contents</td><td>Issues</td></tr>
<tr><td rowspan="4">Theoretical exploration (modeling)</td><td rowspan="4">Why and how there will be ex post CA under PPP?</td><td colspan="2">Ex ante competition for contract (with numerical examples)</td><td>None (as a reference model for later ones)</td></tr>
<tr><td colspan="2">The failure of ex ante contract relationship under PPP</td><td>CR</td></tr>
<tr><td rowspan="2">The failure of PPP</td><td>SBC phenomenon</td><td>SBC (qualitative aspect)</td></tr>
<tr><td>PPP termination</td><td>CR</td></tr>
<tr><td rowspan="2">Empirical investigation (regression)</td><td rowspan="2">What is the consequence of ex post CA under PPP?</td><td colspan="2">The regression of softness of budget constraint (with a simulation for feasibility test of different ex post CA methods)</td><td>SBC (quantitative aspect)</td></tr>
<tr><td colspan="2">the regression of ex post risk</td><td>SBC (quantitative aspect)</td></tr>
</table>

The reason question will be answered in theoretical exploration and empirical investigation, respectively. The part of theoretical exploration will explore mainly why and how there will be *ex post* CA. namely, the reason for and the process of *ex post* CA will be figured out. In the meanwhile, the part of empirical investigation will investigate how budget constraint is softened after *ex post* CA. hence, the consequence of *ex post* CA process will be uncovered. In particular, CA in this research focuses on the *ex post* adjustment; *ex ante* change due to (re)negotiation is investigated.

At the first part, we sets up one model for potential takeover policy under *ex post* CA for PPP program. Government has inherent incentive keep PPP program going, thereby rescuing firm under *ex post* risk. In particular, either rescue policy or takeover policy of government is aimed to compensate directly or indirectly firm under PPP through CA. Our modelling is oriented to draw a picture for the compensation effect of CA under PPP and then give a theory of CA under PPP.

As for those two sets of *ex post* model, the failure of *ex ante* contract relationship involves two situations responding to different beliefs of players; the failure of PPP involves the SBC phenomenon and the termination of PPP. These two sets of model will be under the issues of CR and SBC. The CR issue will explain why and how *ex ante* contract relationship under PPP will be broken by *ex post* CA. In addition, it will also explain the takeover of project, namely, the termination of PPP. The SBC issue will only explain the SBC phenomenon; it will be used to explain why *ex post* efficiency of PPP will be broken on the expectation of *ex post* CA. Considering the causal relationship between SBC phenomenon and *ex post* efficiency, so the qualitative (not quantitative) aspect of SBC issue will be used here. From the application of those two issues, it is seen that the theoretical exploration is mainly based on the issue of CR though the qualitative aspect of SBC issue is related to moral hazard of firm.

To get the answer of research question, the theoretical exploration will apply mathematical analysis (mainly under game theory) to analyze the behaviors of firm and government at *ex post* CA. our model will be given to reveal the relevant incentives of players and corresponding conditions. Author follows the research spirit of Cheung. As insisted by Cheung (1969a), the theoretical exploration should be close to reality; this idea reflects well the Positivism in Chicago School. Following the academic spirit of Cheung, at first, theoretical exploration in this research is aimed to give a full and close picture for *ex post* CA under PPP. Not only the incentives, but also the responding conditions will be emphasized in this research. At the same time, this research focuses on the behavior itself rather than efficiency itself. Moreover, modeling in this research seems complicated since all relevant elements are considered; at the same time, modeling is very cautious since every assumption is given very carefully.

After illustration over theoretical exploration, empirical investigation is done as following. The research theme is mainly under the issue of SBC. The core concept (SBC) is developed into specific indicators (softness) after referring to the literature in SBC according to the requirement of this research. The issue of CR is not directly relevant anymore when we focus on the consequence of *ex post* CA. However, it helps develop other indicators, for example, the measurement on *ex post* CA. At the same time, in spite of the regression on core concept, it needs to be pointed out *ex post* risk will be also regressed for extra insight. In particular, after getting result of regression for softness, different way/method of *ex post* CA gets simulated to test corresponding feasibility.

Two ideas need to especially be pointed out as following. ⑴the issue of SBC seems important, but *ex post* CA is the key concept for regression. Our aim is to test the SBC phenomenon under the consequences of *ex post* CA process. Namely, SBC phenomenon as the consequence of *ex post* CA (instead of the SBC phenomenon itself) will be investigated. ⑵SBC issue in investigation is related to quantitative side of story, by contrast with the issue in modeling, which involves the qualitative aspect. Combining the design of empirical investigation with the corresponding one of theoretical exploration, it could be concluded as following. The CR issue will be the main issue of modeling, with supplement of qualitative aspect of SBC issue for moral hazard; the (quantitative aspect of) SBC issue will be the main issue of investigation with help of CR issue for the development of relevant indicators.

1.5 The contribution of this research

In fact, the contribution of this research has been reflected in Section 1.3.3. Now it is listed especially as following. The first one is theoretical while the latter two are in empirical analysis.

⑴This research gives a theory of *ex post* CA under PPP. We especially model the potential takeover policy under PPP for CA package. With the inherent incentive of government to adopt rescue policy, *ex post* CA package under PPP gets figured out. With these relevant policy of government under *ex post* CA for PPP program, we illustrates how government compensates firm under *ex post* risk in the manner of CA. to sum up, we give a picture for the compensation effect of *ex post* CA under PPP.

⑵the real *ex post* CA under PPP gets measured. To our best information and knowledge, there is no relevant literature to specially measure *ex post* CA. Our data include sixteen indicators with two dummy variables and one qualitative variable. During indicators, there are five for original contract and *ex post* risk, respectively, and six for final situation after *ex post* CA. Meanwhile; the qualitative variable is specifically for government policy under *ex post* CA. more details could be seen in Chapter 5. At least our measurement has two directions for knowledge. On one hand, those indicators (as quantitative data) could reflect more information instead of only in regression. For example, data for *ex post* risks could be used for empirical multivariate distribution, especially to uncover the distribution of *ex post* risk in reality. On the other hand, those real cases help uncover phenomenon related to *ex post* CA in reality.

⑶*ex post* CA in reality is investigated and then *ex post* problems related to CA under PPP is explained. This research gives corresponding policy suggestion after investigation. After investigation, it could be found that different ways of *ex post* CA have practical meanings that are not figured out by modelling since our modelling focuses on behaviours themselves. For example, the debt package could constrain more contribution from government to firm, which is out of modelling finding. The investigation helps us to have a close eye to reality and then give a more sufficient explanation over reality. We get two kinds of conclusion from regression and simulation, respectively, the first one give five precise policy suggestions while the second one reflects the conclusion in modelling.

1.6 The specific design in this dissertation

After introducing the framework of investigation, the following will give important details for the specific design in this dissertation. At first, it is worthy specially pointing out this paper involves two stages, which are divided by the time of official (original) contract assignment of PPP program. The stage before that time involves *ex ante* variables representing *ex ante* expectation/estimation. We call it as the stage of contract stipulation/design in following chapters. The stage after that time will witness *ex post* variables/indicators reflecting *ex post* risk. We call the second stage as the stage of contract implementation in following chapters. At the same time, considering above distinction, *ex ante* variables involve economic elements before official contract assignment while *ex post* variables/indicators are related to those after that point.

Secondly, the traditional way of empirical investigation in economics will be followed in our empirical investigation. However, thirty-two PPP programs as cases will be studied for data generation before the regression in econometrics. The data is from reality and the data generation is a very hard process for this research. Every value of indicator is identified from objective evidence as possible as we can; even some are not available; the estimation for data must be based on the evidence clearly and the estimation error should be surely small. Otherwise, the data ought to be treated as missed or the case should be abandoned. All of these derive from the insistence of focusing on reality. Some data has noise due to the imperfect measurement; however, this kind of data obtained from a hard collection is original for research and meaningful for the realistic world.

Thirdly, after collection, those the cross-sector data is regressed twice in this research. The first set of regression surrounds the SBC issue for *ex post* CA under PPP while the second one focuses on the relationship for *ex post* risk. The investigation uncovers what determines the severity of SBC and *ex post* risk. It could give a direct and practical suggestion for policy. The findings of these data support conclusions from theoretical exploration and provide extra insights over some problems (for example, government relies over debt-support package rather than compensation package in reality).

Finally, modelling and investigation will be linked closely. There are links at macro-level and micro-level. As talked above, the modelling focuses on the incentive and corresponding conditions to explore the process of *ex post* CA while the investigation figures out the determinant factors of consequences. Therefore, the former will be the theoretical base for the latter; the latter will test relevant relationship for the former. This is the macro-connection between two parts. Moreover, every case has a qualitative indicator and sixteen quantitative indicators plus two dummy variables. The qualitative indicator measures government policy under *ex post* CA, which could test the conclusion of modelling directly. The quantitative indicators and two dummy variables will be applied for regression. Therefore, every case relates to theoretical exploration and empirical investigation together. This is the link between two parts in micro-level.

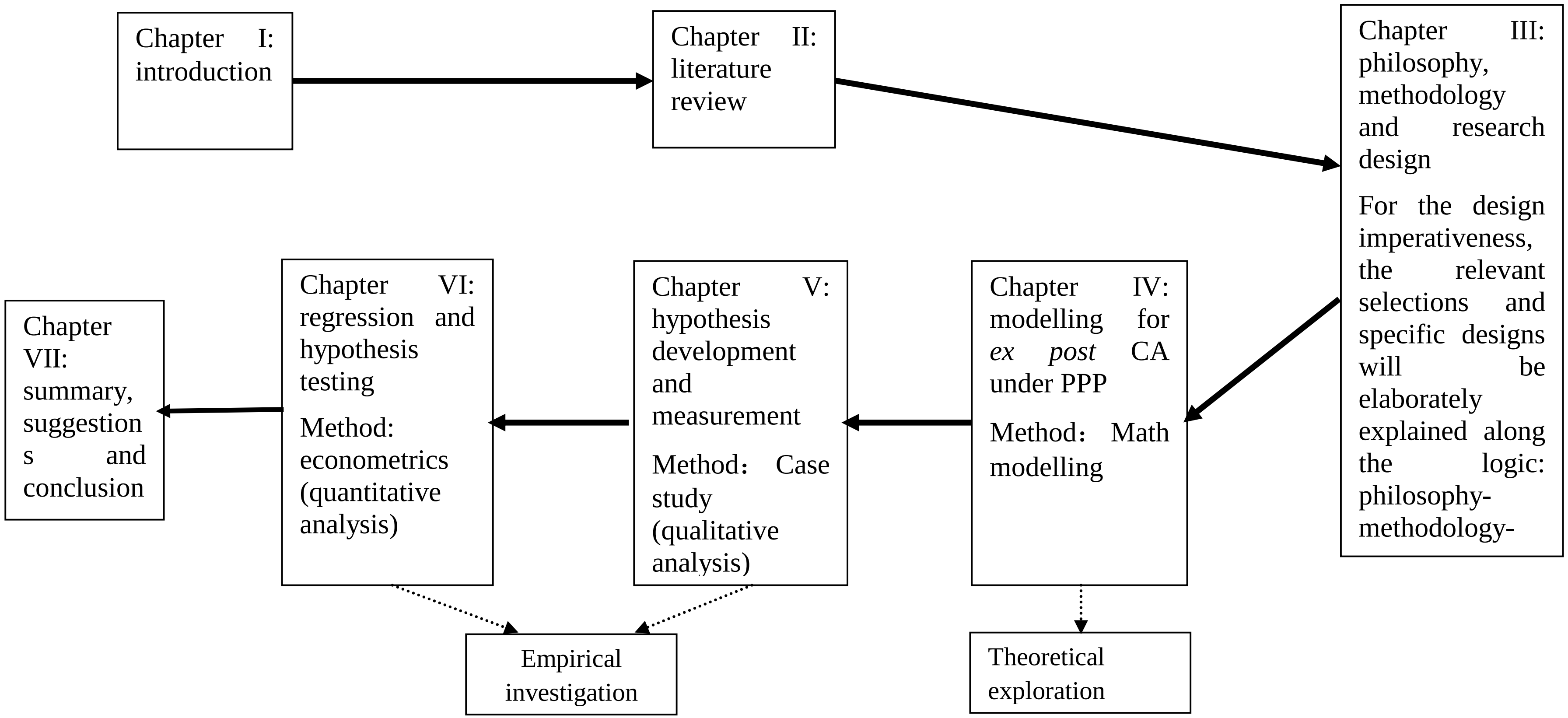
1.7 The framework of this research

This research will have seven chapters. The next chapter will be the literature review, which gives a theoretical base for later exploration and investigation. At the literature review, the relevant theories, issues and problems will be reviewed. In particular, three works of Steven. N. S. Cheung will be reviewed carefully because it gives important idea for the restructure of contract, which gives a theoretical base about CA and then a theoretical support for *ex post* CA under PPP.

The third chapter discusses philosophy, methodology and research design. In particular, for the research design, approach, method, data and even software in this research will be illustrated. The detail of research design will be given mainly in the subsections about methods in modelling, measurement and regression.

After research design, there will be theoretical exploration through modelling. Our model will be constructed for *ex post* CA under PPP. Finally, the empirical investigation will include Chapter 5 for measurement and Chapter 6 for regression (with simulation for extra insight). The former relies on case study while the latter adopts econometrics upon cross-section data. Finally, the seventh chapter will give summary, policy suggestion, the limitation of this research, the suggestion for future research and the conclusion of findings. The framework could be seen in Figure 1-6.

Title: an exploration of *ex post* contract adjustment under public private partnership with special investigation of the transportation industry



Contribution: theoretical exploration and empirical investigation of *ex post* contract adjustment under PPP + preventative policy suggestions

Methodology: mathematical model for theoretical exploration and econometrics for empirical investigation (more details will be seen at Table 3.1 in Chapter 3).

Figure 1-6： the framework of thesis and the chapter headings

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter will introduce relevant theories in EoC (Economics of Contract) and TCE (Transaction Cost Economics) respectively in order to define *ex post* CA and PPP. After that, the issue of CR (Contract Restructure) from three works of Cheung will be revealed carefully since it gives important insight over general CA. in addition, the issue of SBC will be reviewed. Three potential problems under *ex post* CA will be then reviewed for potential insights. Finally, the specific terms used in this research will be clarified before a summary.

2.2 Relevant theories in EoC for the definition of *ex post* CA under PPP

This section will review EoC for the potential definitions of *ex post* CA and PPP. The first three subsections will review relevant theories in EoC. The first one will review contract relationship; the latter two will review the role and structure of property rights, respectively. The relevance of those literatures will be illustrated in the end, where the definition of *ex post* CA under PPP will be given.

The following explains the reason for above review design. Intuitively, CA is the change over previous contract relationship, so contract relationship (the core definition in EoC) need be reviewed firstly. After that, to give a full picture about CA, the role/effect of property rights will discussed in section 2.2.2 so that behaviours of transacting parties could be figured out. In particular, the failure of contract will be also explained in that section. Only after clarify the effect of property rights and the failure of contact relationship, the potential reason for CA could be uncovered. Moreover, to give a full picture about PPP, four forms of property rights structure will be given in section 2.2.3. After outlining the structure, the specific structure of property rights under PPP could be orientated. On the base of above review, the potential definition of CA and PPP will be given separately as the finding from literatures.

2.2.1 Contract relationship

PPP has its own kind of contract relationship, *ex post* CA under PPP must consider about the definition of contract relationship. According to EoC, optimal contract relationship need be designed or chosen to maximize the economic efficiency with constraints of risk dispersion and transaction cost. EoC explains all of economic behaviours from the contract relationship. If PPP corresponds to one specific form of contract relationship, *ex post* CA is a switch of contract relationship. The following will explore contract relationship in essence.

According to Cheung (1983), the contract relationship seems self-evident. It is economic relationship under contract. Contract relationship could be explicit or implicit. The explicit contract relationship fixes the allocation of property rights. This is aimed to identify and normalize expected incentives of transacting parties through contractual stipulation. This path-breaking contribution actually develops the theory of Coase (1937) about the nature of firm. As asserted by Cheung (1983), firm and market are actually different forms of contract relationship; the substitution between firm and market is the switch of contract relationships. Coase and Cheung focus on the change over the form of contract relationship. According to Coase (1934) and Cheung (1983), the change of efficiency or transaction cost derives from the relevant switch over contract relationship.

The implicit contract relationship is constrained by underlying institution such as convention. The best example is the marine fishing, which have a fixed number of fishermen in the specific area of public sea. The relationship between fishing men is maintained or relied on convention (Cheung 1970). Any entry of new fisherman will reallocate the income of fisherman (Cheung 1970); the equilibrium situation would be maintained when there are a conventional/fixed number of fishermen. This kind of conventional number derives always from experience in past years. In general, this kind of contract relationship cannot be measured accurately. However, when the parties have a clear *ex ante* promise/commitment for transaction and the promise/commitment could really affect economic benefit, this implicit contract relationship must be also considered. Cheung (1970) points out the wealth will be reallocated once conventional production is changed. This means the implicit contract relationship could also affect economic behaviours at relevant situation.

Due to the effect of contact relationship, transacting parties will choose contract relationship to realize Pareto optimal. As usual, this kind of choice is related to *ex ante* explicit design for contract relationship. To get optimal contract relationship, not only property rights but also risks are allocated. When need be reallocated, CA is needed. To reduce *ex post* risk, for example, some tenant will prefer renting the land at the fixed-income contract to the share contract (Cheung 1969b).

In spite of stipulation over transaction itself, in fact, the "contingent term" (Shavell 1984: 122) related to specific performance (of the party having a default) or payment (to the other party) is added in contract for contingency in recent decades. When contract breach takes place, this kind of *ex ante* stipulation will maintain original contract relationship by giving provision for *ex post* remedy. In some industry, the right of first refusal has been used in contract for updated contract relationship (Grosskopf and Roth 2009). The right is to award the holder of contract right a protection when the contract comes to end. The contract holder is guaranteed to get a contract right at a new duration with the same price with competitor. Any offer from competitor could win the next duration only when the corresponding offer is higher than the one of the former contract holder.

The two above ways, contingency term and the first refusal right, are used for maintain or extend original contract relationship. At the same time, either of contingency term or the first refusal right could be stipulated into contract; the contract relationship will be constrained by those stipulations. Therefore, the choice in contract relationship undertakes the role of allocating property rights and *ex ante* risk, transferring risks *ex post*, and possibly, remedying contract breach.

2.2.2 The role of property rights and the reason for contract failure

When property rights are not effective, CA is necessary to avoid contract failure. Hence, we need know the role of property rights and the reason for contract failure. Property rights generate at least three kinds of incentive in literature: reducing risk, internalizing externality and enforcing transaction. When property rights cannot be effective, contract failure would take place. The following will explore the role of property rights from literature and then try to get potential reason for contract failure.

As for incentive of reducing risk, Libecap (1986) and Jaffe and Louziotis (1996) argue property rights could generate incentives to reduce risk for bigger rewards or/and smaller costs. In fact, this standpoint is not fully self-evident; it needs some explnation. At first, property rights could award clearly the owner "associated rewards and costs" (Libecap 1986: 227), Most of rational men are risk averse, so the risk will make a premium on return. When a risk-averse man gets property rights, the property rights will induce the rational men to reduce the risk for maximizing utility/wealth. That is why Jaffe and Louziotis (1996) point out that the property rights make effect through reducing risk.

With respect to incentive of internalizing externality, Cheung (1970: 70) boldly points out that any theories focusing on the concept of externality means nothing in academic sense. More details about Cheung's opinion about externality could be seen in section 2.4.2. Externality emerges when the specification of contract relationship is not economical (Cheung 1970). As long as the cost of externality is higher than the reward of specification, property rights would be effective and then externality would disappear. Demsetz (1969) explains how property rights incentivize the owner to internalize the externality. When an owner is given a right to exclude others, resource that is potentially external would be utilized more efficiently under private ownership.

With regard to enforcing transaction, Hart and Moore (2008: 32) argue that "the anchoring of entitlements in turn limits disagreement, aggrievenment, and the deadweight losses from shading". In other words, the property rights could enforce transaction by limiting the unexpected elements (Hart and Moore 2008). In spite of above indirect effect, property rights could enforce transaction in a direct way. The property rights stipulated by contract terms can "widen ex post market conditions" within the self-enforcing range "where performance remains assured" (Klein 1996: 458). In particular, the self-enforcing range is actually a set that includes a series of market conditions, under which the transacting party will be incentivized to implement contract. Namely, Klein believe property rights under contract could increase the probability of implementing original contract and then the corresponding transaction is safer. Similarly, Hart and Holmstrom (2010) believe that (more) intensive property rights under the strategy of reallocating asset ownership could make contract relationship more efficient.

If the above roles of property rights are realized, the corresponding contract relationship cannot be broken. It cannot help to ask why there is contract failure. According to the contract failure theory, Lee (2010: 22) points out that there will be

> '…contract failure, which is a particular type of market failure, occurs in venues in which services [or transaction itself] are difficult to evaluate.'

Along this perspective of Lee (2010), information problem is the main source of contract failure. According to Lee (2010), when there is information problem, clarification of property rights will lead to into potentially expensive transaction cost, so contract relationship will be ineffective and then failed. If the property rights cannot make effect as expected, expensive transaction cost forces transacting parties to abandon contract. Cheung (1969) points out the transaction cost could result from the physical property of goods or service when the measurement is difficult and then expensive. Recalling the externality, externality is one kind of contract failure. From these literatures, the information problem seems to be a source of contract relationship.

However, there is no more precise reason for contract failure; scholars seem stop at the information problem. In particular, seen from above, economists in EoC believe property rights ensures efficiency. In fact, our dissertation will witness property rights cannot exclude the possibility of contract failure due to *ex post* CA. Any contract relationship has a limit to undertake *ex post* risk; when the property rights overload *ex post* risk, the efficiency has no chance to realize.

2.2.3 The structure of property rights

It will be seen from following, PPP program is a private property under the cooperation of government. The structure of property rights under PPP is different from the traditional one, so we need review relevant literature for that. Property rights structure could be reflected in four modes, open access, communal property, private property and state property (Branda˜o and Feder 1995).

Firstly, open access is nonexclusive and non-rival for consumption. Nonexclusive goods are too costly for the providers to get a reward from user while Non-rival means that the consumption of the good diminishes nothing for others to enjoy (Fischel 2000). Therefore, open access makes market transaction failed as general (Ostrom, V and Ostrom, E 1977). It needs to be pointed out that 'open access' is , to some extent, equal to 'public good'; the former reveals the structure of property rights while the latter highlights the target of supply to the public instead of some group of consumers. Considering this, open access is more meaningful to use in this subsection.

Secondly, communal property is only nonexclusive and non-rival for consumption in some group while anyone outside the community will be excluded. Communal property is encouraged to utilize fully within the specific group; Carmona (2008) believes the realization of communal property rights must allow host communities to own the decision rights. However, any usage beyond the limitation will lose efficiency. As general, communal property is the issue in some group instead of private choice.

Thirdly, private property as general is exclusive and rival. Anyone owning the private property could get corresponding income from selling it or utility from enjoying it. Cheung (1974) asserts the private rights own three "distinct sets of rights" including income right, usage right and transfer right. This could be also supported by Zhu (2002). Usually, the first two sets of right(s) are incompatible in transaction.

Fourthly, state property is special property without clear delineation. Baltzer (1998: 6) concludes as following:

> "In fact, what is traditionally designated as state property is a broad range of divisions of property rights between various actors…state property rights may be a structure…"

Considering ⑴PPP is clearly not the state property since the existence of private party in program and ⑵state property has no clear delineation, we spend no effort to review literature about the state property to avoid the un-meaningful wresting.

It is seen that all of above structures of property rights are divided according to the angle of ownership. Every kind of structure may be only suitable for some situation, so the restructure of property rights need some conditions. Cheung (1970) explores how marine fishing cannot be changed into private production. In fact, the restructure of property rights is the adjustment over contract form; it will respect the same principle as CR in essence, which is actually explored by (Cheung 1969b, 1970, 1974) and will be reviewed in section 2.3. However, the theory about structure of proper rights is different from the issue of CR. The corresponding difference is related to the context over the restructure. The restructure of property rights focus on the incentive and behaviours at the macro change while the restructure of contract stays at the micro level. Precisely, the former involves regulation policy to let property become open access, communal access, private access or state access; meanwhile, the latter is only related to individual transacting parties. In particular, even when CR involves government behaviour, government behaviour is just a decision of government as individual transacting party. More details about CR could be seen in section 2.3.

2.2.4 Relevance of EoC for this research

From last three categories of literature in EoC, it is seen that ⑴*ex post* CA is the adjustment over *ex ante* contract relationship by revising stipulation or changing the critical commitment/promise, ⑵PPP is a mechanism that generates an explicit contract relationship between firm and government. Combining the above two definitions, it could be concluded that ⑶*ex post* CA under PPP is one *ex post* adjustment of contract relationship between government and firm under the framework of PPP. Moreover, ⑷the ownership under PPP is a special private property during a specific duration stipulated by contract between firm and government.

Above four conclusions are explained and illustrated with details in following. At first, there are direct/indirect contract relationship. In theory, the explicit adjustment of contract relationship involves clear change over contract stipulation while the implicit way is just a breach over original commitment/promise. In reality, the former includes any change over contractual items that will affect the benefit of transacting parties. The latter only involves the breach of critical promise that is the important component of *ex ante* contract relationship. For example, in the case of Taiwan High Speed Rail (THSR), the bidding winner promises to return a huge profit to government, which is regarded as one of important reasons for the bidding victory (Chi and Amy 2011). However, the promise is totally broken when firm has no any profit in later years. This kind of promise under PPP program will be asserted clearly in bidding, so it should be considered in reality. It needs to be pointed out that the breach over the original convention should be also counted as *ex post* CA in theory, though it will not be applied neither in this research because it is very difficult to verify or confirm implicit CA in an objective way.

Secondly, PPP is the mechanism that constructs an economic relationship for transaction between government and firm. This kind of relationship is different the contract relationship in market, which is totally operated under competition; it is also different from the relationship in firm, which relies mainly on the managerial and hierarchical guide with monitor system. PPP belongs to one kind of contract relationship with a cooperative form. With comparison to market and firm, PPP relies on the cooperation between firm and government and the independence of firm. PPP could lead to higher or lower level of efficiency (and transaction cost). The lower efficiency & higher transaction cost results from the vulnerable property rights, which derives from intervention of government or dependence of firm on government. The higher transaction cost & lower efficiency derives from flexible allocation of property rights. PPP could be a good mechanism realizing efficiency on the better cooperation while it also tests the ability of both partners to deal with *ex post* crisis (for example, raising fund crisis or cost overrun crisis).

Thirdly, *ex post* CA under PPP means the contract relationship of project is *ex post* changed under the framework of PPP. There are three points in applying this definition. At first, any adjustment before program launched, for example, the adjustment after (re)negotiation before PPP contract assignment clarifies the liability of firm and government, cannot be counted as *ex post* CA. secondly, any adjustment after takeover policy of government cannot be counted as *ex post* CA under PPP since takeover policy has already terminated the PPP program. Thirdly, the takeover package itself is the (final) *ex post* CA under PPP because both of firm and government still need reallocate ownership on the base of previous contract under PPP.

From literature, it has been shown that contract allocates the economic benefits with corresponding incentives. Accordingly, *ex post* CA will result in reallocation of benefits with new allocation of property rights. Any *ex post* CA in this research focuses on the change over economic benefit under new contract relationship instead of the change over contract stipulation.

Fourthly, the ownership under PPP is neither fully public property nor independent private property. For one thing, firm could only have the control right over the program during specific years stipulated by contract. For another, firm is always under economic regulation and then its decision right is not as free as private ownership; government (as public partner) has some rights (for example, the debt refinancing need government's approval) or obligations (for instance, government need finish land acquisition for the projects as general) for the PPP program. To some extent, PPP program give a special structure of property rights: a private contract right awarded from government.

2.3 Relevant theories in TCE for *ex post* CA under PPPs

This section will review the relevant literature in TCE. The first subsection will review the intermediate governance structure, thereby giving insight over mechanism of PPP; the second one will discuss three ways of enforcing transaction. The third subsections is for the incentive contract theory. The illustration of relevance will be finished in the fourth subsection.

2.3.1 Intermediate governance structure

PPP has a specific intermediate governance structure between firm and government, so the theory about intermediate government structure need be reviewed. The basic perspective in TCE is to identify "the most economical governance structure" whose "critical dimensions for describing contractual relations are uncertainty, the frequency" and idiosyncratic degree (Williamson 1979: 246).

By contrast to firm or market, the intermediate governance structure has three types of mode including joint venture, minority alliance and contractual alliance (Gulati and Singh 1998).

Among these types, the joint venture is mainly applied under PPPs. It is established as a separate organization which has "independent command structure and authority system with clear defined rules and responsibilities for each partner" (Gulati and Singh 1998: 792).

By contrast, minority alliance and contractual alliance do not create a specialized entity. Under the former, partners always own some minority equity in others (Gulati and Singh 1998, Teng and Das 2008) while partners cooperate with a contract for higher efficiency under the latter (Gulati and Singh 1998).

2.3.2 The role of safeguarding policy

TCE gives three clear and meaningful ways to safeguard transaction; it gives relevant insight over maintaining or adjusting original contract relationship to keep transaction going. Though those theories in TCE do not give a explanation in essence (since the source of *ex post* behaviour/incentive, CA, is overlooked), TCE give some insight on *ex post* problems.

Maitland et al (2009: 5) assert that "governance structures safeguard transactions through contract provisions, credible commitments and dispute resolution". As for contract provision, the performance is stipulated to be detailed term to enforce transaction. When contract provision cannot be complete, transacting partier will keep some space for the flexibility, thereby saving cost for cooperation. The contracting behaviour is called "relational contracting" (Maitland et al 2009: 5) while this corresponding contract is always called "relational contract" (Brown et al 2004) in TCE. Contract provision seems the opposite of relational contract, but contract provision could be necessary component of "relational contracting" (Maitland 2009). The contract provision could be revised *ex post* to safeguard transactions with less transaction cost.

With respect to credible commitment, it will be related to the specific asset. The specific asset is the critical element of increasing transaction cost (Dyer 1997) so that it could lead to holdup problem. However, it has been applied widely to send a signal of credible commitment. As said by Kasuga and Torii (1999: 4) the specific investment will be used 'as "hostage" to the relationship' for cooperation. Simply speaking, there are two kinds of method to make credible commitment, transactional-specific investment or relational-specific investment. The former is related to idiosyncratic asset (visible or invisible) for transaction while the latter is for relationship. These two methods appear different because the latter focuses on the long-term benefits.

With regard to dispute solution, there are three methods, including "contract termination, contract renegotiation and third part enforcement of contract" (Maitland et al 2009: 6). Contract termination is adopted when original contract is beneficial to abandon. It is important to avoid making the problem more severe. For example, when an unexpected situation makes extra cost bigger than profit of buyer and seller, contract termination will be the option. Contract renegotiation will happen when transacting parties is still inclined to implement contract while some of original contract terms are not beneficial or practical. It could make more transaction cost with potentially strategic behaviours (see Bajari and Tadelis 2001) or Pareto improvement (see Segal 1999). When this kind of renegotiation brings improvement with a little transaction cost, the beneficial party will ask for a change by negotiation with some compensation to the other party. If the contract is not practical, the renegotiation will be necessary in reality. To some extent, renegotiation is one of *ex post* trade on the original contract relationship. Third part enforcement of contract is the last resort when the one of transacting parties sticks to original contract precisely. It may reduce the lock-in effect to protect strategic behaviour, thereby avoiding more transaction cost for transaction (Brown et.al 2004).

2.3.3 The incentive contract theory

Incentive contract theory insists on the endogeneity of contract incompleteness. Precisely, incentive contract theory believes that contract is designed to be incomplete with trade-off between incentive and transaction for adaption. According to Bajari and Tadelis (2001) and Bajari et al (2014), on one hand, the bigger degree of contract incompleteness leads to severer friction for *ex post* adaptation since *ex post* adaptation results from inadequate contract design. On the other hand, a more incomplete contract has stronger incentive. Similarly, a less incomplete contract should has weak incentive and less friction for *ex post* adaptation. For example, the cost-plus contract has less incomplete contract than fixed-price contract and then it could accommodate ex post adaptation better (Bajari and Tadelis 2001). In fact, the endogeneity property of contract design is also realized by other scholars. For example, Guasch et al (2008) investigate contract clauses for the renegotiation, Guasch (2004) gives a guidance in comprehensive details for *ex post* renegotiation.

In spite of the endogeneity of contract incompleteness, incentive contract theory emphasizes the prevalence of *ex post* adaptation. Bajari and Tadelis (2001) give some specific anecdotal evidence that *ex post* adaptation is rule instead of exception. The high incidence of renegotiation has been realized by Guasch (2004) and Guasch et al (2008). Especially, Guasch et al (2008) investigate *ex post* renegotiation due to imperfect enforcement of concession contract. It is found that regulation should play the key of deter opportunistic renegotiation. In spite of scholars, the prevalence of *ex post* adaptation has been realized by contract or in reality. Bajari et al (2014) confirmed that the adaptation cost accounts for 8-14 percent for winning bid. Due to the prevalence of *ex post* adaptation in addition to the endogeneity of contract incompleteness, It is asserted by Bajari and Tadelis (2001: 388) that the procurement problem 'is primarily one of *ex post* [italic in original context] adaptation rather than the *ex ante* [italic in original context] screening'. The contract choice hinges actually on the ability of adaptation.

Finally, incentive contract theory has some similarity with traditional literature in TCE, at the same time, it develop the idea of *ex post* adaptation theory from incomplete contract theory. According to incentive contract theory, the contract is chosen for *ex post* adaptation and incentive, this perspective about the endogeneity property of contract choice coincides the idea of Williamson (1985), which points out a less incentivized contract could have an adaptation advantage. By contrast with incomplete contract theory, in which contract incompleteness is assumed to be objective and exogenous because of the assumption of prohibitively expensive contract-writing (Bajari and Tadelis 2001), incentive contract theory draw a picture for subjective and endogenous contract incompleteness. The common point is that both incentive contract theory and incomplete contract theory insists on the necessity of contract incompleteness. To some extent, we could say that incomplete contract theory realizes the contract incompleteness at first; incentive contract theory develop the idea of contract incompleteness by uncovering the endogeneity property of contract incompleteness to exploring the source of contract incompleteness-*ex post* adaptation.

2.3.4 Relevance of TCE for this research

From last three categories of literature in TCE, three conclusions follow: ⑴*ex post* CA under PPP is one *ex post* safeguarding policy between government and firm under the framework of PPP, ⑵PPP as a mechanism that breeds an intermediate governance structure for cooperation between firm and government and ⑶more incomplete contract is expected under PPP and higher probability of *ex post* CA is expected under PPP than public provision.

Above three conclusions are explained and illustrated with details in following. At first, the *ex post* CA under PPPs seems *ex post* safeguarding policy to keep transaction going. New contract provision or new commitment is added; the old one is removed or substituted. The aim of *ex post* CA is to solve the dispute related to *ex post* conflicts.

Secondly, PPP could breed the specific governance structure. Considering firm under PPP acts independently as a cooperation partner of government, PPP will breed any one of three intermediate governance structures. If firm and government act under a joint venture, it means government could have relatively big control right over program. In fact, this happens in a few of cases such as National Air Traffic Service (NATS), in which government has 49 percent of share. With minority alliance, government will only have minor control over program; this happen in some cases such as THSR, in which some government-owned firm has equity in private firm of PPP program. Finally, contractual alliance could be identified when government has no any direct economic benefit in program. This is the most general form of PPP. One of examples is High Speed 1 (HS1), in which government has no direct or indirect equity investment in the firm of PPP program.

Thirdly, PPP program combining the construction and service provision under the same contract relationship instead of just one single construction or service provision (Hart 2003), the complexity of contract is expected. As Bajari and Tadelis (2001) mentioned, a simple project is cheap to design while a complex project will be accompanied by low levels of design completeness. According to the idea of incentive contract theory, severer contract incompleteness (namely, the low level of design completeness) under PPP must lead to higher probability of adaptation. Hence, relatively, *ex post* CA is expected under

PPP due to severer contract incompleteness, which in turn is determined by the complexity property of PPP program.

2.4 The issue of Contract Restructure (CR)

Because the research theme is orientated into CA under a specific mechanism (PPP), the relevant literature about CA itself is worthy reviewing. The next two issues will be reviewed specially. Those shed important insight about the question of this research and give a basic view of behaviour of transacting parties under CA. The following will review closely and carefully Cheung's three papers about potential CA at first. These papers consist of the issue of CR mentioned a lot before. The other issue, SBC will be reviewed in next section.

2.4.1 The Theory of Share Tenancy (1969)

The PhD thesis of Cheung is regarded as the first work of EoC. Before it is really assessed, the thesis had been published in four serial issues of Journal of Law and Economics. In that dissertation, Cheung explores the behaviours of tenant and landowner under the change of rent due to government interruption. The traditional conclusion that share contracting is inefficient relative to fixed-rent-contracting proved 'illusory' by Cheung (1968: 1107). In addition, the empirical investigation of Cheung confirms the existence of compensation effect under that rent change. The details could be reviewed in following.

In modelling of Cheung (1969), the process behaviours towards equilibrium are explored, which is totally different from the convention in neoclassic economics focusing on the initial and resulting situations. Cheung (1969)'s model starts from that government has stipulated cap over the rent; the compensation effect after rent change is figured out. When the market competition is enough, the compensation effect could help landowner gets the same income as before. As Cheung describes, the precise process after rent change is initiated by government intervention. One part of revenue of landowner becomes economic rent[3] due to government interruption. Cheung points out that part of economic rent will not belong to the landowner or current tenant anymore; it will go into the market. Any potential tenant could get it; hence there will be competition from tenant

[3] Economic rent here as a general term in neoclassic economics is also named as 'economic profit', it has no direct relationship with real rent in land.

to get that economic rent. The landowner will choose the tenant for biggest return. Even when nobody could give a higher level of rent to the landowner, the tenant will compensate landowner in implicit or indirect way. The example of former is the key money, it compensate landowner like corruption. The example of indirect way is the promise to undertake more input on the land, so the landowner could save relevant cost for land. When the market competition is enough, the landowner seems to get full return and then the economic rent goes back towards the landowner. When the competition does not exist, for example, the tenant just like a monopoly could take all of economic rent. Simply speaking, one part of economic rent is returned to the landowner; another part of economic rent is transferred towards the winning tenant. In spite of these two parts, there is still transaction cost due to the competition, which is wasted for this (re)allocation of property rights.

In fact, corruption could be constrained by law. The indirect way seems to be the main way. More importantly, the promise to undertake more input could make the agricultural production high efficient. The landowner not only save some cost, but also get more income under sharing tenancy. Cheung (1969) investigates if the productivity is improved after the rent change due to the competition. The data from reality supports compensation effect towards the landowner, thereby disproving the previous theory insisting that the share contracting is inefficient.

The whole dissertation surrounds about the compensation effect after the rent change due to government intervention. This compensation effect realized in the process denies the previous conclusion about the efficiency of share-contracting. It is just the overlook over compensation effect that leads to an ‘illusory’ conclusion (mentioned above).

This compensation effect before final equilibrium will be specifically relevant; it opens a door for theoretical exploration in this research. It is further developed in following two papers.

2.4.2 The structure of a contact and the theory of a non-exclusive resource (1970)

This journal paper gives more direct guide for CA. As pointed out by Cheung (1970), the contract structure is design to have two sets of aim: distributing income and specifying the usage of resource (or goods)[4]. At the same time, the 'transferable right' (Cheung 1970: 50) is also mentioned (here is mentioned just for later). As a subject for study in this paper, marine fishing has specific structure of property rights. In this article, Cheung (1970) explores the structure of contract and dissects the non-exclusive resource. Once resource is non-exclusive, no contract structure could constrain the income distribution and resource use. The competition will have an impact over original contract relationship and corresponding income distribution. This kind of reallocation will not stop until equilibrium reaches. After the analysis, with its special but very profound opinion, the 'externality' concept is totally disregarded (mentioned before) as following (Cheung 1970: 70).

> 'Externality, on the other hands, seems to center on different cases of "divergence" and to ignore the economic problem involved. The concept of "externality" is vague because every economic action has effects; it is confusing because classifications and theories are varied, arbitrary, and *ad hoc*. For these reasons, theories generated by the concept of "externality" are not likely to be useful.'

On the base of idea about contract structure, Cheung (1970) explores how the equilibrium of marine fishing reaches. The core idea is that the non-exclusive resource incentivizes potential entry to do marine fishing with corresponding (transaction) cost. Every new entry will reallocate benefit of existing fisherman until there is no any economic profit and then the completion of non-exclusive resource stops.

This journal paper is very meaningful about two points: the role of contract structure and then the non-exclusive resource generating the incentive. Both of these will be developed maturely in next paper.

[4] In fact, here should include goods because Cheung in that paper focuses on the non-exclusive resource, the transaction on goods are neglected.

2.4.3 A theory of price control (1974)

This paper develops contract structure maturely. Original ideas in first two papers will become more reasonable. In this paper, Cheung (1974: 57) roughly defines three set of property rights. The first one is 'the exclusive right to use, or to decide how to use, the good', we call it usage right; the second one is 'the exclusive right to receive income generated from the use of good', we call it 'income right'; final one is 'the right to transfer, or freely alienate, its ownership to any individual the owner sees fit include the right both to enter into contracts with other individuals and to choose the form of such contracts', we call it 'transfer right'.

Given three sets of right for property rights allocation are separated under contract structure, we could see ⑴ in Cheung's thesis, the economic rent due to the decrease of land rent is actually the part of 'income right' (instead of 'property rights') that the landowner cannot have after government interruption; ⑵ in the paper in 1970, non-exclusive resource derives from the resource lacking an exclusive income right.

It could be clearly seen that these three sets of rights corresponds to relevant aims of contract structure mentioned in Cheung's paper in 1970. The USAGE RIGHT (defined in paper in 1974) is obviously to stipulate the USAGE OF GOODS OR SERVICE (in the paper in 1970); the INCOME RIGHT (defined in the paper in 1974) is obviously to stipulate the INCOME OF GOODS OR SERVICE (in paper in 1970); finally the TRANSFER RIGHT (in the paper 1974) corresponds to the 'transferrable right' (Cheung 1970: 50). The basic opinion in this article is that the contract has a structure to stipulate these three sets of rights. If one of these is not stipulated, there will be non-exclusive right. Moreover, if one of these is changed, the contract actually has a restructure. Therefore, this paper discover the effect of CR.

There are two formal propositions in this article about the effect of CR. Because it is very meaningful for this research, we give it in following.

> 'Proposition 1: *When the right to receive income is partially or fully taken away from a contracting party, the diverted income will tend to dissipate unless the right to it is exclusively assigned to another individual. The dissipation of non-exclusive income will occur either though a change in the form of using or producing the good, resulting*

> *a decline in is value or through a change in contractual behaviour, resulting in a rise in the cost of forming and enforcing contracts, or through a combination of the two.*' (Cheung 1974: 58)
>
> 'Proposition 2: *Given the existence of non-exclusive income and its tendency to dissipate, each and every party involved will seek to minimize the dissipation subject to constraints. This will be done either through seeking alternatives in using or producing the good so that the decline in resource value is the lowest, or through forming alternative contractual arrangements to govern the use or production of the good with the least rise in transaction costs, or though the least costly combination of the two procedures*. (Cheung 1974: 61)'

From above propositions, Cheung gives a clear and full picture for the restructure of contract (mainly when income right is changed). There are two points as following, firstly, there will be a compensation effect when contract is restructured (especially, income right gets changed in this paper). That is why the change mentioned in Proposition 1 will happen. Secondly, resource reallocation is triggered when (part of) the income right is become non-exclusive due to exogenous element (for example, government interruption mentioned in Cheung's thesis paper) or inherent element (for example, the production of marine fishing, which determines income right cannot be exclusive, which is discussed in the paper in 1970). Namely, as Proposition 2 suggests, relevant incentive of transacting parties will be triggered to minimize dissipation for their own interests.

This kind of deep finding and profound opinion about contract structure and restructure is directly relevant for *ex post* CA. However, it is only for general contract restructure; research topic in this dissertation, *ex post* CA under PPP, needs its own development. The reasons include ⑴*ex post* risk make CA to focus on *ex post* influence from *ex ante* non-expectation and ⑵PPP involves government and firm instead of only parties in market. In particular, *ex post* CA need break through the potential limitation of Coase theorem (and later NIE) that overlooks over (*ex post*) risk. In fact, because of the focus on general contract restructure, Cheung's theory cannot figure out the effect of (*ex post*) risk over the property right allocation.

Finally, as a supplementary, it could be seen from above three papers, Cheung theory focuses on the restructure of contract due to the change of income right. However, it needs to be pointed out that the change from usage right or transfer right should also lead to CA.

2.4.4 Relevance of CR issue for this research

It could be seen that the CR issue gets developed gradually from these three papers. Especially, at the paper about price control, the CR due to originally unexpected element gets figured out clearly. Two above propositions give a very clear picture on CR. The relevance of CR issue could be concluded from following insight related to those propositions.

As long as CR is still under relationship between original transacting parties, the CR is actually *ex post* CA. At the same time, except the character of contract relationship for rent change, those two propositions will be directly related to the *ex post* CA under PPP. Simply speaking, there will be a compensation effect (from Proposition 1) and transacting parties will have incentive to minimize the dissipation deriving from compensation effect (from Proposition 2) under *ex post* CA under PPP.

2.5 The issue of Soft Budget Constraint (SBC)

This section will refer to the issues behind *ex post* CA, SBC. It needs to be pointed out that this section will only reviews the qualitative aspect of SBC issue, namely, the causal relationship between SBC phenomenon and *ex post* CA will be focused. The quantitative story about SBC phenomenon will be related in Chapter 5 where the SBC phenomenon is quantified and measured. The first sub-section will review the phenomenon of SBC while the second one will explain the influence of SBC; finally, the relevance of SBC related to the research topic will be reflected in the end.

2.5.1 The SBC phenomenon (related to *ex post* CA under PPP)

The SBC firstly represents economic behaviour under shortage in socialist economies (Kornai et al 2003). SBC phenomenon has been applied towards market economies. It is always related to a specific syndrome. The syndrome has no clear delimitation and SBC is lack of consensus on definition, but the basic meaning of SBC is that government's budget is softened due to some adverse behaviour of firm.

It will be seen that SBC phenomenon derives from *ex post* CA. If *ex post* CA is forced by firm of PPP program under crisis, it must leads to SBC incident. If government decides to bail out firm under PPP, either risk transfer to government or compensation to firm will change original contract relationship. When government decides to take over project, the ownership and all of risk (and even debt) will be transferred to government. That is why SBC derives from *ex post* CA under *ex post* risk. According to the logic of SBC issue, any policy of government to adopt will lead more contribution for the program; the government budget is changed inevitably.

As pointed out by Kornai et al (2003), this phenomenon happens always in socialist economies where political consideration seems get justified; some sectors in capitalism countries have also this kind of phenomenon. This kind of phenomenon is pointed to government behaviours; however, behaviour is aimed to rescuing firm. Therefore, government and firm just are the both sides of coin. This kind of phenomenon, to some extent, must happen only in the sector or program that has public and private elements together, which is character of PPP program. It must be especially pointed out that some of *ex post* CA, for example, internal share transaction of firm, will not lead to SBC phenomenon. To sum up, every *ex post* CA between firm and government (excluding within firm) due to *ex post* risk leads to one SBC incident.

2.5.2 The effect of SBC (related to *ex post* CA under PPP)

There is a sea of literature exploring the reason or effect of SBC, of which the prevalent works adopt the framework of game theory. Among a big amount of literature reviewed by Kornai et al (2003) for the issue of SBC, it seems obvious that the framework developed by Schaffer (1989) give more reasonable explanation. The Schaffer (1989) call SBC the incredible-commitment problem. Under its analysis, the commitment of government to keep its budget was incredible so that firm expects government bail it out, thereby triggering an in-built incentive of the firm to require government rescue. As modelled, the result will be government has to break its previous commitment and then the budget constraint must be softened.

Under the above framework, the expectation (or ‘belief’ in the game theory term) takes an important role in SBC. The scholars (Schaffer is one example of these) are more interested in the expected rescue policy (Kornai et al 2003). Namely the adverse behaviours that derive from firm’s policy (and then lead to corresponding bailing-out package from government) will be the story for study. This kind of expectation will definitely affect firm's behaviour and then the efficiency will be lost and transaction cost may be increased. As for the resulting problem under SBC issue, it could be seen in next section that talks about the moral hazard, adverse selection and holdup problem.

2.5.3 Relevance of SBC issue for this research

From literature about SBC, on one hand, it is seen that previous contract relationship will be broken and new contract relationship will be constructed under the effect of SBC. This gives a direction for our research: CR issue is theoretical base for the exploration over policy or packages of transacting partiers, but the SBC issue could figure out the effect of *ex post* CA over economic relationship between firm and government. In particular, the framework of analysis introduced firstly by Schaffer (1989) will be adopted. Recalling the framework of Schaffer (1989), it uncovers why firm could soften successfully budget constraint to get more contribution from government at *ex post* contract implementation.

On the other hand, SBC issue focus on the contracting decision between firm and government, the literature about relevant problems in contract implementation need be reviewed (in next section).

2.6 potential problems related to *ex post* CA under PPP

There are some problems related to *ex post* CA under PPP. On one hand, government rescues a firm that should not be bailed out, thereby leading to the adverse selection of government[5]. On the other hand, firm makes actually the moral hazard problem. In addition, the holdup problem should be also referred since it could impact contract implementation directly. More details about these problems will be given in following. These problems themselves are not research subject, relevant insight for *ex post* CA under PPP will be figured out especially.

2.6.1 The adverse selection

Adverse selection has been applied in economics. It emerges because of the phenomenon that good item is forced out of market while the bad one takes over the market (Akerlof

[5] The other side of adverse selection, namely, government does not bail out the firm that should be bailed out, is overlooked. The reason is that the basic reason is same. Moreover, the bailing-out that should be adopted must be stipulated in contract, so the relevant phenomenon is not a problem; it is the result of contract design. we focus on ex post behaviour, so this is overlooked.

1970). Then Wilson (1979, 1980) discovers multiply equilibrium in 'lemon market'. However, any of those will make higher transaction cost and lower efficiency. The reason for the existence of 'lemon market' is the exit of 'good' goods and the domination of 'bad' goods at the market. Namely, the reason for this problem has two sides: the competition in market forces the 'good' goods out and then the consumers have no choice but choosing bad goods. This kind of phenomenon will result in a worse equilibrium. According to this, it is justified to define the phenomenon that government has to bail out a firm making low effort for contract implementation as adverse selection. If government has already promised not to rescue a bad firm *ex ante, ex post* bailing-out is definitely an adverse selection.

Comparing with the effect of adverse selection, the source of adverse selection is more relevant in this research. recalling SBC issue has already pointed out *ex post* bailing-out seems inevitable because of incredible *ex ante* commitment (not to bail out firm *ex post*); the literature about adverse selection seems to reflect *ex post* crisis is the condition of bailing out. The reason is that, under *ex post* risk, only firm must be in bad situation. The rescue policy will lead to a reverse selection problem.

To be precise, two crises may lead to the adverse selection: raising-money crisis or cost-overrun crisis. Raising fund crisis in literature could be related to social charity, which involves fund raised as social contribution from the public. The relevant decision in social charity is modelled under the framework of game theory. As uncovered by Andreoni (1998), the reason for involuntary contribution is that the utility to potential contributor is less than expected. Similarly, when firm raises fund from potential minority shareholders, only the controlling shareholders knows the nature of program before equity-raising. Once the profit from equity investment is not big enough to attract investor, firm would meet raising-money crisis and then government would face firm's requirement of *ex post* bailing-out. In spite of raising-fund crisis, the adverse selection could also derive from the overrun-cost-crisis. Comparing with raising-money-crisis, over-optimism behind the cost-overrun-crisis seems to be the general case (Flyvbjerg el at. 2003). That is why too many projects labelled with 'Winner's Curse', which is introduced by Rock (1986).

As pointed out by Varaiya (1988), the reason for the 'Winner's Curse' is the over-optimism. Over-optimism could derive from economic elements. When it happens from economic behaviour, the over-optimism is easy to induce government to select the firm that looks good but is actually bad for the PPP program. In particular, the contract under PPP is always assigned after a competitive tendering. It seems the over-optimism and then adverse selection is difficult to avoid. To some extent, the source (not including incentive or driver) of government's adverse selection is over-optimism.

Finally, as a supplementary, though ex post demand risk could also lead to bailing-out, it is always out of firm's behaviour. By contrast, financial crisis and cost-overrun crisis could derives from firm's strategic behaviour.

2.6.2 The moral hazard problem

Moral hazard is always with the adverse selection. It is defined as the phenomenon that people take an irresponsible role after contract assignment. At first, moral hazard is introduced in insurance industry. As asserted by Pauly (1968), the moral hazard is the phenomenon that some of individuals cannot avoid the moral quality to decrease under the policy of insurer. It is interesting that some of moral people will not buy insurance when the insurance company adds some premium to offset the unmoral behaviours of issuance applicant (Pauly 1968). Hence, the insurance company has to choose the immoral people. To some extent, moral hazard and adverse selection may be two side of one economic phenomenon.

Welfare loss pointed out by Pauly (1968) due to moral hazard is actually transaction cost, according to Nyman (1999). At the same time, as said by Faulkner (1960), moral hazard derives from that individuals cannot be incentivized to keep moral qualities. In other words, the incentive to keep moral qualities is not stimulated and then efficiency cannot be ensured. Combining these two literatures from Nyman (1999) and Faulkner (1960), it is seen that moral hazard could lead to lower level efficiency and higher level of transaction cost relative to optimal situation. According to the definition of moral hazard, when firm taking less effort gets bailed out by government, moral hazard phenomenon will emerge in reality.

Recalling 'Winner's curse' mentioned above, when firm with over-optimism strategy lead to a bigger *ex post* risk than original expectation, moral hazard is the reason for *ex post* CA under PPP. To be precise, raising-money crisis and overrun-cost-crisis could derive from firm moral hazard and then lead to government's adverse selection.

2.6.3 The holdup problem

Holdup could take place between firms or firm and government. In general, the *ex post* appropriation between firms is more general in holdup literature. When holdup problems happens between firm and government with *ex post* appropriation of firm over government, holdup problem becomes actually the other issue, SBC. This part will only talk about the general idea about holdup problem, the literature about SBC issue is omitted here.

The holdup problem in literature is always related to the under-investment of transacting party for the fear of giving the other party increased bargaining power when the party need invest transaction-specific assets (Miceli and Segerson 2011). Simply to speak, holdup problem emerges because of the fear of *ex post* expropriation (Che and Akovics 2004). Hence, it focuses on *ex ante* behaviours, namely, behaviour before contract stipulation. However, holdup problem in literature could be also related to *ex post* expropriation some time. Namely, it could focus on the transacting party that take advantage of bargaining power. For example, all of holdup cases investigated by Klein (1996) involve *ex post* unexpected situation. In fact, the phase of 'hold-up' is similar to 'expropriate' here. Considering our research focuses on *ex post* CA, the Klein's theory will be mainly referred to.

Klein (1996) explores why and how holdup happens. Through the exploration over holdup problem, Klein (1996) gives a range of self-enforcing contract. It is pointed out that holdup problem will emerge as long as the value of appropriation from holdup exceeds the value of penalty. In particular, the penalty includes two kinds of parts. At first, the holdup party will lose revenue in future because the relational contract between two parties is broken. Secondly, the reputation of the holdup party will be lost. The amount of expropriation will be only equal to the value of holdup minus the value of penalty.

As for the effects of holdup problem, According to Klein (1996), holdup could induce the party who causes bigger probability of holdup to have irreversible investment. This is actually the second way Klein suggests for the contract enforcement. By contrast, holdup problem could also reduce irreversible investment of party who is under the danger of holdup in future.

Secondly, there will be more transaction cost. Klein (1986) points out the holdup party should have more transaction cost when it need build new contract relationships with other parties or build new contract with the party held up previously by itself. The reason is that more stipulation are necessary under those situations. In fact, more stipulation is the first way Klein suggests to reduce probability of holdup problem.

After above holdup effect, the following shows the influence of holdup problem over behaviour of transacting parties. In fact, the second effect of Klein actually hints the influence of holdup problem over contract; transacting parties rely on contract (adjustment) instead of relational contract. This is in accord with the theory of contractual reference point (Hart and Moore 2008). However, according to standard theory, the contract will become useless when holdup problem cannot be prohibited (Hoppe and Schmitz 2011). Considering contradictory conclusions between standard theory and idea from Hart and Moore (2008), Hoppe and Schmitz (2011: 197) designs experiment and get the 'support in favor of an explanation along the lines of Hart and Moore's (2008) idea the contracts can serve as reference point'. It needs to be pointed out that the contract is stipulated for expected '*ex post* performance' (Hart and Moore 2008: 1), so it need to be changed in a new/different situation.

Moreover, holdup problem could also add weight of *ex post* CA to avoid contract failure. The contract including adjusted contract must have limit of bearing *ex post* risk. When *ex post* risk is beyond the limit, the contract will be broken. This means holdup problem could also have an impact over the effect of contact in transaction. Shavell (2007: 325-326) points out legal intervention is necessary when contractual holdup takes place in 'situations in which a party to a new or existing contract accedes to a very disadvantageous demand, owing to the party's being in a circumstance of substantial need'. In other words, with excessive *ex post* risk, holdup will spoil contract constraint by *ex post* CA.

In spite of the influence over contract, the reputation will become important element for transaction. In fact, it will also affect the solution of holdup problem. As mentioned above, the final payment will become the value of appropriation minus penalty. One of penalty is the value of the reputation of holdup party.

2.7 The clarification of specific terms used in this research

This section is to clarify some specific terms for this research. Two pairs of similar phrases will be discriminated firstly. After that, the different meanings of incomplete information and CR will be explained for clarification. Finally compensation effect is defined specially.

2.7.1 Ex ante vs. ex post

To some extent, the difference between '*ex ante*' and '*ex post*' could be defined according to dynamic standard or comparative static standard. *Ex post* CA with dynamic standard involves CA on the last updated contract. The comparative static standard fixes one specific point; any decision-making after that will be *ex post* behaviour. The aim of research is to witness how expected outcome of PPP program based on initial estimation is failed through *ex post* CA(s); this focus should be orientated to behaviours after the contract assignment. Therefore, author insists on comparative static standard in this research. All behaviours before the contract assignment belong to *ex ante* scope while the ones after contact assignment should be *ex post* elements. In this way, '*ex ante*' and '*ex post*' will be clarified on the base of the time point of contract assignment.

At the same time, for expository convenience, CA represents only the *ex post* CA between firm and government under PPP from now; without special explanation, the general CA is not involved any more.

2.7.2 Strategy vs. Policy

For expository convenience, strategy in modelling is only related to plan of action of player in dynamic game theory. To be precise, the strategy applied in Model 2 and Model

4 in Chapter 4 represents a series of choice at all decision stages (*plural*). In addition, in modelling preparation, strategy is also used for illustration. By contrast with those places, policy instead of strategy is always used, which represents the choice of behaviour at some stage (*singular*). Namely, the static behaviour is represented by 'policy'. It should be noted the discrimination between strategy and policy does not involve Chapter 3 where strategy is similar to the meaning of methodology in research design, which has no specific meaning in economics.

2.7.3 Different meanings of incomplete information

Incomplete information is always used in game theory or Mechanism Design Theory (MDT). In game theory, it means the other player cannot know the player's payoff; it is similar to the phrase-'asymmetric information'. In MDT, incomplete information means partially obtained information at the time of mechanism design. Namely, the information must be fully obtained *ex post*. For expository convenience and the clarification of meanings, if there is no specific emphasis, when private information is involved, the phase of asymmetric information will be used. By contrast, the phrase of incomplete information will be only used to reflect the meaning in MDT.

2.7.4 Different meanings of CR

Generally, CR relates to 'contract restructure'; however, it will involve 'contract right' in the modelling. However, this is not big problem since CR as a word means contract restructure while CR in modelling has subscript and superscript (for example, CR_g^0 represents the value of contract right).

2.7.5 Compensation effect

Compensation effect is very important in this research. It is defined as the economic principle due to CA, which is seen in section 2.4. It includes direct and indirect ways of government for rescuing PPP program to continue under *ex post* risk. At the same time, compensation is always used in rescue package of government, for example, government give a side payment for firm under trouble. It only involves the direct way of government to rescue firm. To avoid the potential contradiction, only compensation effect, this phrase as specific item, reflects the economic principle in CA; any other place without specific emphasis, compensation or other similar words (compensate, compensating and so on) means the general words related to direct way for crisis.

2.8 Summary

This chapter introduces relevant theories (EoC and TCE) for potential definition of CA under PPP. After that, three Cheung's papers related to the potential effect of CA are reviewed especially. Then SBC issues gets later discussed for later exploration or investigation. Before clarification of special items, three problems during CA under PPP get reviewed.

CHAPTER 3 PHILOSOPHY, METHODOLOGY AND RESEARCH DESIGN

3.1 Introduction

This chapter shows firstly conventional philosophy and methodology in modern economics. Approach selection will be mentioned briefly since it has been determined by selected methodology. Research design will be elucidated in the sections about methods for this research. All of corresponding selections could be seen clearly at Table 3.1. Moreover, the quality of research will be considered explicitly in a separate section. Finally, the last section will summarize main contents of this chapter.

Table 3-1: relevant elements and corresponding arrangement for research design

HIERARCHY	ARRANGEMENT
philosophy	Positivism
methodologies	Positivist methodology in economics
approaches	Mixed approaches
Methods (under positivist methodology)	Mathematical analysis (game theory) for proposition generation; case study for measurement, Econometrics for hypothesis testing; Simulation for extra insight (numerical example for Model 1 and simulated scenarios for econometrical models).
Data	Multiply sources of qualitative and quantitative data for hypothesis testing
Data analysis software	Eviews 7 for regression

3.2 Philosophy selection—positivism (in the Chicago School)

This section will talk about firstly potential philosophies for economic research and then the conventional one in modern economics. The different versions of conventional philosophy in modern economics will be illustrated later. After that, author will give reasons in brief for adopting positivism in Chicago School for this research.

3.2.1 Potential philosophies in economic research

Philosophy includes the elements of ontology and epistemology. The former describes the nature of reality while the latter deals with the knowledge (Flowers 2009). Any philosophy forms specific paradigm at “basic ontological and (the related) epistemological positions” (Flowers 2009: 2).

In history, economics experiences changes of philosophy. At first, economics originally as “a branch of moral philosophy” had been evolved with influence of natural science (Rossi 2009: 3). In recent decades, economics opens “the space for philosophy reflection” with exchange from social science (Rossi 2009: 4). For example, the labour economics has applied (explicitly or implicitly) constructivism/interpretivism as philosophy for some investigation (Bitsch 2000 and 2001, Piore 1979 and 2006). However, in the history of modern economics, the positivism maintains the mainstream role. As for the positivism itself, it could be elucidated in following subsection.

3.2.2 Conventional philosophy in modern economics

Positivists (with objective ontology and epistemology) believe that generality will be obtained in theoretical model(s) and that valid knowledge must be observable (Flowers 2009).

The position at ontology and epistemology emphasizes objectiveness even it gives an impression of departing from social reality; this stance traces back to philosophy history in economics. At first, modern science evolves from two ‘major opposing trends developed in the philosophy of science’ (Wilber and Wisman 1975: 666). On one hands, rationalists believe the knowledge from reasoning alone. On the other hand, empiricists argue only experience could be the source of knowledge. This opposition between rationalism and empiricism has not been changed until the logical positivism emerges by combining both of types. Rationality insists on the rational induction while empiricism relies on experience. Precisely, rationalist relies on mathematics generally while empiricist pursues to get the verification or refutation over reality. To some extent, both trends avoid subjectiveness.

Logical positivists use rationalism to construct an explanation and then use empiricism to test the explanation over reality. In fact, the explanation construction under rationalism is actually the process of hypothesis generation while the testing of explanation over reality is the process of hypothesise testing. These two steps are actually common in different versions of current positivism. Under this specific combination, logical positivism and later versions of positivism are necessarily objective due to the influence of rationalism and empricalism.

Given social reality is complicated, the normative topics, which are deemed to be controversial and subjective, are abandoned under positivism. In this way, economic research could be developed more consistently. In fact, this kind of manipulation will be 'pragmatically useful' (Katz 1996: 2246). To some extent, economists believe the subjective and controversial topics is the job of policymaker instead of economists.

3.2.3 Different versions of positivism in modern economics

Positivism gets embraced in most of economic research, but there are four versions of economic positivism. The following will only refer to the paper of Boland (1991), which give a very clear picture about different versions of positivism.

Firstly, the experimental economists assert that 'available data are seldom decisive in any direct way' (Boland 1991: 4). The experiment will be designed to create a real-world to test the hypothesis; to some extent, the data outside experiment cannot get accepted for experimental economists. This kind of positivism version is called as ''Harvard positivism'.

Secondly, the followers of Paul Samuelson only require the positive theory to be 'empirically refutable *in principle* [italics in original text]' (Boland 1991: 4). Those only require positive theory cannot be a tautology. It seems as if there is no empirical requirement, so this version, 'MIT positivism', is usually supported by mathematical economists.

Thirdly, Chicago school emphasizes the usefulness, which is its distinct characteristic. This kind of positivism advocates neoclassic economics (EoC is integrated into the neoclassic economics) as the background and source of policy suggestion. For ensuring the usefulness of research, either prediction is emphasized for empirical investigation, as Friedman argues, or objective mathematical analysis is required to model real world for theoretical exploration, as Stigler asserts. The former requires more weight of empirical investigation while the latter requires more role of theoretical exploration. Both these two ways are located in middle of the first two versions of positivism. Especially, the version asserted by Stigler provides a (transaction) cost perspective for decision-making.

Finally, the popular version asserted by Lipsey is suspicious of the economic model-building and requires big weight located in empirical investigation. Econometrics get more supported and applied while model-building is neglected explicitly or implicitly.

3.2.4 Reasons for selecting positivism in the Chicago School

Author decides to adopt Chicago positivism because of following considerations. It is worthy pointing out that author of this thesis follows and insists on the academic spirit of Steven. N.S. Cheung, focusing on the reality and studying the practical problem. On one hand, Harvard positivism and MIT positivism are not suitable for this thesis because both of them are away from reality. The former focuses on the created ‘real world’ while the latter focus on the created ‘mathematical model’. Moreover, the Lipsey positivism may be also inappropriate when theoretical exploration seems necessary for this research topic that is studied scarcely. On the other hand, author prepares to use EoC mainly to explore the problems. Obviously, the version of Chicago positivism is clearly suitable one (EoC is created by Chicago School).

Moreover, It is noted that the version of Chicago positivism may be limited to make some path-breaking contribution on economics itself because it regards implicitly the neoclassic economics as ‘a set of “exemplars” which guide the pursuit of normal scientific research’ (Wilber and Wisman 1975: 673). However, author aims to apply EoC (as part of neoclassic economics) to economic problem instead of contributing to neoclassic economics. Hence, the limitation is unimportant.

3.3 Methodology selection—positivist methodology in economics

It seems important of methodology as discipline-specific strategy for research, but methodology in economics has been disregarded by scholars, according to Frey (2000). Unlike other social science, the formal list of potential methodologies for economic research cannot be found in literature.

Although there may be more than one methodology for economic research, most of economic researches adopt the same format in the history of modern economics. The conventional methodology is named as ‘positivist methodology’ or some synonymous ones. In this thesis, author calls the conventional strategy for economic research by 'positivist methodology'.

Positivist methodology could be represented by the standard format including four parts in order: introduction, model, empirical result and conclusions. Behind the format, there are mainly two corresponding parts for economic research: theoretical exploration and empirical investigation. The weight of each one depends on author's intension and research context.

3.4 Approach selection—mix approaches and corresponding research design

There are two approaches for research, quantitative or qualitative ones. In fact, any economic work must involve qualitative elements (Steinmann, 1997) though it is mainly quantitative. Simply speaking, mixed approaches is necessary option, but the ratio of qualitative approach in mixture depends on the author's intension and research itself. Considering the necessity of mixed approaches, only following details are given.

According to the arrangement of philosophy and methodology in this research, it seems natural to adopt quantitative approach under theoretical exploration. At the same time, this research gets thirty-two cases; all of data come from thirty-two case studies. Hence, qualitative approach is necessary for the measurement. The necessity for qualitative element is determined by the identification of indicator values within every case study. More details about data could be seen more clearly later.

3.5 Method selection for theoretical exploration and corresponding research design

The strategy behind the positivist methodology in economics is fixed, but there are some alternative options of method for theoretical exploration or empirical investigation. This section will talk about the method for theoretical exploration and corresponding research design. The empirical investigation will be involved in next two sections.

3.5.1 Reason for selecting mathematics analysis for theoretical exploration

Mathematical analysis is dominant for theoretical exploration in mainstream economics. It seems traditional to construct mathematical analysis with model(s) for economic research. One of main reason is the rigorous logic behind mathematical analysis via natural (mathematical) language, not logic language. Though case study could be also applied in institutional area by scholars in NIE, the corresponding work may get controversy. Hence, mathematical analysis is the first option for theoretical exploration in economics. The most famous work in NIE, the Coase theorem, proves unsupported after mathematical analysis. For example, Usher (1998: 3) believe the Coase theorem is 'tautological, incoherent or wrong' through mathematical analysis.

3.5.2 Corresponding design of mathematical analysis

Under mathematical analysis as the method, this research study the behaviours of players at Chapter 4. Our modelling will be based on one basic fact that government has inherent incentive keep PPP program going, thereby rescuing firm under *ex post* risk. This incentive is intuitive and reasonably. If government has no incentive to adopt PPP for program, PPPP will not be launched at the first place. When firm under PPP gets stuck by *ex post* risk, government should have an inherent to rescue firm; otherwise the original PPP arrangement will be ruined due to bankruptcy problem. For giving a clear picture of CA under PPP, based on this basic fact, we focus on the potential takeover policy of government under PPP.

The takeover policy of government could be adopted due to holdup problem under asymmetrical information and uncontrollable CAs under consistent *ex post* risk. Our model discusses how holdup problem or/and uncontrollable CAs lead to potential takeover policy.

After explanation of potential takeover policy, we combines the inherent incentive of government's rescue policy with the potential takeover policy we explore to figure out how compensation effect. Precisely, we will draw a picture for how government compensates firm under PPP by CA in the manner of rescue policy or takeover policy and then give a theory of CA under PPP. For our theory close to reality, the practical way of firm to get compensated through CA(s) under PPP is also illustrated especially.

3.6 Method selection for measurement and corresponding research design

For empirical investigation, it is related to measurement, hypothesis formulation and hypothesis testing. For convenience, hypothesis is formulated in the chapter for measurement. So our measurement includes the development of indicator, hypothesis formulation and identification of indicator value. The testing involves data extraction, regression and analysis & conclusion. In particular, the analytical tool for regression is Ordinary Least Squares (OLS) and advanced tool developed from OLS. This section will talk about the measurement only, namely, the research design for Chapter 5. Any details about regression will be involved in next section.

3.6.1 Reason for selecting case study for measurement

Our measurement involves the development of indicator, hypothesis formulation and identification of indicator values. Firstly, the construction of indicator need be determined by the character of PPP and the scope of investigation. The type of indicator must be considered on the base of samples; otherwise, the data are not effective for later regression. Case study is appropriate method for indicator construction. In addition, the prediction upon the relationship between relevant variables must be on the common characteristics of samples. Under case study method, hypothesis could be formulated closer to reality. Moreover, indicator value need be identified on the base of objective evidence, referring to multiple original data; case study is most appropriate. To sum up, case study method emphasizes relevance on investigation; it is definitely suitable as measurement tool for later regression.

3.6.2 Corresponding design of case study for measurement

Simply speaking, there will be three arrangements. At first, for the indicator development, there are two options, selecting the existed indicators in relevant literature or developing the new ones with reference from similar works. The first one is preferred if it is possible, but the second one seems practical for some measurement. For example, for the core variable of ‘softness’, author could get alternative indicators from literature (Kornai et al 2003). Those options will be selected after relevant comparison. This way could ensure the effectiveness of indicator. For the safety, the core indicators had better adopt this way. All of other indicators have to be constructed for the sake of core concept at first, hence, those should be mainly developed by author. For example, indicators reflecting *ex post* risk in contract implementation are constructed as ratio between original and real values (see Chapter 5).

All relevant data for this research is constructed as indicators for later regression, so there will be many relationships to test. Given this, the formal hypothesis formulation is substituted by a series of prediction, which are listed in one table. The essence of hypothesis is still maintained while the test will seem clearer when comparing the table for prediction and the result table after regression.

Finally, the value of indicators could be identified after case studies. For the objectiveness of judgment for identifying indicator value, the measured variables need to be identified clearly. Any judgment must be made with explicit evidence; any controversial element should be avoided as best as possible. In particular, the case study method here is only aimed for measurement.

3.7 Method selection for testing and corresponding research design

The core of empirical investigation in this research is regression. Data processing affects regression directly, so the following will talk about data processing, namely, initial data analysis, firstly; other regression steps will be discussed after that. Every meaningful step for regression will be illustrated carefully in order.

3.7.1 Initial data analysis

Before formal regression, there will be two steps worth to attempt: the data correction and initial multiple regression. The first one is to make data fitting better for later regression without losing economic meaning. The second one is to find out how much the collected data could explain the reality.

Only the data gets significantly improved, the transformed data will be chosen in this research; otherwise raw indicator is used for later regression. In spite of two dummy variables, there are fourteen raw indicators and two derivative indicators (constructed from two raw indicators). Every indicator will be experimented to have a transformation. The standard of data distribution improvement depends on the Jarque-Bera test. When the test shows probability value is bigger than 5 percent, it means the null hypothesis of normality cannot be rejected. Therefore, when the probability value of Jarque-Bera test for an indicator data becomes bigger than 5 percent after transformation, the data is effectively corrected and then applied for later regression.

The general way of data correction is the log transformation (Frideline et al 2012). However, considering our data has zero and negative values, the transformation according to Inverse Hyperbolic Sine (IHS) function will be adopted when it is necessary. IHS function is firstly introduced by Johnson (1949). For one thing, it could correct the skewed data like the natural log function. For another, it could correct non-positive data in order to retain the size of sample and avoid the excessive sensitivity at the zero-value point. In fact, this transformation has been generally applied in literature investigating wealth (Frideline et al 2012). When wealth is investigated, it is found that positive value of indicator cannot be guaranteed; the zero or negative level of worthy cannot be avoided. Therefore, the investigation upon wealth has to deal with the non-positive data. There could be different version of IHS function, but the simplest version of IHS will be adopted in this research as following since it is more close to the natural log (Frideline el at. 2012).

$$ihs(x) = \log(x + \sqrt{x^2 + 1}).$$

After above data correction, the initial multiple regression will be done. There will be two sets of regression. The first is to check how much the ten independent variables explain the six alternative dependent variables (four raw indicators and two derivative indicators) reflecting softness[6] in the situation of final CA. The ten variables include two sets of data: ⑴initial variables including three ones reflecting initial softness and two *ex ante* risk indicators, ⑵five process variables reflecting *ex post* risk. The first kind is stipulated by original contract, the second one reflects the situation of contract implementation. After that, the second set of regression will use five process variables as optional dependent variables and all of other variables except two derivative variables as independent

[6] Softness means the severity of SBC phenomenon, the indicator development is seen in Chapter 5.

variable. In particular, two derivative indicators is not used in this set of regression since those are not from the realistic world.

3.7.2 Stepwise analysis

Stepwise regression is the main method for our data analysis though other regressions are used for later endogeneity issue or heteroskedasticity issue. Considering the significance of stepwise regression, the necessity and usefulness of stepwise regression are illustrated firstly in following. Then the research design of stepwise regression in this thesis is given.

Stepwise regression is significant for this research because it emphasizes the information of real data instead of the underlying theory behind data. Stepwise regression is the best regression method to construct model based on the reality data. Under stepwise regression, any explanatory variable should be selected according to its p-value. Only when the p-value is lower than the specific standard (e.g. 5 percent), the null hypothesis of t-test, the corresponding variable is insignificant, could be rejected. If a variable could be identified in regression in principle, stepwise regression is not needed; however, it is necessary when we focus on the reality. Using stepwise regression to pick out real explanatory variable has been done by a number of scholars such as Verburg et al (1997).

At the same time, the usefulness of stepwise regression could be shown by its objectiveness and convenience. Under stepwise regression, any potential explanatory variable could be removed or selected for model as long as it is insignificant in data. Practically, the selection or removing process could be finished by software automatically. In particular, when different forms of variable (e.g. x or x^2) and different variables are potential explanatory variables, stepwise regression could help find the best ones automatically. Objectiveness and convenience may be lost partially without stepwise regression.

By contrast with multiple regression reflecting the data fitting without consideration over significance as initial data analysis, the stepwise regression tests the significance of variable. In this research, stepwise regression is firstly finished before relevant manual manipulation.

The stepwise regression with only the original items (i.e. x instead of x^2) gets bad results since the corresponding determination coefficients are low. This means some significant information, for example, non-linear relationship is omitted. There are two ways to solve this problem. One is to get additional variables; another is to add non-linearity trend. The first way is impractical for this research, because all relevant data has been used. Only the second way is potential solution. In particular, the square value of original independent variable is included for regression. It need be pointed out that adding square items includes non-linearity trend, but regression function maintains linearity between dependent variable and independent variables. The reason could be seen in section 3.7.3.

The stepwise regression could choose the better variable to fit data. The inclusion of square items may lead to co-linearity problem, but it could be solved later. Stepwise regression has a respective innate weakness for different versions. The stepwise backwards regression could include superfluous variable(s) while the stepwise forward regression could remove significant variable(s). Namely, relative to stepwise forwards regression, the stepwise backwards regression is safer though it may include insignificant variables, which could be removed manually. By contrast, the stepwise forwards regression has the danger of omitting the significant variables.

After above automatic regression step, there are two jobs to adjust the results. On one hand, the insignificant variable (selected by backwards stepwise regression) and the variable that leads co-linearity should be removed. Co-linearity happens since stepwise regression is only a regression tool for t-test. Any variable with probability value bigger the 5 percent should be insignificant (we assume 95 percent as significance level in this research, which is common in economics). On the other hand, some institutively important variables are worth to try being added. In fact, for safety, we tried adding back manually every variable abandoned by software.

With respect to variables leading co-linearity problem, the Variance Inflation Factor (VIF) value is referred to. VIF measures the level of collinearity between the regressors in an equation (QMS 2010). According to the definition of VIF, The VIF is the reciprocal of tolerance (O'Brien 2007). As Menard (1995: 66) states, a “tolerance of less than 0.20 is cause for concern; a tolerance of less than 0.10 almost certainly indicates a serious collinearity problem”. According to the statement of Menard (1995: 66), VIF value had better be less than 5. Namely, we will use 5 as the standard for the VIF value. There are two options of VIF, the centered one and uncentered one. According to QMS (2010), VIF is equal to $1/(1-R^2)$. In the centered VIF, R^2 is the R-squared from the regression of that regressor on all other regressors including constant in equation; uncentered VIF only use other regressors without the constant. Therefore, there is no reason to not use the centered VIF when it is available. In other words, the centered VIF is used generally when the constant in regression exists; otherwise, the uncentered VIF is used.

To sum up, removing and adding are two jobs for manual adjustment. Only after above procedures, the results could be seen as formal and reliable models for later steps.

3.7.3 Simultaneous equations estimation and endogeneity issue

After stepwise regression, it is found three *ex post* risks get affected. Considering the estimation of OLS will be biased and inconsistent due to the existence of endogenous variables (Bound et al 1995), simultaneous equations estimation must be adopted for those three models.

To be precise, Two-Stage Least Square (TSLS) is used for simultaneous functions of three *ex post* risks. Though TSLS is still biased, it is consistent. It could reduce the adverse effect relative to OLS. In particular, when the data satisfy the independence and homoskedasticity of error, the estimation under TSLS is much efficient (Ronald et al 2010).

Most of literature uses the predetermined variables for TSLS. Precisely, the lags are always used for time series data (see Crinò 2008) while the other independent variables and the independent variables of endogenous variable are used as instrument for cross-section data. The only difference from OLS is TSLS need add those instruments in regression. In particular, if instrument in TSLS is valid, the null hypothesis of J-statistics will not be rejected (Murray 2006). Hence, J-statistics is good standard for judging the validity of model under TSLS.

However, in spite of simultaneity, another two sources of endogeneity issue, omitted variable and measurement mistake, could be identified from relevant works (Beuve and Saussier 2012, Desrieux et al 2013 and Chong et al 2006). Once no suitable predetermined variable could be used as instrument, for example, when the endogeneity issue come from omitted variable or measurement mistake, TSLS cannot be adopted. The alternative way for solving endogeneity issue is to use instrument for estimation. Unfortunately, this is very hard since instrument is required be correlated to independent variable of interest but without relationship with residual series (Greene 2003). When the instrument has only weakly correlation with endogenous variable, estimation will be seriously biased (Bound et al 1995). The instrument selection is different case to case. After reviewing relevant papers (Beuve and Saussier 2012, Desrieux et al 2013 and Chong et al 2006), either omitted measurement or measurement mistake is always related to the questionable (not all) dummy variable(s). The instructive way is to use the indicator reflecting the dummy variable without noise (see Beuve and Saussier 2012); for example, to measure the decision within some function in a given sector, "the average prevalence of the variable we [Beuve and Saussier] want to instrumentalize in the same function in different sector" (Beuve and Saussier 2012: 823) is used. Though this way cannot be general for all cases, it is indicated that the potential endogeneity issue due to omitted variable and measurement mistake invovles the idiosyncrasy of economic existence the dummy variable measures. Not all dummy variables need consider the endogeneity issue; the relevant identification of endogeneity/instrument is, to some extent, based on theoretical analysis.

3.7.4 Confirming Gauss-Markov assumptions

OLS is traditional for econometrics; it is also the base of other regression tools. Therefore the requirement of OLS need be satisfied; otherwise, the result is not valid.

The requirement of OLS involves Gauss-Markov assumptions in three parts: linearity, homoscedasticity and independence of error distribution. At first, the linearity is actually satisfied. The nonlinearity trend is considered in our models by adding the square item of original variable. In our final results (see Chapter 7), original item and square item do not exist simultaneously. When the result include a square item, the linearity between the whole square item as independent variables and dependent variable still is maintained though the non-linearity trend is added in regression. In addition, because the cross-section data is adopted, the independence assumption is irrelevant (Verbeek 2004). Simply to speak, even the error under OLS is autocorrelated, it means nothing for cross-section cases. One error of case will not relate to another case in economics when these cases come from different sections. A numerical example is given in Chapter 6.

Finally, the homoscedasticity assumption is very important for cross-section data. The most general way for checking this problem is White Test (WT) (Verbeek 2004). as Quantitative Micro Software (QMS 2010) says, WT tests the heteroskedasticity in the unknown and general form. we do not assume any specific form of potential heteroskedasticity, so WT is suitable for our regression. Any model having a probability less than 5 percent will reject the null hypothesis of homoscedasticity; namely, the model will has heterscedasticity.

Under the heteroscedasticity problem, the estimation over coefficient of OLS is still unbiased, but it is not efficient (Long and Ervin 2000). Standard errors of OLS will be biased due to heteroscedasticity (Breusch and Pagan 1979), so usual confidence intervals and test statistics are not correct. Therefore, the estimation of OLS is not appropriate due to the heteroscedasticity (Long and Ervin 2000). Given this effect of heteroscedasticity problem towards OLS, there are two main directions to solve the problem, which lead to three methods of dealing with heteroscedasticity problem.

The first one is suggested by White (1980), the heteroscedasticity-consistent standard errors that could be valid under either heteroscedasticity or homoscedasticity is adopted for OLS estimation. In this way, the standard error will be guaranteed to be unbiased so that OLS could be still relied on. In particular, when the heteroscedasticity is difficult to reduce, it is very useful (Long and Ervin 2000). This method is very practical and convenient now since all of packages in econometrics almost have an specific option for this special kind of estimation. The special standard error is always called as White standard errors in econometrical software. The only difference from general OLS is to choose the White standard errors when OLS is used.

In spite of above way, hteroscedasticity problem could be also solved with a weight series. In this direction, a weight series is added into estimation to make the variance of errors as a constant. Along this direction, if the weight is known, Weight Least Squares (WLS) is suggested to adopt (Wooldridge 2000). This estimation has only one extra step of adding a weight series for estimation, the Eviews (or other econometrical software) will give every variable the relevant weight number so that heteroscedasticity problem is avoided.

The weight is the key for WLS. In fact, the heteroscedasticity is seldom really known. The common stipulation of WLS is to try some series that is potential weight for estimation. Before fixing a weight, three source of heteroscedasticity should be known, including ⑴group data (Baum 2006), ⑵random coefficient (Swarmy and Mehta 1975, Breusch and Pagan 1979) and ⑶different mean square of fitted value (Amemiya 1973). The first one always happens at the regression with average data, the population of group will be the weight, thereby avoid heteroscedasticity problem (Wooldridge 2000). When variance of error is assumed to be affected randomly across section, the source of heteroscedasticity is one of independent variable. So independent variables will be tried to add as a weight series (Swarmy and Mehta 1975, Long and Ervin 2000). Considering the heteroscedasticity form is not sure (even we know the source of heteroscedasticity), the other forms of variable (for example, the square item) could be also tried (Greene 2003). When the variance of error is assumed to be affected by the square of mean of fitted value, the source is the scale of data value. For making convenience, the error series of OLS will be added as the weight (Greene 2003) since the error series is inversely related to the fitted value.

It is seen from above that WLS tries independent variable, error series or other forms of first two, with relevant assumption of heteroscedasticity form. This way is pragmatically useful As long as WT (or others) reveals the heteroskedasticy problem is not existed anymore after adding some (potential) weight series. Meanwhile, it must be noted that the final result under WLS depends on what series is tried in research. Hence, the best efficient estimation is not obtained since the best weight may not be tried. However, as long as the heteroscedasticity problem is really removed, the result is much better than the one under OLS. In other words, if WLS (with relevant assumption) helps solve the heteroscedasticity problem, it is at least an improvement though it may be not the optima. The qualitative relationship between the dependent variable and independent variables is the main target of investigation. Therefore, whether the regression is best seems irrelevant.

Because WLS assumes the source of heteroscedaticity problem and the corresponding form (Verbeek 2004), there may be different series to solve the problem in reality. For example, when both of residual series of OLS and independent variable could solve the problem, there is a choice between those. Two standards will be referred for that. The first is the determination coefficient, the series fitting data better will be preferred. Moreover, the significance should also be considered. Namely, if one series gets bigger determination coefficient but original variable(s) become not significant anymore; this series cannot be chosen.

When all of experienced weight series cannot deal with the problem, it seems necessary to use the potential best estimation. Comparing with WLS, Feasible or Estimated Generalized Least Squares (FGLS or EGLS) need estimate (instead of assuming) the weight series before estimation. WLS assumes where heteroscedasticity is from (namely, independent variable or other source); FGLS needs to confirm the source and then estimate the form of heteroscedasticity (Verbeek 2004).

FGLS has three options to solve the problem. The first two options of FGLS corresponds to two of three source of heteroscedasticity mentioned above. The first one is to check if the variance of error is really affected randomly between sections. Namely, the square of error series of OLS will be checked if it could be really regressed on the one of independent variables and its square item (Powell ca 2013). If it is satisfactory, the error variance is really from the variable, the new fitted values will be the weight series in FGLS. The new fitted values are definitely related to the independent variable (or its other form), so that is why WLS just try the relevant independent variable to solve the problem.

The second way is to check if the variance of error is really proportional to the square of mean of fitted value of OLS. The step is to check if the square item of error series of OLS could be really regressed on the square item of fitted values of OLS (Powell ca 2013). If so, the square item of fitted values of OLS will be the weight series. In fact, the fitted value of OLS is inversely related to the residual series, so WLS used residual series' form (e.g. -1st power) as weight series for estimation. Namely, the way of using residual series gets supported by FGLS.

The third way seems reasonable in theory, but it is complex. Only the second way cannot solve the problem, the third way will be adopted. The third way assume firstly the standard variance of error is related to the exponential value of fitted value as following (Verbeek 2004).

$$V\{\varepsilon_i|x_i\} = \sigma_i^2 = \sigma^2 exp\{\alpha_1 z_{i1} + \cdots + \alpha_j z_{ij}\}.$$

$V\{\varepsilon_I|x_i\}$ is the error variance, σ_i^2 is the value affected between sections. σ^2 is the value unaffected between sections. *exp* is the exponential function while α is the coeffiencit of parameter and z is independent variables.

Let $h = exp\{\alpha_1 z_{i1} + \cdots + \alpha_j z_{ij}\}$, $V\left\{\frac{\varepsilon_i}{\sqrt{h}}\middle|x_i\right\} = \frac{V\{\varepsilon_i|x_i\}}{h} = \sigma^2$. Then the estimation with weight series of $h^{-\frac{1}{2}}$ will satisfy homoscedasticity assumption. Namely, h is the target of estimation as a weight series under FGLS. The following is to show how to estimate the weight series. According to the above assumption, there is also $\sigma_i^2 = \sigma^2 \exp\{\alpha_1 z_{i1} + \cdots + \alpha_j z_{ij}\}$, in particular, then

$$log\,\sigma_i^2 = log\,\sigma^2 + \{\alpha_1 z_{i1} + \cdots + \alpha_j z_{ij}\} \rightarrow log\,e_i^2 = log\,\sigma^2 + \{\alpha_1 z_{i1} + \cdots + \alpha_j z_{ij}\} + log\,e_i^2 - log\,\sigma_i^2$$

$$\rightarrow log\,e_i^2 = log\,\sigma^2 + \{\alpha_1 z_{i1} + \cdots + \alpha_j z_{ij}\} + \upsilon, \upsilon = log(e_i^2/\sigma_i^2).$$

Therefore, there are several steps under this way as followings. At first, the residual series is obtained in original regression (Verbeek 2004, Wooldridge 2000). Secondly, the regression of $\log(e_i^2)$ is run over the constant and original independent variables (Verbeek 2004, Wooldridge 2000). Thirdly, get the estimated values of α_i and then get the values of $\{\alpha_1 z_{i1} + \cdots + \alpha_j z_{ij}\}$. Fourthly, get the exponential value of $\{\alpha_1 z_{i1} + \cdots +$

$\alpha_j z_{ij}\}$ (Verbeek 2004) and then create a new series equal to $(exp\{\alpha_1 z_{i1} + \cdots + \alpha_j z_{ij}\})^{-\frac{1}{2}}$, which will be the real weight series. Finally, add weight series under WLS for regression.

3.7.5 Verifying normality

After above confirmation of Gauss-Markov assumptions, there is another requirement. If the residual series of model is not normal, it means there are still non-random elements, thereby leading the result unreliable. For this, there is normality test finally. Only the normality is verified, the model is reliable. For the test of normality, Eviews 7.0 use the Jarque Bera test, only when the probability in the test reaches or outnumbers five percent, the null hypothesis of Jarque Bera test cannot be rejected and then the series is normal.

3.8 Simulation as the supplement method for extra insights

Simulation is not used as a strategy for this research, but it will be used to get extra insight. To be precise, it will be used in modelling to figure out potential tendency of function when some of variable keeps changed. In the meanwhile, it will be applied to construct simulated scenarios to obtain more information from data and econometrical models. In fact, the former is deliberated to give a numerical example; some of tendency that cannot be found out from function itself could be exposed. The latter is a more general application for economic research; it designs some situations with real data and effective economical models to give a picture about some important variables.

In our research, a numerical example is used in Model 1 (of Chapter 4) to figure out profit distributions under competition when there is a limit of *ex post* risk upon firm under PPP or not. This will just give extra insight for specific arrangement of PPP after the general conclusion has been proven. Moreover, after getting the final regression models in chapter 6, scenario simulation will be used to test what sets of dummy variables will make dependent variables outside sets that those should be in. In this way, the infeasible sets of dummy variables could be figured out and then relevant methods of CA (determined by the sets of dummy variables) could be exposed.

It needs to point out that either numerical example (by simulation) or the scenario simulation for extra insight is not necessary for this research, but it is meaningful.

3.9 Data type, data source, data collection technique and data analysis software

The data in this research has its own character. The following illustrates the types and sources of data before introducing the collection technique and analysis software for data.

3.9.1 Data type

This research will have two kinds of data, regression data and case data. The former is consisting of indicator values after case study while the latter is the evidence about economic variables of cases. Regression data is from author's own case studies, so it is original. For the sake of objectiveness and truth, the identification of indicator value must be from evidence, namely, from case data. For example, the clear statement in journal paper is one kind of case data. Generally speaking, regression data (our data) is made up from clear evidence (case data) and then it is definitely original.

Moreover, except a qualitative indicator for government policy and two dummy variables for the way of CA, the data in this research is in ratio form. To get enough samples for research, we start from High Speed Rail (HSR) sector, but only six are suitable. Other cases may have no enough information or may have no CA. It is just because of the specialty of subject for the investigation that we go through a very hard process of data collection. Considering the regression should be on the base of big sample, after HSR sector, the scope of investigation is extended to rail sector. After rail sector, there are another two extensions to include eleven other cases in transportation and four facility programs. The scale of project is inevitable to vary with a huge degree. To avoid the hug difference between industries, only ratio indicators are adopted. This design itself for data reflects the application of case study method for measurement, as mentioned before.

3.9.2 Data source

The case data mainly derives from archival materials. There will be five data sources: government reports, reports of organization, corporate reports, academic papers (for example, journal papers, theses or conference papers), and news. Of which, author will choose the official publication firstly. For instance, for the Case 2 (HS1), the literature from National Audit Office will be the main reference. Moreover, the reports from organization are also reliable. For example, World Bank gives evidence for cases such as Case 28 (NATS). Thirdly, the corporate report is also applied, for example, Case 25

(Vasco da Gama Bridge) uses information about corporate fund from the corporate website. Furthermore, some of academic works is also very reliable; for example, the master thesis making case study on THSR is referred fully in Case 1 (THRS). In spite of those, some of news has same credibility. Some formal CAs are officially asserted as news in website of regulatory authority.

3.9.3 Data collection technique (document analysis)

As for data collection, author decides to adopt document analysis, which is actually applied frequently in economic investigation. Second-hand data could be picked up from archival materials, because PPP program as huge government-work is exposed well. At the same time, interview, focus groups and other techniques are not feasible, because relevant personnel in charge of PPP program lie at high level of government or academic departments. Even if author could contact those, some persons are no longer involved with the program.

3.9.4 Data analysis software (Eviews 7)

Eviews 7 is generally used in econometric analysis. There may be other software to use, but Eviews 7 shows analysis step by step and it is more easily to apply. Given that no any software will be superior to others in current academic and that author has been familiar to it, Eview 7 is chosen. Moreover, the flaw of early version of Eviews has been improved. For example, Eviews 6 has no tool to test the co-linearity problem, but the most important indicator, VIF, has been added especially in Eviews 7.

3.10 The way to keep decimals in this research

This research has its own measurement for data collection and regression for quantitative relationship. All of results in contents that have more than four decimals will be rounded off with only four decimals. Simply speaking, any decimals after fourth decimal of measured data (in Chapter 5) or regression results (in Chapter 6) will be rounded off in this research. When the number has less than four decimals, no zero is especially added in the end. For example, when the number of CA is 4, it is not meaningful in economics to exchange it especially into 4.0000.

This rule need be illustrated. At first, any results in appendixes, which are obtained from the software, will have its original form. In this way, reader could check precise regression results. Further, this rule will not be applied for the process number. For example, any original data in Chapter 5 may have many decimals; the aim is to ensure the value of indicator as precise as possible. Moreover, this rule is not applied to the number for value that is not measurement data or regression data neither. For example, when the significance level is decided, 0.05 is especially pointed out instead of 0.0500 since it is just a standard value for regression test instead of measured data or regression results.

3.11 Quality of research

Although this research will be related to qualitative analysis for measurement, it is mainly under quantitative framework. So the reliability and validity that are the main consideration for quantitative research, instead of the triangulation that always emerges for qualitative research, need to be mainly reflected in this research.

With regard to reliability, author uses thirty-two cases for empirical investigation. Author goes through a very hard process of data collection, the aim is to have big sample for regression. Simply speaking, different samples (with an enough big size of thirty-two) are adopted to have reliability to reduce the effect of random as well as possible. Moreover, author use mathematical modeling firstly and then regression, thereby applying different types of method for research

As for validity, author follows the positivism methodology and designs specific data for regression according to the demand of research; the corresponding reason is to ensure the validity for research.

3.12 Summary

This chapter finishes author's research design under the corresponding research philosophy, methodology and approach. Author designs research for questions themselves, not only following the general template in economics. The difference from general work in economic investigation could be reflected from the data creation for regression.

Chapter 4 Modelling for ex post Contract Adjustment under PPP

4.1 Introductions

In a whole, this chapter explores the potential takeover policy of government under CA for PPP program. Our model will be based on one assumption that government has inherent incentive to rescue firm of PPP program under *ex post* risk. This assumption is naturally satisfied, given that PPP mechanism has be adopted for the projects. The exploration of our model will be concentrated on the potential takeover policy of government due to holdup problem under asymmetrical information or uncontrollable CAs under consistent *ex post* risk.

This chapter will start a special section for model setup. The payoffs of government will be especially given in the second section. After that, we will explore the potential takeover policy due to holdup problem under once-off CA and then holdup problem with uncontrollable CAs, respectively. Then a sensitivity will be analysed for the adverse effect of uncontrollable CAs and other exogenous variables. There is also a separate section for findings from our model. Finally, we want to give a theory of CA under PPP by illustrating the compensation effect of CA under PPP.

4.2 Model setup

As mentioned before, Government under CA has an incentive to rescue firm to keep PPP program going; otherwise, PPP will not adopted at the first place. With every *ex post* rescue policy of government, bailing-out package must be used by government. Hence, it goes without doubt that more contribution for the program will come from government. The potentially repeated rescue policy will not stop until government has to take over the project. Namely, it is expected to see *ex post* bailing-out package until the takeover policy of government.

There are two basic assumptions in modelling. The first one is the maximization of worth as the principle of decision-making. Secondly, all of economic variable is assumed to be valued, for example, contract right or reputation loss.

This model explores why takeover policy is taken in relevant situations. In other words, this model will explain the termination of PPP though rescue policy is preferred by government. The first situation involves asymmetric information leading to holdup problem under once-off CA. the second one involves similar information situation but under uncontrollable CAs. Especially, these situations are determined by the belief of government and firm, not necessarily the real facts. Once-off CA should reflect the situation when firm and government has confidence to use CA package to solve *ex post* risk. With the uncontrollable CAs, government expects another CAs in future for later contract implementation.

PPP starts from competition for contract, the economic profit of program should be allocated after competition between firm and government. In particular, property rights and risk are allocated *ex ante* by contract. This thesis tells *ex ante* variable from *ex post* variable. The former is considered in the stage of contract design/assignment while the latter is involved for CA, namely, in the stage of contract implementation. *Ex ante* variable in modelling will be represented by superscript of ‘0’. The *ex post* variables in modelling will be represented by the superscript of ‘1’. Furthermore, for expository convenience, we especially give a list of basic symbols for later induction.

ER_e^0: expected (‘e’ as subscript) Economic Rent (ER in symbol) at the stage of contract design (‘0’ as superscript). The similar symbol, ER_e^1 involves economic rent at CA.

CR_g^0: Contract Right (CR in symbol) of government (‘g’ as subscript) at the stage of contract design (‘0’ as superscript), it is stipulated in original contract. The similar symbol s include CR_f^0 and CR_f^1, which are the contract right for firm at the stage of contract design and CA, respectively.

ΔCR_g^1, the change (‘Δ’) of Contract Right (CR in symbol) of government (‘g’ in subscript) at CA stage (‘1’ in superscript). The contract right at CA, CR_g^1, use CR_g^0 plus ΔCR_g^1. In this way, ΔCR_g^1 reflecting the change due to *ex post* CA gets emphasized.

When government adopt rescue policy, government should compensate directly or indirect firm for PPP program. When the program face *ex post* crisis and private firm of PPP program is under bankruptcy problem, government must avoid the firm lose more than its own equity value (W); hence, $\Delta CR_g^1 = -\beta(CR_f^1 + W) = -\beta\left(ER_e^1 - CR_g^0 + W\right)$. β is the ratio of unfinished part of program; according to above illustration, CR_f^1 is the economic profit of firm at CA, which is equal to $ER_e^1 - CR_g^0$. Given firm under bankruptcy problem, CR_f^1 and $CR_f^1 + W$ must be negative[7] and $-\beta\left(CR_f^1 + W\right)$ must be positive. Let p_b represent the probability of bankruptcy problem. When $p_b = 0$, an *ex post* crisis requires only government to transfer the corresponding risk without the change of property rights. More symbols will be introduced later.

Before formal induction, there are two assumptions for *ex post* risk and CA, respectively.

Assumption 1 (A1): $ER_e^0 \sim N\left(CR_g^0, \delta^2\right)$, $ER_e^1 \sim N(a, \delta_1^2)$; $\delta_1 > \delta$; $a < CR_g^0$.

Assumption 2 (A2): $\Delta C > TrC$.

At A1, $ER_e^0 \sim N\left(CR_g^0, \delta^2\right)$ derives from the conclusion of auction theory. From auction theory, competition for contract right will ensure zero profit to bidding winner when there is sufficient competition. The competition for contract right under PPP is practical since PPP is launched after a long time preparation. Hence, the expected economic profit of PPP program (ER_e^0) will be equal to the value of contract right of government (CR_e^0). At the same time, the *ex post* profit of program is assumed to be less than the expected one, a $< CR_g^0$. The uncertainty will be bigger than the estimated one, $\delta_1 > \delta$. In one sentence, A1 assumes *ex post* risk reduces the profit of PPP program with bigger uncertainty. In particular, risk in this thesis is regarded as unexpected elements, reducing the economic profit if original contact design is insisted; it is not equal to the concept of uncertainty.

[7] If $CR_f^1 + W \geq 0$, firm will not be under bankruptcy problem.

A1 insists on the adverse effect of *ex post* risks: a $< CR_g^0$ and $\delta_1 > \delta$. In particular, a $< CR_g^0$ derives from two basic opinions in this research as following: ⑴information is not complete and then *ex post* efficiency is better than *ex ante* efficiency[8]; ⑵contract is incomplete and then *ex post* risk cannot be specified in contract when players design *ex ante* contract[9].

A2 emphasizes the adverse effect of exit barrier of contract. The cost of exit cannot be overlooked once contract relationship is stipulated. The cost of exit barrier is assumed to be bigger than the cost-saving in the negotiation between original firm and government. This assumption is very weak and practical. The takeover policy by government means there will be a negotiation between government and a new firm; the new firm is either new partner under PPP or agent on the behalf of government. Considering the time limit and the fact that the market has no prepared firm for the project under PPP any more, the barrier cost (related to the negotiation with new firm) should be bigger than the cost of negotiation between original firm and government.

4.3 Payoffs of government

Government under PPP have two alternative policies for CA. Government adopts either rescue (*Re*) policy or takeover (*T*) policy. With *Re* policy, the contract right of project is still under the hand of firm; otherwise, government will get back the contract right fully. Need to note government could award PPP program towards a new firm under *T* policy, but the payoff of government will not be different. The reason is that the old PPP firm undertakes the loss before takeover while the new PPP firm will ask a normal profit from the program; government cannot get any profit from requiring a new firm for taking over program. More practically, awarding program to a new firm under PPP, it involves

[8] This is basic idea of mechanism design theory.
[9] This is the basic idea of human irrationality in Transaction Cost Economics and it is also supported by incomplete contract theory (e.g. Grossman and Hart (1986))and incentive contract theory (e.g. Bajari and Tadelis (2001)).

actually the topic of *ex ante* contract design instead of *ex post* CA. due to these two reasons we do not consider the takeover policy with a new firm under PPP.

In particular, if government decides to rescue firm, it should take an active role in renegotiation for CA package since government should transfer risk from firm (e.g. guaranteeing *ex post* debt package for firm) or compensate directly firm (e.g. giving a new price scheme or granting a new subsidy). On the contrary, government has inactive role in renegotiation. For one thing, the risk transfer or property right reallocation is not needed. For another, the ownership switch due to project takeover needs only liquidation procedure, which should be finished by bank. Considering different role of government in renegotiation for CA package, we use α_b to represent the bigger ratio of transaction cost for active role of government; $\alpha_b \geq 1/2$. Meanwhile, α_s is the smaller ratio for inactive role of government for CA package; $\alpha_s \leq 1/2$. Consequently, $\alpha_b \geq \alpha_s$; $1-\alpha_b$ or $1-\alpha_s$ is the ratio of transaction cost undertaken by firm for CA package under PPP.

With different policy options, the payoff of government are followings. For the decision-making, we assume no *T* policy under previous CAs. The reason is that takeover policy will terminate contract relationship between government and firm under PPP and then there is no decision-making to consider.

$$\begin{cases} V_g(Re) = E\pi_e^0 + CR_g^0 - p_b\left(\Delta CR_g^1 + h\right) - (i+1+n)\cdot\alpha_b\cdot TrC - (i+n+1)\gamma, \\ V_g(T) = E\pi_e^0 + \beta(i)ER_e^1(n) + \left(1-\beta(i)\right)CR_g^0 - K_g^a - i\cdot\alpha_b TrC - \alpha_s TrC - \Delta C - \\ (i+1)\gamma - K_g^r, \\ \alpha_b \geq \frac{1}{2}, \alpha_s \leq \frac{1}{2}, \delta > 0, \beta \leq 1, p_b \in [0,1], \\ \frac{d\beta}{di} < 0; ER_e^1(n) = CR_f^1(n) + CR_g^0, \frac{dER_e^1}{dn} < 0, \frac{dCR_f^1}{dn} < 0. \end{cases} \tag{1}$$

'*n*' is the number of potential CA in future if the project is still under PPP. '*i*' is the number of CA under PPP in the past. On one hand, the payoff of *Re* will have the transaction cost of past, current and future CAs, $(i+1+n)\cdot\alpha_b\cdot TrC$. The external benefit ($E\pi_e^0$) and original value of contact right (CR_g^0) could be expected; but the former will be reduced because of uncontrollable CAs. For the convenience of payoff expression, γ is introduced as the average loss of external benefit; so $(i+n+1)\cdot\gamma$ will be subtracted for rescue policy. In particular, there will be potential compensation (ΔCR_g^1) and the holdup amount (h). On the other hand, with T policy, the external benefit ($E\pi_e^0$) need only suffer the loss for previous rescue policies; namely, only $(i+1)\gamma$ is subtracted. The economic profit of unfinished program ($\beta(i)ER_e^1(n)$) will be undertaken by government since then; the contract right of government for finished program ($\left(1-\beta(i)\right)CR_g^0$) has been realized. In addition, the specific investment of government with original firm for PPP program, K_g^a, will be lost while there is exit barrier (ΔC) for terminating contract right with the old PPP firm. The payoff of 'T' will have the transaction cost of previous CAs (rescue packages), $i\cdot\alpha_b\cdot TrC$, and the transaction cost of current takeover policy. Finally, there will be reputation loss (K_g^r) for PPP termination due to takeover policy.

In particular, economic profit of PPP program, $ER_e^1(n)$, should be divided into two parts, $CR_f^1(n)$, the economic profit of contract right under PPP undertaken by firm, and CR_g^0, contract right of government in original contract, which ensures *ex ante* government income[10] from the firm through PPP auction. Furthermore, β (the ratio of unfinished project) and ER_e^1 (*ex post* economic profit of program) will be affected by the number of previous CA and the number of future CA, respectively. (1)the ratio of unfinished project will be negatively correlated to the previous CAs and (2)the real economic profit of program should be the updated one after future CAs. Namely, there are $\frac{d\beta}{di}<0$; $\frac{dER_e^1}{dn}<0, \frac{dCR_f^1}{dn}<0$. The first point comes from a basic view that a (adjusted) contract could keep program going, so more CAs will witness less unfinished part of program; if the adjustment cannot promote the contract implementation, there should not be adjustment and then the contract will be abandoned totally. The second point means economic profit

[10] It could be negative when auction winner requires government to subsidy for PPP program.

of program (to firm under PPP) will be updated with less value with more CAs due to *ex post* risk.

In particular, when $n = 0$, the above payoff will become the one under once-off CA. for expository convenience, $V_g(Re|n = 0)$ and $V_g(T|n = 0)$ denote the payoff of *Re* and *T* for government under once-off CA.

4.4 The takeover policy due to holdup problem

The takeover policy could be adopted when there is disputation between firm and government about the arrangement of CA. Under asymmetrical information, government would suspect firm of holding it up. When the potential amount held up by firm reaches or surpasses the loss of takeover policy for government, government would abandon (original) PPP program to keep project going at the hand of government or a new firm as the co-operator[11]. As mentioned before, this section discuss only the takeover policy deriving from holdup problem under once-off CA.

With intuitive perspective, the biggest value that firm could hold up government will be result of $\mathrm{V_g}(\mathrm{Re}|n = 0) - \mathrm{V_g}(\mathrm{T}|n = 0)$. Any requirement more than that value will result in $V_g(Re|n = 0) < V_g(T|n = 0)$, which will forces government to adopt *T* policy. However, this is only partially true since the result of $\mathrm{V_g}(\mathrm{Re}|n = 0) - \mathrm{V_g}(\mathrm{T}|n = 0)$ does not consider the reputation of firm. When *ex post* risk is obviously from firm's mistake, government could save an amount that is equal to the value of reputation loss of firm.

Theorem 1*: the holdup amount cannot be bigger than $\bar{h}$ for once-off CA package. Once the holdup amount is bigger than $\bar{h}$, government will take over the program. The value of*

[11] When holdup problem is not considered in former models, asymmetrical information will not affect the decision-making. As pointed out by Proposition 2-1, information property is not relevant when rescue policy is dominant policy.

$\overline{h}$ is following. In particular, when the reputation loss of firm is big enough (see $K_f^r > A$ in following), there will be no takeover policy due to holdup problem.

$$\overline{h} = \begin{cases} 0, when\ K_f^r > A \\ \frac{K_g^a + [\Delta C - (\alpha_b - \alpha_s\ ) \cdot TrC] - (1-p_b)\beta \cdot \mathrm{CR}_\mathrm{f}^1 + \left(K_g^r - K_f^r\right)}{p_b} + W, p_b \in (0,1], when\ K_f^r \leq A; \\ A = p_b \cdot W + K_g^a + [\Delta C - (\alpha_b - \alpha_s\ ) \cdot TrC] + K_g^r - (1-p_b)\beta \cdot \mathrm{CR}_\mathrm{f}^1 \end{cases}$$

Proof: according to (1), when $n = 0$, there is following.

$$V_g(Re|n = 0) - V_g(T|n = 0) \leq 0 \leftrightarrow$$

$$p_b(\Delta CR_g^1 + h) \leq K_g^a + [\Delta C - (\alpha_b - \alpha_s\ ) \cdot TrC] - \beta \cdot \mathrm{CR}_\mathrm{f}^1 + K_g^r. \qquad (2)$$

In (2), the left part is the potential CA package including the compensation for firm to avoid bankruptcy problem, ΔCR_g^1, and the amount of holdup, h. In fact, for *ex post* bailing-out package, the reputation loss of party taking holdup strategy should be also considered (Klein 1996). Namely, the value equal to reputation loss of firm (K_f^r) could be saved for government. Hence, for holdup strategy of firm should be following.

$$p_b(\Delta CR_g^1 + h) \leq K_g^a + [\Delta C - (\alpha_b - \alpha_s\ ) \cdot TrC] - \beta \cdot \mathrm{CR}_\mathrm{f}^1 + (K_g^r - K_f^r) \qquad (3)$$

As mentioned in section 4.2.1, the precise value of ΔCR_g^1 is $-\beta(CR_f^1 + W)$, put it into (3) and then reorganize it; there is following.

$$h \leq \frac{K_g^a + [\Delta C - (\alpha_b - \alpha_s\ ) \cdot TrC] - (1-p_b)\beta \cdot \mathrm{CR}_\mathrm{f}^1 + \left(K_g^r - K_f^r\right)}{p_b} + W, p_b \in (0,1]. \qquad (4)$$

In fact, whether (4) could be really satisfied depends on one condition, $h \geq 0$. If $h < 0$, the firm of PPP program under bankruptcy will get compensation less than ΔCR_g^1, so the rescue package is not effective.

$$0 \leq h \leq \frac{K_g^a + [\Delta C - (\alpha_b - \alpha_s) \cdot TrC] - (1-p_b)\beta \cdot \mathrm{CR_f^1} + \left(K_g^r - K_f^r\right)}{p_b} + W$$

$$\rightarrow \; K_f^r \leq p_b \cdot W + K_g^a + [\Delta C - (\alpha_b - \alpha_s) \cdot TrC] + K_g^r - (1 - p_b)\beta \cdot \mathrm{CR_f^1}. \qquad (5)$$

In other words, when (5) is satisfied, based on (4), the biggest value of h should satisfy $\overline{h} = \frac{K_g^a + [\Delta C - (\alpha_b - \alpha_s) \cdot TrC] - (1-p_b)\beta \cdot \mathrm{CR_f^1} + \left(K_g^r - K_f^r\right)}{p_b} + W, p_b \in (0, 1]$.

When (5) is not satisfied, namely, the reputation loss seems to force firm go to bankruptcy since *ex post* rescue package cannot bail firm out if the reputation is really a constraint condition. However, in that situation, PPP firm should abandon partially its own reputation, just requiring *ex post* rescue package equal to ΔCR_g^1 to avoid bankruptcy problem. At the same time, government will agree to grant ΔCR_g^1 instead of $\Delta CR_g^1 + h$ since the latter cannot rescue firm and then takeover policy must be adopted. The incentive of government agreement could be seen following.

When (5) is not satisfied, If government agrees to rescue firm under once-off CA with only the value of ΔCR_g^1 instead of $\Delta CR_g^1 + h$. The payoff is actually equal to $V_g(Re|h = 0, n = 0)$ in (1). At the same time, if government refuses the firm requirement, it then must adopt takeover policy; so the payoff is actually $V_g(T|n = 0)$ in (1).

$$V_g(Re|h = 0, n = 0) > V_g(T|n = 0) \leftrightarrow -p_b \cdot \Delta CR_g^1 + [\Delta C - (\alpha_b - \alpha_s) \cdot TrC] - \beta \cdot \mathrm{CR_f^1} + K_g^a + K_g^r > 0$$

$$\leftrightarrow (p_b - 1)\beta \cdot \mathrm{CR_f^1} + p_b \cdot W + [\Delta C - (\alpha_b - \alpha_s) \cdot TrC] + K_g^a + K_g^r > 0.$$

Seen from above inequity, $(p_b - 1)\beta \cdot \mathrm{CR}_\mathrm{f}^1$ is positive since $\mathrm{CR}_\mathrm{f}^1 < 0$ and $p_b \leq 1$. In addition, according to definition, $p_b \cdot W$, K_g^a and K_g^r are positive. According to A2, $\Delta C > TrC$, there must be $\Delta C - (\alpha_b - \alpha_s) \cdot TrC > 0$. Namely, all of parts in left side are positive. So the above inequity must be satisfied. Hence, government will approve *ex post* rescue package equal to $-\beta\left(CR_f^1 + W\right)$ when (5) is not satisfied.

To sum up, when (5) is not satisfied, (4) must be satisfied for holdup strategy; otherwise, firm will not hold up government and it only requires government to bail it out. Therefore, the value of $\bar{h}$ will be equal to the one in Theorem 1. ▌

Need to note, among above induction process, $V_g(Re|h = 0, n = 0) > V_g(T|n = 0)$ actually uncovers that government prefers to rescue firm when there is no asymmetrical information. On the contrary, with asymmetrical information, the rescue package is difficult to identify. When required subsidy bigger than the expected subsidy, government regards the difference as the holdup amount. Once the suspected holdup amount is big enough, government will adopt takeover policy. That is the effect of asymmetrical information. In particular, even when the difference does not come from firm's holdup strategy, government may also take over the program because it is the belief of government instead of objective situation to affect government decision.

Considering $\bar{h} = 0$ means *ex post* rescue package has no disputation between firm and government, at the same time, it means there is no holdup problem. For the application of Theorem 1 to reality, we could omit the situation of $\bar{h} = 0$. We especially consider the situation of $\bar{h} > 0$ for the conclusion of holdup strategy under CA in following.

Proposition 1: when the disputation about ex post rescue package between firm and government is big enough due to asymmetrical information, government will suspect the holdup strategy and then adopt takeover policy under once-off CA.

4.5 The takeover policy due to uncontrollable CAs

The last section discusses the holdup problem under once-off CA, now we extend it to the uncontrollable CAs. Namely, the decision-making at this section involves two problems, uncontrollable CAs and potential holdup problem. Even when confidence is lost, the takeover policy may not happen. There is another important condition for *T* policy in spite of the loss of confidence. Before the formal inference about the condition for policy change, there need be two assumptions as following.

Assumption 3 (A3): $\begin{cases} n = \begin{cases} n(i), i \geq i_{min} \geq 0 \\ 0, \ i < i_{min} \end{cases} \\ \frac{dn}{di} > 0, i \geq i_{min} \\ \frac{dn}{di} \in \emptyset, i < i_{min} \end{cases}$.

A3 points out the future number of CA will depend on the number of CA in the past when confidence is lost. In particular, it assumes extra CAs are expected when experienced number of CA is big enough ($i \geq i_{min}$). This is reasonable and practical, the confidence will be only lost when (unexpected) CA happens more than the limit value (i_{min}) in government's belief. In fact, uncontrollable CAs has defined $n = n(i), i \geq i_{min}$.

Given this section consider holdup problem and uncontrollable CAs, there are $n \neq 0, h \neq 0$ in (1). Under uncontrollable CAs with potential holdup problem, takeover policy will be adopted when $V_g(T) > V_g(Re)$. We want to find out how uncontrollable CAs for government to adopt T policy, namely, we need find out how $V_g(T) - V_g(Re) > 0$ when i and n are endogenous variable for decision-making. Let $f(i,n) \equiv V_g(T) - V_g(Re)$. As mentioned above, the uncontrollable CA has defined $n = n(i), i \geq i_{min}$. Hence, according to A3, there is $f(i) = f(i, n(i)) = f(i,n)$ and then following.

$$f(i) = (1 - p_b) \cdot \beta(i) \cdot (ER_e^1(n(i)) - CR_g^0) + p_b \cdot h - p_b \cdot W - K_g^a - K_g^r - \alpha_s \cdot TrC - \Delta C + (1 + n(i)) \cdot \alpha_b \cdot TrC + n(i) \cdot \gamma, h \leq \overline{h}. \quad (6)$$

In particular, $h < \bar{h}$ in (6) because previous CAs cannot have takeover policy of government; otherwise, contract relationship has been terminated and then CA under PPP is not possible.

Assumption 4 (A4): the number of CA could be definitely divided, then $n(i)$ is continuous function for all i while $f(i)$ is continuous function when $i \geq i_{min}$. A4 is just for mathematical analysis.

Theorem 2: $\exists i \geq i_{min}, f(i-\varepsilon) \leq 0, f(i) = 0, f(i+\varepsilon) > 0$; *let* $i^* = \min(\{i | f(i-\varepsilon) \leq 0, f(i) = 0, f(i+\varepsilon) > 0\})$. *Government will take over project at* $(i^*+1)^{st}$ *CAs by itself or a new firm.*

This theorem is aimed to get i^*, which will induce takeover policy to be preferred.

Proof: according to A3, $n(i_{min} - \varepsilon) = 0$. Considering $n(i)$ is continuous function (see A4), $n(i_{min}) = n(i_{min} - \varepsilon) = 0$. $f(i_{min}) = V_g(T | n = 0, h \leq \bar{h}) - V_g(Re | n = 0)$. Recalling Theorem 1, under once-off CA, government will not take over PPP program except $h > \bar{h}$. Namely, $f(i_{min}) = V_g(T | n = 0, h \leq \bar{h}) - V_g(Re | n = 0) \leq 0$. Need to note, $f(i_{min}) = V_g(T | n = 0, h < \bar{h}) - V_g(Re | n = 0) = -p_b \cdot (\Delta CR_g^1 + h) + [\Delta C - (\alpha_b - \alpha_s) \cdot TrC] - \beta \cdot \mathrm{CR}_\mathrm{f}^1 + K_g^a + K_g^r \neq -\infty$. In particular, $h \leq \bar{h}$ is ensured because of uncontrollable CAs; once $h > \bar{h}$, government will adopt takeover policy and then there is no uncontrollable CAs.

Considering $f(i_{min}) \leq 0$ and $f(i_{min}) \neq -\infty$, if there is no i^*, which satisfying $f(i) = 0, f(i+\varepsilon) > 0$, there must be $f_i' \leq 0$, when $i \geq i_{min}$. However, $f_i' \leq 0$ cannot be sure because of following.

$$f(i) \rightarrow f_i{}' = (1 - p_b) \cdot \frac{d[\beta(i) \cdot (ER_e^1(n(i)) - CR_g^0)]}{di} + \frac{dn}{di} \cdot (\alpha_b \cdot TrC + \gamma) \text{ when } i \geq i_{min}.$$

If $f_i' \leq 0$ when $i \geq i_{min}$. There will be $\frac{d[CR_f^1(n(i^*))]}{di} \leq \frac{-\frac{dn}{di}\cdot(\alpha_b \cdot TrC+\gamma)}{\beta(1-p_b)} - \frac{\frac{d\beta}{di}\cdot CR_f^1}{\beta}$.

According to definition, α_b, TrC, γ, β and $(1-p_b)$ are positive; according to A1, $CR_f^1 < 0$; according to (1), $\frac{d\beta}{di} < 0$ and $\frac{dCR_f^1}{di} < 0$; finally according to A3, $\frac{dn}{di} > 0$. Therefore, $\frac{-\frac{dn}{di}\cdot(\alpha_b \cdot TrC+\gamma)}{\beta(1-p_b)} - \frac{\frac{d\beta}{di}\cdot CR_f^1}{\beta} < 0$.

Hence, $f_i' \leq 0 \rightarrow \frac{d[CR_f^1(n(i^*))]}{di} < 0$. This is impossible. Recalling the definition of CR_f^1, it is the profit of PPP program towards firm. $\frac{d[CR_f^1(n(i^*))]}{di} < 0$ means experienced CAs decrease the profit for firm. There are two reason to refuse it. Firstly, if that happens, PPP firm must be bankrupted and then government must take over the program. This contradicts the premise of uncontrollable CA, considering the decision-making under uncontrollable CA witness repeated rescue policy. Secondly, if CA is consistently ineffective so that the profit to PPP firm decrease, neither firm and nor government will have incentive to have a CA package. PPP termination takes inevitably place, which means, more practically, a takeover policy of government.

Given $f_i' > 0$, $f(i_{min}) \leq 0$ and $f(i_{min}) \neq -\infty$, there must be $\exists i^*, f(i^* - \varepsilon) \leq 0, f(i^*) = 0, f(i^* + \varepsilon) > 0$. Namely, government will adopt takeover policy after i^* CAs, namely, at the $(i^* + 1)^{st}$ CA. ▌

This section proves repeated CAs (in the manner of rescue packages) will lead to takeover policy of government unless the PPP program expires. As long as there are enough CAs, government has to take over PPP program under *ex post* risk. Considering this conclusion, there is following.

Proposition 2: under uncontrollable CAs, when the number of CA is big enough under PPP, government will take over PPP program.

4.6 The sensitivity analysis-the takeover policy under holdup problem and uncontrollable CAs

Recalling (1) and later induction, h is amount required by firm with holdup strategy; in fact, it could increase with more CAs. We could assume $h = (i + 1 + n)ah$, ah here is assumed to be the averaged holdup amount. With more CAs, h will be bigger and then takeover policy is more probable. On one hand, this does not contradict the above induction because uncontrollable CAs have confirmed $h < \overline{h}$; $h \geq \overline{h}$ leads to takeover policy and then three is no (uncontrollable) CAs for decision-making. On the other hand, it hints us bigger holdup problem could enforce takeover policy sooner under uncontrollable CAs. This idea will be proven in following.

Corollary 1: $\frac{\partial i^*}{\partial K_g^a} > 0, \frac{\partial i^*}{\partial \alpha_s} > 0, \frac{\partial i^*}{\partial \Delta C} > 0$ and $\frac{\partial i^*}{\partial p_b} < 0, \frac{\partial i^*}{\partial h} < 0, \frac{\partial i^*}{\partial TrC} < 0, \frac{\partial i^*}{\partial \alpha_b} < 0, \frac{\partial i^*}{\partial \gamma} < 0$. i^* is defined in Theorem 2.

Proof: According to Theorem 2, $i^* = \min(\{i | f(i-\varepsilon) \leq 0, f(i) = 0, f(i+\varepsilon) > 0\})$; hence, there is following.

$$f(i^* + \varepsilon) > f(i^*) \geq f(i^* - \varepsilon) \to \lim_{i \to (i^*)^+} \frac{\partial f}{\partial i} > 0 \text{ and } \lim_{i \to (i^*)^-} \frac{\partial f}{\partial i} \leq 0$$

$$\to i \in [i^*, i^* + \varepsilon), \frac{\partial f}{\partial i} > 0;\ i \in (i^* - \varepsilon, i^*), \frac{\partial f}{\partial i} \geq 0$$

$$\to i \in (i^* - \varepsilon, i^* + \varepsilon), \frac{\partial f}{\partial i} \geq 0. \tag{7}$$

let $h = (i + 1 + n)ah$, putting it into (6) and then there is following.

$f(i) = (1 - p_b) \cdot \beta(i) \cdot (ER_e^1(n(i)) - CR_g^0) + p_b \cdot (i + 1 + n(i))ah - K_g^a - \alpha_s \cdot TrC - \Delta C + (1 + n(i)) \cdot \alpha_b \cdot TrC + n(i) \cdot \gamma$. Let $f(i) = 0 \to i^* = i(p_b, K_g^a, ah, \alpha_s, TrC, \Delta C, \alpha_b, \gamma)$.

$$\rightarrow \begin{cases} \frac{\partial f}{\partial p_b} = -\beta(i)\cdot\left(ER_e^1\big(n(i)\big) - CR_g^0\right) + (i+1+n(i))ah > 0, \\ \frac{\partial f}{\partial K_g^a} = -1, \\ \frac{\partial f}{\partial ah} = p_b(i+1+n) > 0, \\ \frac{\partial f}{\partial \alpha_s} = -1, \\ \frac{\partial f}{\partial TrC} = -\alpha_s + \big(1+n(i)\big)\cdot\alpha_b > 0, \\ \frac{\partial f}{\partial \Delta C} = -1, \\ \frac{\partial f}{\partial \alpha_b} = \big(1+n(i)\big)\cdot TrC > 0 \\ \frac{\partial f}{\partial \gamma} = n > 0 \end{cases} \quad (8)$$

$$(7)+(8) \rightarrow \begin{cases} \frac{\partial i^*}{\partial p_b} = -\frac{\frac{\partial f}{\partial p_b}|_{i=i^*}}{\frac{\partial f}{\partial i}|_{i=i^*}} = -\frac{-\beta(i)\cdot(ER_e^1(n(i))-CR_g^0)+(i+1+n(i))ah}{\frac{\partial f}{\partial i}|_{i=i^*}} < 0, \\ \frac{\partial i^*}{\partial K_g^a} = -\frac{\frac{\partial f}{\partial K_g^a}|_{i=i^*}}{\frac{\partial f}{\partial i}|_{i=i^*}} = -\frac{-1}{\frac{\partial f}{\partial i}|_{i=i^*}} > 0, \\ \frac{\partial ii^*}{\partial ah} = -\frac{\frac{\partial f}{\partial ah}|_{i=i^*}}{\frac{\partial f}{\partial i}|_{i=i^*}} = -\frac{p_b(i+1+n)}{\frac{\partial f}{\partial i}|_{i=i^*}} < 0, \\ \frac{\partial i^*}{\partial \alpha_s} = -\frac{\frac{\partial f}{\partial \alpha_s}|_{i=i^*}}{\frac{\partial f}{\partial i}|_{i=i^*}} = -\frac{-1}{\frac{\partial f}{\partial i}|_{i=i^*}} > 0, \\ \frac{\partial i^*}{\partial TrC} = -\frac{\frac{\partial f}{\partial TrC}|_{i=i^*}}{\frac{\partial f}{\partial i}|_{i=i^*}} = -\frac{-\alpha_s+(1+n(i))\cdot\alpha_b}{\frac{\partial f}{\partial i}|_{i=i^*}} < 0, \\ \frac{\partial i^*}{\partial \Delta C} = -\frac{\frac{\partial f}{\partial \Delta C}|_{i=i^*}}{\frac{\partial f}{\partial i}|_{i=i^*}} = -\frac{-1}{\frac{\partial f}{\partial i}|_{i=i^*}} > 0, \\ \frac{\partial i^*}{\partial \alpha_b} = -\frac{\frac{\partial f}{\partial \alpha_b}|_{i=i^*}}{\frac{\partial f}{\partial i}|_{i=i^*}} = -\frac{(1+n(i))\cdot TrC}{\frac{\partial f}{\partial i}|_{i=i^*}} < 0 \\ \frac{\partial i^*}{\partial \gamma} = -\frac{\frac{\partial f}{\partial \gamma}|_{i=i^*}}{\frac{\partial f}{\partial i}|_{i=i^*}} = -\frac{n}{\frac{\partial f}{\partial i}|_{i=i^*}} < 0 \end{cases}$$

$$\rightarrow \frac{\partial i^*}{\partial K_g^a} > 0, \frac{\partial i^*}{\partial \alpha_s} > 0, \frac{\partial i^*}{\partial \Delta C} > 0 \text{ and } \frac{\partial i^*}{\partial p_b} < 0, \frac{\partial i^*}{\partial ah} < 0, \frac{\partial i^*}{\partial TrC} < 0, \frac{\partial i^*}{\partial \alpha_b} < 0, \frac{\partial i^*}{\partial \gamma} < 0. \ \blacksquare$$

The above give a series of sensitive analysis at the area of $(i^* - \varepsilon, i^* + \varepsilon)$. This area is enough for policy choice. The policy choice depends only on the area of $(i^* - \varepsilon, i^* + \varepsilon)$

since there must be rescue policy at the area of $[0, i^* - \varepsilon]$. The above sensitivity analysis exposes the effects of relevant variables for potential takeover policy.

In one sentence, the number of CA to adopt takeover policy will be negatively related to holdup amount in each CA package (ah), the total transaction cost for each CA (TrC), the part of transaction cost for rescue policy (α_b), the loss of external benefit of government (γ) and the speed of contract implementation ($1-\beta$); while positively correlated to the idiosyncratic asset investment of government (K_g^a), the part of transaction cost for takeover policy (α_s) and the exit barrier cost (ΔC).

For one thing, when holdup problem exists under controllable CAs under PPP, according to Corollary 1, the holdup problem will decrease the number of CA before the potential takeover policy for government. In other words, there is following.

Proposition 3: the bigger holdup amount will enforce takeover policy sooner than the counterpart with a smaller one.

For another, for all of other exogenous elements, the number of uncontrollable CAs would be affected as following.

Proposition 4: government will take over PPP project sooner when there is bigger transaction cost for rescue package, bigger external loss or the faster contract implementation but smaller idiosyncratic asset investment of government, smaller transaction cost for takeover policy and smaller exit barrier.

In particular, Proposition 3 and Proposition 4 are intuitive except the relationship involving the speed of contract implementation. In fact, the relationship involving the speed of contract implementation gets also supported by reality. Takeover policy is always only adopted at relatively later stage. At the early stage, PPP program either has not finished the construction, which is difficult to take over from firm, or needs more time to get information about cost, demand (and then *ex post* risk) to decide PPP termination.

4.7 The findings

This section explores the termination of PPP. At first, we uncovers that the holdup problem deriving from asymmetrical information could lead to takeover policy. The holdup problem under once-off CA is especially given in Proposition 1. Secondly, we explain why (uncontrollable) CAs itself could lead to the takeover policy. The uncontrollable CAs is considered in Proposition 2. After that, a sensitivity analysis is given, exploring the holdup problem under uncontrollable CAs and figuring out the effect of other exogenous elements over takeover policy. The former is related to Proposition 3; the latter is concluded in Proposition 4. The following discusses the findings from our model and then testes our findings with literature.

4.7.1 The basic findings

Proposition 1 develops the theory of Klein (1996) about holdup. According to Klein (1996), the holdup problem has two sanctions to reduce the claim value (namely, holdup amount, $\overline{h}$): the future loss due to the contract termination (K_g^a in $\overline{h}$) and the reputation loss due to the holdup behaviour (K_g^r and K_f^r in $\overline{h}$). We develops Klein's idea to the situation under CA. According to Proposition 1, the biggest holdup amount ($\overline{h}$) involves transaction cost during CA (TrC), exit barrier (ΔC), the rescue package ($-\beta \cdot \mathrm{CR}_{\mathrm{f}}^{1} - w$) and the probability of bankruptcy (p_b) in spite of ones Klein (1996) discovered. In addition to the above support and extension, comparing with the theory of Klein (1996), Proposition 1 could also reflect the difference between this thesis and the literature on contract renew. The literature in contract renew studies on expected and periodical contract renew, which means there are potentially other transacting parties. Meanwhile, our model explores the unexpected situation under *ex post* risk between original transacting parties.

Proposition 2 gives a very interesting conclusion, uncontrollable CAs force PPP program to end with government takeover policy when *ex post* risk need much enough CAs.

Otherwise, PPP will have rescue policy of government until the program expiration. In other words, if *ex post* risk leads government to rescue firm once again and again, government has to take over the program unless that PPP program expires before the potential takeover policy. Proposition 2 gives a picture for firm and government under uncontrollable CAs. Either repeated CAs end up a reluctant but necessary takeover policy or those CAs cannot stop during the whole PPP program. Both of these two outcomes will affect the application of PPP mechanism for government.

Proposition 3 tell us the holdup problem will force government to adopt takeover policy sooner. This seems natural. Holdup problem will deteriorate the economic benefit of government; hence it will force government to abandon the program earlier. In other words, the number of CA could also lead to a severer holdup problem and then takeover policy must be adopted earlier.

Proposition 4 illustrates clearly the effect of other elements for takeover policy. Though those are exogenous variables for decision-making, PPP program under CA will be affected individually by those variables. The significance of Proposition 4 could be seen clearer in hypothesis formulation for potential economic relationship.

4.7.2 The testing our finding with relevant literature

Our model and relevant propositions support incomplete contract theory, incentive contract theory and the literature in renegotiation issue. For the incomplete contract theory, firstly, our model reflects the basic conclusion of Grossman and Hart (1986) about *ex post* distribution due to contract incompleteness. Grossman and Hart (1986) assume the *ex post* contractible quantity, which cannot be specified *ex ante*, leads to *ex post* distribution of surplus. This kind of *ex post* distribution is 'sensitive to ownership rights' (Grossman and Hart 1986: 696). Our model assumes the effect of *ex post* risk so that *ex ante* design is broken; at the same time, *ex post* situation must be contractible relative to *ex ante* one. Similar to Grossman and Hart (1986), our model reflect the *ex post* distribution due to the *ex post* contractible elements quantity. Precisely, *ex post* distribution gets discovered by our sensitivity analysis. As mentioned, the sensitivity of *ex post* distribution would generate interest conflict since government and firm under PPP has equal relationship to each other. Namely, due to contract incompleteness, government has no control of residual rights under PPP, *ex post* interest conflict cannot be solved by government unilaterally. Different from Grossman and Hart (1986), our model involves *ex post* distribution of loss.

Secondly, all above propositions coincide with the integration theory of Grossman and Hart (1986). By contrast to contractual relationship, the integration could prevent *ex post* return (Grossman and Hart 1986). Applying this to CA under PPP, takeover policy of government, with which government is in charge of program, could avoid the requirement of compensation. Our model uncovers holdup problem and uncontrollable CAs could force government to take over program. The holdup problem comes definitely from the strategy of firm requiring government support. At the same time, CA under *ex post* risk would get directly or indirectly government contribution. Therefore, the takeover policy of government prohibits indeed *ex post* return from firm under PPP.

Thirdly, as Hart (2003) suggests that PPP had better be adopted when service quality is easier to specify than the building quality. In other words, when service quality is not easy to design, public provision instead of PPP had better be adopted. Our proposition 4 list relevant variables for takeover policy. In particular, the external loss (related to PPP service quality) could leads to higher probability of takeover policy, which means PPP is abandoned for government choice. This actually coincides with the suggestion of Hart (2003).

As for the theory of incentive contract, our model contribute to the property of *ex post* adaptation. Recalling our propositions answer when to adopt takeover policy under PPP for CA, this actually show the different policy of CA for *ex post* adaptation under PPP. Relative to Bajari and Tadelis (2001) and Bajari et al (2014), which focus on the endogeneity of *ex post* adaptation, our model figures out that the specific policy of CA for *ex post* adaptation depends on the transacting players, namely, extending the endogeienity property from just *ex post* adaptation towards the specific policy of CA for *ex post* adaptation. This finding is not substantial contribution, but we could say that our propositions support the theory of incentive contract. In addition, our propositions about holdup problem actually reflect the idea of regulation for deterring strategic renegotiation (Guasch 2004 and Guasch et al 2008). Recalling Proposition 4 involves external loss for potential takeover policy, it is worth of government as economic regulator or public agent to consider it.

Finally, our model does not contradict the idea of some literature focusing the determining factor of renegotiation. To some extent, our model extends renegotiation literature to the stage of CA. The determining factors of renegotiation include the political institutional issue (Guasch 2004), relational-specific investment (Joskow 1987), regulatory policy (Estache et al 2009, Guasch et al 2006 and Guasch et al 2008), economic shock (Guasch et al 2006 and Guasch et al 2008) and so on. All of these factors could lead to more renegotiation and then lead to a bigger transaction cost under PPP for CA package and finally lead to a bigger probability of takeover policy under PPP for CA package. Meanwhile, the political institutional issue, regulatory policy and economic shock could be related to the external benefit of PPP program. When all of these factors leads to external loss under controllable CAs, as our model suggests, there will be a takeover policy to end the PPP program. As for the relational-specific investment, it is denoted by K_g^r for government in our model. The corresponding effect gets reflected in Proposition 4. To sum up, all of these determining factors leads to (more) renegotiation and then, as our model suggests, a bigger probability of takeover policy under PPP.

4.8 A theory of CA under PPP

Our model focuses on the potential takeover policy because government has a clear and obvious incentive to rescue firm under *ex post* risk to keep PPP contract going. If the inherent incentive of policy does not exist, government will not use PPP for the project at the first place. By combining the incentive of rescue policy with the model for potential takeover policy, the following illustrates how government compensates directly or indirectly PPP firm under CA. Simply to speak, we will give a clear picture for the compensation effect under CA for PPP program.

Moreover, as a supplement, the practical way of getting *ex post* government contribution is illustrated for firm under PPP. With the clear picture and the supplementary illustration, we hope to give a theory of CA under PPP.

4.8.1 The compensation effect reflected from our modelling

Either rescue policy or takeover policy under CA forces government to compensate firm under PPP directly or indirectly. Under recue policy, when there is bankruptcy problem (namely, $p_b = 1$ in modelling), government has to compensate directly firm under PPP. The compensation tool includes *ex post* subsidy, new price scheme, approval of firm's claim and so on. All of these must reallocate property rights; the aim is to improve the economic situation of firm immediately. Without the direct compensation, the firm under PPP must be bankrupted and the project gets suspended. When there is no bankruptcy problem, $p_b = 0$ in model, there is no direct compensation package; government only need transfer *ex post* risk from firm to compensate firm indirectly. This kind of situation is always witnessed in reality. For example, in High Speed 1 (HS1) program, government give an *ex post* debt guarantee to bail firm out from financial crisis and it also transfers the construction job to UK's national railway operator. This *ex post* arraignment is for transferring *ex post* financial risk to government and *ex post* construction risk to another partner. This kind of *ex post* risk transfer compensates risk indirectly. Returning to HS1 case, *ex post* debt guarantee could help firm to avoid expensive financial cost for project fund while *ex post* arrangement of construction helps firm to avoid cost overrun. More details about HS1 case could be seen in Chapter 5.

With either rescue policy or takeover policy under CA, the compensation effect under CA for PPP program could be ensured. Put this idea further, we could say every CA could give firm under PPP a chance to get government contribution. When takeover policy is adopted, the whole PPP program is contributed by government. If the condition of takeover policy is satisfied as figured out in our model, the potentially biggest compensation effect will be realized due to takeover policy. When CA ends up just rescue policy, the compensation effect has not been at the biggest level. However, the compensation effect will increase until there is no CA under PPP. In other words, when there is no takeover policy, *ex post* government contribution will not stop unless *ex post* risk is solved so that there is no CA any more.

Given *ex post* contribution is necessary for CA package under PPP, the budget of government for the program must be softened. In particular, our model points out that holdup problem due to asymmetrical information or uncontrollable CAs due to consistent *ex post* risk could force government to take over PPP program. With takeover policy, the project either goes at the hand of government or in the charge of new firm. The former will require government to undertake the budget for the project since then; the latter will require government ensure the new firm with the normal profit, which also means a bigger budget for the program than before. This idea will be discussed in later empirical investigation.

Recalling the compensation effect asserted by Cheung (1969, 1970 and 1974), every Contract Restructure (CR) will induces non-exclusive property rights and the non-exclusive rights will distribute between the transacting parties. One of transacting party will be compensated by the other party. At the same time, there will be waste for the compensation effect, e.g. transaction cost for the CR. The CA under PPP actually is an *ex post* CR under PPP. As figured out above, the firm under PPP will compensated directly or indirectly by government through CA. This coincides with the basic thought of about CR. If CA is triggered as a strategy for firm under PPP, the program controlled by firm relies actually on government. At that situation, the compensation effect is extremely clear.

4.8.2 A practical way of firm to get compensated through CA(s)

The following will explain how firm gets compensated through CA(s) in practical way. At bidding competition, firm estimates total revenue $TR_f^0 = p_c^0 \cdot q_e^0$, in which p_c^0 and q_e^0 means the capped price under regulation and the expected quantity of demand at the stage of contract assignment, respectively. As for total cost, there is following equations.

$$\begin{cases} TC_f^0 = CC_f^0 + FC_f^0 = \left(1+\pi_f^0\right)\cdot CC_f^0 = \left(1+\pi_f^0\right)\cdot (W_{co}+W_{mi}+W_{de}) \\ CC_f^0 = W_{co}+W_{mi}+W_{de} \\ FC_f^0 = \pi_f^0 \cdot (W_{co}+W_{mi}+W_{de}) \end{cases}.$$

TC represents total cost, *CC* reflects construction (and operation) cost, *FC* is the financial cost. *Π* is the interest level (the financial cost) of capital. W_{co} is the capital from controlling shareholders, W_{mi} is from minority shareholders and W_{de} is debt.

The economic profit of program will be income minus cost, $ER_e^0 = TR_f^0 - TC_f^0$. Competition for contract will ensure full economic profit to government; so $CR_f^0 = ER_e^0 - CR_g^0 = 0$. There are following further.

$$CR_f^0 = TR_f^0 - TC_f^0 - CR_g^0 = p_c^0 \cdot q_e^0 - \left(1+\pi_f^0\right)\cdot (W_{co}+W_{mi}+W_{de}^0) - CR_g^0 = 0.$$

However, under the influence of *ex post* risk, the real profit of firm will be lowered:

$$CR_f^1 = TR_f^1 - TC_f^1 - CR_g^0 = p_c^1 \cdot q_e^1 - \left(1+\pi_f^1\right)\cdot (W_{co}+W_{mi}+W_{de}^1) - CR_g^0 < 0.$$

Ex post risk could affect four variables. Under *ex post* risk, there is $p_c^1 < p_c^0, q_e^1 < q_e^0, \pi_f^1 > \pi_f^0$ or $W_{de}^1 < W_{de}^0$. Some or all of these four inequities could be satisfied under *ex post* risk.

Firm could get compensated from government to offset fully or partially the influence of *ex post* risk. At first, firm could also force government to increase the regulated price if PPP program is the monopoly in the industry: $p_c^1 + \Delta p > p_c^1$. Similarly, firm could require government to remove/block competitor, for example, removing a road near the PPP program of Airport Rail Link in Case 21 (in Chapter 5); there will be $q_c^1 + \Delta q > q_c^1$. Thirdly, if government involves the financial restructure, the lower-interest debt could be obtained usually at renegotiation: $\pi_f^1 - \Delta\pi < \pi_f^1$, thereby reducing the financial cost. At the same time, with *ex post* government guarantee, more debt will be obtained: $W_{de}^1 + \Delta W_{de} > W_{de}^1$. Although this will not improve firm situation directly, it saves the transaction cost undertaken by firm: $\alpha_s \cdot TrC < TrC$. Namely, firm need only $\alpha_s \cdot TrC$ to get a new debt with government support instead of TrC. Fifthly, firm could require government a direct compensation package, $\Delta \mathrm{CR}_{\mathrm{g}}^1$. Finally, firm could also hold up government with h amount. Putting all of these ways together, the profit of firm after CA, $(CR_f^1)_{CA}$, will be followings.

$$(CR_f^1)_{CA} = (p_c^1 + \Delta p) \cdot (q_e^1 + \Delta q) - \left(1 + \pi_f^1 - \Delta\pi\right) \cdot (W_{co} + W_{mi} + W_{de}^1 + \Delta W_{de}) - CR_g^0 + \Delta CR_g^1 - \alpha_s \cdot TrC + h > CR_f^1.$$

The only variable in above inequality reduce the value of CR_f^1 is $\alpha_s \cdot TrC$, it must be offset by other increments. Otherwise, either firm has no incentive to require government to bail it out, or it will face a deteriorated situation, which could lead to another dilemma of bailing-out.

Whether $(\mathrm{CR}_{\mathrm{f}}^1)_{CA}$ is bigger than CR_f^0, it depends on the value of Δp, Δq, $\Delta\pi$, ΔCR_g^1, $\alpha_s \cdot TrC$ and h. Even when $(\mathrm{CR}_{\mathrm{f}}^1)_{\mathrm{CA}} > \mathrm{CR}_{\mathrm{f}}^0$, it does not contradict A2, which assume that *ex post* risk reduces the profit of PPP program instead of profit of firm. All potential positive profit of firm must be from government compensation.

This chapter explores the policies and packages for PPP program under CA(s), thereby uncovering relevant behaviours of firm and government; the following chapters will investigate how government will compensate firm for PPP program under CA(s). In particular, the next chapter will develop and identify indicators for measurement and generate hypothesis for later regression.

CHAPTER 5: HYPOTHESIS DEVELOPMENT AND MEASUREMENT

5.1 Introduction

This empirical investigation in this thesis is designed to test predicted relationship by regression. There will be two set of regression after measurement. At first, the quantified indicator for SBC phenomenon will be definitely regressed. Namely, the government contribution for program under PPP through CA will be especially investigated. Furthermore, *ex post* risk will be also regressed for extra insight. The former is the main subject while the later will help understand the contract implementation with CA.

For getting the regression from real data, this chapter is specially orientated to finish the measurement for later data regression. Relevant indicators must be developed firstly. Simply speaking, the core concept, softness of budget constraint (softness in following), is developed into indicator from existing literature. After that, the form of indicator is specially designed for this research. All of others are constructed around the softness indicators. The number of data is the biggest one for this research to our best information. Furthermore, given data in this research must be identified after understanding the cases, case study is definitely the method of measurement. In other words, just with the general technique of data collection, document analysis, the measurement in this research cannot be finished effectively.

The following is indicator development firstly. After the indicator development, the third section is the hypothesis development, which is aimed to give predictions on the base of previous theoretical exploration. The fourth section explains the government policies of our thirty-two real cases for PPP programs under CA. For getting a big size of sample, we choose four facility projects under PPP with CA into our data while all of other cases are in transportation industry. Considering there may be big dilution effect of adding those four cases in our data, a comparative analysis shows especially in the section 5.5 that the potential dilution effect is much less than it seems. The final section will be the findings on the base of section 5.4 and 5.5. The details of measurement involving complicated and objective evidence are given in the appendix of this chapter.

5.2 The development of indicators

There will be three categories of variable to measure. Consequently, there will be three sets of indicator to develop. At first, four indicators about core concept (softness) will be constructed on the base of literature. Another two derivative indicators will be also designed. In spite of those six indicators, two dummy variables related to the way of CA are designed immediately in the first subsection since those two indicators affect the tendency of softness indicators directly. These eight indicators are aimed to measure the situation of final CA. The second set of indicator will be developed for initial situation. Two *ex ante* risk indicators and three *ex ante* contribution indicators will be developed, all of which will be fixed under original contract. Finally, contract implementation will be reflected. Five *ex post* risk indicators will be specially designed.

In particular, any potential problem or error for measurement will be especially pointed out. On one hand, the way to solve those problems will be correspondingly figured out. On the other hand, if the problem is not important, it will be explained clearly. In these ways, it is hoped to keep an honest attitude in academic. At the same time, the detail of measurement to avoid problem could reflect our attitude to keep the shortest distance to reality.

5.2.1 The identification of indicators for softness and dummy variables

The following will give a precise definition for the SBC phenomenon firstly and then design the indicator forms. After that, two dummy variables will be defined to distinct different ways of CA for better data fitting.

This needs a precise definition for softness of budget constraint. To some extent, the softness is actually the ratio of government contribution over the total project fund. Namely, the softness is actually the value of government contribution relative to project fund. Therefore, we give a definition of SBC in one sentence for measurement: the degree of government contribution relative to the total amount of project fund is the softness of budget constraint. The softness will be represented in following by S_{BC}.

For measuring $\mathrm{S_{BC}}$, Kornai et al (2003) give a comprehensive list of instrument for measuring softness, of which four instruments seems plausible for this research. These instrument include 'The percentage of fund with government's contribution in total', 'debt/equity (asset) ratio', 'Frequency of bailouts' and 'bad loan'. But only the first two are feasible for this research. at first, the final is obviously subjective; objective judgement on "bad" loan is beyond this research.

In addition, the frequency of bailouts involves some subjective judgement about whether it was a bailing out or not. More practically, the frequency cannot represent the softness well. When a CA that is not a bailing-out package takes place in the middle of a series of bailing-out, the frequency will have a discontinuous derivative at that point. A simple example is following. Assuming there are six bailout CAs and one non-bailout at the fourth CAs, so the frequency of bailouts relative to total numbers of CA will be: 1, 1, 1, $\frac{3}{4}$, $\frac{4}{5}$, $\frac{5}{6}$ and $\frac{6}{7}$. It could be seen that the frequency decrease sharply at the fourth CA while increase very slowly after that. If Firm A just has three CAs with bailing-out package while Firm B has all seven CAs with one non-baling-out package at the forth CA. Using this indicator to measure softness, it will say Firm B will have a lower softness than Firm A. However, this cannot reflect the reality since Firm B has three more CAs though it has one non-bailout CA.

Though choosing the first two indicators from Kornai et al (2003), there is still extra processing. At first, first indicator should also include contribution from banks because the debt must be supported by government; the debt support transfers risk from firm and it is indirect way of softness (Jin and Zhou 2003). Secondly, the value of asset is unrealistic to obtain because the depreciation information is unavailable or very hard to get for some cases, so the debt/equity instead of debt/asset ratio is chosen. In fact, the equity had better be substituted by the ratio between project fund so that the value of indicator (debt/project fund) will be fall into [0, 1]; otherwise, the value (debt/equity) could has no definite limit. As a consequence, two alternative indicators could be constructed as following.

$S_{BC}^{1} = \frac{TF_{gb}}{TF}$, *TF* is the total amount of raised fund for project under program while TF_{gb} is the one explicitly contributed by government in manner of subsidy or implicitly supported in the manner of debt support. $\mathrm{S}_{\mathrm{BC}}^{1} \epsilon [0, 1]$. It represents the global softness.

$S_{BC}^{2} = \frac{V_d}{TF}$, Vd is the value of debt. $S_{BC}^{2} \epsilon [0, 1]$. It represents (total) indirect softness and reflects the ratio of debt relative to project fund.

Combining above two indicators, the first one measures the global softness while the second one is for indirect softness related to the bank involvement. In particular, the second indicator reflects the involvement of bank (representing market) system. From theoretical exploration, government prefers to bail firm out and then the softness of budget constraint will be bigger with more CAs. This tendency will be reflected by the first indicator. The second one will be different; it will be increased when there is new loan package while it will be decreased when there is debt refinancing. Debt refinancing is aimed to reduce the financial burden, so the second indicator would decrease correspondingly. When two indicators get increased, it could be known that firm get supported with a bigger role of new loan; otherwise, the support is mainly from a debt refinancing package. This inconsistence of tendency is meaningful.

After defining the form, there are still extra two manipulation as followings. Firstly, rescue package always involves the reduction of interest cost for firm. The interest reduction is small relative to the fund itself; the change of interest cost in refinancing package is generally confidential. Given these two elements, it is practical to neglect the interest cost. Secondly, the project fund in reality is consisted of separate parts; the changes in the price level will be ignored. All data in following case studies are available with big units (for example, million or billion pound), so those are approximate values. Considering the approximation itself in data, the consideration of price level cannot improve the data really; hence, data about project fund in following will neglect price effect.

Moreover, it must be noted that both above indicators have two limitations. At firstly, both of indicators are mainly to measure the financial (re)structuring. For example, the extension of concession length, the softness of budget constraint cannot be reflected from the indicators. Secondly, the above indicators cannot reflect the original financial arrangement at contract and *ex post* softness.

As for the first limitation, all of cases experience financial restructuring or the change of ownership, which is our target to measure, so the limitation is not a big issue for this research. It will go beyond this research to constitute an effective indicator for measuring the value of property rights under a long time contract. With respect to the second one, another set of indicator as substitutive ones for measurement will be adopted as followings.

$S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c}$, The superscript ‘c’ represents fund stipulated by *ex ante* contract. S_{BC}^3 represents *ex post* or net softness.

$S_{BC}^4 = \frac{V_d}{TF} - \frac{V_d^c}{TF^c}$, V_d is the value of debt. S_{BC}^4 represents *ex post* indirect softness or net debt.

The ones at above with superscript of ‘c’ means the assigned at original contract.

It is worthy to mention that S_{BC}^2 and S_{BC}^4 make some trouble for practical measurement when some cases do not give final debt amount. Fortunately, the data are basically creditable because of followings. At first, the newest debt is updated with information, this include Case 1, Case 3, Case 8, Case 12, Case 13, Case 19, Case 21-23, Case 28, Case 29 and Case 31[12]. All of these cases have either debt refinancing package (such as Case 3) or evidence about new debt (some book or paper investigating these cases, for example, Case 12) and then the debt information will be given clearly. The initial debt is stipulated in original contract, so final debt could be figured out after getting data about new debt. Secondly, some cases could be confirmed without debt increase such as Case 2 and Case 24. Thirdly, some cases adopt the compensation package instead of debt support. Even the compensation package is not prompt some times; the debt could also be offset due to the later liability transfer towards government. This kind of situation includes Case 4, Case 5, Case 7, Case 9, Case 11, Case 17, Case 20, Case 25 and Case 30. Fourthly, eight cases with a clear bankrupt danger since the operation; any debt increase will be given under effective financial supervision; otherwise, no change of debt

[12] Individual cases are discussed in Appendix in the end of this Chapter.

will be confirmed[13]. This situation includes Case 10, Case 14-16, Case 18, Case 26-27 and Case 32. Finally, Case 6 is very special; firm withdraw at a very early stage. In fact, it is the future cost overrun that forces firm makes the withdrawal decision. Hence, so no debt increase happens in the past.

To making full use of data, there are two following indicators to create from raw data, which may give additional insight.

$R_{ap} = S_{BC}^2/S_{BC}^1$. It could reflect the reliance of government over the debt support, also means the reliance over bank involvement or market system.

$NR_{ap} = S_{BC}^4/S_{BC}^3$. It have the similar meaning for the measurement as $\mathrm{R_{ap}}$, but it reflects only the *ex post* reliance since $\mathrm{S_{BC}^3}$ and $\mathrm{S_{BC}^4}$ are only related to *ex post* contribution and net debt ($\mathrm{S_{BC}^3}$ and $\mathrm{S_{BC}^4}$) are involved.

All of these values of indicators will be obtained after case studies.

Because all of parts in $\mathrm{S_{BC}^3}$ or $\mathrm{S_{BC}^4}$ will be in [0, 1], hence, $\mathrm{S_{BC}^3}$ or $\mathrm{S_{BC}^4}$ will be in [-1, 1]. If any of the final two indicators is negative, the original proposal must be too ambitious so that the project fund in proposal cannot be finished or firm must have *ex post* debt refinancing (to reduce debt). If it is positive, after CA, project fund is enlarged than the initial one. In fact, the range of final two indicator value could be more precise. It will be in $[-\frac{TF_{gb}^c}{TF^c}, 1-\frac{TF_{gb}^c}{TF^c}]$ or $[-\frac{V_d^c}{TF^c}, 1-\frac{V_d^c}{TF^c}]$. Namely, the value of indicator is constrained by $\frac{TF_{gb}^c}{TF^c}$ or $\frac{V_d^c}{TF^c}$, which, in turn, depends on the original contract. This hints the effect of (*ex ante*) contract.

Besides above softness indicators, there will be two dummy variables as following. At first, compensation is a special bail-out tool, which will increase $\mathrm{S_{BC}^1}$ and $\mathrm{S_{BC}^3}$, but decrease $\mathrm{S_{BC}^2}$ and $\mathrm{S_{BC}^4}$. This tendency is different from the one of debt support package.

[13] There may be a potential assumption that the bankruptcy law will be effective when the project has a clearly bankruptcy danger. A bankrupt danger under an effective bankrupt law will monitor the debt closely. The danger will be confirmed in evidence in later case study.

Compensation package has a direct support to firm under CA(s). Moreover, other forms under CA have the similar effect as compensation pacakge, including *ex post* investment of government and government approval of gain to firm from the refinancing. Considering the specific property of all these tools, a dummy variable will be introduced as following.

$$x1 = \begin{cases} 1, \text{there is } ex\ post \text{ direct contribution of government in CA(s)} \\ 0, \text{there is no } ex\ post \text{ direct contribution of government in CA(s)} \end{cases}$$

This dummy variable is specially created to isolate direct contribution of government in CA(s). Once compensation package exists, the willing of softening the budget constraint to bail out firm could become obviously more active. Introducing this dummy variable, could help distinct the direct compensation effect from debt support, thereby uncovering the difference the direct/indirect support package of rescue policy will make.

The above dummy variable also makes some trouble for practical measurement. There are some seeming (but not real) compensation in CAs. Those should be neglected. the design of dummy variable is oriented to fit data better. When some package compensate firm in theory but it cannot affect the softness in our data, this kind of package would not be counted as a real compensation in this research. In our measurement, there are following three kinds of seeming compensation, ⑴the extension of concession towards firm, ⑵toll increase approval and ⑶ the implicit or hiding compensation. All of those three packages cannot be reflected in the softness indicators, the dummy variable is still equal to zero. in particular, the implicit or indirect compensation, For example, the changed profit sharing mechanism and other arrangements in Case 7, it cannot be regarded as *ex post* direct contribution of government in CA. it is actually a return for *ex post* investment from shareholders, which will be quantified in next dummy variable.

Comparing to compensation, the shareholders' *ex post* investment could decrease all softness indicators. When there is *ex post* investment of shareholders, it seems that firm has underlying incentive of self-rescue. Though it happens seldom, it must take place when the investment will be returned in some way. This kind of influence is worthy investigation because it will tell us what will happen when firm has some willing of self-rescue instead of only forcing government to bail it out. For that, a dummy variable will be introduced as following.

$$x2 = \begin{cases} 1, \text{there is } ex\ post \text{ investment of firm from shareholders in CA(s)} \\ 0, \text{there is no } ex\ post \text{ investment of firm from shareholders in CA(s)} \end{cases}$$

In particular, if *ex post* investment of firm is from debt, it would be reflected in softness and the investment cannot reflect the willing of self-rescue. Correspondingly, the effect mentioned above is expected to disappear, so only *ex post* investment from shareholders will be considered.

5.2.2 The development of indicator for measuring initial situation

After defining the softness of budget constraint for the final situation after CA(s) under PPP, the initial situation of program should be measured here. To reflect the initial situation of program, two indicators reflecting *ex post* risk and three indicators for *ex ante* government contribution, namely, *ex ante* softness, will be developed respectively, in following. It is worth mentioning again that risk is not equal to uncertainty in this thesis, it should be adverse property of contract/program decreases profit of firm under PPP.

$$R_d = \frac{V_d^r}{V_d^c}, R_i = \frac{I_{min}^c + CR^r}{TI^c} = 1 - \frac{I_{co}^c + CR^{-r}}{TI^c}.$$

R_d measures risk of raising fund from debt holders. This is always stipulated in *ex ante* contract, so there is superscript of 'c' for the denominator. The superscript of 'r' for the numerator represents the risk. 'V' represents the value of debt. V_d^r is the debt demand which should be satisfied under risk, not the whole debt. According to the above definition, $V_d^r \leq V_d^c$; V_d^r should exclude the debt guaranteed or lent by government while V_d^c should include the whole debt. In particular, even when the debt that has been obtained by firm before the time of contract assignment (to be precise, several programs in later case studies stipulate contract after, or at the same time as, financial close), this kind of debt is still counted as V_d^r. The value of R_d reflects the risk at initial situation. Considering the risk relates to raised fund from debt market, it could be called as external fund risk.

R_i measures risk of raising fund from investors. The superscript of 'c' is used for the same meaning as before. For convenience of measurement, two ways of computation could be used. The first one measures the ratio in direct way, the investment from minority shareholder (I_{min}^c), and the contract right under *ex post* risk (CR^r, for example, the property rights awarded to firm from government is under *ex post* risk) will be accounted as numerator while the denominator is the total investment as stipulated in contract, TI^c. By contrast, the second one measures the ratio in opposite way. The investment from controlling shareholders (I_{co}^c) and the contract right under no *ex post* risk (CR^{-r}, for example, the subsidy) will be excluded from computation. This ratio mainly involve the risk at the equity market, reflecting how much of equity from the public. Considering the risk relates to raise fund from equity investment, it could be called as internal fund risk.

R_i may be hard to identify because the financial information in some cases is not complete. For example, if the public offering is not available or neglected in the reference, the indicator will be meaningless. To avoid potential mistake because of that, we refers firstly and mainly to the original contract or special report of government/firm for the case. The original contract is investigated including Case 7, Case 9-10, Case 20, Case 23, Case 26-27 and Case 29-30. The report is applied for Case 2, Case 15-16, Case 24, Case 28 and Case 31-32. In particular, Case 31 is from firm's report; other reports are finished in the name of government. If there is no original contract or report, formal academic materials such as dissertation (for example, from the Massachusetts Institute of Technology) or journal/conference paper would be used. Those materials must be focused on the financial arrangement and behaviours under contract; otherwise, some information may be missed for our measurement (including R_i). The dissertation is used for Case 1, Case 8 and Case 25. The academic paper is referred for Case 3, Case 5 and Case 12-14. In spite of above, some organizations give detailed and reliable information for measurement in the manner of report or case study. For example, the World Bank, European Commission and so on. Cases on the base of these organizations' information include Case 6, Case 17-19 and Case 21-22. Finally, Case 4 and Case 11 are relatively special. The former refers mainly to an internet journal, which gives a close and complete report for the program. The latter uses firm's report and journal paper together since that program is much less transparent than other cases. The above just show main types of source for each case; more sources are used in later case studies. This explanation for source of case data is not only for R_i, but also be relevant for all indicators.

In spite of above two indicators reflecting *ex post* risk, another three indicators reflecting the initial situation stipulated by contract as followings.

$S_{BC}^{01} = \frac{TF_{gb}^{c}}{TF^{c}}$. It reflects the initial (global) contribution from government. This ratio is actually shown as part of S_{BC}^{3}, so its precise meaning could be referred to S_{BC}^{3}.

$S_{BC}^{02} = \frac{V_{d}^{c}}{TF^{c}}$. It reflects the initial indirect contribution from government in the manner of debt. This ratio is actually shown as part of S_{BC}^{4}, so its precise meaning could be referred to S_{BC}^{4}.

$S_{BC}^{03} = \frac{TF_{g}^{c}}{TF^{c}}$. It reflects the initial subsidy, namely, the direct contribution from government.

Considering there are multiple indicators for softness, we specially divide those into three kinds for telling the difference between those. At first, (total) softness includes S_{BC}^{1} and S_{BC}^{2}, which represents global and indirect softness, respectively. Secondly, *ex post* softness includes S_{BC}^{3} and S_{BC}^{4}, which represents *ex post* global and indirect softness, respectively. Finally, *ex ante* softness includes S_{BC}^{01}, $S_{BC}^{02}$and S_{BC}^{03}, which represent *ex ante* global, indirect and direct softness. In particular, there are also two derivative indicators deriving from softness indicators, R_{ap} and NR_{ap}. These reflect the reliance of government for global or *ex post* contribution of government.

5.2.3 The development of indicators for process variables

The process variables reflecting *ex post* risk during the contract implementation under PPP are measured here. The number of CA between firm and government will be measured firstly since it is an important concept in this research.

N_{CA}, the number of *ex post* CA between firm and government, will be also specifically measured. As a process variable, N_{CA} reflects the risk of CA between firm and government. In definition, any explicit/implicit adjustment relative to previous contract stipulation is *ex post* CA. However, for the objectiveness of measurement, only explicit one would be used in this research. The following cases will check all of forms of CA, including the extension of concession contract, equity issuing, equity restructure, liquidation, compensation package, *ex post* subsidy for firm or other explicit promise breach. The above list has almost included all of potential forms of CA[14]. Among above forms, the extension of concession cannot reflect any change on the value of softness indicators, but it indeed change the previous contract relationship. It need point out that the internal restructure of firm cannot change the contract relationship between firm and government though it could change the contract relationship within firm. Moreover, the information about sale of equity within firm cannot be available sometimes; the measurement will have error if internal restructure is included.

Moreover, *ex post* debt package (for example, new loan or debt refinance) is not identified as CA between firm and government for keeping objectiveness of measurement. In reality, *ex post* debt package is always related to CA package mentioned above; it is attached with one of those CA packages together or successively. If we treat *ex post* debt package as CA between firm and government in measurement, the value of N_{CA} could be arbitrary when the program involves *ex post* debt package consisting of several minor ones or the one realized by firm itself. In particular, whether *ex post* debt package gets government support or not is difficult to identify, then the value of N_{CA} (it measures only the number of CA between firm and government) could become easily arbitrary.

From above definition of CA, it could be seen that the identification of the number of CA will be dependent on the qualitative analysis over economic incident of the program. The value identification is actually the process of proving with evidence how many relevant incidents happen in program duration. The measurement may be controversial, but just as a potentially useful indicator, it is worthy being included in measurement. Need to emphasize here, even this indicator is not effective (due to the controversy), it will not

[14] These forms come from later case studies. In this way, the definition of CA could be made practical for empirical investigation, on one hand. On the other hand, it may be limited since the study cannot include all of cases in reality. For avoid the subjective judgement, we choose this way. At the same time, we try best to exam all cases carefully to avoid the potential loss of generality.

affect the regression using all other indicators. Because all other indicators measure the variables after CA, but have no relationship with the number of CA in definition.

To measure the existence of CA, the difference between *ex post* decision and *ex ante* commitment (explicit one, for the sake of objectivity) or original contract stipulation is the evidence. For the sake of completeness, the renegotiation that lasts long time and that makes more than one revises over original contract is still counted as one separate CA when it is only designed for the same crisis over the program. For example, the renegotiation lasting about two and half years in the case of Channel Tunnel from 1995 will be defined only as one CA. To treat long-term renegotiation as one CA may be controversial, but this could effectively avoid subjective judgement on the value of N_{CA}.

$$R_c = \frac{C}{C^e}\, or\ R_c = \frac{\mathrm{TF}}{\mathrm{TF^c}} = \frac{\mathrm{TF^c}+\Delta\mathrm{F}}{\mathrm{TF^c}},\ R_t = \frac{t_{building}}{t^e_{building}},\ R_q = \frac{Q}{Q^e}.$$

R_c measures the cost inflation until the final CA; the superscript of 'e' represents the expected one while the variable without superscript means the real one. The measurement will be finished in two ways. On one hand, $R_c = \frac{C}{C^e}$, if the program has no *ex post* fund. When there are cost data with specific/same price level, the comparison will be feasible. Only two cases use this formula because the condition for measurement is difficult to satisfy. To be precise, Case 15 have cost in the same year while Case 6 gives every couple of cost (estimated one and real one) in the same year for every part of project. On the other hand, $R_c = \frac{TF}{TF^c} = \frac{\mathrm{TF^c}+\Delta\mathrm{F}}{\mathrm{TF^c}}$, if there is *ex post* fund for project. This way could avoid to wrest with the price effect since the price effect is minor when we use project fund. The detailed reason for neglecting the price effect (when project fund is used) has been discussed above. This kind of manipulation involves thirty cases, all of which have *ex post* fund for project. In particular, *ex post* fund includes multiple types including extra equity issuing, debt issuing, loan borrowing and compensation from government and (unexpected) loss. The loss is only applied in two cases when firm has no any other extra fund. Both Case 10 and Case 18 get the loss equal to the original equity investment, which is confirmed on the evidence that original investment[15] is consumed.

R_t measures the time inflation of construction; the superscript of 'e' is also used for the same meaning as above. In fact, this indicator costs author much effort since schedule in some cases are regarded as confidential information. However, twenty-five cases get precise information. The resting seven cases get identified as following (details could be checked in later cases).

At first, five cases has no delay risk; $R_t = 1$. Precisely, Case 17 (MRT-3 project) and Case 21 (Don Muang Tollway) have no delay issue; Case 23 (A4 Motorway) and Case 28 (National Air Traffic Service) have no construction plan; Case 16 (Tube Lines) gets clear evidence that delay derives from negotiation instead of construction.

Secondly, two cases have no clear and hard target of project completion while firm finishes the project before the implicit targets. Case 7 (Sydney ARL) and Case 29 (Stadium Australia) are especially initiated for the specific event, Olympic game in 2000. Considering that there is no clear target but there is clear evidence that firm finishes before the implicit targets, no issue of delay will exist between firm and government; hence $R_t = 1$ is also held in those cases. It is noted that the value may be not precise in this way. However, given this indicator is orientated to measure the risk, it is safe to assign one to indicator value when there is no issue between firm and government.

Comparing with R_c and R_t reflecting the degree of overrun under contract implementation, R_q measures the degree of demand deflation. This indicator represents *ex post* demand risk under contract implementation. In particular, R_q is the unique indicator that cannot collect values for all programs; only twenty-seven data is identified. When the data about the quantity in the first operation year is not available, the second year is used (for example, Case 11) and the comparison between average quantities for

[15] There may be also a potential assumption for Case 10: the bankruptcy law will be effective when the project has a clearly bankruptcy danger. Under an effective bankrupt law, the loss should be equal to equity investment. By contrast, Case 18 proves just at the bankruptcy point, hence, that assumption is not necessary in Case 18.

expectation and reality are used (for example, Case 26). This indicator is limited, but it is still used because the *ex post* demand risk is generally important elements for CA.

$t_{CA} = \frac{M_{CA}}{t_{program}}$. M_{CA} is the amount of month towards the final CA, $t_{program}$ is the duration of program with the unit of month, which is assigned at latest contract after adjustment(s).

t_{CA} as the indicator measuring the risk of contract implementation under CA(s) for PPP program, For convenience of data analysis, it is treated as process variable and then allocated in this subsection. For reducing the potential problem of using this indicator, two problems have to be solved. Firstly, if the adjustment behaviour lasts long time (this is usual case if the renegotiation is related), the time point of new assignment or settlement will be used for counting M_{CA}; if the revise relates to more than one assignment of contract, the first one will be accounted as official time point for judgement.

Secondly, if the contract length is revised later, the length of concession contract, $t_{program}$, must be the updated one, not the original one. The corresponding reason is this way could avoid two following problems. At first, if we use the original one, the value of t_{CA} will be bigger than 1 when some CAs happen after the original terminal time point. Moreover, if original length is used for CA(s) before the revise of concession length while the updated length is used for later CAs, the consistence of indicator measurement is broken and then T_{CA} become discontinuous. By the contrast, the value of t_{CA} will be into [0,1] and it will be continuous when updated length is used.

All of above indicators will be seen together in Table 5-1. The data could be seen in Table 5-2 and Table 5-3.

Table 5-1: indicators	
Categories	Indicator form and meanings.
Final situation indicators	Softness indicators: $S_{BC}^{1}=\frac{TF_{gb}}{TF}$. TF is the total project fund while TF_{gb} is the fund including government subsidy and debt. S_{BC}^{1} represents global softness. $S_{BC}^{2}=\frac{V_{d}}{TF}$. V_d is the value of debt. S_{BC}^{2} represents (total) indirect softness and reflects the ratio of debt relative to project fund. $S_{BC}^{3}=\frac{TF_{gb}}{TF}-\frac{TF_{gb}^{c}}{TF^{c}}=S_{BC}^{1}-S_{BC}^{01}$. TF_{gb}^{c} represents stipulated subsidy and debt in contract. S_{BC}^{3} represents *ex post*/net softness. $S_{BC}^{4}=\frac{V_{d}}{TF}-\frac{V_{d}^{c}}{TF^{c}}=S_{BC}^{2}-S_{BC}^{02}$. It represents *ex post*/net indirect softness.
	Reliance indicators: $R_{ap}=S_{BC}^{2}/S_{BC}^{1}$. It reflects the reliance of government over the debt support for global contribution. $NR_{ap}=S_{BC}^{4}/S_{BC}^{3}$. It reflects the reliance of government over the debt support for *ex post* contribution.
	Dummy variables: $\text{x1}=\begin{cases}1, \text{there is } \textit{ex post} \text{ direct contribution of government in CA(s)}\\0, \text{there is no } \textit{ex post} \text{ direct contribution of government in CA(s)}\end{cases}$. $\text{x2}=\begin{cases}1, \text{there is } \textit{ex post} \text{ investment of firm from shareholders in CA(s)}\\0, \text{there is no } \textit{ex post} \text{ investment of firm from shareholders in CA(s)}\end{cases}$.

Categories	Indicator form and meanings.
Ex ante situation variables	Ex ante softness: $S_{BC}^{01} = \frac{TF_{gb}^{c}}{TF^{c}}$. It reflects the *ex ante*/initial contribution from government. $S_{BC}^{02} = \frac{V_{d}^{c}}{TF^{c}}$. It reflects the *ex ante*/initial indirect contribution from government in the manner of debt. $S_{BC}^{03} = \frac{TF_{g}^{c}}{TF^{c}}$. It reflects the *ex ante*/initial subsidy, namely, the *ex ante*/initial direct contribution from government.
	Ex ante risk: $R_d = \frac{V_d^r}{V_d^c}$, V_d^r is the debt under risk to realize while V_d^c is the total debt. R_d represents *ex ante* risk in debt market. $R_i = \frac{I_{min}^{c}+CR^{r}}{TI^{c}} = 1 - \frac{I_{co}^{c}+CR^{-r}}{TI^{c}}$. I_{min}^{c} or I_{co}^{c} is investment from minority or controlling shareholder, CR^{r} or CR^{-r} is the contract right whose value is under *ex post* risk or not, TI^{c} is total investment in original contract. R_i represents *ex ante* risk in equity market.
Ex post risk variables	$R_c = \frac{C}{C^e}$ or $R_c = \frac{TF}{TF^c}$. C is the real project cost while C^e is the expected project cost. R_c represents the degree of cost overrun. $R_t = \frac{t_{building}}{t_{building}^{e}}$, $t_{building}$ is the duration of construction while $t_{building}^{e}$ is the estimated one. R_t represents the degree of delay. $R_q = \frac{Q}{Q^e}$. Q is the demand at the first operation year while Q^e is the expected one. R_q represents the deflation of demand. N_{CA} is the number of *ex post* CA between firm and government. $t_{CA} = \frac{M_{CA}}{t_{program}}$. M_{CA} is the amount of month towards the final CA, $t_{program}$ is the duration of program with the unit of month, which is assigned at latest contract after adjustment(s). t_{CA} measures the period under *ex post* risk of CA relative to the whole duration. It also reflect the stage of PPP program under CA.

Table 5-2: the data include ratios for the initial and *ex post* variables in later regression										
Case	Variables reflecting initial contract					Variable reflecting risk in process				
	R_d	R_i	S_{BC}^{01}	S_{BC}^{02}	S_{BC}^{03}	N_{CA}	R_c	R_t	R_q	t_{CA}
1:THSR	1.0000	0.4900	0.69	0.6900	0.0000	4	1.4223	1.1724	0.2778	0.3452
2: HS1	0.8906	0.4654	0.8819	0.5337	0.3482	3	1.3123	1.5106	0.3958	0.1481
3: Channel Tunnel	1.0000	0.9550	0.8299	0.8299	0	8	2.3541	1.1714	0.1824	0.2005
4: Perpignan-Figures	1.0000	0	0.8919	0.3418	0.5501	1	1.1348	1.1667	0	0.0947
5: HSL-Zuid	0.6096	0	0.8350	0.8350	0	1	1.2444	1.4143	0	0.1222
6: Treno Alta Velocita	0	0	0.64	0.4913	0.4	1	1.6078	1.1392	1	0.1333
7: Sydney ARL	0.05	0	0.9756	0.9756	0	2	1.5220	1	NA	0.4511
8: Seoul ARL	1	0.5291	0.7500	0.7500	0	3	1.1413	1.1752	0.0696	0.2515
9: Southern Cross Station	1	0	0.7834	0.7834	0	1	1.3556	1.3333	1	0.1143
10: Reliance Rail	1	0	0.9460	0.9460	0	1	1.0540	1.1458	1	0.1494
11: Tagus South LRS	0	0	0.7571	0	0.7571	1	1.178	1.8500	0.4375	0.0778
12: STAR LRTS	0.75	0	0.9	0.8	0.1	1	1.8286	1	0.3881	0.1819
13: PUTRA LRTS	0.6784	0	0.796	0.796	0	1	1.4995	1	0.3333	0.1597
14: KL Monorail	0	0	0.78	0.78	0	1	1.4746	1.3226	0.1571	0.2646
15: Metronet	0.05	0	0.8660	0.8660	0	1	1.2069	1.2500	1	0.1417
16: Tube Lines	0.05	0	0.8513	0.8513	0	3	1.2049	1	1	0.2472
17: MRT-3 project	1	0	0.7099	0.7099	0	2	1.3939	1	0.0556	0.5493
18: M1/M15 Motorway	1	0	0.82	0.82	0	1	1.18	1.125	0.5500	0.1714
19: M5 Motorway	0	0	0.82	0.82	0	1	3.4324	1.2348	0.6250	0.2682

Case	Variables reflecting initial contract					Variable reflecting risk in process				
	R_d	R_i	S_{BC}^{01}	S_{BC}^{02}	S_{BC}^{03}	N_{CA}	R_c	R_t	R_q	t_{CA}
20: M2 Motorway	1	0.8378	0.6270	0.6270	0	5	1.8649	0.825	0.7352	0.3124
21: Don Muang Tollway	1	0	0.77	0.77	0	1	1.5135	1	0.3333	0.2867
22: M6 Tollway	1	0	0.7793	0.7793	0	1	1.6552	1.0278	NA	0.1258
23: A4 Motorway	0	0	0.7798	0.7798	0	2	2.3256	1	NA	0.3186
24: Delhi Noida Bridge	1	0.7465	0.7001	0.7001	0	1	1.4987	0.8621	0.37	0.2778
25: Vasco da Gama Bridge	0.1463	0	0.77	0.41	0.36	6	1.6805	1	NA	0.4394
26: Lane Cove Tunnel	1	0	0.6778	0.6778	0	7	1.0425	1.2821	0.63	0.1839
27: Cross City Tunnel	1	0	0.6765	0.6765	0	2	1.2956	0.9412	0.3371	0.1212
28: NATS	0.6774	0	0.9777	0.6883	0.49	1	1.1077	1	NA	0.0367
29: Stadium Australia	1	0.8958	0.4199	0.2160	0.2039	2	1.3314	1	0.3140	0.0925
30: Orange Health Project	1	0	0.2169	0.2169	0	1	1.1605	1.3438	1	0.0893
31: NNUH	1	0	0.7850	0.7850	0	3	2.0421	0.8958	1	0.1495
32: Royal Armouries Museum	1	0	0.8662	0.1972	0.6690	1	1.2958	1	0.0412	0.0792

Table 5-3: the data include ratios for ending-variables, dummy variables and government policy										
Case	Variables reflecting softness in the end						Dummy variables		Government policy	
	S_{BC}^{1}	S_{BC}^{2}	S_{BC}^{3}	S_{BC}^{4}	R_{ap}	NR_{ap}	$x1$	$x2$	Re/T	group
1:THSR	0.9276	0.7720	0.2376	0.0820	0.8323	0.3451	0	0	Re→T	3rd
2: HS1	1	0.6447	0.1181	0.1110	0.6447	0.9399	0	0	Re→T	3rd
3: Channel Tunnel	0.8235	0.2008	-0.0064	-0.6290	0.2438	98.2813	0	1	Re	1st
4: Perpignan-Figures	0.9047	0.3626	0.0128	0.0208	0.4008	1.625	1	0	Re	1st
5: HSL-Zuid	0.8674	0.6710	0.0324	-0.1640	0.7736	-5.0617	1	0	Re	1st
6: Treno Alta Velocita	1	0.4913	0.36	0	0.4913	0	0	0	T*	5th
7: Sydney ARL	0.9840	0.6410	0.0084	-0.3346	0.6514	-39.8333	1	0	Re	1st
8: Seoul ARL	0.9714	0.5569	0.2214	-0.1931	0.5733	-0.8722	0	0	Re→T	3rd
9: Southern Cross Station	0.8402	0.8008	0.0568	0.0174	0.9531	0.3063	1	0	Re	1st
10: Reliance Rail	1	0.9460	0.0540	0	0.946	0	0	0	T*	5th
11: Tagus South LRS	0.7938	0	0.0367	0	0	0	1	0	Re	1st
12: STAR LRTS	1	0.8906	0.1	0.0906	0.8906	0.906	0	0	Re#	4th
13: PUTRA LRTS	1	0.8640	0.204	0.0680	0.864	0.3333	0	0	Re#	4th
14: KL Monorail	1	0.8508	0.22	0.0708	0.8508	0.3218	0	0	Re#	4th
15: Metronet	1	0.8660	0.1340	0	0.8958	0	0	0	T*	5th
16: Tube Lines	1	0.7727	0.1487	-0.0785	0.9238	0.4380	1	0	T	6th
17: MRT-3 project	1	0.5317	0.2901	-0.1782	0.5317	-0.6143	1	0	Re→T	3rd
18: M1/M15 Motorway	1	0.82	0.18	0	0.82	0	0	0	T*	5th
19: M5 Motorway	0.9683	0.9476	0.1483	0.1276	0.2163	0.2163	0	0	T*	5th
20: M2 Motorway	0.8	0.8	0.1730	0.1730	1	1	0	1	Re	1st
21: Don Muang Tollway	0.8494	0.7490	0.0794	-0.0210	0.8818	-0.2644	0	1	Re	1st
22: M6 Tollway	0.8667	0.575	0.0874	-0.2043	0.6634	-2.3375	1	0	Re	1st

Case	Variables reflecting softness in the end									
	S^1_{BC}	S^2_{BC}	S^3_{BC}	S^4_{BC}	R_{ap}	NR_{ap}	$x1$	$x2$	Re/T	group
23: A4 Motorway	0.9053	0.9053	0.1255	0.1255	1	1	0	0	Re	1st
24: Delhi Noida Bridge	0.7999	0.4672	0.0998	-0.2330	0.8752	0	0	1	Re	1st
25: Vasco da Gama Bridge	0.8631	0.2380	0.0931	-0.1720	0.2758	-1.8475	1	0	Re	1st
26: Lane Cove Tunnel	0.6910	0.6502	0.0131	-0.0276	0.9410	-2.1069	1	0	Re^	2nd
27: Cross City Tunnel	0.7106	0.7106	0.0341	0.0341	1	1	0	1	Re^	2nd
28: NATS	0.9597	0.6396	-0.0180	-0.0487	0.6665	2.7056	1	1	Re	1st
29: Stadium Australia	0.5643	0.2326	0.1444	0.0166	0.4123	0.1150	1	0	Re	1st
30: Orange Health Project	0.3252	0.3252	0.1083	-0.0300	1	-0.2771	0	1	Re	1st
31: NNUH	0.9336	0.7002	0.1486	-0.0848	0.75	-0.5707	1	0	Re	1st
32: Royal Armouries Museum	1	0.3804	0.1338	0.1833	0.3804	1.3700	0	0	T*	5th

The ratio in this table is shown with four digits of decimal number only for illustration. The real number is kept with 16 digit of number when the Eviews implements the computation to generate new series.

Re→T: rescue package followed by a takeover package in the final CA.

Re: rescue package(s) in CA(s); T: voluntary takeover package.

T*: the inevitable takeover policy because firm withdraws from the program directly or the bankruptcy has been inevitable.

Re#: the special rescue policy. Though government takes over the project, but all of liability is transferred from firm to government.

Re^: failed rescue policy. Government rescue firm at first time(s) and then let it go to bankruptcy without taking over it due to the political intervention.

The column of group is for discussion of government policy in section 5.4.

5.3 The formulation of hypothesis

This section involves three procedures. At first, we will specify our model for economic meaning. Then five hypotheses will be given after combining the model with the indicator characteristics. Finally, the predicted economic relationships will be given according to hypotheses.

5.3.1 The specification of economic meaning of our model

Our model discusses the potential takeover policy due to holdup problem and uncontrollable CAs. At the same time, government is incentivized to take rescue policy except the situation with takeover policy. Our model reflects especially the compensation effect. Now, let us specify the economic meaning of our modelling, namely apply the propositions to prediction.

According to Proposition 1, when there is a big enough *ex post* disputation, government will decide to take over project. The key of question is that government will suspect firm to hold up government under asymmetrical information. Once the suspected holdup amount is big enough, government would like to take over the project and then PPP is failed for the project. The (suspected) holdup problem is *ex post* disputation problem in reality. Proposition 1 tell us actually that *ex post* disputation will be the direct reason for takeover policy. The takeover policy means the biggest contribution of government. We must expect that any element leading to bigger *ex post* disputation should lead to a bigger probability of takeover policy, which means a bigger final contribution from government for PPP program. This idea will be developed into hypothesis in next section.

Similarly, according to Proposition 2, when there is enough CAs under PPP, government will adopt takeover policy. The key of question is that the consistent *ex post* risk forces firm and government under PPP to adjust contract repeatedly. Once the uncontrollable CAs reaches the limit the government could be tolerated with, potential takeover will be adopted. Uncontrollable CAs derives from consistent *ex post* risk. We must expect that any element leading to bigger number of CA should lead to a higher probability of takeover policy, which means a bigger final contribution from government for PPP program. This idea will be developed into hypothesis in next section.

At the same time, according to Proposition 2, the government cannot rescue firm infinitely because every CA will force government to lose external benefit with reputation loss and transaction cost. The elements will be talked once again in following.

In particular, as Proposition 3 points out, when (suspected) holdup problem and uncontrollable CAs combined together, the potential takeover policy will be adopted easier. This just ensures the idea of Proposition 1 and Proposition 2 for hypothesis development.

Proposition 4 uncovers the relevant exogenous elements could contribute to or constrain the potential takeover policy. Those exogenous elements include the speed of contract implementation $(1-\beta)$, the exit barrier cost (ΔC), idiosyncratic asset investment of government (K_g^a), the variables mentioned above under uncontrollable CAs. In particular, the speed of contract implementation is actually represented by the indicator of t_{CA}. According to Proposition 4, $(1-\beta)$, representd by t_{CA} in data, should have a positive relationship with potential takeover policy that related to bigger government contribution for PPP program.

To sum up four propositions, according to our propositions, any element leading to bigger *ex post* disputation or bigger number of CA should lead to a bigger government contribution for PPP program. Meanwhile, *ex ante* government contribution should have positive relationship with government contribution in the end under PPP.

According to above ideas, we will specify the regression model for SBC issue as following.

$$y_i = c + \sum_{j=1}^{j=a} \alpha_{i,j} x_{i,j}^{ante} + \sum_{j=1}^{j=b} \beta_{i,j} x_{i,j}^{risk} + u_i$$

Where y_i is the optional dependent variable (one of S_{BC}^1, S_{BC}^2, S_{BC}^3, S_{BC}^4, R_{ap} and NR_{ap}), $x_{i,j}^{ante}$ is the significant independent variable involves *ex ante* situation, which could be some of S_{BC}^{01}, S_{BC}^{02}, S_{BC}^{03}, R_d and R_i or some square items of those variables, $x_{i,j}^{risk}$ is the significant independent variable of *ex post* risk indicators, which could be some of N_{CA}

R_c, R_t, R_q and t_{CA} or some square items of those variables. In particular, which variables are significant will be selected by software based on our data. u_i in above equation is assumed to be identical and independent distribution for the regression of SBC issue.

In spite of specifying empirical model for SBC issue, we actually consider the potential source of *ex post* risk. The corresponding specification is following, similarly.

$$x_i^{risk} = c + \sum_{j=1}^{j=a} \alpha_{i,j} x_{i,j}^{ante} + \sum_{j=1}^{j=b-1} \beta_{i,j} x_{i,j}^{-risk} + \sum_{j=1}^{j=c} \beta_{i,j} S_{i,j} + v_i$$

Where x_i^{risk} is the optional dependent variable of *ex post* risk indicators (one of N_{CA} R_c, R_t, R_q and t_{CA}), $x_{i,j}^{ante}$ is same as before, $x_{i,j}^{-risk}$ is the significant independent variable of *ex post* risk indicators except the one as dependent variable, $S_{i,j}$ is the significant variable reflecting final situation, which could be some of S_{BC}^1, S_{BC}^2, S_{BC}^3 and S_{BC}^4 or some square items of those variables. In particular, R_{ap} and NR_{ap} are not used here since these two variables are derivative indicators, reflecting no direct economic property of PPP program. v_i in above equation is assumed to be identical and independent distribution for the regression of *ex post* risk.

5.3.2 Hypotheses

Our propositions give a basic framework for hypothesis, we will extend it with indicator characteristic to develop hypothesis as following.

Recalling our indicators, there are three categories, (1)*ex ante* indicators including S_{BC}^{01}, S_{BC}^{02} and S_{BC}^{03} measuring *ex ante* government contribution in different way or with different aspect and R_d and R_i for *ex ante* risk, (2)*ex post* risk indicators including N_{CA} R_c, R_t, R_q and t_{CA} and (3)final situation indicators including four softness indicators reflecting government contribution in the end (S_{BC}^1, S_{BC}^2, S_{BC}^3 and S_{BC}^4), two reliance indicator deriving from four softness indicators (R_{ap} and NR_{ap}) and two dummy variables for CA packages ($x1$ and $x2$).

Discussed as above, any element leading to bigger *ex post* disputation should lead to a bigger government contribution for PPP program. If there is bigger *ex ante* government contribution, government be more reluctant for *ex post* contribution, which could lead to a bigger *ex post* disputation and then a bigger probability of takeover policy. This indicates *ex ante* contribution indicators (S_{BC}^{01}, S_{BC}^{02} and S_{BC}^{03}) should lead to a smaller *ex post* contribution, but a bigger government contribution in the end. In particular, government contribution in the end are presented by four final softness indicators. Therefore, there are following.

Hypothesis 1: ex ante contribution indicators (S_{BC}^{01}, S_{BC}^{02} and S_{BC}^{03}) have a negative relationship with ex post contribution indicators (S_{BC}^{3} and S_{BC}^{4}).

Hypothesis 2: ex ante contribution indicators (S_{BC}^{01}, S_{BC}^{02} and S_{BC}^{03}) have a positive relationship with final softness indicators ($S_{BC}^{1}$and S_{BC}^{2}).

In fact, according to Hypothesis 2, S_{BC}^{3} *and* S_{BC}^{4} as final softness indicators should be also positively correlated to *ex ante* contribution indicators, which is contradictory to Hypothesis 1. Namely, the prediction between *ex ante* contribution indicator and S_{BC}^{3} and S_{BC}^{4} may not be identified; we need regression result to fix those relevant economic relationships. In fact, in later specific prediction between variables, more relationships need to be fixed from regression result according to the characteristics of specific indicators (see Table 6-11).

Furthermore, any element leading to bigger *number of CA* should lead to a bigger government contribution for PPP program. CA derives from *ex post* risk, it is natural to say *ex post* risk indicator should have a positive relationship with final softness indicators. In particular, the number of CA, namely, N_{CA} should be the risk to program; so it should also have a positive relationship with four final softness indicators.

Hypothesis 3: ex post risk indicators have a positive relationship with final softness indicators (S_{BC}^{1}, S_{BC}^{2}, S_{BC}^{3} and S_{BC}^{4}).

At the same time, *ex ante* risk cannot lead to CA directly, but it affect directly the *ex post* contract implementation and then it could increase the probability of *ex post* risk and CA. Therefore, there is also following.

Hypothesis 4: ex ante risk is correlated to government contribution indicators (S_{BC}^1, S_{BC}^2, S_{BC}^3 and S_{BC}^4) positively.

All of above hypotheses are developed with proposition; the aim is to find out the potential economic relationship for SBC issue.

For extra insight and for taking full use of our data, we want to regress *ex post* risk indicators. Though we cannot get some evidence about the positive correlation between *ex post* risks, it should be intuitive to expect the positive relationship between *ex post* risks. Considering the special characteristics of R_q, there is following.

Hypothesis 5: N_{CA} R_c, R_t and t_{CA} are positively correlated to each other. R_q is negatively related to the other ex post risk indicators (N_{CA} R_c, R_t and t_{CA}).

5.3.3 Predicted economic relationships.

Though we have formulated hypotheses as section 5.3.2, the predicted relationship should be designed more details. At firstly, we should consider the potential economic relationships for different issues, SBC issue or *ex post* risk. The SBC issue involves six dependent variables including four softness indicators and two reliance indicators. These variables will have same independent variables including five initial indicators (R_d, R_i, S_{BC}^{01}, S_{BC}^{02} and S_{BC}^{03}) and process indicators (N_{CA} R_c, R_t, R_q and t_{CA}). This set of regression is aimed to test the relationship between softness indicators (or reliance indicators) and relevant variables for initial situation and *ex post* risk.

The issue of *ex post* risks involves the five process variables (N_{CA} R_c, R_t, R_q and t_{CA}) as dependent variables and all of other raw indicators will be used for regression. Precisely, all indicators excluding five *ex post* risk indicators themselves and two derivative indicators (R_{ap} and NR_{ap}). Table 5-4 includes the predicted relationships for regression.

Some potential relationships are not to be identified, which is labelled with ‘o’ in Table 5-4.

Secondly and more practically, we must consider the difference between similar indicators. For example, for four softness indicators, those measuring government contribution in the end in different way. All of these practical consideration could be seen in following design of predicted relationships.

Table 5-4: predicted relationships

X_i	Dependent variables (Y_i)										
	S_{BC}^1	S_{BC}^2	S_{BC}^3	S_{BC}^4	R_{ap}	NR_{ap}	N_{CA}	R_c	R_t	R_q	t_{CA}
R_d	$+$	$-$	$+$	$-$	$-$	$-$	$+$	$+$	$+$	$-$	$+/-$
R_i	$+$	$-$	$+$	$-$	$-$	$-$	$+$	$+$	$+$	$-$	$+/-$
S_{BC}^{01}	$+/-$	$+$	$-$	$+$	$+/-$	$-$	$+/-$	$+$	$+$	$-$	$+/-$
S_{BC}^{02}	$+$	$-$	$+$	$-$	$-$	$-$	$+/-$	$+$	$+$	$-$	$+/-$
S_{BC}^{03}	$+/-$	$-$	$+/-$	$-$	$+/-$	$-$	$+/-$	$+$	$+$	$-$	$+/-$
N_{CA}	$+/-$	$+/-$	$+/-$	$+/-$	$+/-$	$+/-$	$\times$	$+/-$	$+/-$	$+/-$	$+/-$
R_c	$+$	$-$	$+$	$-$	$-$	$-$	$+$	$\times$	$+$	$-$	$+/-$
R_t	$+$	$-$	$+$	$-$	$-$	$-$	$+$	$+$	$\times$	$-$	$+/-$
R_q	$-$	$+$	$-$	$+$	$-$	$-$	$-$	$-$	$-$	$\times$	$+/-$
t_{CA}	$+/-$	$+/-$	$+/-$	$+/-$	$+/-$	$+/-$	$+/-$	$+/-$	$+/-$	$+/-$	$\times$
$x1$	$+$	$-$	$+$	$-$	$-$	$-$	$+/-$	$+$	$+$	$-$	$+/-$
$x2$	$+/-$	$-$	$-$	$-$	$+/-$	$+/-$	$+/-$	$+$	$+$	$-$	$+/-$
S_{BC}^1	o	o	o	o	o	o	$+$	$+$	$+$	$-$	$+/-$
S_{BC}^2	o	o	o	o	o	o	$+$	$+$	$+$	$-$	$+/-$
S_{BC}^3	o	o	o	o	o	o	$+$	$+$	$+$	$-$	$+/-$
S_{BC}^4	o	o	o	o	o	o	$+$	$+$	$+$	$-$	$+/-$

$+$: positive, $-$: negative, $+/-$: mixed (positive or negative), o: no relationship.

The following is prediction, whose symbol expression could be seen in Table 5-4. At first, it is worthy pointing out that the most special indicator is t_{CA}, which could reflect *ex post* risk positively and negatively. The former derives from the accumulation of *ex post* risk and the latter comes from the monotone decrease of *ex post* risk distribution during contract implementation. Considering every case has its own *ex post* risk distribution, so

t_{CA} could be affected by and affect other indicators with positive or negative direction. This kind of indicator may be useful for economic regulation since it tells how much percent of duration will be under CA danger. Therefore, t_{CA} will have a mixed prediction Table 5-4 as independent variable or dependent variable.

Secondly, N_{CA} is also special. It has positive relationship with softness due to ratchet effect. However, every CA may contribute the information transfer from firm to government and bank, which constrains the softness. Therefore, there are mixed potential relationships between N_{CA} (as independent variable) and softness indicators. However, when it is dependent variable, it is an *ex post* risk. There should be clear relationship with independent variables like R_c, R_t and R_q. The clear relationship is scattered in following.

Putting $\mathrm{R_d}$ as an example, it represents risk in debt market, it should have a positive relationship with S_{BC}^1 and S_{BC}^3. The basic logic is more risk is given and then more contribution of government is needed. However, it will have a negative relationship with S_{BC}^2 and S_{BC}^4, which derives from that less involvement of bank is with more risk of program due to risk-averse attitude of bank. Considering different relationships between R_d and these four softness indicators, R_d will have negative relationship with R_{ap}according to the definition of R_{ap}. As for NR_{ap}, it should be negatively related toR_d since bigger *ex ante* involvement (R_d) will have less role of *ex post* rescue package. Furthermore, R_d should have positive relationship with R_c, R_t and N_{CA} since risk variables should be positively related to each other. In needs to be pointed out that R_q reflects *ex post* risk inversely, so the prediction of R_q should be inversely related to the one of R_d. Based on above analysis, the predictions related to R_d, R_i, R_c, $\mathrm{R_t}$ and R_q are given in Table 5-4.

Fourthly, S_{BC}^{01} determines the start point and (inversely) the potential maximized amount for future government contribution. The start point and the potential maximized amount for future government contribution should have positive relationships with the global softness. Hence, there is only a mixed expectation between S_{BC}^{01} and S_{BC}^1. According to definition, $S_{BC}^{01} + S_{BC}^3 = S_{BC}^1 \leq 1$, S_{BC}^{01} will have negative relationship with S_{BC}^3. At the same time, a bigger value of S_{BC}^{01} could ensure the bank involvement in *ex post* CA, so it will have a positive relationship with S_{BC}^2 and S_{BC}^4. Because of the mixed expectation between S_{BC}^1 and S_{BC}^{01}, S_{BC}^{01} will have a mixed prediction with R_{ap}. As for *ex post* reliance over bank (NR_{ap}), it should be smaller when initial support of government including S_{BC}^{01}, S_{BC}^{02} and S_{BC}^{03} is bigger. Moreover, *ex ante* contribution of government including S_{BC}^{01}, S_{BC}^{02} and S_{BC}^{03}, on one hand, could avoid more CAs; on the other hand, more contribution of government will have a more complex contract that should have bigger probability of CA. Namely, there should be mixed relationship with initial softness and N_{CA}. Furthermore, S_{BC}^{01}, S_{BC}^{02} and S_{BC}^{03} will be positively related to *ex post* risk since the former three softness indicators should be based on expectation over *ex post* contract implementation. Hence, S_{BC}^{01}, S_{BC}^{02} and S_{BC}^{03} should be a positive relationship with R_c, R_t and negative one with $\mathrm{R_q}$. Combining above analysis, the predictions for S_{BC}^{01} and first five softness and for S_{BC}^{01}, S_{BC}^{02} and S_{BC}^{03} and NR_{ap} and five process variables are listed in Table 5-4.

Fifthly, S_{BC}^{02} determines the degree of bank involvement, which will has a positive relationship with the global softness (S_{BC}^1) and *ex post* softness (S_{BC}^3) since more bank involvement should give more confidence of government to rescue firm. However, S_{BC}^{02} should have a negative relationship with S_{BC}^2 or S_{BC}^4 since the bank will monitor and control firm debt. Combining the prediction about S_{BC}^1 and S_{BC}^2, according to the definition of R_{ap}, S_{BC}^{02} and R_{ap} should be negatively correlated. Combining these analyses, the predictions of S_{BC}^{02} with first five softness indicators are listed in Table 5-4.

Sixthly, S_{BC}^{03} is the degree of direct government contribution. As one part of global contribution, it will have the similar role as S_{BC}^{01}. Only three different symbols in Table 5-4 should be related to S_{BC}^2, S_{BC}^3 and S_{BC}^4, because $\mathrm{S_{BC}^{03}}$ also reflects the attitude of government to bail out the project and then it also has a positive role with *ex post* contribution (or net contribution), S_{BC}^3. Namely, in spite of constraining the value of S_{BC}^3, the positive is also expected. Moreover, S_{BC}^{03} measures the direct softness; bigger is S_{BC}^{03}, the debt package should be used less, which means S_{BC}^2 and S_{BC}^4 are smaller. Hence, a negative relationship of S_{BC}^{03} with S_{BC}^2 or S_{BC}^4 is expected. Combining these analyses, the predictions related to S_{BC}^{03} with first five softness indicators are given in Table 5-4.

Seventhly, according to the definition of $x1$, it will have a positive relationship with global softness (S_{BC}^{1}) or *ex post* softness (S_{BC}^{3}) but negative one with bank involvement including (S_{BC}^{2} and S_{BC}^{4}). According to the definition of $x2$, it seems to have a negative relationship with each of four softness indicators. Here need a special attention to $\mathrm{S}_{\mathrm{BC}}^{1}$, when $x2 = 1$, more *ex post* shareholder contribution is always with $x1 = 1$, so the negative effect may be offset by positive effect from $x1$, so there could be positive or negative relationship between $\mathrm{S}_{\mathrm{BC}}^{1}$ and $x2$. As for the relationship between $\mathrm{S}_{\mathrm{BC}}^{3}$ and $x2$, it is not necessary to consider the offset effect because $\mathrm{S}_{\mathrm{BC}}^{3}$ is mainly constrained by risk that is positively related to $x2$ (otherwise shareholders will has no extra investment for getting contribution from government). According to definition of $x1$ and above prediction on S_{BC}^{1}, S_{BC}^{2}, S_{BC}^{3} and S_{BC}^{4}, there will be a negative relationship between R_{ap}, NR_{ap} and $x1$. At the same time, considering the relationships of $x2$ with four final softness indicators, there should be also mixed relationship between $x2$ and R_{ap} or NR_{ap}. In spite of t_{CA}, N_{CA} will be also mixed with $x1$ or $x2$ since the way of CA has no direct relationship with the number of CA. Finally, the direct support from government and extra investment from shareholders are always used for unexpected or new arrangement, which corresponds to high level of *ex post* risk, so $x1$ or $x2$ should be positively related to R_c, R_t and negatively correlated to R_q.

Finally, four final softness indicators as independent variables should be positively correlated to *ex post* risk indicators since bigger government contribution will witness worse situation with higher level of *ex post* risk. Therefore, it could be seen in Table 5-4 that four raw softness indicators will be positively related to N_{CA}, R_c and R_t but negatively correlated to R_q. The relationship with t_{CA} is still mixed, the reason is seen in above.

5.4 The explanation upon government policy (reflected in data) under CA for the indicator of government policy

From Table 5-2, all cases could be categorized into six groups according to government policy under CA(s) as following, ⑴rescue package(s) in CA(s), ⑵rescue package and then bankruptcy (namely, failed rescue package in Table 2), ⑶rescue package followed by a takeover package in the final CA, ⑷rescue policy in the manner of takeover, ⑸ inevitable takeover policy because of bankruptcy problem or withdrawal of private partner and finally and ⑹takeover policy when the rescue policy is feasible. The following will explain that the data cannot deny the conclusion in our modelling, namely, rescue policy is superior for government when takeover policy is not inevitable.

The following will analyse the once-off takeover policy firstly. Namely, the final three groups of case will be explained firstly. After that, the takeover policy after rescue packages will be analysed. Namely, the third of phenomena will be focused. Finally, the first two groups of case will be analysed, which involves rescue packages in reality.

5.4.1 The explanation on takeover policy in reality

At first, there are three groups related to takeover policy, namely the final three. The forth group takes the form of bankruptcy, but government undertake all of liabilities of firm, thereby leaving only contract right with firm whose shares go to government. The project under PPP program gets actually rescued without being interrupted (more details seen in following). This group includes Case 12, 13 and 14 (all in Kuala Lumpur). As for the fifth group, takeover policy is compulsory since the private firm gets (or is going to get) bankruptcy (Case 10, 15 or Case 18, 19 and 32) or withdraws from PPP program (Case 6). Finally, takeover policy that is chosen voluntarily by government only involves Case 16. Case 16 (Tube Lines) has a very special institutional background that PPP program is under framework of Economic Regulation. Government terminates the PPP program in advance, thereby avoiding future crisis or CA. In spite of the mature regulation system in UK, the key fact is that intensive disputation happens coincidently at the periodical review. Without those two elements, the program will not be taken over before bankruptcy.

From above analysis, the real takeover policy includes only seven examples, among six of which takeover policy seems the last resort while only Case 16 is voluntary to take over the project from firm. In other words, when the rescue policy is feasible, only one of thirty-two cases goes though the takeover policy. This reflects highly the rescue policy as dominant policy under PPP when contract is needed to be adjusted. This conclusion will be gets more supported with following analysis and proof.

At first, takeover policy must be adopted when firm faces bankruptcy because of the legal requirement. Government either takes over it and then keep project operating at the public hand when government injects new fund, or just take the control of firm temporarily in the administration. Namely, the former rescues firm with takeover package while the latter takes over project for administration. In our cases, the first way not only rescue program, but also the firm is bailed out (though firm goes to public hand). Hence, this group of project-takeover is actually especial rescue policy. The proof is the fact that government undertakes all debt of firm under PPP program though government takes over the project; the details of proof could be seen in Case 12, 13, and 14.

Moreover, the second way of takeover (for administration) will only force government manage program during the after-bankruptcy period. This group of takeover policy for administration seems necessary. This includes Case 10, 15, 18, 19 and 32. Furthermore, under Case 6, the private partner withdraws from PPP program. When firm could really withdraw from PPP program after contract stipulation, government must also take it over. The proof of withdrawal of private partner could be seen in Case 6. Combining these six cases, takeover policy is compulsory (or necessary), the conclusion in modelling cannot be denied. In fact, it is worthy pointing out that case 6 is as special for the explanation over takeover policy. The private partner could withdraw from assigned contract; this should be under political influence. Contract cannot lock firm to fulfil its liability for transaction, which is unusual.

Simply speaking, the forth group of case adopts rescue policy though the project is taken over by government, the takeover policy in the fifth group of case seems necessary and then inevitable, only the sixth group of case (only Case 16) contradicts the prediction. Just from statistics, the preference of government over rescue policy cannot be denied by data when takeover policy is not inevitable.

5.4.2 The explanation on takeover policy after rescue packages in reality

The third group of case could expose the reason for takeover policy though government indeed prefers rescue policy (otherwise, rescue policy will not be adopted firstly). This group of case include Case 1, Case 2, Case 8 and Case 17.

Case 1 (THSR) has takeover policy after three CAs. The repeated CAs breaking the promise of government or firm once again and again gives a very bad publicity for the

PPP program. The project is taken over by government in 2009 after firm has been near-bankruptcy (Yu and Johannesson 2010). The takeover policy is definitely under political intervention because the 'president'[16] of those days asserts the political consideration is one of three important elements under consideration for THSR program (Chi and Amy 2011).

At Case 2 (HS1), takeover policy is adopted after twice rescue packages. Government give a good protection for the project and private investors so that the project is finished successfully after CAs and shareholders gets guaranteed by government. Even 'political protection'[17] cannot be labelled as political intervention; there is the other evidence of political intervention. The change of rules in EU promotes the restructure of HS1 (NAO 2012: 15) and then takeover policy is necessary for restructure. Therefore, the takeover policy in this case could be identified under political intervention.

Case 8 (Seoul ARL) has very less public information. If there were no theses from Massachusetts Institute of Technology, this case cannot be investigated. However, Case 8 happens in Korea that has the background of political intervention, is probably under political intervention. More importantly, the acquisition from state-owned-firm to take over PPP program should be mainly affected by government. Therefore, it is worth suspecting the takeover policy under political intervention.

Case 17 (MRT-3 project) gets taken over after rescue policy. As shown in Case 17, before the takeover policy initiated by the new president, government has already subsidized firm repeatedly so that compensation reaches more than ten times of original project fund. Before that takeover, government actually takes 80 percent of equity in 2008 through Land Bank of the Philippines and the Development Bank of the Philippines (Gonzales and Agcaoili 2012). The acquisition is criticised by the Bangko Sentral ng Pilipinas (the central bank of the Philippines); it is neither competencies and nor banking function for

[16] As a student from PRC, I am not supposed to admit Taiwan has a real president; so quotation marks must be used here. Political intervention is even in daily life.
[17] It will not be reasonable of economic benefit for government, so the protection is political.

those two banks (Gonzales and Agcaoili 2012). If the repeated subsidy is suspicious of political intervention, the acquisition is definitely under the political intervention.

It could be seen from above that takeover policy after rescue policy definitely is under political intervention in (at least) three of four cases. The political consideration could force government to take over the program though rescue policy is preferred. This response to the effect of external benefit (here is political benefit, $E\pi_g^1$) in modelling.

5.4.3 The explanation on rescue policy in reality

As general, the first and second group of case are more general, including 18 cases. The first group reflects that rescue policy is normally the first choice. Some of these cases even witness PPP programs rescued repeatedly. This will happen either when *ex post* risk is solved within one or two CAs, for example, Case 4; or when external background allows multiple CAs, for instance, Case 3.

It is very interesting of the second group (Case 26 and Case 27). As intuitive insight, these PPP programs under uncontrollable CAs should be taken over by government after bankruptcy. However, those get bought by new private firms (Wikipedia 2013k and 2012c, respectively). There are two potential reasons. Firstly, highway PPP program could be taken over by new firm. Takeover by a new firm seems very impractical in HSR sector. For example, in HS1 case, government could only require Railtrack (the owner and operator of national railway network in UK at those days) to undertake the building job and purchase the first section of project after competition (Butcher 2011). Secondly, there is political intervention after severe accidents in those two cases (Dahdal 2010).

Seen from the first group of case, government prefers rescue policy to takeover policy while the external effect (political influence, especially) might change the situation in the end.

5.5 Comparative analysis-the data description in different category

As mentioned before, we add four facility projects in our measurement to get big size of sample (over 30). To check the potential dilution effect (namely, the adverse effect of including four facility programs with other transportation cases), the following make comparative analysis between four groups of sample. Following four tables give statistics of mean, median, maximum, minimum, standard deviation and skewness for comparison.

Table 5-5: the data description in HSR sector (6 cases)

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness
RD	0.750033	0.9453	1	0	0.397361	-1.3097
RI	0.3184	0.2327	0.955	0	0.389987	0.625653
SBC01	0.794783	0.83245	0.8919	0.64	0.104699	-0.60577
SBC02	0.620283	0.61185	0.835	0.3418	0.198287	-0.13893
SBC03	0.216383	0.1741	0.5501	0	0.246139	0.224076
NCA	3	2	8	1	2.75681	1.066597
RC	1.512617	1.3673	2.3541	1.1348	0.442747	1.299322
RT	1.262433	1.1719	1.5106	1.1392	0.158363	0.80282
RQ	0.309333	0.2301	1	0	0.372284	1.141512
TCA	0.174000	0.1407	0.3452	0.0947	0.090896	1.258502
SBC1	0.920533	0.91615	1	0.8235	0.070949	-0.039
SBC2	0.523733	0.568	0.772	0.2008	0.21413	-0.39338
SBC3	0.12575	0.07525	0.36	-0.0064	0.145861	0.684149
SBC4	-0.09653	0.0104	0.111	-0.629	0.277886	-1.36944
RAP	0.564411	0.568	0.832255	0.243837	0.226636	-0.16621
NRAP	16.02159	0.6425	98.28125	-5.06173	40.3691	1.774581

Table 5-6: the data description in Rail sector (17 cases)

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness
RD	0.592859	0.75	1	0	0.448596	-0.42942
RI	0.1435	0	0.955	0	0.28489	1.750494
SBC01	0.816706	0.8299	0.9756	0.64	0.091007	-0.14968
SBC02	0.7047	0.7834	0.9756	0	0.243212	-1.63174
SBC03	0.126788	0	0.7571	0	0.236349	1.625115
NCA	2.058824	1	8	1	1.819017	2.222667
RC	1.407941	1.3556	2.3541	1.054	0.314492	1.686484
RT	1.214794	1.1714	1.85	1	0.224501	1.380365
RQ	0.456075	0.3607	1	0	0.402058	0.463643
TCA	0.213676	0.159700	0.5493	0.0778	0.129057	1.382185
SBC1	0.9478	1	1	0.7938	0.073257	-0.99729
SBC2	0.638994	0.671	0.946	0	0.260309	-1.03985
SBC3	0.131094	0.1181	0.36	-0.0064	0.108949	0.510621
SBC4	-0.06569	0	0.111	-0.629	0.1894	-1.73323
RAP	0.663888	0.7727	0.953106	0	0.265174	-1.05259
NRAP	3.302901	0	98.28125	-39.8333	26.32994	2.736899

Table 5-7: the data description in Transportation industry (28 cases)						
	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness
RD	0.639368	0.9453	1	0	0.440081	-0.6049
RI	0.143707	0	0.955	0	0.293737	1.717639
SBC01	0.795793	0.7817	0.9777	0.627	0.094648	0.164468
SBC02	0.704596	0.77465	0.9756	0	0.200294	-1.81169
SBC03	0.107336	0	0.7571	0	0.212059	1.765423
NCA	2.25	1	8	1	1.993043	1.648982
RC	1.518986	1.4081	3.4324	1.0425	0.502941	2.25739
RT	1.141054	1.1321	1.85	0.825	0.214118	1.372966
RQ	0.472948	0.3881	1	0	0.3438	0.38245
TCA	0.220521	0.1829	0.5493	0.0367	0.121651	0.947412
SBC1	0.911664	0.94365	1	0.691	0.095016	-0.75195
SBC2	0.655907	0.6908	0.9476	0	0.236703	-1.05604
SBC3	0.115868	0.0999	0.36	-0.018	0.094372	0.688911
SBC4	-0.04869	0	0.173	-0.629	0.169232	-1.56956
RAP	0.717757	0.796788	1	0	0.257297	-1.0548
NRAP	1.922295	0	98.28125	-39.8333	20.37077	3.663866

Table 5-8: the data description in Facility sector (4 cases)						
	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness
RD	1	1	1	1	0	NA
RI	0.22395	0	0.8958	0	0.4479	1.154701
SBC01	0.572	0.60245	0.8662	0.2169	0.306133	-0.17666
SBC02	0.353775	0.21645	0.785	0.1972	0.287627	1.151223
SBC03	0.218225	0.10195	0.669	0	0.315514	0.867721
NCA	1.75	1.5	3	1	0.957427	0.493382
RC	1.45745	1.3136	2.0421	1.1605	0.396659	1.032602
RT	1.0599	1	1.3438	0.8958	0.195537	0.928402
RQ	0.5888	0.657	1	0.0412	0.487699	-0.15231
TCA	0.102625	0.0909	0.1495	0.0792	0.03176	1.04214
SBC1	0.705775	0.74895	1	0.3252	0.317975	-0.24731
SBC2	0.4096	0.3528	0.7002	0.2326	0.203104	0.843895
SBC3	0.133775	0.1391	0.1486	0.1083	0.018089	-0.7852
SBC4	0.021275	-0.0067	0.1833	-0.0848	0.115694	0.72703
RAP	0.635648	0.581096	1	0.3804	0.294908	0.331295
NRAP	0.159311	-0.08103	1.369955	-0.57066	0.854568	0.803173

As mentioned before, there are six cases in HSR, seventeen cases in rail, twenty-eight cases in transportation while final four cases are facility projects. The inclusion of final four could help the later regression on the base of big sample, though it may have dilution effect.

Table 5-5 to Table 5-8 analyse these data in four categories, including HSR sector, rail sector, transportation industry and facility industry. The data description including all cases will be finished in next chapter; here is only the descriptive statistics for these four categories.

5.5.1 The analysis of HSR sector relative to the transportation industry

Table 5-9, Table 5-10 and Table 5-11 examines the average level between two groups to find data tendency in specific sector/industry relative to the benchmark of transportation industry (we focus on general situations of transportation industry).

Table 5-9: the data tendency in HSR sector relative to the one in transportation industry

	R_d	R_i	S_{BC}^{01}	S_{BC}^{02}	S_{BC}^{03}	N_{CA}	R_c	R_t	R_q	t_{CA}	S_{BC}^{1}	S_{BC}^{2}	S_{BC}^{3}	S_{BC}^{4}	R_{ap}	NR_{ap}
Result	>	>	<	<	>	>	<	>	<	<	>	<	>	<	<	>

>: bigger, <: smaller.

Seen from Table 5-9, HSR sector has a higher level of raising-money risk ($R_d$and R_i) behind original contract and higher level of government subsidy (S_{BC}^{03}). By contrast, *ex ante* debt (S_{BC}^{02}) and global contribution from government (S_{BC}^{01}) is smaller than the average level in transportation industry. On one hand, high degree of raising-money risk explains why higher level of *ex ante* subsidy (S_{BC}^{03}) exists. On the other hand, more reluctant attitude of bank (see S_{BC}^{02}) and also explains less amount of *ex ante* global contribution from government.

As for variables during contract implementation (including $\mathrm{N_{CA}}$, R_t, R_c, R_q and t_{CA}), HSR industry has more CAs (bigger N_{CA}), delay risk (bigger R_t) and bigger demand risk (smaller R_q). At the same time, smaller cost overrun risk (bigger R_c) takes place with earlier CA (due to smaller t_{CA}).

Finally, for the softness in the situation of final CA, HSR samples have bigger global softness (S_{BC}^1) and its increase amount (S_{BC}^3) while get smaller values for debt (S_{BC}^2) and its increase amount (S_{BC}^4). Considering the tendency in four softness indicators, according to the definition, it is reasonable to have a smaller R_{ap} and NR_{ap}. The former get supported in data while the latter seems contradictory to the data. Especially, the contradiction hints NR_{ap} cannot reflect the reality suitably.

In one sentence, samples in HSR sector has bigger *ex ante* risk and less *ex post* CAs; government has to contribute more to keep program going but the more resource from market needs to be related.

5.5.2 The analysis of rail sector relative to the transportation industry

Seen from Table 5-10, rail sector has a lower level of *ex ante* financial risk behind original contract (R_d and R_i) and then *ex ante* contribution in different ways (S_{BC}^{01}, S_{BC}^{02} and S_{BC}^{03})relative to general situation in transportation industry.

Table 5-10: the data tendency in rail sector relative to the one in transportation industry

	R_d	R_i	S_{BC}^{01}	S_{BC}^{02}	S_{BC}^{03}	N_{CA}	R_c	R_t	R_q	t_{CA}	S_{BC}^1	S_{BC}^2	S_{BC}^3	S_{BC}^4	R_{ap}	NR_{ap}
Result	<	<	>	>	>	<	<	<	<	<	>	<	>	<	<	>

>: bigger, <: smaller.

Moreover, among the variables under contract implementation, each indicator hasa smaller value on average in rail sector relative to transportation industry. This means rail sector has less CAs, less cost overrun risk, less delay risk but a bigger *ex post* demand and shorter period of CA danger.

Finally, the softness in the situation of final CA seems complex in rail sector. The global softness and *ex post* softness is relatively big while indirect softness and *ex post* indirect softness is relatively small. This means bank gets less involved for program. At the same time, it explains why the reliance of government over bank for global softness (R_{ap}) is smaller. However, the reliance for *ex post* softness (NR_{ap}) is bigger, which is contradictory with the tendency behind four softness indicators. This hints NR_{ap} may be unable to reflect the reality reasonably once again.

In one sentence, rail sector as a subtype of transportation industry has smaller *ex ante* risk, bigger *ex ante* contribution of government, mixed *ex post* risk (smaller cost overrun and delay risk but bigger demand risk), bigger global softness (and its increase) and less indirect softness (and its increase). It could be seen that the rail sector get supported more *ex ante* and *ex post*.

5.5.3 The analysis of facility sector relative to the transportation industry

It has been mentioned that four cases of facility are collected for research. The corresponding dilution effect should be considered. The following table could conclude data tendency in facility sector.

Table 5-11: the data tendency in facility sector relative to the one in transportation industry

	R_d	R_i	S_{BC}^{01}	S_{BC}^{02}	S_{BC}^{03}	N_{CA}	R_C	R_t	R_q	t_{CA}	S_{BC}^{1}	S_{BC}^{2}	S_{BC}^{3}	S_{BC}^{4}	R_{ap}	NR_{ap}
Result	>	>	<	<	>	<	<	<	>	<	<	<	>	>	<	<

>: bigger, <: smaller, ≥: no less than, na: no clear relationship.

At first, the facility in research has bigger risk than transportation industry since R_d and R_i is relatively bigger in facility sector. However, the global and indirect contribution at stage of project launch gets less involvement since S_{BC}^{01} and S_{BC}^{02} is smaller. It is interesting that the direct contribution (S_{BC}^{03}) of government gets bigger. This may derive from the facility is less commercial.

Furthermore, *ex post* risk get smaller in facility sector since R_c R_t is smaller and R_q gets bigger. At the same time, less CAs take place at earlier stage since both of N_{CA} and t_{CA} are smaller.

Finally, the global softness and global debt in the situation of final CA gets less value while those increase amounts get bigger. Namely, S_{BC}^{1} and S_{BC}^{2} is smaller while S_{BC}^{3} and S_{BC}^{4} get bigger. The reliance of government over bank involvement gets smaller for global or *ex post* contribution since R_{ap} and NR_{ap} is smaller in facility.

After giving separate property of data in special industries, the dilution of including facility sector could be figured out. The dilution effect of including non-transportation sector seems smaller than expectation. At first, comparing with the average level of transportation industry, facility sector has the same tendency in data as HSR sector for all *ex ante* variables (see Table 5-9 and Table 5-11). As for the five variables for contract implementation, facility sector has very similar tendency as rail sector since only R_q gets different level between these two groups relative to average level of transportation (see Table 5-10 and Table 5-11). Finally, facility sector has also half of variables in the situation of final CA, having same symbols as HSR or rail sector (see Table 5-9 or Table 5-10 and Table 5-11).

5.6 Findings

This chapter could have two sets of findings. One involves the testing related to the real government policy relative to the basic conclusion from modelling; the other one is related to the dilution effect of including four facility cases for later regression. The following includes the four findings for the testing of government policy in reality while one finding for the potential dilution effect.

As discussed in Section 5.4, there are three predictions from theoretical exploration: firstly, government prefers rescuing policy to takeover policy. Of thirty-two cases, there is only one case that government choose to take over the project directly when the rescue package is available.

Furthermore, due to the external effect, especially the political intervention in our cases, government will adopt takeover policy after a series of rescue packages. On one hand, three of four cases that the takeover policy is adopted after rescue policy have the evidence of political intervention. On the other hand, the extra case is susceptive of political intervention.

Thirdly, seen from the last section, the mean value of S_{BC}^{3} is positive in every category, this proves that government will have *ex post* contribution to keep program going when there are *ex post* risk under PPP program. It reflects the compensation effect necessary under CA(s).

Fourthly, we find the mean values of S_{BC}^{4} in HSR sector, rail sector and transportation industry are negative. The bank is averse to *ex post* involvement under *ex post* CA. This conclusion will be confirmed in latter analysis from regression result.

Finally, after above comparative analysis, it is found that the dilution of adding facility sector into research is smaller than it seems. Moreover, the size of facility sector only reaches four. Considering these two reasons, it is worthy adding these samples in this research so that the latter regressions could be based on the big size of sample.

Appendix: The measurement through case studies

All of indicators will be evaluated in every case. The structure of every case study will go along the same format for the convenience of value-assignment and expression. The following is the details of common structure for every case study.

The following measurement will start six cases in HSR, seventeen cases in rail, twenty-eight cases in transportation and four facility projects, in order. However, cases within group are introduced in random.

In every case, the background will be introduced very simply; the aim is to tell which country or area the PPP program is located in. After that, N_{CA} will be assigned firstly since the outline of Story could be described basically in this way. Five initial indicators will be assigned then when the original contract is reviewed. At the same time, the value of $t_{program}$ will be identified for the latter t_{CA} since the former is one determinant of the latter. After that, two *ex post* risk indicators including R_t and R_q have respective assignment. The rest of risk indicators will be involved in following place. t_{CA} will have assignment when six softness indicators are assigned since all of latter six indicators involve final CA. R_c could be evaluated after identifying the value of softness indicators since it involves the real fund amount after CA(s). Finally, dummy variables related to the way of every CA will be assigned on the base of all of previous details.

After those case studies, the data could be given in Table 5-2 and Table 5-3. The former includes initial variables and process variables while the latter gives variables for the others. In particular, Table 5-3 involves six variables for final situation, two dummy variables and one qualitative indicator for government policy.

Case 1(THSR in Taiwan)

THSR (Taiwan High Speed Rail) links the north and south in Taiwan Island. Taiwan High Speed Rail Corporation is the holder of contract right under PPP program. This project is actually the first program of PPP in Taiwan island and is also one of biggest construction scheme in the whole world. As a first and biggest case for Taiwan government, the underestimation of *ex post* risks makes the program experience dangers of contract termination. This project is almost started and finished simultaneously with the project of

Channel Tunnel Rail Link (Case 2). These two projects share the same problem at the early stage, but go into different way.

At this case, there is $N_{CA} = 4$. After firm cannot raise project fund, three-party-contract (among firm, government and bank) is assigned to bail out firm. The three-party-contract breaks the promise of firm to build the HSR line with no government funding in original contract of PPP (Chi and Amy 2011). Moreover, the three-party-contract stipulates that those syndicated banks only support the 75% of debt and requires firm to get equity investment at least 150 billion New Taiwan Dollar (NTD) before debt supply (Lin 2003). These two stipulations get broken in following CAs. Just a little after that three-party-contract, the corporate restructure results from the change of core system. This internal restructure[18] switches two original members of private promoters by Japan corporations (Lin 2003). This switch is asserted to raise the rest (25%) of debt from Japan banks, but the plan is not really implemented. Government has to rescue the project and the bank is forced to supply the rest fund (Lin 2003); this is the second CA. At this CA, government promises not to bail out firm any more. Though firm gets agreement of banks to supply debt, firm meets crisis in equity market when 150 billion NTD cannot be realized by the time of financial close. After the equity cannot be realized certainly, government requires the banks to reduce the requirements about equity investment. This changes the three-party-contract once again, as the third CA. The final financial restructure is the forth CA, which transfers the control right of firm to government (Yu and Johannesson 2010).

At original contract, firm promises to get debt amounting to 69% of project fund while get 31% of project fund in equity. Government approval itself represents government support. In addition, the concession is assigned to last 35 years on 23 July 1998 (Lin 2003). Combining these facts, there are followings.

[18] This kind of internal restructure is CA within firm, but it is not a CA between firm and government. For the measurement of softness, it will not be counted. The reason has been mentioned before. This way will be followed in later cases.

$\mathrm{R_d} = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = 0.69,\ S_{BC}^{02} = \frac{\mathrm{V_d^c}}{\mathrm{TF^c}} = 0.69, S_{BC}^{03} = \frac{\mathrm{TF_g^c}}{\mathrm{TF^c}} = 0$[19]$, t_{program} = 35 * 12 = 420.$

As for the ratio of investment under risk in original contract, $\mathrm{R_i} = 1 - \frac{\mathrm{I_{co}^c + CR^{-r}}}{\mathrm{TI^c}} = 1 - 0.51 = 0.49$. This is because the private promoters will provide 51% share while the rest will come from institutional investors or public offering (Lin 2003), according to the original contract.

The project is expected to finish on 31 Oct 2005 (Lin 2003) while the project is not finished until Jan 5th 2007. (Wikipedia 2013a). As mentioned, the contract is assigned in July 1998, hence, $R_t = \frac{\{t|July\ 1998 - Jan\ 2007\}}{\{t|July\ 1998 - Oct\ 2005\}} = \frac{102}{87} = 1.1724.$

The project experiences huge *ex post* risk of demand. The original ridership estimate 180000 per day (Cheng 1997) after launch in the first operation year while the real one only reaches 50000 (Taipei times 2007). Hence, $R_q = \frac{50000}{180000} = 0.2778.$

The 4th CA, government is forced to rescue the project with total guarantee for loan that reaches upwards NTD 308.3 billion. For this rescue program, new eight banks are involved (MTAC 2010). Meanwhile, government officially allows another loan worthy of NTD 73.7 B (MTAC 2010), though those are not guaranteed by government. Before that, government has allowed a mortgage proposal of facility that is worth NTD 65.5 billion (MTAC 2010). In addition, all of investment except the equity form private promoters gets the support of government due to *ex post* tax policy. Anyone investing the program will have tax-exemption. Hence, all investment except sponsor equity (from private promoters) cannot be irrelevant from government's contribution. In particular, the founder shareholders invest NTD 41.99 billion while the total equity is NTD 132.2 billion (Lin 2003). The latest CA takes place at 1 Aug 2010 (MTAC 2010). Combining above facts, there are followings.

[19] If government gives firm some subsidy, we will mention it specially; otherwise, no point will be made in later cases.

$S_{BC}^1 = \frac{308.3+73.7+65.5+132.2-41.99}{308.3+73.7+65.5+132.2} = \frac{537.71}{579.7} = 0.9276, S_{BC}^2 = \frac{308.3+73.7+65.5}{308.3+73.7+65.5+132.2} = \frac{447.5}{579.7} = 0.7720;\ S_{BC}^3 = \frac{308.3+73.7+65.5+132.2-41.99}{308.3+73.7+65.5+132.2} - 0.69 = 0.2376, S_{BC}^4 = \frac{308.3+73.7+65.5}{308.3+73.7+65.5+132.2} - \frac{69}{100} = \frac{447.5}{579.7} - \frac{69}{100} = 0.0820, t_{CA} = \frac{\{t|July\ 1998 - Aug\ 2010\}}{t_{program}} = \frac{145}{420} = 0.3452.$

From above, it could be seen that the total project fund is NTD 579.7 billion from firm. At the same time, this program is originally expected to raise 11.99 billion USD (Lin 2003) in private fund. The conversion to NTD could be obtained because Lin (2003) mentions the total fund (including public and private fund) is 15.1 billion USD (NTD 513.3 billion) at the same time. So the original fund is $513.3 * \frac{11.99}{15.1}$. Hence, $R_c = \frac{579.7}{513.3*\frac{11.99}{15.1}} = 1.4223.$

After above investigation, there is no any government's *ex post* compensation or firm's *ex post* investment from shareholders in this case, so $x1 = 0$ and $x2 = 0$. Finally, government adopts rescue policy under CA firstly. But the (partial) takeover policy is actually taken after a series of rescue packages because the board has already been mainly (not fully) from public partner in the final CA.

Case 2 (HS1 in UK)

HS1 is also named as Channel Tunnel Rail Link (CTRL). It links the Channel Tunnel towards London. London and Continental Railways (LCR) gets the contract right of this PPP program. At original contract, this program is linked with Eurostar UK (EUKL) to raise project fund.

At the case of HS1, there is $N_{CA} = 3$. At first, the first CA derives from the speciality of financial arrangement at original contract, in which government grants income right of Eurostar UK to LCR. UK government hopes the 'revenue primarily from Eurostar UK and from use of the link by domestic train services' to support the project (Butcher 2011: 2). This kind of arrangement leads the danger to the program due to the over-optimistic forecast of revenue from Eurostar UK. To bail out the project, Railtrack is introduced into program with complicated rescue package (Butcher 2011), thereby leading a CA.

However, all of partners do not realize the introduction of Railtrack also bring new risk element into program since Railtrack gets bankrupted later and then the relevant contract arrangement must be broken. A second CA is inevitable. After completion of project, the British government asserts to a sale plan, which results in the termination of PPP program, the third CA.

Furthermore, at original contract, £1.7B is granted by government to firm (National Statistics 2006). When firm is established, the initial fund includes '£70 million of equity contributions from its founder shareholders and £430 million of bank facilities secured on EUKL revenues' (National Statistics 2006: 9). In particular, bank facilities are obtained with government support because government makes a guarantee (National Statistics 2006). Besides, firm is also given other property rights from government: (1) European Passenger Services (EPS), (2) Union Railways, (3) the land & properties needed at Kings Cross and (4) the land & properties needed at Stratford. The first one is valued at £798M while the second one is worthy of £42.6M (Butcher 2010). The awarded land and properties at two places are estimated at £10.6M and £12.5M[20], respectively (Butcher 2010). Despite of these property rights, LCR at biding proposal expects to raise £0.8B of equity and borrow £3~£4 billion for project (National Statistics 2006). For measuring financial structure at original contract, the loan is identified as £3.5 billion[21]. The contract is assigned in Feb 1996 (Butcher 2010). The contract is expected to last 90 years though it stipulates initially to have 999 years (Butcher 2010). Combining these facts, there are followings.

$$\mathrm{R_d} = \frac{V_d^r}{V_d^c} = \frac{3500}{430+3500} = \frac{3500}{3930} = 0.8906, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} =$$
$$\frac{430+10.6+12.5+3500+1700+798+42.6}{70+430+10.6+12.5+800+3500+1700+798+42.6} = \frac{6493.7}{7363.7} = 0.8819, S_{BC}^{02} = \frac{V_d^c}{TF^c} =$$
$$\frac{430+3500}{70+430+10.6+12.5+800+3500+1700+798+42.6} = \frac{3930}{7363.7} = 0.5337, S_{BC}^{03} = \frac{TF_g^c}{TF^c} =$$

20 In fact, these two values are in 1996 price and government subsidy is in 1995 price while others are in 1997 price. We do not exchange the funds towards the same price level because the price affect could be neglected. The reason has been discussed in the section 5.2.1.

21 If there is debt without *ex post* risk to get, for example, a guarantee of debt from government for firm or a loan from government, it will be excluded from $\mathrm{V_d^r}$ but it should be included in $\mathrm{V_d^c}$. This kind of debt will be specifically mentioned when $\mathrm{V_d^r} \neq \mathrm{V_d^c}$; otherwise, no point will be given in particular. This will be followed in later parts of thesis.

$\frac{10.6+12.5+1700+798+42.6}{70+430+10.6+12.5+800+3500+1700+798+42.6} = \frac{2563.7}{7363.7} = 0.3482, t_{program} = 90 * 12 = 1080.$

From above, it could be seen that the investment of this case has four sources: the private promoter, the public offering, the property rights with risk (the Eurostar UK) and property rights granted without risk (the subsidy or the land from government). The ratio of investment under *ex post* risk will include the investment from the public offering and the value of Eurostar UK since the public offering may not be realized while the Eurosrar UK could be overestimated.

$R_i = \frac{I^c_{min}+CR^r}{TI^c} = \frac{800+798}{70+10.6+12.5+800+1700+798+42.6} = \frac{1598}{3433.7} = 0.4654.$

The contract is assigned in Feb 1996 (NAO 2001) and fully completed in Dec 2007 (NAO 2012). The project is expected to finish in 2003 (Butcher 2010). This means the target is not clear and hard, for safety, the Dec 2003 will be used for measurement. Hence, $R_t = \frac{\{t|Feb\ 1996 - Dec\ 2007\}}{\{t|Feb\ 1996 - Dec\ 2003\}} = \frac{142}{94} = 1.5106.$

The project experiences huge *ex post* risk of demand. The awarded Eurostar UK gets overestimated for the ridership and then firm cannot get enough funds for the project. According to the estimation before the start of construction, the Eurostar UK is expected to have 21 million to 27 million passengers by 2010, while the real one only have 9.5 million (BOOZ&CO 2012). To measure the deflation, we use the mean value between 21 million and 27 million. Hence, $R_q = \frac{9.5}{24} = 0.3958$[22].

Finally, the PPP program is terminated when LCR is restructured in June 2009 (Butcher 2011). The control of LCR is taken formally by government. Hence, there is followings.

[22] The traffic deflation in the first year of operation is not available. In this situation, the available information in the earliest year of operation will be adopted to substitute the one in the first year. This will be followed in later cases.

$S_{BC}^{1} = 1,\ S_{BC}^{3} = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^{c}}{TF^{c}} = 1 - \frac{6493.7}{7363.7} = \frac{870}{7363.7} = 0.1181;$

However, the debt is not changed though it is transferred to government. As for the debt, it is dependent on the first CA since the second and third CA do not change the financial structure of HS1. At the first CA on 3 June 1998, a new debt package worthy of £5.8 billion is approved by government to substitute the original debt (Butcher 2011). Hence, there are followings.

$S_{BC}^{2} = \frac{V_d}{TF^c} = \frac{430+5800}{5800+70+430+10.6+12.5+800+1700+798+42.6} = \frac{6230}{9663.7} = 0.6447, S_{BC}^{4} = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{6230}{9663.7} - \frac{3930}{7363.7} = 0.1110.$

The completion of restructure could be identified in June 2009 because of following.

> 'In June 2009 Lord Adonis, then Secretary of State for Transport, confirmed that the restructuring of LCR [firm] was complete.' (Butcher 2011: 9)

Hence, $t_{CA} = \frac{\{t|Feb\ 1996 - June\ 2009\}}{t_{program}} = \frac{160}{1080} = 0.1481$[23].

From above, it could be seen that the total project fund is £9663.1 million (see S_{BC}^{1}). At the same time, this program is originally expected to raise 7363.7 (see S_{BC}^{01}). Hence, $R_c = \frac{9663.1}{7363.7} = 1.3123.$

After above investigation, there is no any government's *ex post* compensation or firm's *ex post* investment from shareholders in this case, so $x1 = 0$ and $x2 = 0$. Finally, government adopts rescue policy under CA firstly, and then takeover policy is applied in third CA.

[23] Though the program is terminated, $t_{program}$ is still equal to 90 years instead of the real length of contract implementation since the former is the expectation of partners. Therefore, when the project is taken over by government, the later cases will follow the same way.

Case 3 (Channel Tunnel between UK and France)

At the Channel Tunnel project, Eurotunnel is the holder of contract right for the PPP program. This program is distinct from other case at government's role. This case involves the British and France governments. The launch of program is based on the no direct contribution of government, but it is criticized by many scholars due to the severe principal-principal problem (Vilanova 2006).

At the case of Channel Tunnel, there is $\mathrm{N_{CA}} = 8$. After original financial arrangement, two *ex post* equities are issued in 1990 and 1994, respectively. In Dec 1993 and between these two CAs, the termination of concession is extended to July 2052 from July 2042. There is another *ex post* set of warrants to issue in 1995. After four revises, the financial restructure lasts for two and half year, which also extends the concession towards 2086 from 2052. In spite of those, there are equity issuing to buy back some debt in 1999 and equity offer in 2002. Finally, another restructure is taken in 2007. Concluding these, there are eight CAs consequently. All of details about the CA come mainly from the investigation of Schueler (2007) while other literatures are referred as complementary evidence. Since the debt is constituted of different currency, there is no uniform number for measurement. Author adopts mainly Schueler (2007)'s number because it at least most precise and comprehensive numbers for this case.

At original contract, the 'setting up of the project began with the November 1987 IPO that raised £770 million and with a syndicated loan of £5 billion' (Vilanova 2006: 1). In particular, Schueler (2007) give the precise number of loan, which is £4985 million. We will use the precise amount for the following measurement. The debt gets approved, but it has no government guarantee. In spite of that, there are £46 M and £ 206M from founder shareholders and private institutional placement, respectively (Schueler 2007). The original contract is assigned in Aug 1987 and the concession is concession is originally up toward July 2042 (Li and Wearing 2000). As mentioned above, the concession is extended towards 99 years; it also should be finished in the same month. So the program is expected to last from Aug 1987 to July 2086, namely, 99 years minus one month. Combining these facts, there are followings.

$R_d = \frac{V_d^r}{V_d^c} = 1,\ S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{4985}{4985+770+46+206} = \frac{4985}{6007} = 0.8299, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{4985}{4985+770+46+206} = \frac{4985}{6007} = 0.8299,\ S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = \frac{I_{min}^c+CR^r}{TI^c} = \frac{770+206}{770+46+206} = 0.9550, t_{program} = 99*12-1 = 1187.$

In addition, it is 'officially opened… on 6 May 1994' (Wikipedia 2012a) though 'Originally planned to open in May 1993' (Vilanova 2006: 11).The program is started in July 1987. Hence, $R_t = \frac{\{t|July\ 1987 - May\ 1994\}}{\{t|July\ 1987 - May\ 1993\}} = \frac{82}{70} = 1.1714.$

This project experiences huge risk of demand. It is expected to have 15.9 million passengers in the first opening years while there are actually only 2.9 million passengers (Wikipedia 2012a). Hence, $R_q = \frac{2.9}{15.9} = 0.1824.$

The softness at the 7th CA cannot be measured straight. It must trace back to examine every CA since this case has a series of complex CAs that are 'autocorrected' in history. To tell the difference between every ratio at respective CA, the more detailed symbol of superscript is used before the final ratio. For example, $\mathrm{S}_{\mathrm{BC}}^{11}$ represents the level of SBC in first way at first CA while $\mathrm{S}_{\mathrm{BC}}^{12}$ reflects the one measured in first way at second CA; however, $\mathrm{S}_{\mathrm{BC}}^{21}$ will reveal the level of softness in second way at the first CA. Namely, the first number of superscript is related to the way of measurement while the second one is the number of CA.

In comparison with the original contract, at the first CA in Nov 1990, the Equity 4 is worthy of £568M (Schueler 2007 and Vilanova 2006). A little before the Equity 4, additional loans from bank syndicate (worthy of £1.8B) and European Investment Bank (worthy of £300M) are obtained in Sep 1990 (Schueler 2007 and Vilanova 2006: 40). Therefore, at the first CA, $\mathrm{S}_{\mathrm{BC}}^{11}$ and $\mathrm{S}_{\mathrm{BC}}^{21}$ will be followings[24].

[24] $\mathrm{S}_{\mathrm{BC}}^{31}$ and $\mathrm{S}_{\mathrm{BC}}^{41}$ are not necessary to give since they depends on the $\mathrm{S}_{\mathrm{BC}}^{11}$ and $\mathrm{S}_{\mathrm{BC}}^{21}$. At later CA before the final one, the third and forth indicator will not be given neither. This will be followed in later cases.

$$S_{BC}^{11}=\frac{TF_{gb}}{TF}=\frac{4985+300+1800}{6007+1800+300+568}=\frac{7085}{8675},S_{BC}^{21}=\frac{V_d}{TF^c}=\frac{4985+1800+300}{6007+1800+300+568}=\frac{7085}{8675}.$$

At the second CA, the terminal year of program is extended from original 2042 to 2052 in Dec 1993. None of ratios of SBC is changed.

At the third CA, the Equity 5 (worth of £ 858M) is issued in June 1994 (Schueler 2007 and Vilanova 2006). At the same time, there is syndicated loan worthy of £647 million for the project (Schueler 2007). In addition, before the third CA, there is debt worthy of £200 million from European Coal and Steel Community in 1991 (Schueler 2007 and Vilanova 2006). It is mentioned by Vilanova (2006), only the debt in June 1994 is senior debt while others are junior debt. Namely, after third CA, firm has 7285 million junior debt (7085 million as existing one and 200 million as new junior debt) and £647 million senior debt. Moreover, there is interest guarantee so that firm will save £29 million in debt (Schueler 2007). Considering that, junior debt should be £7256 million while the senior debt should be still £647 million; the total debt is equal to £7903 million. The structure of debt will be relevant for later measurement. At the third CA, there are followings.

$$S_{BC}^{13}=\frac{7903}{8675+200+858+647-29}=\frac{8043}{10351},S_{BC}^{23}=\frac{7903}{8675+200+858+647-29}=\frac{8043}{10351}.$$

After that, there is two sets of warrants to issue *ex post* in 1995 (Grant 1997). However, only the first set of warrant is successfully raised, which gets £48 million to firm while the second set of warrant (worthy of £158 million) is failed (Grant 1997). Hence, at the forth CA, there are followings.

$$S_{BC}^{14}=\frac{7903}{8675+200+858+647-29+48}=\frac{8043}{10399},S_{BC}^{24}=\frac{7903}{8675+200+858+647-29+48}=\frac{8043}{10399}.$$

At the fifth CA, the financial restructure is finished with multiply-player-renegotiation since 1995. In July 1997, the proposal is approved by shareholders. This CA involves a very complex series of instruments to rearrange the debt. As mentioned by Vilanova (2006), all of junior debt that gets restructured. Recalling the junior debt reaches £7256 million, which is restructured into five packages (Vilanova 2006). At first, one set of junior debt worthy of £908 million is exchanged to be common equity while another set worthy of £906 is converted into equity notes (Schueler 2007). Moreover, £1092 million is converted into participating loan notes and £1366 million becomes resettable facility (Schueler 2007). Finally, the rest of junior debt worthy of £2984 million (getting from the reduction from previous amounts) will be new junior debt. Simply speaking, two sets worthy of £908 and £906 million become equity from debt while the total fund is not changed at all. At 5th CA, there are following.

$$S_{BC}^{15}=\frac{7903}{10399}=\frac{7903}{10399},S_{BC}^{25}=\frac{7903-908-906}{10399}=\frac{6089}{10399}.$$

At 6th CA, additional equity is issued to buy back debt in Nov 1999; the new share is priced at £ 65p to raise fund of £162M (Harrison 1999). After that, firm purchases the debt by £143 million of £162 million, thereby reducing the debt whose face value is £317M (Harrison 1999). This kind of equity issuing is not forbidden though it obviously affects the shareholders' interest. Due to political interests and willing of investor, this special equity gets successfully issued. If there is no government approval, this share cannot be issued. Therefore, at the sixth CA, there are followings.

$$S_{BC}^{16}=\frac{7903+162}{10399+162}=\frac{8065}{10561},S_{BC}^{26}=\frac{6089-317}{10399+162}=\frac{5772}{10561}.$$

At the 6th CA, the equity note tender is offered in May 2002. The fund worthy of £740 million is raised to buy back debt so that the debt gets reduced £443 million (FE Trustnet 2002). Similar to the last CA, there are following at the seventh CA.

$$S_{BC}^{17}=\frac{8065+740}{10561+740}=\frac{8805}{11301},S_{BC}^{27}=\frac{5772-443}{10805+740}=\frac{5329}{11301}.$$

The final CA, the second financial restructure is finished in May 2007 after a long renegotiation (BBC news 2007). At this CA, a new loan is obtained (worthy of £2.8B) and 'the balance of the debt' was 'exchanged for equity' (Wikipedia 2013b). as told by BBC (2007), firm has debt £2.84 billion, so we believe the above new loan should be precisely equal to £2.84 billion. Combining above facts, there are followings.

$S_{BC}^{1} = S_{BC}^{18} = \frac{8805+2840}{11301+2840} = \frac{11645}{14141} = 0.8235, S_{BC}^{2} = S_{BC}^{28} = \frac{2840}{11301+2840} = \frac{2840}{14141} = 0.2008;\ S_{BC}^{3} = S_{BC}^{38} = \frac{11645}{14141} - \frac{4985}{6007} = -0.0064, S_{BC}^{4} = S_{BC}^{48} = \frac{2840}{14141} - \frac{4985}{6007} = -0.6290, t_{CA} = \frac{\{t|July\ 1987 - May\ 2007\}}{t_{program}} = \frac{238}{1187} = 0.2005.$

Seen from above, the total project fund is £14141 million (see S_{BC}^{1}). At the same time, it is originally expected to raise 6007 (see S_{BC}^{01}). Hence, $R_c = \frac{14141}{6007} = 2.3541$.

After above investigation, there is no any government's *ex post* compensation, but firm has *ex post* investment in the manner of new equity issuing in this case, so $x1 = 0$ and $x2 = 1$. Finally, government adopts rescue policy under CA.

Case 4 (Perpignan- Figures in Spain)

Perpignan–Figueres is a high speed rail line between Perpignan in France and Figueres in Spain. The contract right is awarded to TP Ferro consortium on 17 Feb 2004 (Wikipedia 2013c).

At the case of Perpignan-Figureres, there is $N_{CA} = 1$. The operation of this whole line is based on that the line between Barcelona and Figueres could be opened in time. However, non-completion of line between Barcelona and Figueres delays the operation of whole project. Due to this, the Spain government compensates firm for the forecast deficit of traffic.

At original contract, the total investment (€952M) will be consisted of government subsidy (€523.7M), the share capital (€102.9M) from TP Ferro and the loan for rest of project fund (Preston 2004). The line will operate for 53 years (Preston 2004). The contract is assigned in Feb 2004 and the service of line has not been started until Dec 2010, hence we could say the concession will last from Feb 2004 towards Dec 2063. Combining these facts, there are following.

$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{952-102.9}{952} = \frac{849.1}{952} = 0.8919, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{952-523.7-102.9}{952} = \frac{325.4}{952} = 0.3418, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = \frac{523.7}{952} = 0.5501, t_{program} = \{t|Feb\ 2004 - Dec\ 2063\} = 718.$

This case is different from first three cases, there is no public offering and then $R_i = 0$[25].

As pointed out by Preston (2004), the construction is expected to finish within 60 months since contract assignment. The final section of construction is finished in Dec 2009 (Wikipedia 2013c). Hence, $R_t = \frac{\{t|Feb\ 2004 - Dec\ 2009\}}{60} = \frac{70}{60} = 1.1667.$

This project experiences absolute risk of demand[26] due to the delay. The CA aims to compensate firm for the un-realization of finished line. Hence, $R_q = 0$.

The package in Nov 2009 gives €62M as compensation, a government loan (worthy of 45.9M) and an approval of loan (worthy of €20.4M) (RGI 2009a). In spite of explicit revise of contract, the concession of operation is also extended towards 53 year from 50 year (RGI 2009b). Combining these facts, there are followings.

$S_{BC}^1 = \frac{TF_{gb}}{TF} = \frac{849.1+62+45.9+20.4}{952+62+45.9+20.4} = \frac{977.4}{1080.3} = 0.9047, S_{BC}^2 = \frac{V_d}{TF^c} = \frac{325.4+45.9+20.4}{952+62+45.9+20.4} = \frac{391.7}{1080.3} = 0.3626;\ S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = \frac{977.4}{1080.3} - \frac{849.1}{952} = 0.0128, S_{BC}^4 = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{325.4+45.9+20.4}{952+62+45.9+20.4} - \frac{325.4}{952} = \frac{391.7}{1080.3} - \frac{325.4}{952} = 0.0208, t_{CA} = \frac{\{t|Feb\ 2004 - Nov\ 2009\}}{t_{program}} = \frac{68}{718} = 0.0947.$

[25] If there is a demand of raising external equity capital, namely, public offering, it will be specifically mentioned. Otherwise, we will not points out in particular when $R_i = 0$. This will be followed in later parts of thesis.

[26] We measure all risks before the final CA, so here is absolute risk of demand and then $R_q = 0$.

Seen from above, total project fund is €1080.3 million (see S_{BC}^{1}). At the same time, it is originally expected to raise €952 million (see S_{BC}^{01}). Hence, $R_c = \frac{1080.3}{952} = 1.1348$.

After above investigation, there is government's *ex post* compensation, but firm has *ex post* investment in this case, so $x1 = 1$ and $x2 = 0$. Finally, government adopts rescue policy under CA.

Case 5 (HSL-Zuid in Nertherlands)

HSL-Zuid project is a high speed rail line in Netherlands with extension towards Belgian. The contract right is awarded to Infraspeed in June 2001 (Wilden 2004). This case is always boasted as the most successful PPP program in history; however, it still experiences one special CA; there is $N_{CA} = 1$.

The new European policy interrupts the project progress and then delays the construction, for which the Netherland government undertakes responsibility. Accordingly, the affected (delayed) time is still counted as operation time and then firm gets payment from government; this is not in stipulation of original contract.

At original contract, the PPP part of project is funded by multiply source of money. The total fund is €1.227B, of which the outside funds include €605M (from commercial loan facility) and €400M (from loan of EIB) and subordinated loan, as mentioned by Wilden (2004). As for subordinated loan, Wilden (2004) points out that the Sponsor equity and subordinated loan supply €120 million together. According to Fluor (2013), the sponsor provides $90 million USD in equity. The exchange rate in 2001 between EUR and USD is 0.895969 (Ozforex 2013). Therefore, the subordinated loan has $120 - \frac{90}{0.895969}$ million EUR.

As for firm's own source, in spite of 90 million USD in equity (Fluor 2013), there are also €15M in working capital facility, €87million in cash flow (Wilden 2004). In addition, the contract is awarded to Infraspeed in June 2001 with 30 year concession (including construction period) (Wilden 2004). Combining these facts, there are following.

$R_d = \frac{V_d^r}{V_d^c} = \frac{605+120-90/0.895969}{605+400+120-90/0.895969} = \frac{725-90/0.895969}{1125-90/0.895969} = 0.6096, S_{BC}^{01} = \frac{\mathrm{TF}_{\mathrm{gb}}^{\mathrm{c}}}{\mathrm{TF}^{\mathrm{c}}} = \frac{605+400+120-90/0.895969}{1227} = \frac{1125-90/0.895969}{1227} = 0.8350, S_{BC}^{02} = \frac{605+400+120-90/0.895969}{1227} = \frac{1125-90/0.895969}{1227} = 0.8350, S_{BC}^{03} = \frac{\mathrm{TF}_{\mathrm{g}}^{\mathrm{c}}}{\mathrm{TF}^{\mathrm{c}}} = 0, \mathrm{R_i} = 0, \mathrm{t_{program}} = 12 * 30 = 360.$

In addition, as pointed out by Davies and Eustice (2005), 1st April 2007 is scheduled to complete for the whole line. However, the real time is 7th Sep 2009 (Wikipedia 2013d). Hence, $\mathrm{R_t} = \frac{\{t|June\ 2001 - Sep\ 2009\}}{\{t|June\ 2001 - April\ 2007\}} = \frac{99}{70} = 1.4143.$

This project experiences absolute risk of demand due to the delay. The CA aims to compensate firm for the un-realization of finished line. Hence, $R_q = 0$.

In Feb 2005, a memorandum of understanding (UoC) assigned by the European Commission forces projects in six priority corridors to use the European Rail Traffic Management System (ERTMS) (Corridor 2009). The HSL-Zuid must adjust ordered and furnished part of project because it belongs to one of those six corridors (RGI. 2012). Due to this adjustment, the construction gets delayed with resulting loss. Different from other cases, Netherlands government pays for the construction delayed (due to the political intervention) as operation. As Infraspeed (2011) says the HSL-south section get Certificate of Availability and payment since July 28th, 2006 while the north section does since 21st Dec, 2006. The project is finished officially in 7th Sep 2009. In comparison with the original contract, the north section gets compensated (since there is no operation during affected time) for $3\frac{2}{12}$ years while the south section gets compensated for $2\frac{9}{12}$ years for the delayed (or affected) parts of project. The full project gets €118 million every year as stipulated in contract (Hertogh et al 2008). Moreover, for measurement, we assume the two section gets same weight of payment, namely, both gets $118 \times \frac{1}{2}$ million for one year. Therefore, there are following.

$S_{BC}^1 = \frac{TF_{gbs}}{TF} = \frac{1125-90/0.895969+(3\frac{2}{12}*118*\frac{1}{2}+2\frac{9}{12}*118*\frac{1}{2})}{1227+(3\frac{2}{12}*118*\frac{1}{2}+2\frac{9}{12}*118*\frac{1}{2})} = 0.8674, S_{BC}^2 = \frac{V_d}{TF^c} = \frac{1125-90/0.895969}{1227+(3\frac{2}{12}*118*\frac{1}{2}+2\frac{9}{12}*118*\frac{1}{2})} = 0.6710;\ S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} =$

$\frac{1125-90/0.895969+(3\frac{2}{12}*118*\frac{1}{2}+2\frac{9}{12}*118*\frac{1}{2})}{1227+(3\frac{2}{12}*118*\frac{1}{2}+2\frac{9}{12}*118*\frac{1}{2})} - \frac{1125-90/0.895969}{1227} = 0.0324, S_{BC}^{4} = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{1125-90/0.895969}{1227+(3\frac{2}{12}*118*\frac{1}{2}+2\frac{9}{12}*118*\frac{1}{2})} - \frac{1125-90/0.895969}{1227} = -0.1640, t_{CA} = \frac{\{t|June\ 2001 - Feb\ 2005\}}{t_{program}} = \frac{44}{360} = 0.1222.$

Seen from above, the total project fund is €$1227 + (3\frac{2}{12} * 118 * \frac{1}{2} + 2\frac{9}{12} * 118 * \frac{1}{2})$ million (see S_{BC}^{1}). At the same time, it is originally expected to raise €1227 million (see S_{BC}^{01}). Hence, $R_c = \frac{1227+(3\frac{2}{12}*118*\frac{1}{2}+2\frac{9}{12}*118*\frac{1}{2})}{1227} = 1.2444.$

After above investigation, there is government's *ex post* compensation while firm has no *ex post* investment in this case, so $x1 = 1$ and $x2 = 0$. Finally, government adopts rescue policy under CA.

Case 6 (Treno Alta Velocita in Italy)

Treno Alta Velocita (TAV) is the high speed train line under PPP in Italy. At the same time, TAV also represents firm, the holder of contract right under PPP.

At this case, there is $N_{CA} = 1$. After the huge cost overrun, the private partner withdraws from the PPP program and government takes over the project directly.

At the original contract, despite of private fund, the program is either funded by government (owning 40% of shares) or gets state-guarantee-debt from the commercial banks (Virtuosity Consulting 2005). Hence, $R_d = 0, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0.4, R_i = 0$.

Because firm itself is partial private (or public), the program under PPP allocates the fund between project firm and government just with a ratio for project fund instead of detailed proposal. The original contract stipulates government supply 40% of debt while firm need raise 60% debt from commercial banks with government guarantee (Virtuosity Consulting 2005). As for the initial government contribution, government has 40% share of project and supply 40% in debt (Virtuosity Consulting 2005). For measuring the softness, the part of ownership in government has maximum value (equal to one); the other part will be equal to $\frac{TF_{gb}^{c}}{TF^{c}}$. Hence, $S_{BC}^{01} = 0.4 * 1 + 0.6 * 0.4 = 0.64$. This way of measurement will be followed in later cases when government has some share in firm.

Firm has share capital worthy of 55 million USD (Virtuosity Consulting 2005). The other amounts of fund from different sources in original contract are not available, but it could be figured out from project fund in later stage according to the relationship stipulated as above, since the takeover policy itself will not change the proposal. In 2004, 6.76 billion dollar is raised in debt while 7 billion dollar in equity (Virtuosity Consulting 2005). Hence, $S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{6.76}{6.76+7} = 0.4913$.

The original contract award firm 50 years concession (including construction) towards 2041 from 1991 (Virtuosity Consulting 2005). Hence, $t_{program} = 50 * 12 = 600$.

The project is finally finished when the third (final) phase is completed in Dec 2009 (PwC 2011) while the contract is awarded in July 1991 (Wikipedia 2013e). The original schedule cannot be obtained. From the PwC (2011), the first two phases has no time overrun; the third phase cost 96 months but it is expected to use 69 months. Namely, the project delay 27 months relative to the schedule. Hence, $R_t = \frac{\{t|July\ 1991 - Dec\ 2009\}}{\{t|July\ 1991 - Dec\ 2009\} - 27} = \frac{221}{194} = 1.1392$.

The PPP program does not involve any *ex post* risk of demand because the private partner has been withdrawn from PPP program before its operation. Hence, $R_q = 1$.

In March 1998, government takes over the private partner (Transportweb 2013), the relevant debt is not changed at all in CA. So there are followings.

$S_{BC}^{1} = 1, S_{BC}^{2} = \frac{V_d}{TF^c} = \frac{V_d^c}{TF^c} = 0.4913, S_{BC}^{3} = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = 1 - 0.64 = 0.36, S_{BC}^{4} = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = 0, t_{CA} = \frac{\{t|July\ 1991 - March\ 1998\}}{t_{program}} = \frac{80}{600} = 0.1333$.

This project experiences huge *ex post* cost overrun, which leads the private partner withdraw from the program. The project has three phases. The first phase get €4.3 billion without cost overrun, the second one is expected to cost €1 billion while it actually costs €5.2 billion, the third one is estimated to cost €4.9 billion but it cost €6.9 billion (PwC 2011). Hence, $R_c = \frac{4.3+5.2+6.9}{4.3+1+4.9} = \frac{16.4}{10.2} = 1.6078$.

After above investigation, there is no any government's *ex post* compensation or firm's *ex post* investment in this case, so $x1 = 0$ and $x2 = 0$. Finally, government has to adopt the takeover policy because the private partner withdraws from the program. To more precise, due to the inability of firm to solve problem such as the land expropriation (PwC 2011), which will lead to huge cost overrun if firm is stick to implement the contract by itself, firm withdraws from program directly.

Case 7 (Sydney ARL)

Sydney Airport Rail Link (Sydney ARL) is also named officially as New Southern Railway. It links Central station with the East Hills line that, in turn, is linked with Sydney Airport (NSW 2005). This project includes four underground stations, which are in charge of private sector. Airport Link Company Pty Limited is the holder of contract right for this program. Firm is required to finance, design, construct and then operate and maintain those four stations.

At the case of Sydney ARL, there is $\mathrm{N_{CA}} = 2$. In 2005, there is a dispute settlement and a change over the profit sharing mechanism (The treasury 2013a). On 01 Mar 2011, the Station Usage Fee (SUF) is cancelled at two stations and then firm is compensated with 'a Shadow SUF based on an adjusted actual patronage volume and a Shadow SUF Value per passenger' (The Treasury 2013a). In 2000, this project goes actually into receivership due to too low patronage (Baker al et 2006), but it has not gone into administration until now. The receivership that does not go into administration cannot be accounted as CA.

At original contract, firm is funded with '$5 million in equity and $10 million in subordinated loans' (NSW 2005: 5). Besides, there is approximately $190 million from National Australia Bank as project finance (NSW 2005). In addition, the contract is started on 30 Jun 1995 and the concession will be terminated 20 May 2030 (The Treasury 2013a). Combining these facts, there are followings.

$R_d = \frac{V_d^r}{V_d^c} = \frac{10}{10+190} = 0.05, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{10+190}{5+10+190} = \frac{200}{205} = 0.9756, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{10+190}{5+10+190} = \frac{200}{205} = 0.9756, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, t_{program} = \{t|Jun\ 1995 - May\ 2030\} = 419, \mathrm{R_i} = 0.$

As for the time of construction, no precise time is required except it must be finished before the Sydney Olympic Game in 2000. In fact, Sydney ARL is finished three months ahead from the deadline (Wikipedia 2012b). Considering there is no clear and hard target for the construction, it is within the budget of time. So it is safe to say $\mathrm{R_t} = 1$.

This project experiences huge risk of demand. As mentioned above, too low patronage leads firm go into receivership. Unfortunately, there is no available data about the forecast and actually number about the patronage or ridership, $R_q = NA$. There is at least $R_q < 1$. Otherwise, we need consider if this case is needed to abandon.

In comparison with the original contract, the softness at the final CA is dependent on the package in dispute settlement (as the first CA). The settlement has two compensation packages. The first one reallocate 34 million AUD towards firm directly while the second one awards 73 million AUD that is 'due as CityRail earns revenue from Airport Line business' (Wikipedia 2012b). In spite of explicit revise, there is implicit but fundamental adjustment including "a revised profit sharing mechanism, a relaxation of the RailCorp's performance standards and revised termination provisions" (The Treasury 2013a). The implicit revise aims to increase the patronage in the manner of decreasing the fare for consumer, but it does not change firm's property rights. So the implicit revise will not be accounted into measurement. The second (final) CA happens in March 2011, as mentioned before. Combining these facts, there are followings.

$S_{BC}^1 = \frac{TF_{gb}}{TF} = \frac{200+34+73}{205+34+73} = \frac{307}{312} = 0.9840, S_{BC}^2 = \frac{V_d}{TF^c} = \frac{200}{205+34+73} = \frac{200}{312} = 0.6410;\ S_{BC}^3 = \frac{TF_{gbs}}{TF} - \frac{TF_{gb}^c}{TF^c} = \frac{200+34+73}{205+34+73} - \frac{200}{205} = \frac{307}{312} - \frac{200}{205} = 0.0084, S_{BC}^4 = \frac{V_d}{TF^c} -$

$\frac{V_d^c}{TF^c} = \frac{200}{205+34+73} - \frac{200}{205} = \frac{200}{312} - \frac{200}{205} = -0.3346, t_{CA} = \frac{\{t|Jun\ 1995 - March\ 2011\}}{t_{program}} = \frac{189}{419} = 0.4511.$

Seen from above, the total project fund is AUD 312 million (see $\mathrm{S}_{\mathrm{BC}}^{1}$). At the same time, it is originally expected to raise AUD 205 (see $\mathrm{S}_{\mathrm{BC}}^{01}$). Hence, $R_c = \frac{312}{205} = 1.5220$.

After above investigation, there is government's *ex post* compensation for firm while firm has no *ex post* investment in this case, so $x1 = 1$ and $x2 = 0$. Finally, government adopts rescue policy under CA.

Case 8 (Seoul ARL)

Seoul Airport Rail Link (Seoul ARL) is always named as AREX (Wikipedia 2013f). As a PPP program, it links Seoul with Gimpo Airport and Incheon International Airport. Incheon International Airport Railroad, abbreviated as IREX, is the holder of contract right of this PPP program. In November 30, 2009, firm is renamed as Korail Airport Railroad (KAR) after an acquisition.

At the case of Seoul ARL, there is $N_{CA} = 3$. The details of first two CAs cannot be found in general channel, but the change of contract relationship is coincidently recorded by two master theses from Massachusetts Institute of Technology (Sech 2003 and Nickel 2011). The previous financial package is substituted by new ones in Dec 2003 and Oct 2004. In particular, government subsidy is introduced at first changed proposal after a long term negotiation. After operational loss, government requires the Korail, a public firm to acquire the IREX and then firm is renamed as KAR, which is the third CA.

At original contract, as recorded by Sech (2003), the total fund (worthy of 5507.5 billon Won) will be raised. As mentioned by Sech (2003), all of plan data gets from Incheon International Airport Railroad Company (2001). Of original plan, 4130.6 billon Won will be raised from loan while 1376.9 billion Won will be raised in equity. In the plan of equity investment, the 'own capital' has only 648.4 B Won (Sech 2003). Namely, the equity-capitalization-ratio should be required to reach 25% (Sech 2003). No government subsidy is required. In addition, the program is started from July 1998 (Wikipedia 2013f). The concession period for operation is 30 year after the competition of phase 2 (Baker 2012). The real time of operation of Phase 2 is Dec 29th 2010 (Wikipedia 2013f) and then the concession will be terminated by Dec 29th 2040. This judgement gets supported by Nickel (2011). Combining these facts, there are followings.

$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{4130.6}{5507.5} = 0.7500, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{4130.6}{5507.5} = 0.7500, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = 1 - \frac{I_{co}^c}{TI^c} = 1 - \frac{648.4}{1376.9} = 0.5291, t_{program} = \{t|July\ 1998 - Dec\ 2040\} = 509.$

As for the time of construction, program starts in July 1998 and is expected to finish in Dec 2009 (Oh 2005). However, the real complement of last section of project is 29 Dec 2011 (Wikipedia 2013f). Hence, $R_t = \frac{\{t|July\ 1998 - Dec\ 2011\}}{\{t|July\ 1998 - Dec\ 2009\}} = \frac{161}{137} = 1.1752.$

This project experiences huge risk of demand. It is expected to have 230000 passengers daily in the first opening years while there are actually only 16000 passengers (Wikipedia 2013f). Hence, $R_q = \frac{16000}{230000} = 0.0696.$

As for the ratio measuring the situation of final CA, it is evolving from the first CA, so it is necessary to explore the whole story. The proposal at original contract is failed. After a long negotiation for project fund, the execution plan raises much less money and introduces government subsidy. As pointed out by Korail Airport Railroad (2009), the Execution Plan in Dec 2003 (called as ‘project goal’ by KAR) transfers 845.8B Won as government subsidy to the IREX while equity will be issued with value of 931B Won while loan worthy of 2172.2B Won will be lent from bank. Combing the above proposal from Sech (2003), there are followings.

$S_{BC}^{11} = \frac{TF_{gb}}{TF} = \frac{2172.2+845.8}{845.8+931+2172.2} = \frac{3018}{3949}, S_{BC}^{21} = \frac{V_d}{TF^c} = \frac{2172.2}{3949}.$

At the second CA in Oct 2004, the raised fund gets enlarged towards 4506.8B Won. The equity investment becomes 1151B Won from 931B Won while the debt turns 2510B Won from the previous 2172.2B Won (Oh 2005). Therefore, at the second CA, there are followings.

$$S_{BC}^{12}=\frac{2510+845.8}{845.8+1151+2510}=\frac{3355.8}{4506.8}, S_{BC}^{22}=\frac{2510}{845.8+1151+2510}=\frac{2510}{4506.8}.$$

After continuous loss, IREX get acquired by Korail, a public firm with requirement from government. The 88.8% of share is taken by Korail in March 2009 (Wikipedia 2013f). Hence 88.8% of ownership (project fund) is contributed directly by government while the rest (12%) keeps the previous ratio of government contribution. At the acquisition package, the ratio of debt is not changed at this CA. combining above facts, there are followings.

$$S_{BC}^{1}=S_{BC}^{13}=\frac{88.8}{100}*1+\left(1-\frac{88.8}{100}\right)*S_{BC}^{12}=\frac{88.8}{100}*1+\left(1-\frac{88.8}{100}\right)*\frac{3355.8}{4506.8}= 0.9714, S_{BC}^{2}=S_{BC}^{23}=S_{BC}^{22}=\frac{2510}{4506.8}=0.5569;\ S_{BC}^{3}=S_{BC}^{33}=\frac{88.8}{100}*1+\left(1-\frac{88.8}{100}\right)* \frac{3355.8}{4506.8}-\frac{4130.6}{5507.5}=0.2214, S_{BC}^{4}=S_{BC}^{43}=\frac{2510}{4506.8}-\frac{4130.6}{5507.5}=-0.1931, t_{CA}= \frac{\{t|July\ 1998-March\ 2009\}}{t_{program}}=\frac{128}{509}=0.2515.$$

Seen from above, the total project fund is 4506.8 billion Won (see S_{BC}^{2}). At the same time, it is originally expected to raise 3949 billion Won (see S_{BC}^{11}). Hence, $R_c=\frac{4506.8}{3949}= 1.1413$. It needs to be pointed out that the project goal (3.949) instead of the project fund in original contract (5.5075) should be referred for measuring cost overrun risk because the latter is failed without being really implemented. The details could be seen above about the first CA.

After above investigation, there is no any government's *ex post* compensation or firm's *ex post* investment in this case, so $x1=0$ and $x2=0$. Finally, government adopts rescue policy under CA firstly, but the takeover policy is later taken when more than half of ownership has been in public partner.

Case 9 (Southern Cross Station in Australia)

Southern Cross Station is one of first and largest rail project under PPP program in Victoria, Australia. Civil Nexus Consortium is the holder of contract right under PPP.

At the case of Southern Cross Station, there is $N_{CA} = 1$. The relevant responsibility of firm due to the delay is waived; a compensation package is transferred to firm (PwC 2005).

At original contract, the project is expected to raise $ 135 million AUD as inflation linked bond, $ 158 million AUD as 'nominal bullet bond' and $ 81 million from equity investment (PwC 2005: 22). This program awards firm operation lasting 30 years (Victorian government 2007), the contract termination will be dependent on the date of completion of project. The project is officially operated in July 2007 (IPA 2008c), so the contract is expected to July 2037. In addition, the contract is assigned on 2 July 2002 (Victorian government 2007). Combing these facts, there are following.

$$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_g^c}{TF^c} = \frac{135+158}{135+158+81} = \frac{293}{374} = 0.7834, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{135+158}{135+158+81} = \frac{293}{374} = 0.7834, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = 0, t_{rogram} = \{t|July\ 2002 - July\ 2037\} = 420.$$

This project experiences '15-month delay' while it is expected to finish by 27 April 2006 [27] (Victorian government 2007: 41). Hence, there is $R_t = \frac{\{t|July\ 2002 - April\ 2006\}+15}{\{t|July\ 2002 - April\ 2006\}} = \frac{60}{45} = 1.3333$.

This program transfers no demand risk to firm since firm is expected to get payment for the relevant service from government (Victorian government 2007). Hence, $R_q = 1$.

Finally, on 31 July 2006, the renegotiation between stakeholders leads to a global settler agreement (Victorian government 2007). The agreement involves a complex package; there are two main arrangements for firm. At first, responsibility of firm is waived for the

[27] If treating the time of operation start as the time of project completion, the delay will be longer. The difference may be derives from the result negotiation that tell the date of completion from the one of operation.

delay. The other one is the transfer of $ 20 million AUD to firm. Namely, firm get compensation of 20 million AUD and pay nothing for the delay. It need to be pointed out that firm gets actually another bond worthy US$ 74 million in April 2003 (PwC 2005). The exchange rate between AUD and USD in 2003 is 0.654801 (OZFOREX 2013). Combining above facts, there are following.

$$S_{BC}^{1}=\frac{TF_g}{TF}=\frac{293+\frac{74}{0.654801}+20}{374+\frac{74}{0.654801}+20}=0.8402, S_{BC}^{2}=\frac{V_d}{TF^c}=\frac{293+\frac{74}{0.654801}}{374+\frac{74}{0.654801}+20}=0.8008, S_{BC}^{3}=\frac{TF_{gb}}{TF}-\frac{TF_{gb}^{c}}{TF^c}=\frac{293+\frac{74}{0.654801}+20}{374+\frac{74}{0.654801}+20}-\frac{293}{374}=0.0568, S_{BC}^{4}=\frac{V_d}{TF^c}-\frac{V_d^c}{TF^c}=\frac{293+\frac{74}{0.654801}}{374+\frac{74}{0.654801}+20}-\frac{293}{374}=0.0174, t_{CA}=\frac{\{t|July\ 2002-July\ 2006\}}{t_{program}}=\frac{48}{420}=0.1143.$$

Seen from above, the total project fund includes the original fund plus *ex post* debt dollar and compensation (see S_{BC}^{1}). Hence, $R_c=\frac{374+\frac{74}{0.654801}+20}{374}=1.3556.$

After above investigation, there is no any government's *ex post* compensation while firm has no *ex post* investment in this case, so $x1=1$ and $x2=0$. Finally, government adopts rescue policy under CA.

Case 10(Reliance Rail in Australia)

Reliance Rail is the special vehicle under PPP program in New South Wales (NSW), Australia. It is established to finance, manufacture and maintain the train carriage for the rail network of Sydney. In particular, Rail Corporation New South Wales (Railcorp) is the regulation and administration agency of government.

At the case of Reliance Rail, there is $N_{CA}=1$. After financial distress, the NSW government takes over the project. On one hand, the financial crisis takes place in Global Financial Crisis (Aston 2012); neither government nor firm believes any *ex post* fund could be raised except government's takeover policy. The rescue package is infeasible. On the other hand, firm has already been under bankruptcy problem (Smh 2011). Takeover policy seems necessary.

At original contract, firm designs and manufactures the train and maintains the trains for 30 years (with potential two extension options of concession). This contract starts from 3 Dec 2006 (NSW 2012). The delivery is started in July 2011 (Railway-technology 2012). Namely, the program will originally last to July 2041. Under the original contract, about 2.4 billion AUD in debt and 137 million AUD in equity are arranged (Reliance Rail 2012). There is no public offering, after checking carefully to the details of NSW (2012). Combining these facts, there are following.

$$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{2400}{2400+137} = \frac{2400}{2537} = 0.9460, S_B^{02} = \frac{V_d^c}{TF^c} = \frac{2400}{2400+137} = \frac{2400}{2537} = 0.9460, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = 0, t_{program} = \{t|Dec\ 2006 - \ July\ 2041\} = 415.$$

The project has a delay. The time of delivery is expected to start in Dec 2010 while it is not really started until July 2011 (Railway-technology 2012). Hence, $R_t = \frac{\{t|Dec\ 2006\ to\ July\ 2011\}}{\{t|Dec\ 2006\ to\ Dec\ 2010\}} = \frac{55}{48} = 1.1458.$

Firm has no any demand risk under this PPP program, any of deflation of volume will not affect the income of firm (NEW 2012). Hence, $R_q = 1$.

On 3 Feb 2012, government asserts to take over the project (NSW 2012). This takes place when banruptcy problemhits the program (Smh 2011). It is government's bailout that ensures the banks extend the repayments of loan further; otherwise, firm will be bankrupted immediately (Smh 2011). Because of takeover policy by government, the contribution of government will include the whole project; meanwhile, the debt will not be reduced since 'the debt holders will be spared' (Aston 2012: 1). At the same time, debt will not be added since there is new loan for the project. Though the package will be implemented in 2018, the decision time, namely, the assignment of new agreement is in Feb 2012. The time of CA should be identified in 2012 rather than 2018[28]. Therefore, there are following.

[28] It is the expectation under the adjustment that affects the behaviours of stakeholders rather than the adjustment itself, so the decision time instead of implement time is the time of CA.

$S_{BC}^{1}=1, S_{BC}^{2}=\frac{2400}{2537}=0.9460, S_{BC}^{3}=1-\frac{2400}{2537}=\frac{137}{2537}=0.0540, S_{BC}^{4}=0, t_{CA}=\frac{\{t|Dec\ 2006\ to\ Feb\ 2012\}}{t_{program}}=\frac{62}{415}=0.1494.$

Seen from above, this program is originally expected to raise AUD 2537 million (see S_{BC}^{01}). It is actually bankrupted so that the equity is worthless (Aston 2012 and Saulwick 2012). Namely, firm get loss equal to equity investment of AUD 137 million (also see S_{BC}^{01}). Hence, $R_c=\frac{2537+137}{2537}=1.0540$.

After above investigation, there is no any government's *ex post* compensation or firm's *ex post* investment in this case, so $x1=0$ and $x2=0$. Finally, this case does not experience administration under the danger of bankruptcy; government takes over the project before that. This kind of takeover policy without administration process illustrates government is inclined to rescue firm even government has to take over it. In other words, government still rescue firm (though) in the manner of takeover package.

Case 11 (Tagus South LRS in Portugal)

Tagus South Light Rail System (Tagus South LRS) gets little revealed, though it is the one of first PPP programs in Portugal. It is named as above because it is located on the south bank of Tagus River. It links the cities of Almada and Lisbon (Cruz and Marques 2012). Metro transportes do sul is the holder of contract right for this program.

At the case of Tagus South LRS, there is $N_{CA}=1$. Due to the opposition of local government, the project is interrupted when it is close to finish. The Portuguese government compensates firm for that.

At original contract, the project is expected to raise 350 million EUR[29] (Cruz and Marques 2012). At that proposal, about 265M EUR is invested from government while firm need to invest about 86 million EUR[30] (Mota-Engil SGPS SA 2003: 28). It is hardly surprising

[29] The total fund is only 350 million though government invests 265 million while firm does 86 million. The difference between the first one and the sum of the other values should be from the approximation error.
[30] The total investment of firm includes €59 million for rolling stock while €27 million for operation and maintenance.

to understand no debt in project fund because of the significant contribution of government. In 2002, the consortium gets awarded the contract right with concession period of 30 year (including construction period) towards 2032 (Barraqueiro Group 2002).

$R_d = \frac{V_d^r}{V_d^c} = 0, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{265}{350} = 0.7571, S_{BC}^{02} = \frac{V_d^c}{TF^c} = 0, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = \frac{265}{350} = 0.7571, R_i = 0, t_{program} = 30 * 12 = 360.$

The project is expected to finish in Dec 2005 while it is actually finished in Nov 2008 (Lardlar 2009). The original contract is assigned in Aug 2002 (Mota-Engil SGPS SA 2003). Hence, $R_t = \frac{\{t|Aug\ 2002\ to\ Nov\ 2008\}}{\{t|Aug\ 2002\ to\ Dec\ 2005\}} = \frac{74}{40} = 1.85.$

This project experiences huge risk of demand. It is expected to have 80000 million passengers daily in the second year opening years[31] while there are actually only 35000 million passengers (Cruz and Marques 2012). Hence, $R_q = \frac{35000}{80000} = 0.4375.$

In comparison with the original contract, the renegotiation due to the opposition of local government 'between 2002 and 2004' is revealed without the precise time of decision (Cruz and Marques 2010: 4029). At the same time, Cruz and Marques (2012) points out that the compensation is implemented by Court of Audit in 2005. The final time of negotiation is necessarily the time of decision of renegotiation. So we could fix Dec 2004 as the decision time of renegotiation (namely, the time of CA). Due to the renegotiation, the project is delayed and then government pays for firm. As told by Cruz and Marques (2012), the compensation paid is 62.3M EUR.

$S_{BC}^1 = \frac{TF_{gb}}{TF} = \frac{265+62.3}{350+62.3} = \frac{327.3}{412.3} = 0.7938, S_{BC}^2 = \frac{V_d}{TF^c} = 0;\ S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = \frac{327.3}{412.3} - \frac{265}{350} = 0.0367, S_{BC}^4 = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = 0, t_{CA} = \frac{\{t|Aug\ 2002 - Dec\ 2004\}}{t_{program}} = \frac{28}{360} = 0.0778.$

[31] The comparison in first operational year is not available.

From above, it could be seen that the total project fund is €412.3 million (see S_{BC}^{1}). At the same time, this program is originally expected to raise €350 million (see S_{BC}^{01}). Hence, $R_c = \frac{412.3}{350} = 1.178$.

After above investigation, there is government's *ex post* compensation to firm while firm has no *ex post* investment in this case, so $x1 = 1$ and $x2 = 0$. Finally, government adopts rescue policy under CA.

Case 12 (STAR Light Rail Transit System in Kuala Lumpur)

There are three cases in Kuala Lumpur, the capital of Malyasia, in following. All these three cases under PPP program are taken over by government after financial distress. This case will talks about Light Rail Transit System (LRTS) undertaken by Sistem Transit Aliran Ringan Sdn Bhd (STAR) while the next one will deals with LRTS undertaken by Projek Usahasama Transit Ringan Automatik (PUTRA). Case 14 will talk about KL Monorail project.

STAR LRTS is the first rail-project in Kuala Lumpur with private partnership. The STAR is the holder of contract right under PPP. The contract starts in Nov 1991 (Cledan 2009). As mentioned before, this case is terminated as takeover package of government after financial distress; therefore, $N_{CA} = 1$.

At original contract, the program is expected to last 60 years since the start of program in Nov 1991 (Cledan 2009). The project gets US$ 0.92 billion or RM 3.5 billion (Schwarcz 2003). Government contribute 10% of fund and support 20% for the project in the loan (Kiggundu 2009). Among the rest, 10% is invested by private promoters and 60% gets from domestic commercial debt (Kiggundu 2009). Combining these facts, there are following.

$$R_d = \frac{V_d^r}{V_d^c} = \frac{0.6}{0.6+0.2} = 0.75, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = 0.1 + 0.2 + 0.6 = 0.9, S_{BC}^{02} = \frac{V_d^c}{TF^c} = 0.2 + 0.6 = 0.8, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0.1, R_i = 0, t_{program} = 60 * 12 = 720.$$

As given clearly by Tan (2008: 112), the construction is "completed on schedule". Hence, that $R_t = 1$.

This program experiences unexpected ridership. The project forecast in 1999 is 165000 to 170000 while the actual one only reaches 65000 (Tan 2008:120). Hence, according to the comparison in 1999, the mid-point between 165000 and 170000 is used as the denominator, $R_q = \frac{65000}{167500} = 0.3881$.

Finally, this program is taken over by government on 1 Sep 2002 without debt restructuring (Schwarcz 2003). The program is fully bailed out by government (Phang 2006). Hence,

$$S_{BC}^1 = \frac{TF_{gb}}{TF} = 1, S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = 1 - 0.9 = 0.1, t_{CA} = \frac{\{t|Nov\ 1991 - Sep\ 2002\}}{t_{program}} = \frac{131}{720} = 0.1819.$$

Moreover, in Nov 2001, firm has un-serviced debt RM 5.7 billion when government starts to take the assets of firm (Kiggundu 2009). All the debt should be transferred to government after takeover because there is no administration process after bankruptcy problem. The original debt takes only 80 percent of project fund (RM 3.5 billion), namely only RM 2.8 billion. If there is no *ex post* debt, the total debt cannot be enlarged towards RM 5.7 billion. Therefore, firm actually gets *ex post* RM 2.9 billion in debt before bailing-out. Hence, $S_{BC}^2 = \frac{V_d}{TF^c} = \frac{5.7}{3.5+2.9} = \frac{5.7}{6.4} = 0.8906, S_{BC}^4 = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{5.7}{6.4} - 0.8 = 0.0906.$

From above, it could be seen that the total project fund is RM 6.4 billion (see S_{BC}^2). At the same time, this program is originally expected to raise RM 3.5 billion (also see S_{BC}^2). Hence, $R_c = \frac{6.4}{3.5} = 1.8286$.

After above investigation, there is no any government's *ex post* compensation or firm's *ex post* investment in this case, so $x1 = 0$ and $x2 = 0$. Finally, government has to take over the project because it missed the chance to rescue firm. The increased debt (RM 2.8

billion) is over the equity investment (RM 0.7 billion); the bankrupted problem is severe. However, government undertake all of debt and firm has no administration process. This kind of takeover policy is actually special rescue package.

Case 13 (PUTRA Light Rail Transit System in Kuala Lumpur)

This case will study PUTRA LRTS. PUTRA is the holder of contract right under PPP. The contract starts in Feb 1993 (Cledan 2009). At this case, as mentioned before, government take over the project. Hence, $N_{CA} = 1$.

At original contract, the program is expected to last 60 years (Cledan 2009). The project gets US $ 1.15 billion or RM$ 4.4 billion (Schwarcz 2003). Government provide 25.6% of fund in the manner of soft loan, the consortium provide 20.4% as investment and 54% comes from "domestic commercial debt" (Kiggundu 2009: 9). Combining these facts, there are followings.

$$R_d = \frac{V_d^r}{V_d^c} = \frac{0.54}{0.256+0.54} = \frac{0.54}{0.796} = 0.6784, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = 0.256 + 0.54 = 0.796, S_{BC}^{02} = \frac{V_d^c}{TF^c} = 0.256 + 0.54 = 0.796, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, t_{progra} = 60 * 12 = 720, R_i = 0.$$

As given clearly by Tan (2008: 113), the construction is "completed on time". Hence, that $R_t = 1$.

This program experiences unexpected ridership. The project is assumed to have 360000 passengers per day while the reality only has 120000 in 1999 (Tan 2008:120). According to these number, hence, $R_q = \frac{120000}{360000} = 0.3333$.

This program is taken over together with the STAR LRTS by government on 1 Sep 2002 (Schwarcz 2003). Hence,

$$S_{BC}^1 = \frac{TF_{gb}}{TF} = 1, S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = 1 - 0.796 = 0.204, t_{CA} = \frac{\{t|Feb\ 1993 - Sep\ 2002\}}{t_{program}} = \frac{115}{720} = 0.1597.$$

Moreover, in Nov 2001, firm has also un-serviced debt RM 5.7 billion when government starts to take the assets of firm (Kiggundu 2009). All the debt should be transferred to government after takeover because there is no administration process. The original debt takes only 25.6 percent from government and 54 percent from banks while the original project fund is RM$ 4.4 billion, namely debt only reaches RM 3.5024 billion; now it reaches RM 5.7 billion. Firm actually gets *ex post* RM 2.1976 billion before bailing-out. Hence, $S_{BC}^{2}=\frac{V_d}{TF^c}=\frac{5.7}{4.4+2.1976}=\frac{5.7}{6.5976}=0.8640, S_{BC}^{4}=\frac{V_d}{TF^c}-\frac{V_d^c}{TF^c}=\frac{5.7}{6.5976}-0.796=0.0680.$

Seen from above, the total project fund is RM 6.5976 billion (see $\mathrm{S}_{\mathrm{BC}}^{2}$). At the same time, it is originally expected to raise RM 4.4 billion (also see $\mathrm{S}_{\mathrm{BC}}^{2}$). Hence, $R_c=\frac{6.5976}{4.4}=1.4995.$

After above investigation, there is no any government's *ex post* compensation or firm's *ex post* investment in this case, so $x1=0$ and $x2=0$. Finally, just as last case, government has to take over the project because it missed the chance to rescue firm. As mentioned, the increased debt is RM 2.1976 billion while equity investment has only 20.4 percent of project fund (RM 4.4 billion), namely RM 0.8976 billion. The increased debt is over the equity investment; the bankrupted problem is severe. However, government undertakes all of debt and firm has no administration process. This kind of takeover policy is actually special rescue package.

Case 14 (KL Monorail in Kuala Lumpur)

KL Monorail is similar to the above two cases in Kuala Lumpur. KL Monorail is the holder of contract right under PPP program. This cases has the similar situation, $N_{CA}=1$.

At original contract, the program is expected to last 40 years. The project gets US $310.5 million or RM 1.18 billion (Schwarcz 2003). Government supports the project in the debt (78%) while the private equity invests the rest (22%) (Kiggundu 2009). Because this program is not based on special purpose vehicle like the above two cases. No public offering is issued. Combining these facts, there are followings.

$R_d = \frac{V_d^r}{V_d^c} = 0, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = 0.78, S_{BC}^{02} = \frac{V_d^c}{TF^c} = 0.78, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = 0, t_{program} = 40 * 12 = 480.$

The contract under PPP starts on 29 Oct 1996 (Schwarcz 2003). The project is scheduled to finish at the end of 2001, but is actually finished on 31 Aug 2003 (Palapus and Hanaoko 2009). Hence, $R_t = \frac{\{t|Oct\ 1996 - Aug\ 2003\}}{\{t|Oct\ 1996 - Dec\ 2001\}} = \frac{82}{62} = 1.3226.$

This case also experiences severe over-estimation of ridership. The project is projected to have 60000-80000 per day at first year of operation (Tan 2008:120), but the real figure is only 11000 in 2003. 2003 is the first operation year in reality, so the ridership is expected to have 60000-80000 while the real one is only 11000. Hence, $R_q = \frac{11000}{70000} = 0.1571.$

This program declares bankruptcy after repeatedly miss of debt repayments on 15 May 2007 before takeover by government (Palapus and Hanaoko 2009). Because firm gets taken over by government after administration in the end, the global softness should reach the maximum value. Combining these facts, there are followings.

$S_{BC}^1 = \frac{TF_{gb}}{TF} = 1, S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = 1 - 0.78 = 0.22, t_{CA} = \frac{\{t|Oct\ 1996 - May\ 2007\}}{t_{program}} = \frac{127}{480} = 0.2646.$

Moreover, in fact, the project has already experienced financial crisis before bankruptcy. Firm is resumed only after additional RM$ 300 million as soft loan from government and extra RM$ 260 million from bank (Wikipedia 2013g). Hence, $S_{BC}^2 = \frac{V_d}{TF^c} = \frac{1180*0.78+300+260}{1180+300+260} = 0.8508, S_{BC}^4 = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{1180*0.78+300+260}{1180+300+260} - 0.78 = 0.0708.$

Seen from above, the total project fund is originally RM 1.180 billion (Schwarcz 2003), but it gets *ex post* debts of RM 300 million and RM 260 million. Hence, $R_c = \frac{1.18+0.3+0.26}{1.18} = \frac{1.74}{1.18} = 1.4746.$

After above investigation, there is no any government's *ex post* compensation or firm's *ex post* investment in this case, so $x1 = 0$ and $x2 = 0$. Finally, government has to take over the project because it missed the chance to rescue firm. Government takes over the project after administration process; this is different from last two cases.

Case 15 (Metronet in London)

London Underground is a complex system. It enters into PPP program with two private consortiums, Metronet and Tube Lines. The former is responsible for the maintenance over nine lines while the latter undertake the same role over the rest three lines. London Underground Limited (LUL) is responsible for the operation of underground system, as a public corporation. Each of concessions lasting 30 years is split as four $7\,{}^{1}/_{2}$-year periods. This part will talk about the PPP program with Metronet. The next part will talk about the one with Tube Lines.

This case has one CA in the manner of takeover by government, namely, $N_{CA} = 1$. This case witnesses a private firm go to bankruptcy before finishing one $7\,{}^{1}/_{2}$-year period, this does not contradict the conclusion of modelling though government takes over the project rather bail out firm. Banruptcy problemhits firm before the decision time.

At original contract, Metronet will have 30-year concessions. On 4 April 2003, Metronet formally takes over the lines under PPP (National Statistics 2007). In contract, Metronet will raise £2650 million in debt while £410 million in equity (HM Treasury 2005). Combining these facts, there are followings.

$S_{BC}^{01} = \frac{TF_{gb}^{c}}{TF^{c}} = \frac{2650}{2650+410} = 0.8660, S_{BC}^{02} = \frac{V_{d}^{c}}{TF^{c}} = \frac{2650}{2650+410} = 0.8660, S_{BC}^{03} = \frac{TF_{g}^{c}}{TF^{c}} = 0, t_{program} = 30 * 12 = 360.$

However, 95% of debt gets guaranteed from government (National Statistics 2007), in other words, at contract, 95% of debt gets no risk due to government guarantee.

$R_d = \frac{V_d^r}{V_d^c} = 1 - 0.95 = 0.05.$

All of fund in equity derives from the Metronet's original 'equity stake' (National Statistics 2007: 6), namely, the equity fund under PPP program does not need to gather from outside.

$R_i = 0.$

Due to the bankruptcy, the program has not been finished. The time inflation could be only estimated with relevant facts. The Metronet has 34 schemes delayed in April 2007, of which some lines are delayed more than one year while some of them are delayed almost one year (Richardson 2007). Any finish time of project must be the day of latest part; hence, Metronet has delayed more than one year until April 2007. Because of no precise time, it is safe to 'one year' as the delay time to avoid the over-estimation of time-overrun-risk. Hence, $R_t = \frac{\{t|April\ 2003 - April\ 2007\}+12}{\{t|April\ 2003 - April\ 2007\}} = \frac{60}{48} = 1.25.$

This program transfers no demand risk to the private firm since firm gets payment for its performance (National Statistics 2007). Hence, $R_q = 1$.

At the bankruptcy, government does not let the program stop; the project is totally taken over by government. In particular, there is no additional loan to firm. On 18 July 2007, the Metronet was placed in administration. Combining these facts, there are following.

$S_{BC}^1 = \frac{TF_{gb}}{TF} = 1, S_{BC}^2 = \frac{V_d}{TF^c} = \frac{2650}{2650+410} = 0.8660, S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = 1 - \frac{2650}{2650+410} = 0.1340, S_{BC}^4 = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = 0, t_{CA} = \frac{\{t|April\ 2003 - July\ 2007\}}{t_{program}} = \frac{51}{360} = 0.1417.$

The Metronet is estimated to cost £ 8.7 billion at original plan while the number is updated to 10.5 billion in reality (NAO 2009). These two values are in the same price level, since NAO (2009) pints out that the difference between these two amounts leads to the dispute and then the takeover policy by government. Hence, $R_c = \frac{10.5}{8.7} = 1.2069.$

After above investigation, there is no any government's *ex post* compensation or firm's *ex post* investment in this case, so $x1 = 0$ and $x2 = 0$. Finally, government takes over firm because firm goes to bankruptcy. Though government want to resell it to a new partner, however, this is not realized (Wikipedia 2013h). Until now, this program is still controlled by government. Government may rescue firm, but the takeover policy must be applied due to the bankruptcy problem.

Case 16 (Tube Lines in London)

This part will talk about the PPP program with Tube Line. The background has been illustrated in last part.

This case has three CAs, including a refinance, compensation and the final takeover; hence, $N_{CA} = 3$. The first one is refinance package in May 2004, which adds more equity fund. In 2009, the PPP arbitrator agrees compensation worthy £400 million to firm, which actually reallocate the income right of firm for the first $7\,{}^{1}/_{2}$-year period. In 2010, government asserts to buy out the share of Tube Lines; the PPP program is over.

At original contract, Tube Lines has 30-year concession. On 31 December 2002, the project is formally taken over by the Tube Lines (National Statistics 2007). In contract, the Tube Lines is expected to raise £1803 million in debt while £315 million in equity (HM Treasury 2005). Combining these facts, there are followings.

$S_{BC}^{01} = \frac{TF_{gb}^{c}}{TF^{c}} = \frac{1803}{1803+315} = \frac{1803}{2118} = 0.8513, S_{BC}^{02} = \frac{V_{d}^{c}}{TF^{c}} = \frac{1803}{1803+315} = 0.8513, S_{BC}^{03} = \frac{TF_{g}^{c}}{TF^{c}} = 0, t_{program} = 30 * 12 = 360.$

However, 95% of debt gets guaranteed from government (National Statistics 2007), in other words, at contract, 95% of debt gets no risk due to government guarantee.

$R_{d} = \frac{V_{d}^{r}}{TF^{c}} = 1 - 0.95 = 0.05.$

All of fund in equity derives from the Tube Lines' original 'equity stake' (National Statistics 2007: 6), namely, the equity fund under PPP program does not need to gather from outside.

$R_i = 0.$

As for the time inflation of Tube Lines program, all of delay derives from the dispute over the second periodic payment (Butcher 2012a). The delay of Tube Lines is stimulated by economic regulation instead of PPP. Hence, $R_t = 1$.

Firm has no any demand risk; any of deflation of volume will not affect the income of firm since firm gets payment for its performance (National Statistics 2007). Hence, $R_q = 1$.

At the first periodic review, PPP arbitrator will only give £4.46 billion while firm insists on £5.75 billion as payment for the second period. After dispute cannot be resolved under PPP, in May 2010, government decides to buy out the Tube Lines. If both of estimations are right, firm will have potential loss of £1.29 billion[32]. Obviously, this kind of loss will consume the equity capital (at original one is £315 million, the updated one will be £180 million). The project will also have the danger of bankruptcy in second period. With expectation of potential collapse, government takes the Tube Lines to avoid the same consequence in Metronet (Butcher 2012). Combining above facts, there are followings.

$$S_{BC}^1 = 1, S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = 1 - \frac{1803}{1803+315} = 0.1487, t_{CA} = \frac{\{t|Dec\ 2002 - May\ 2010\}}{t_{program}} = \frac{89}{360} = 0.2472.$$

The financial structure is changed in May 2004 (the first CA), the debt is increased towards £1972 million and equity is reduced to £180 million (NAO 2009). After that, the debt is not changed once again, but firm gets £400 million (mentioned above) as

32 1.29 billion derives from 5.75 billion minus 4.46 billion, which are respective payments firm and government insist on.

compensation from government at the second CA. In addition, the takeover policy does not change financial arrangement except the ownership transfer. Hence, there are followings.

$S_{BC}^{2} = \frac{V_d}{TF^c} = \frac{1972}{1972+180+400} = \frac{1972}{2552} = 0.7727, S_{BC}^{4} = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{1972}{1972+180+400} - \frac{1803}{1803+315} = -0.0785.$

Seen from above, the total project fund is £2552 billion (see $\mathrm{S}_{\mathrm{BC}}^{2}$). At the same time, it is originally expected to raise £2118 billion (see $\mathrm{S}_{\mathrm{BC}}^{01}$). Hence, $R_c = \frac{2552}{2118} = 1.2049$.

After above investigation, there is government's *ex post* compensation to firm while firm has no *ex post* investment in this case, so $x1 = 1$ and $x2 = 0$. Finally, government adopts the takeover policy when the bankruptcy problem is expected under the next period. This is very special case. Under most of PPP program, there is no period review for PPP program. It is obvious that this case use PPP mechanism and economic regulation together. In this way, government may be able to avoid some problem in future at the review time.

Case 17 (MRT-3 project in Philippines)

Manila Metro Rail Transit System Line 3 (MRT-3) is the first urban rail project under PPP in Philippines. Metro Rail Transit Corporation (MRTC) is the holder of contract right under this program.

This case has four CAs, $N_{CA} = 2$. At first, as the first PPP program in Philippines (Llanto and Zen 2013), the contract awarded on 7 Nov 1991 (Cledan 2003) is not effective due to legal problem. In Aug 1997 after a series of renegotiation, the really effective contract is signed to MRTC. The contract in 1997 will be the original contract for investigation in this case. In 2008, government buys out the 80 percent of equity through two government-owned banks (Gonzales and Agcaoili 2012). In 2012, government buyout the project fully including purchasing 80 percent from two banks.

At original contract signed in Aug 1997, this project is expected to raise US$ 655 million (Llanto and Zen 2013). US$ 190 million is in equity while US$ 465 million is in debt

(Cledan 2003). All of equity comes from MRTC, there is no public offering (Llanto and Zen 2013). Moreover, the contract is expected to have 25-year operation. The termination time of contract depends on the real date of completion. Actually, the project is finished on 20 July 2000 (Wikipedia 2013i). Namely, the contract is implemented until July 2025. Combining these facts, there are followings.

$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_g^c}{TF^c} = \frac{465}{655} = 0.7099, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{465}{655} = 0.7099, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = 0, t_{program} = \{t|Aug\ 1997 - July\ 2025\} = 335.$

This project is first PPP in Philippines; it has extremely protection from *ex post* risk. One of them is that the contract awards firm 25 years after the real date of completion. Namely, there is no date-target of completing project and then no issue of project delay. Hence, $R_t = 1$.

Under this program, firm gets guaranteed rate of return for investment by 15 percent per year (Llanto and Zen 2013). Government adjusts payment for firm around the threshold level of 450000 ridership per day (Cledan 2003). Namely, the expectation of ridership is 450000. However, the real one in the first year (1999) reaches only 25000 (Okada et al 2003). Hence, $R_q = \frac{25000}{450000} = 0.0556$.

Finally, the contribution of government should reach the maximum value when the project is buyout fully by government on Dec 2012 (Gonzales and Agcaoili 2012). Hence, $S_{BC}^1 = \frac{TF_g}{TF} = 1, S_{BC}^3 = \frac{TF_g}{TF} - \frac{TF_g^c}{TF^c} = 1 - \frac{465}{655} = \frac{190}{655} = 0.2901, t_{CA} = \frac{\{t|Aug\ 1997 - Dec\ 2012\}}{t_{program}} = \frac{184}{335} = 0.5493.$

When firm starts to construct the project, the debt becomes 485.5 million dollar and then the toatal project fund is increased towards 675.5 million dollar (Llanto and Zen 2013). In addition, at this case, government compensates firm continuously before the buyout, reaching 7 billion Peso (Philippines' currency) (Gonzales and Agcaoili 2012). The total fund will include the original 655 million USD in original contract, 20 million USD at the construction start and the subsidies of 7 billion Peso. The above US dollar should be converted into Philippines' Peso for the following measurement. The original plan is in 1997, the exchange rate in 1997 between dollar and Peso is 29.470658[33] from PWT (2013). Hence, there are following.

$S_{BC}^2 = \frac{V_d}{TF^c} = \frac{485.5*29.4706583333333}{675.5*29.4706583333333+7000} = 0.5317, S_{BC}^4 = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{485.5*29.4706583333333}{675.5*29.4706583333333+7000} - \frac{465}{655} = -0.1782.$

Seen from above, the total project fund is 675.5 million dollar plus later 7 billion Peso (see S_{BC}^1). At the same time, it is originally expected to raise 655 million dollar (see S_{BC}^{01}). Hence, $R_c = \frac{675.5*29.4706583333333+7000}{655*29.4706583333333} = 1.3939$.

After above investigation, there is government's *ex post* compensation while firm has no *ex post* investment in this case, so $x1 = 1$ and $x2 = 0$. Finally, government adopts rescue policy under CA firstly, and then takeover policy is applied in third CA.

Case 18 (M1/M15 Motorway in Hungary)

M1/M15 motorway in Hungary has two sections, M1 and M15. The M1 links Gyor with Austria border while the M15 links the M1 with Bratislava. Elso Magyar Koncesszios Autoplaya Rt. (ELMKA) is the holder of contract right for this program.

At the case of M1/M15 Motorway, there is $N_{CA} = 1$. Due to the forecast deficit for the traffic volume, firm experiences loss and then the Hungary government takes over the job of ELMKA.

At the original contract, the M1/M15 motor way is funded with 320M USD. Among the project fund, debt and equity accounts for 82% and 18%, respectively (IDEA, 2010). There is no government grant or subsidy. At the same time, as pointed out by IDEA (2010), all of fund is gathered by the consortium, not firm. In addition, as mentioned by

[33] The precise value of it for measurement is 29.4706583333333. Any value before the final result will be kept as precise as possible.

Smith (2006), the contract starts from April 1993 and it covers the period length of 35 years. Combining these facts, there are followings.

$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = 0.82, S_{BC}^{02} = \frac{V_d^c}{TF^c} = 0.82, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = 0, t_{program} = 35 * 12 = 420.$

In addition, the project is on schedule for the first section, which is officially open in Jan 1996 (PPIAF 2009). However, firm decide to stop the construction of the second section to force government bail it out. Because this program has no tine requirement for the second section and the first section is finished as expected, the time target for this project will be equal to the total time of construction minus the time of unmoving. The time of suspension reaches seven months (Carpintero 2010). The program starts in April 1993 and the second section of project is finished in July 1998 (PPIAF 2009). Therefore, we have $R_t = \frac{\{t|April\ 1993 - July\ 1998\}}{\{t|April\ 1993 - July\ 1998\}-7} = \frac{63}{63-7} = 1.125$.

This project experiences huge risk of demand. The actual traffic on average in the first year of operation is only 55% of estimation[34] (Carpintero 2010). Hence, $R_q = 0.55$.

In comparison with the original contract, the restructure appealed by firm is obtained in manner of government taking over the project in April 1999 (Smith 2006). Firm's debt is only transferred into a sovereign debt (Smith 2006); debt is not added or reduced before CA. Combining above facts, there are followings.

$S_{BC}^1 = \frac{TF_{gb}}{TF} = 1, S_{BC}^2 = \frac{V_d^c}{TF^c} = 0.82;\ S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = 1 - 0.82 = 0.18, S_{BC}^4 = 0, t_{CA} = \frac{\{t|April\ 1993 - April\ 1999\}}{t_{program}} = \frac{72}{420} = 0.1714.$

From above, it could be seen that this program is originally expected to raise 320 million dollar (see above). It is actually bankrupted so that 'sponsors lost their equity' (IDEA 2008: 34). In particular, this case has no more loss since IDEA (2008) points out firm gets

[34] The average comparison during the whole operation is about 46% (PPIAF 2009).

nearly bankrupted in spite of the statement that equity is lost. Namely, firm get loss when the equity investment should be 320*18% million dollars. Hence, $R_c = \frac{320+320*18\%}{320} = 1.18$.

After above investigation, there is no any government's *ex post* compensation or firm's *ex post* investment in this case, so $x1 = 0$ and $x2 = 0$. Finally, government adopts the takeover policy under bankrupt problem.

Case 19 (M5 Motorway in Hungary)

M5 Motor way in Hungary has three phases, linking Budapest, Kecskemét, Szeged and finally Röszke at the Sebian border. The special purpose company, Alflold Koncesszios Autopalya Rt. holds the contract right of program.

At this case, there is $N_{CA} = 1$. As the one of first motorways under PPP program, the traffic volume is also overestimated once again. The restructure ends up in manner of acquisition by government-owned firm.

Furthermore, at the original contract, the M5 motor way is funded with project fund of 370M ECU (EC 2004). Among the fund, only 66.6M ECU derives from equity while the rest comes from loan. All of the debt comes from European Bank for Reconstruction and Development (EBRD) directly or indirectly[35] (EC 2004), so there is no risk in raising debt. The contract is assigned in May 1994 while the concession will last towards Jan 2031 (European PPP Center 2012).

$$R_d = \frac{V_d^r}{V_d^c} = 0, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{370-66.6}{370} = \frac{303.4}{370} = 0.82, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{370-66.6}{370} = \frac{303.4}{370} = 0.82, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = 0, t_{program} = \{t|May\ 1994 - Jan\ 2031\} = 440.$$

As mentioned by 2003 (EC 2004), the construction is expected to finish by 2003. The start time of contract in May 1994 while the real end time of construction in March 2006

[35] The indirect means the loan gets the EBRD's guarantee.

(European PPP Center 2012), Hence, $R_t = \frac{\{t|May\ 1994 - March\ 2006\}}{\{t|May\ 1994 - Dec\ 2003\}} = \frac{142}{115} = 1.2348$.

This project experiences large risk of demand. The actual traffic is 35%-40% lower than the forecast (Kerali 1999). For the measurement, we use the mean value to reflect the demand risk. Hence, $R_q = 1 - 0.375 = 0.625$.

In comparison with the original contract, the acquisition in March 2004 transfers partial risks towards government, changes the payment mechanism and supports loan towards firm. As European PPP Center (2012) points out, 39.48% share is sold to the state-owned-firm while two sets of loan (worthy of 750M and 150M, respectively) is agreed.

$S_{BC}^1 = \frac{39.48}{100} + \left(1 - \frac{39.48}{100}\right) * \frac{750+150+303.4}{750+150+370} = 0.9683, S_{BC}^2 = \frac{TF_{gb}}{TF} = \frac{750+150+303.4}{750+150+370} = \frac{1203.4}{1270} = 0.9476;\ S_{BC}^3 = \frac{39.48}{100} + \left(1 - \frac{39.48}{100}\right) * \frac{750+150+303.4}{750+150+370} - \frac{303.4}{370} = 0.1483, S_{BC}^4 = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{1203.4}{1270} - \frac{303.4}{370} = 0.1276, t_{CA} = \frac{\{t|May\ 1994 - March\ 2004\}}{t_{program}} = \frac{118}{440} = 0.2682$.

The project has additional sets of *ex post* loan worthy of 750M and 150M (see S_{BC}^2), respectively while the original fund is 370M ECU (see S_{BC}^{01}). Hence, $R_c = \frac{370+750+150}{370} = 3.4324$.

After above investigation, there is no any government's *ex post* compensation or firm's *ex post* investment in this case, so $x1 = 0$ and $x2 = 0$. Finally, government adopts the rescue policy when the huge *ex post* risk hits the program. The risk scale could be seen from the indicator of R_c and R_q.

Case 20 (M2 Motorway in Australia)

M2 (Hill) Motorway is the PPP program in Sydney. Hill Motorway Limited (HML) is the holder of contract right for the project.

This case has six CAs, $N_{CA} = 5$. During 2007-2010, the project witnesses a series of minor changes that is officially confirmed in four contract amendments. Therefore, there are four CAs during 2007-2010 (TR&TA 2010). After that, there is a big revise in 2010 which changes the original project plan and refinances the program. Among these CAs, only the last one changes the corporation's finance structure, the first four have no additional fund-raising.

Under the original contract, firm will raise $ 496 million AUD, which includes 111 million AUD in debt, 200 million AUD in CPI bonds, 155 million AUD in investor equity and 30 million AUD in sponsors equity (IPA 2008a). Namely, there will be $ 311 million AUD in debt and $ 185 million AUD in equity. Among equity, only $ 30 million AUD is from founder shareholders. At original contract, the contract lasts from 26 Aug 1994 to 26 May 2042; however, it is extended to 26 May 2046 in "M2 Upgrade Arrangements" that is stipulated in 2010. Combining these facts, there are followings.

$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{311}{496} = 0.6270, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{311}{496} = 0.6270, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = \frac{155}{155+30} = \frac{155}{185} = 0.8378, t_{program} = \{t|Aug\ 1994 - May\ 2046\} = 621.$

The project is operated seven months ahead of schedule (the Treasury 2013b) on 26 May 1997. Hence, $R_t = \frac{\{t|Aug\ 1994 - May\ 1997\}}{\{t|Aug\ 1994 - May\ 1997\}+7} = \frac{33}{40} = 0.825.$

This case has *ex post* demand risk. This firm is scarcely open to outside world. The demand deflation could be only estimated. As pointed by Goldberg (2006), the M2 Motorway is expected to have 91902 vehicles per day in 2006. The extrapolation is 2% per year from 2006 forward to 2042 or backward to 1998 (Goldberg 2006). Hence, the estimation in 2000 is $91{,}902/(1+0.02)^6$ vehicles per day. However, the real one in 2000 is only 60,000 vehicles per day. Hence, $R_q = \frac{60000}{91{,}902/(1+0.02)^5} = 0.7352$. As for the real traffic in 2000, it could be inferred from following.

'During the last 10 years [2000-2010], Average Annual Daily Traffic (AADT) traffic volumes along M2 have increased from 60,000 vehicles per day (vpd) to over 95,000 vpd···' (NSW government 2010a: 23)

The final CA refinancing the project is taken effect on 18 Nov 2010. At that revise, firm must fund the upgrade project with estimated cost of $ 546 million AUD while the concession will be extended towards 2046 (the Treasury 2013b). For this extra project, new debt ($ 275 million AUD) gets from six banks while the existing debt ($ 465 million)[36] is also refinanced (Transurban 2010). From last sentence, there are two important meanings: (1) there is new loan worthy of 275 million AUD in final CA and (2) there must be *ex post* debt worthy of 154 million AUD (from original 311 million towards 465 million AUD) before the final CA. It is obvious that this debt cannot be realized without government allowance for the concession extension. Combining above facts, there are following[37].

$$S_{BC}^{1} = \frac{TF_{gb}}{TF} = \frac{311+275+154}{496+275+154} = \frac{740}{925} = 0.8, S_{BC}^{2} = \frac{V_d}{TF^c} = \frac{311+275+154}{496+275+154} = \frac{740}{925} = 0.8, S_{BC}^{3} = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^{c}}{TF^c} = \frac{311+275+154}{496+275+154} - \frac{311}{496} = 0.1730, S_{BC}^{4} = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{311+275+154}{496+275+154} - \frac{311}{496} = 0.1730, t_{CA} = \frac{\{t|Aug\ 1994 - Nov\ 2010\}}{t_{program}} = \frac{194}{621} = 0.3124.$$

Seen from above, the total project fund is AUD 925 million (see S_{BC}^{1}). At the same time, it is originally expected to raise AUD 496 million (see S_{BC}^{01}). Hence, $R_c = \frac{925}{496} = 1.8649$.

After above investigation, there is no government's *ex post* compensation while firm has *ex post* investment since new approved debt (275 million AUD) is less than the cost of extra project (546 million AUD) in this case, so $x1 = 0$ and $x2 = 1$. Finally, government adopts rescue policy under CA.

[36] The debt is updated towards 465 million AUD from originally 311 million AUD. The increased debt should derive from new loan; otherwise, the total debt cannot be increased.

[37] For measuring S_{BC}^{2} and S_{BC}^{4}, we will use $ 465 million (the existing debt before CA) rather than $ 311 million (the debt at original contract) because the new debt is based on the existing financial situation.

Case 21 (Don Muang Tollway in Thailand)

Don Wuang Tollway is one of first PPP program in Thailand. Don Muang Tollway Public Company Limited, led by a German firm, is the holder of contract under PPP (PadeCo 1999).

This case has one complex CA, $N_{CA} = 1$. The bailing-out package includes extension of project, debt refinancing and buyout of some equity from firm.

At original contract, the project is expected to US$ 407 million, of which 23 percent is from equity (PadeCo 1999). The contract is expected to last 25 years (PadeCo 1999). The relevant debt does not get government involvement and there is no public offering. Combining these facts, there are followings.

$$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_g^c}{TF^c} = 1 - 0.23 = 0.77, S_{BC}^{02} = \frac{V_d^c}{TF^c} = 1 - 0.23 = 0.77, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = 0, t_{program} = 25 * 12 = 300.$$

This program gets a fixed time to firm; as an early PPP program in Thailand, no hard time target is found from available information. More importantly, the delay risk from construction will be fully transferred to contractor of firm (the construction firm) from firm with liquidated damages (Mody 1996). In other words, even there is delay risk; it will be transferred from firm to the construction firm. This research focuses on contract relationship between firm and government, the potential of delay risk will only be related to firm and the construction firm. Considering no potential issue about construction risk between firm and government, $R_t = 1$.

The project experiences *ex post* risk of demand. Government does not realize its promise of removing two flyovers in neighbourhood of the project before CA; hence the traffic is lowered than the estimated one. Firm gets only one third of “forecast revenue” (ADB 2000: Appendix-30). In view of ADB (2000), the lower revenue derives from low traffic; hence, $R_q = \frac{1}{3}$.

The bailing-out package includes five aspects. The first one is the realization of government promise at original contract, the second one includes two extensions of project, the third one is to increase the level of toll, the forth one is firm should invest another US$ 61 million and borrow US$ 148 million for extension of project (PadeCo 1999). The final one is the buyout decision of government (40 percent of equity) from firm (ADB 2000). For the measurement, only the last two will be used as following. In particular, the original contract is signed on 21 Aug 1989 (UKP 2007) while the adjusted one is in Oct 1996 (PadeCo 1999). Combining these facts, there are followings.

$S_{BC}^1 = \frac{TF_g}{TF} = 0.4 * 1 + 0.6 * \frac{407*(1-0.23)+148}{407+61+148} = 0.8494, S_{BC}^2 = \frac{V_d}{TF^c} = \frac{407*(1-0.23)+148}{407+61+148} = \frac{461.39}{616} = 0.7490, S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = 0.8494 - 0.77 = 0.0794, S_{BC}^4 = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{461.39}{616} - 0.77 = -0.0210, t_{CA} = \frac{\{t|Aug\ 1989 - Oct\ 1996\}}{t_{program}} = \frac{86}{300} = 0.2867.$

From above, it could be seen that the total project fund is 616 million USD while this program is originally expected to raise €407 million USD (see S_{BC}^2). Hence, $R_c = \frac{61+148+407}{407} = \frac{616}{407} = 1.5135$.

After above investigation, there is no any direct government's *ex post* compensation while firm has *ex post* investment from shareholders (61 million USD, see above), which will be compensated in the manner of toll increase. So $x1 = 0$ and $x2 = 1$. Finally, government adopts rescue policy under CA.

Case 22 (M6 Tollway in Birmingham)

This case specially studies M6 Tollway in Birmingham, as the first Tollway under PPP in Britain (Aecom 2007). Midland Expressway Limited (MEL) is the holder of contract right under PPP.

This case has two CAs, $N_{CA} = 1$. The debt gets refinanced in 2007. Firm get full gain of $700 million from refinancing since government does not require to share gain; firm decides to make additional investment in return for government contribution (Aecom

2007). This kind of debt restructure infuses *ex post* fund and extends the original contract scope, thereby adjusting original contract relationship.

At the original contract, the project is expected to raise 1.13 billion USD in debt and 0.32 billion USD in equity (Virtuosity Consulting 2005). The debt has no government guarantee while the equity comes from the private promoter. The contract starts from Sep 2000 and will last 53 years (Aecom 2007). Because of these, there are following.

$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{1.13}{1.13+0.32} = \frac{1.13}{1.45} = 0.7793, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{1.13}{1.13+0.32} = \frac{1.13}{1.45} = 0.7793, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = 0, t_{program} = 53 * 12 = 636.$

The original contract awards firm 50 years for operation after three-year construction (Wikipedia 2013j). However, the project is not finished until Oct 2003 since the start time in Sep 2000 (Aecom 2007). Namely, there is one month delay with the 3-year expectation, $R_t = \frac{37}{36} = 1.0278.$

This project is early PPP program and it experiences the local opposition, the forecast of demand cannot be available. The local opposition delays the program start for eight years, so the forecast of demand in original proposal may lose meaning after eight-year delay, so the ratio of R_q is missed in this case. $R_q = NA$.

The project gets *ex post* debt worthy 0.25 million USD[38] after original plan (Virtuosity Consulting 2005), thereby leading the project fund to reach 1.7 billion dollar. In May 2007, the project has a refinancing package in firm's $1.1 billion debt[39] (Aecom 2007). Government approves all of gain of $ 700 million in order that firm will make early profit from investment (Aecom 2007). Due to the gain, firm decides to invest new project as

[38] The precise time of subsequent debt cannot be ensured, but it must be before May 2005 because the source of information is in May 2005. From this, we could be sure that the debt will be before two CAs.

[39] Here should be 1.13 billion, referring above literature. This kind of tiny difference is always from the fact that the authors of literature neglect it when those are unimportant.

return to government. Because the new investment is from gain, it will not be added as additional fund for project. Combining these facts, there are followings.

$S_{BC}^{1} = \frac{TF_g}{TF} = \frac{1.13+0.25+0.7}{1.7+0.7} = 0.8667, S_{BC}^{2} = \frac{V_d}{TF^c} = \frac{1.13+0.25}{1.7+0.7} = 0.575, S_{BC}^{3} = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^{c}}{TF^c} = \frac{1.13+0.25+0.7}{1.7+0.7} - \frac{1.13}{1.45} = 0.0874, S_{BC}^{4} = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{1.13+0.25}{1.7+0.7} - \frac{1.13}{1.45} = -0.2043, t_{CA} = \frac{\{t|Sep\ 2000 - May\ 2007\}}{t_{program}} = \frac{80}{636} = 0.1258.$

Seen from above, the total project fund is 2.4 billion dollars (see $\mathrm{S}_{\mathrm{BC}}^{1}$). At the same time, it is originally expected to raise 1.45 billion (see $\mathrm{S}_{\mathrm{BC}}^{01}$). Hence, $R_c = \frac{1.7+0.7}{1.45} = 1.6552$.

After above investigation, there is government's approval of gain in refinancing while firm has no *ex post* investment from shareholders in this case, so $x1 = 1$ and $x2 = 0$. Finally, government adopts rescue policy under CA.

Case 23 (A4 Motorway in Poland)

A4 Motorway is the first motorway under PPP in Poland. Stalexport S.A (SSA) and then Stalexport Autostrada Małopolska S.A. (SAM) is the holder of contract under PPP. In 2004, due to the legal security, the concession is transferred to SAM, the special purpose vehicle, from SSA as a consortium (SAM S.A 2009).

This case has two CAs, hence, $N_{CA} = 2$. In Oct 2005, there is a new concession agreement (Cuttaree et al 2009). In Nov 2006, the vignette system is introduced and then firm has lost some income right.

This project is launched from treasury of government by a loan from Europe Band of Reconstruction Development (EBRD) (Hertogh et al 2008). In particular, the loan from EBRD is €60 million (Hertogh et al 2008 and Cuttaree et al 2009), which is serviced by the state treasury, but is repaid by firm in future (Cuttaree et al 2009). This kind of debt is a loan for firm with strong support from government instead of grant. The total amount of project fund should be estimated from data in later stage. As pointed by INECO (2006), firm raises €102 million from commercial bank, representing 57% of project fund. At the same time, a new loan (from commercial banks) is obtained from new loan agreement in 2005 (Hertogh et al 2008), so the original contract has (1) project fund worthy of only $\frac{102}{0.57} - 102$ million EUR and (2) private fund worthy of $\frac{102}{0.57} - 102 - 60$ million EUR. There is no public offering because two of shareholders own 100% equity (see Cuttaree et al 2009). Firm is awarded on March 15 1997 (Cuttaree et al 2009). The operation is started in April 2000 and expected to last 27 years (Cuttaree et al 2009). Namely, the program will last from March 1997 to April 2027. Combining these facts, there are followings.

$$R_d = \frac{V_d^r}{V_d^c} = 0, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{60}{\frac{102}{0.57} - 102} = 0.7798, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{60}{\frac{102}{0.57} - 102} = 0.7798, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0,\ R_i = 0,\ t_{program} = \{t | March\ 1997 - April\ 2027\} = 361.$$

This project has actually a second extension under PPP. The new extension is expected to last from 2010 to 2018; it is not included in this case study for investigation since the new extension is not finished. At the same time, there is no delay problem when the project has still a construction plan. Hence, $R_t = 1$. Because the program experiences essential changes (ASECAP 2011), the traffic risk becomes irrelevant. Hence; $R_q = NA$.

In Oct 2005, there is a new concession agreement between firm and government (Cuttaree et al 2009). As stipulated by the new concession agreement, firm get an approval by government to have a new loan from commercial banks worthy of €102 million EUR (mentioned above) for the new (a second) phase of project. Hence, the total fund reaches 102/0.57 million EUR. In Nov 2006, vignette system is introduced and then firm has no right to get toll from vehicle driver over 3.5 ton (Hertogh et al 2008). Though government promises to compensate 70% of revenue loss, the dispute is still not able to be settled (Cuttaree et al 2009). Considering the compensation package is not officially formed, it will not be included in measurement. Another reason for neglecting the potential compensation is firm has a corresponding improvement in financial position in the first month of applying new system (Hertogh et al 2008). The compensation dispute around (potential) revenue loss is not relevant any more. Combining above facts, there are followings.

$S_{BC}^{1} = \frac{TF_g}{TF} = \frac{102+60}{102/0.57} = 0.9053, S_{BC}^{2} = \frac{V_d}{TF^c} = \frac{102+60}{102/0.57} = 0.9053, S_{BC}^{3} = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^{c}}{TF^c} = \frac{102+60}{102/0.57} - \frac{60}{\frac{102}{0.57}-102} = 0.1255, S_{BC}^{4} = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{102+60}{102/0.57} - \frac{60}{\frac{102}{0.57}-102} = 0.1255,\ t_{CA} = \frac{\{t|Match\ 1997 - Nov\ 2006\}}{t_{program}} = \frac{115}{361} = 0.3186.$

Seen from above, the total project fund is €102/0.57 million (see $\mathrm{S}_{\mathrm{BC}}^{1}$). At the same time, it is originally expected to raise €(102/0.57-102) million (see $\mathrm{S}_{\mathrm{BC}}^{01}$). Hence, $R_c = \frac{102/0.57}{\frac{102}{0.57}-102} = 2.3256$.

After above investigation, there is no direct government's *ex post* compensation or firm's *ex post* investment in this case, so $x1 = 0$ and $x2 = 0$. It should mention that the project is from debt instead of investment of firm, so $x2 = 0$. Finally, government adopts rescue policy.

Case 24 (Delhi Noida Bridge in India)

Delhi Noida Bridge is the one of projects developed under PPP in India. Noida Toll Bridge Company Limited is the holder of contract right under PPP as a special vehicle. It is responsible for the design, operation and maintenance of the bridge.

This case has one CA, hence, there is $N_{CA} = 1$. Because of overestimation of volume; the heavy interest cost consumes all of revenue in the first year. Firm gets a financial restructure.

At original contract, the program starts on 12 Nov 1997 and will last 30 years, including construction period (Pargal 2007). Government guarantees firm's revenue and limits the liability of firm. Moreover, under original contract, the project will raise Indian Rupee (Rs.) 285.8 crore (equal to '10 millions' in British English) in debt while Rs. 122.4 crore (Pargal 2007) in equity. The financial arrangement is independent from government contribution. In particular, the International Leasing & Financial Service Limited (IL&FS) is the private promoter. It supply 25.35% equity stake (PPFAS 2010). Namely the rest should be still raised from outsider by the IL&FS. Combining these facts, there are following.

$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{285.8}{122.4+285.8} = \frac{285.8}{408.2} = 0.7001, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{285.8}{122.4+285.8} = \frac{285.8}{408.2} = 0.7001,\ S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = 1 - 0.2535 = 0.7465, t_{program} = 30 * 12 = 360.$

The project is expected to finish in 29 months, but is finished four months before the schedule (IL&FS Transportation Network 2001). Hence, $R_t = \frac{29-4}{29} = \frac{25}{29} = 0.8621$.

The project experiences severe *ex post* demand risk, the traffic only achieves 37% in the first operation year (Pargal 2007). Hence, $R_q = 0.37$.

Finally, the offering of Global Depository Receipt (US$ 45 million) is officially issued on Feb 21 2006 (Hindustan Times 2006). For the measurement, 45.240779, the exchange rate in 2006 between dollar and Indian rupee is used (OZFOREX 2013). Firm gets additional investment from new shareholders. Before that, debt is restructured in 2002; the debt amount is not changed, though the structure of debt is adjusted (see PwC 2007: 130-132). Combing these facts, there are followings.

$S_{BC}^1 = \frac{TF_{gb}}{TF} = \frac{285.8+4.5*45.240779}{408.2+4.5*45.240779} = \frac{489.3835055}{611.7835055} = 0.7999, S_{BC}^2 = \frac{V_d}{TF^c} = \frac{285.8}{408.2+4.5*45.240779} = 0.4672, S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = \frac{489.3835055}{611.7835055} - \frac{285.8}{408.2} = 0.0998, S_{BC}^4 = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{285.8}{408.2+4.5*45.240779} - \frac{285.8}{408.2} = -0.2330, t_{CA} = \frac{\{t|Nov\ 1997 - Feb\ 2006\}}{t_{program}} = \frac{100}{360} = 0.2778.$

Seen from above, the total project fund is 408.2 crore Indian Rupee (Rs.) plus 45 million dollars (see S_{BC}^1). At the same time, it is not originally expected to raise 45 million dollars (see S_{BC}^{01}). Hence, $R_c = \frac{408.2+4.5*45.240779}{408.2} = 1.4987$.

After above investigation, there is no any government's *ex post* compensation while firm gets *ex post* investment from new shareholders in this case, so $x1 = 0$ and $x2 = 1$. Finally, government adopts rescue policy under CA.

Case 25 (Vasco da Gama Bridge in Portugal)

Vasco da Gama Bridge is the project with repeated CA under PPP in Portugal. Lusoponte is the holder of contract right under this PPP program.

This case has six CAs, hence, $N_{CA} = 6$. This project experiences a series of disputes between government and firm. Every dispute solution is written down as a Financial Rebalance Agreement (FAR). There are six FARs (Pinto 2012), so there are six CAs. Among of six CAs, the fifth one leads a refinancing package and compensation while the others only have compensation arrangement.

At the original contract, the project is expected to raise 897 million EUR (Lusoponte 2013a). The more precise data is given by Carbonaro (2011). The private promoters will invest 13% in equity and other own sources (4%). During the construction, there will be revenue to supply 7% of project fund. At the same time, there is EU Cohesion Fund granted to firm covering the 36% of project fund. All of these funds actually belong to firm under contract, which accounts 59% of project fund. EIB supply 35% fund as loan to firm while the other loan provides 6% of total fund. This program starts in April 1994 (Lusoponte 2013b) and duration is to last firm 33 years (Cruz and Marques 2011). Combining these facts, there are followings.

$$R_d = \frac{V_d^r}{V_d^c} = \frac{0.06}{0.06+0.35} = 0.1463, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = 0.36 + 0.35 + 0.06 = 0.77, S_{BC}^{02} = \frac{V_d^c}{TF^c} = 0.35 + 0.06 = 0.41, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0.36, R_i = 0, t_{program} = 33 * 12 = 396.$$

The project is scheduled to finish in March 1998 (Waymarking 2006) and the actual completion date is 29 March 1998 (Lusoponte 2013b). Hence, $R_t = 1$.

It is not clear if *ex post* demand risk exists at this case, but it explicitly meet the revenue risk. The toll increase agreed in original contract is protested by the public so that some people block the bridge and then finally leads to "violent ordeal" (Pinto 2012: 10). The traffic risk, R_q loses sense due to this kind of toll decrease relative to original contract. $R_q = NA$. However, the existence of *ex post* risk in revenue ensures the relevance of the case for this research.

This case experiences six CAs in the manner of the dispute solutions after unilateral renegotiation. Six solutions compensate firm 90.4 million EUR, 4.9 million EUR, 3.8 million EUR, 63.2 million EUR, 306.1 million EUR and 22 million EUR, respectively (Pinto 2012). In addition, Moreover, the fifth CA approves the additional loan worthy 120 million EUR (Pinto 2012). After the debt refinancing, the debt accounts 29% from EIB and 11% from commercial bank (relative to original project fund) (Carbonaro 2011).The final CA happens on 28th Nov 2008. Combining above facts, there are followings.

$S_{BC}^1 = \frac{TF_{gb}}{TF} = \frac{897*0.77+90.4+4.9+3.8+63.2+306.1+22+120}{897+90.4+4.9+3.8+63.2+306.1+22+120} = \frac{1301.09}{1507.4} = 0.8631, S_{BC}^2 = \frac{V_d}{TF^c} = \frac{(0.29+0.11)*897}{897+90.4+4.9+3.8+63.2+306.1+22+120} = 0.2380, S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = \frac{1301.09}{1507.4} - 0.77 = 0.0931, S_{BC}^4 = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{(0.29+0.11)*897}{897+90.4+4.9+3.8+63.2+306.1+22+120} - 0.41 = -0.1720,$

$t_{CA} = \frac{\{t|April\ 1994 - Nov\ 2008\}}{t_{program}} = \frac{174}{396} = 0.4394.$

This project is expected to raise 897 million EUR (see above) while it gets 1507.4 million EUR. (see S_{BC}^1). Hence, $R_c = \frac{1507.4}{897} = 1.6805.$

After above investigation, there are government's *ex post* compensation packages while firm has no *ex post* investment in this case, so $x1 = 1$ and $x2 = 0$. Finally, government adopts rescue policy under CA.

Case 26 (Lane Cove Tunnel in Australia)

Lane Cove Tunnel is failed PPP program; its failure is 'famous' in Australia and even the whole world. Lane cove Tunnel Company Consortium, later known as 'Connector Motorways' is the holder of contract right under PPP. This program starts on 9 Dec 2003 (RTA 2007).

This case seems to have just one or two CA before it is administration, which does not lead government to take over the project. However, after checking original contract, this program experience six revises in spite of administration. Hence, there is $N_{CA} = 7$. During contract assignment and the start of construction, there is a revise in Mar 2004, which results in government's compensation formally. This project has two stages in construction. At the 'stage 1' of project, four minor changes that lead government to compensate for that (see RTA 2007). At the stage 2 of project, there is one package including a set of change approved officially in 2007 (RTA 2007). The last change delays the completion of the project for five months. This revise is criticized strongly by opponent party and the public for the election consideration. Similarly, this revise lead a compensation package to firm. Plus the administration as the final CA under PPP program, there are seven CAs.

At original contract, the program lasts during on 9 Dec 2003 and 9 Jan 2037 (the Treasury 2013c). The project is expected to raise $1142 million AUD in debt and $542.8 million AUD in equity (Road-traffic 2012). Government does not guarantee or involve the financial arrangement. Combining these facts, there are followings.

$$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{1142}{1142+542.8} = \frac{1142}{1684.8} = 0.6778, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{1142}{1142+542.8} = \frac{1142}{1684.8} = 0.6778, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = 0, t_{program} = \{t|Dec\ 2003 - Jan\ 2037\} = 397.$$

The project has not been really completed "by 25 Feb 2008" (RTA 2007: 4). Before that day, there are 11 months deferred by firm (RTA 2007). Hence, $R_t = \frac{\{t|Dec\ 2003 - Feb\ 2008\}}{\{t|Dec\ 2003 - Feb\ 2008\}-11} = \frac{50}{39} = 1.2821.$

The project experiences huge loss of traffic, especially after a collapse accident in 2 Nov 2005. According to Davidson (2011), the Lane Cove Tunnel is 37 percent lower than the forecast on average[40]. Hence, $R_q = 1 - 0.37 = 0.63$.

[40] The comparison in the first operation year is not available.

The repeated revises with resulting compensations change original contract relationship, but there is no debt change. Firm goes to administration because the bank refuses to extend the repayment of debt and government does not save it out because of the accident scandal. During the six repeated revises, The compensations at repeated changes include 11.5 million and 30 million with two packages for the first CA (the Treasury 2013c), 2.75 million, 0.05 million, 1.713372 million and 0.633916 million at the 'stage 1' of project for the 2nd, 3rd, 4th and 5th CA (RTA 2007), and 6.108916 and 18.891094 with two package at the 'stage 2' of project (due to the changed proposal in 2006) for the 6th CA (RTA 2007). Though the administration does not lead to a takeover policy by government, the softness will be changed after those compensation packages. Combining above facts, there are followings.

$$S_{BC}^{1}=\frac{TF_{gb}}{TF}=\frac{1142+11.5+30+2.75+0.05+1.713372+0.633916+6.108916+18.891094}{1142+542.8+11.5+30+2.75+0.05+1.713372+0.633916+6.108916+18.891094}=\frac{1213.647298}{1756.447298}=0.6910, S_{BC}^{2}=\frac{V_d}{TF^c}=\frac{1142}{1756.447298}=0.6502, S_{BC}^{3}=\frac{TF_{gb}}{TF}-\frac{TF_{gb}^{c}}{TF^c}=\frac{1213.647298}{1756.447298}-\frac{1142}{1684.8}=0.0131, S_{BC}^{4}=\frac{V_d}{TF^c}-\frac{V_d^c}{TF^c}=\frac{1142}{1756.447298}-\frac{1142}{1684.8}=-0.0276.$$

The PPP program ended up without government bailing-out since government and firm has a bad reputation over the revise package in 2006 and the accident in 2005, respectively. Firm goes to administration in Jan 2010 (Wikipedia 2013k). Hence, $t_{CA}=\frac{\{t|Dec\ 2003-Jan\ 2010\}}{t_{program}}=\frac{73}{397}=0.1839.$

Seen from above, the total project fund is 1756.447298 million AUD (see S_{BC}^{1}). At the same time, it is originally expected to raise 1684.8 million AUD (see S_{BC}^{01}). Hence, $R_c=\frac{1756.447298}{1684.8}=1.0425.$

After above investigation, there are no any government's *ex post* compensation packages while firm has no *ex post* investment in this case, so $x1=1$ and $x2=0$. Finally, government adopts rescue policy under CA firstly, but this rescue policy is failed because firm goes to bankruptcy in the end.

Case 27 (Cross City Tunnel in Australia)

The Cross City Tunnel is famously failed PPP program as the first administration project in Australia. Cross City Motorway is the holder of contract right under PPP.

This case has two CAs, there is $N_{CA} = 2$. The first one is implemented in Jan 2005 when government requires additional equity-investment with expense of a bigger toll for firm (RTA 2008). The second one is the administration of firm (RTA 2008), which will not add softness of budget, since government does not take over the project.

At original contract, the program will last towards 18 Dec 2035 from the start of program in Dec 2002 (RTA 2008). The project is expected to raise \$ 680 million AUD in total, of which \$ 220 million AUD is invested in equity while \$ 460 million gets from debt (Wikipedia 2012c). All of equity is from several founder shareholders while the debt gets no government' guarantee and contribution. Combining these facts, there are followings.

$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{460}{680} = 0.6765, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{460}{680} = 0.6765, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = 0, t_{program} = \{t|Dec\ 2002 - Dec\ 2035\} = 396.$

The project is expected to complete in Oct 2005 while it is actually finished in Aug 2005 (RTA 2008). Hence, $R_t = \frac{\{t|Dec\ 2002 - Aug\ 2005\}}{\{t|Dec\ 2002 - Oct\ 2005\}} = \frac{32}{34} = 0.9412.$

This case has huge *ex post* risk of demand; in sixteen months after operation, firm is bankrupted (Samuel 2007). It is expected to have 89000 ridership per day while it has only 30000 daily in reality during sixteen months (Samuel 2007). These data covers a little longer than one year. At the same time, the data for the first year is not available; so these data are used for measurement. Hence, $R_q = \frac{30000}{89000} = 0.3371.$

In fact, 166 million AUD is obtained and then the total fund reaches 846 million AUD after a debt refinancing package in 2003 (Johnston and Gudergan 2007). Hence the extra 166 million AUD should be debt to firm. This is not a CA, but it should be reflected in relevant indicator at final CA. At the revise in Jan 2005, firm raise \$ 35 million AUD from the third party as investment while government allow it to increase "possible maximum toll on tunnel users" (RTA 2008: 5). The administration is implemented on 27 Dec 2006 (Wikipedia 2012c). Combining above facts, there are followings.

$S_{BC}^{1} = \frac{TF_{gb}}{TF} = \frac{460+166}{680+166+35} = \frac{626}{881} = 0.7106, S_{BC}^{2} = \frac{V_d}{TF} = \frac{460+166}{680+166+35} = \frac{626}{881} = 0.7106, S_{BC}^{3} = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^{c}}{TF^{c}} = \frac{626}{881} - \frac{460}{680} = 0.0341, S_{BC}^{4} = \frac{V_d}{TF} - \frac{V_d^{c}}{TF^{c}} = \frac{626}{881} - \frac{460}{680} = 0.0341, t_{CA} = \frac{\{t|Dec\ 2002 - Dec\ 2006\}}{t_{program}} = \frac{48}{396} = 0.1212.$

From above, it could be seen that the total project fund is 881 million AUD (see S_{BC}^{1}). At the same time, this program is originally expected to raise 680 Million AUD (see S_{BC}^{01}). Hence, $R_c = \frac{881}{680} = 1.2956$.

After above investigation, there is no any government's *ex post* compensation while firm has *ex post* investment ($35 million AUD, see above) in this case, so $x1 = 0$ and $x2 = 1$. The increase of toll cannot affect the value of indicators, so this arrangement will not be counted as compensation for value of $x1$. Finally, government adopts rescue policy under CA firstly, but this rescue policy is failed because firm goes to bankruptcy in the end.

Case 28 (NATS in UK)

National Air Traffic Service (NATS) is a special PPP program that government maintains some share in firm. Airline Group (AG) is the private partner, which owns 46% share of NATS while government has 49% share and the employee has 5% share (HM Treasury 2003).

This case has one CA in 2003, there is $N_{CA} = 1$. Government supports a loan and invest same capital after the private partner gets same investment.

At original contract, the project is expected to raise £ 758 million for government to sell its 51% share to AG (HM Treasury 2003). Among these capitals, £ 65 million is from equity investment while the rest is from debt (HM Treasury 2003). Obviously, this project will not have a public offering. On 26 July 2001, AG officially takes over the NATS. This program is aimed for the large investment accommodating the double forecast in next 25 years (DETR 2001). Namely, this program is aimed for the next 25 years. Moreover, according to HM Treasury (2003), firm has debt £330 million before PPP. Hence there will be several conclusions for following measurement: (1) project fund is £758/0.51, (2) total debt includes previous £330 million and new one worthy £ 693 million. Combining these facts, there are followings.

$$R_d = \frac{V_d^r}{V_d} = \frac{693}{330+693} = 0.6774, R_i = 0, t_{program} = 25 * 12 = 300.$$

This kind of non-pure PPP program, government has very high level of contribution for the project. As for S_{BC}^{01}, government controls 49% of ownership and then the contribution for this part of ownership will be equal to one. At the same time, for the other ownership, the ratio of government contribution will be equal to $\frac{758/0.51-65}{758/0.51}$. Hence, $S_{BC}^{01} = \frac{\mathrm{TF_g^c}}{\mathrm{TF^c}} = 0.49 + 0.51 * \frac{758/0.51-65}{758/0.51} = 0.9777$. As for S_{BC}^{02}, the debt amount is equal to 330 plus 693 million GBP while the total fund should be 758/51%, so $S_{BC}^{02} = \frac{\mathrm{V_d^c}}{\mathrm{TF^c}} = \frac{330+693}{758/0.51} = 0.6883$. In addition, there is $S_{BC}^{03} = \frac{\mathrm{TF_g^c}}{\mathrm{TF^c}} = 0.49$.

This program has no construction plan, though it has investment of facility in future. Hence, $R_t = 1$.

The project experiences large *ex post* traffic risk due to September 11th, Severe Acute Respiratory Syndrome (SARS) or the second Gulf War (Francis et al 2006). As for the deflation of traffic, it has no precise information and then R_q is not available in this case, $R_q = NA$. However, the economic loss during 2001-2005 amounts to £190 million (Politics 2012). There is at least $R_q < 1$. Otherwise, we need consider if this case is needed to abandon.

Finally, at the CA, government firstly support £30 million in debt and invest £65 million (after additional private investment of £65 million is obtained) on 18 June 2002 (Butcher 2012b). Therefore, there are following.

$S_{BC}^1 = \frac{TF_g}{TF} = 0.49 + 0.51 * \frac{\frac{758}{0.51} - 65 + 30 + 65}{\frac{758}{0.51} + 30 + 65 + 65} = 0.9597, S_{BC}^2 = \frac{V_d}{TF^c} = \frac{330+693+30}{\frac{758}{0.51} + 30 + 65 + 65} = 0.6396, S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = 0.49 + 0.51 * \frac{\frac{758}{0.51} - 65 + 30 + 65}{\frac{758}{0.51} + 30 + 65 + 65} - \left(0.49 + 0.51 * \frac{\frac{758}{0.51} - 65}{\frac{758}{0.51}}\right) = -0.0180, S_{BC}^4 = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{330+693+30}{\frac{758}{0.51} + 30 + 65 + 65} - \frac{330+693}{758/0.51} = -0.0487, t_{CA} = \frac{\{t|July\ 2001 - June\ 2002\}}{t_{program}} = \frac{11}{300} = 0.0367.$

Seen from above, the total project fund is $(\frac{758}{0.51} + 30 + 65 + 65)$ Million GBP (see $\mathrm{S}_{\mathrm{BC}}^2$). At the same time, it is originally expected to raise $\frac{758}{0.51}$ billion GBP (see $\mathrm{S}_{\mathrm{BC}}^{02}$). Hence, $R_c = \frac{\frac{758}{0.51} + 30 + 65 + 65}{\frac{758}{0.51}} = 1.1077.$

After above investigation, there is *ex post* investment form government or firm in this case, so $x1 = 1$ and $x2 = 1$. Finally, government adopts rescue policy under CA.

Case 29 (Stadium Australia in Australia)

Stadium Australia is PPP program for the Olympic Game in Sydney. Stadium Australia Group is the holder of contract right under PPP.

This case has two CAs, there is $N_{CA} = 2$. At first, firm cannot raise fund as expected and then government approve a financial restricting plan in 1998 (Searle 2002). At this plan, government allows firm to (1) sell remaining seat to get fund and (2) buy back the unsold ticket to resell those to 'football codes' (Searle 2002: 852). The plan does not change the income rights, but government awards or turns back the transfer right of tickets so that firm will sell the unsold ticket to other clients. Moreover, in 1999, the project has a reconfigure whose total cost is \$ 68 million; government contributes \$ 6 million AUD (Searle 2002). At the same time, the rest of fund gets approved on 20 Dec 1999 (SOPA 2002). After those two CAs, though there are internal restructure within firm and then the name of firm is renamed twice in 2002 and 2010 (Wikipedia 2013l); those do not change contract relationship between firm and government.

At original contract, government will contribute $ 135 million AUD while the rest of fund will be from private party (Searle 2002). For the private party, there are long-term $ 125 million AUD, sub-debt $ 18 million AUD and equity $ 40 million AUD (IPA 2008b). In spite of those, firm issues a public flotation (of tickets) to get $ 344 million AUD; the unit holder could enter stadium for Olympic and other games. To some extent, this is *ex ante* ticket-selling before the construction of project. The contract lasts from Nov 1996 to Jan 2031 (the Treasury 2013d). Combining these facts, there are following.

$$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{135+125+18}{135+125+18+40+344} = \frac{278}{662} = 0.4199, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{125+18}{135+125+18+40+344} = \frac{143}{662} = 0.2160, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = \frac{135}{135+125+18+40+344} = \frac{135}{662} = 0.2039, R_i = \frac{344}{40+344} = \frac{344}{384} = 0.8958, t_{program} = \{t|Nov\ 1996 - Jan\ 2031\} = 411.$$

The project is expected for Olympic game (the Treasury 2013d), there is no strict schedule for project. In addition, the project is finished in March 1999 (the Treasury 2013d) and then there are eighteen months for its fully testing (IPA 2008b). Hence, there is no time inflation. Considering these two aspects, there is no issue between firm and government and then it is safe to say $R_t = 1$.

At this case, firm undertakes risk of demand. As mentioned before, this specific project extends the demand risk towards the construction phase because firm raises revenue *ex ante* for the project. *Ex ante* ticket issuing reflects the risk of demand. The target is $ 344 million AUD while it only gets $ 108 million AUD (Searle 2002). There is $R_q = \frac{108}{344} = 0.3140$.

At the first CA, the transfer right is awarded back by government and then firm will buy the ticket back with expense of $ 20.6 million for 17200 tickets (that is worthy 172 million AUD) (Searle 2002). Namely, firm will get potentially $151.4 million AUD from ticket buyback permission. Thought firm may not realize the benefit fully because not all of ticket could be resold, the contribution of government should reach $ 151.4 million AUD. At the second CA, the reconfigure plan includes government $ 6 million AUD, which is explicitly the contribution of government. In particular, extra cost ($ 62 million AUD) gets from new loan (SOPA 2002). Finally, the second CA takes place in Dec 1999 (Wikipedia 2013l). Combining above facts, there are followings.

$S_{BC}^{1}=\frac{TF_{gb}}{TF}=\frac{135+125+18+151.4+68}{135+125+18+40+344+151.4+68}=\frac{497.4}{881.4}=0.5643, S_{BC}^{2}=\frac{V_d}{TF^c}=\frac{125+18+62}{135+125+18+40+344+151.4+68}=\frac{205}{881.4}=0.2326, S_{BC}^{3}=\frac{TF_{gb}}{TF}-\frac{TF_{gb}^{c}}{TF^c}=\frac{497.4}{881.4}-\frac{278}{662}=0.1444, S_{BC}^{4}=\frac{V_d}{TF^c}-\frac{V_d^c}{TF^c}=\frac{205}{881.4}-\frac{143}{662}=0.0166, t_{CA}=\frac{\{t|Nov\ 1996-Dec\ 1999\}}{t_{program}}=\frac{38}{411}=0.0925.$

Seen from above, the total project fund is 881.4 million AUD (see $\mathrm{S}_{\mathrm{BC}}^{1}$). At the same time, it is originally expected to raise 662 million AUD (see $\mathrm{S}_{\mathrm{BC}}^{01}$). Hence, $R_c=\frac{881.4}{662}=1.3314$.

After above investigation, there is government's *ex post* investment ($ 6 million AUD, see above) while firm has no *ex post* investment from shareholders in this case, so $x1=1$ and $x2=0$. Finally, government adopts rescue policy under CA.

Case 30 (Orange Health Project in Australia)

Orange and associated health service PPP project involves financing, designing, building, refurnishing and maintaining relevant facilities under contract in New South Wale in Australia. Pinnacle Healthcare Care (PHC) consortium is the holder of contract under this PPP program.

This case has one CA, there is $N_{CA}=1$. Government has a revise of project with relevant change of payment mechanism in 2010.

At original contract, the project is expected to raise $ 255.4 million AUD (NSW Government 2010), of which, PHC will underwrite the $ 200 million AUD in the time of financial close (ASX 2007). PHC is not a special vehicle; it will finish investment without risk of raising outside capital. This could be proved by the fact that the time of financial close is on the day of program start, 21 Dec 2007. If there is public offering, some days must be spent for financial arrangement after program start. Finally, this program lasts to 21 Dec 2035 (The Treasury 2013e). Combining these facts, there are following.

$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_{gb}^c}{TF^c} = \frac{255.4-200}{255.4} = \frac{55.4}{255.4} = 0.2169, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{255.4-200}{255.4} = \frac{55.4}{255.4} = 0.2169, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = 0, t_{program} = \{t|Dec\ 2007 - Dec\ 2035\} = 336.$

The project gets a very detailed schedule with a set of target date; some of them are delayed while some of them are finished ahead of schedule. After checking the contract carefully, there are several final parts are scheduled to finish on 16 Aug 2010 while those are really finished on 18 July 2011 (NSW government 2007). Hence, $R_t = \frac{\{t|Dec\ 2007 - July\ 2011\}}{\{t|Dec\ 2007 - Aug\ 2010\}} = \frac{43}{32} = 1.3438.$

Under the PPP program, firm has no any demand risk because firm will get payment from government, demand risk cannot affect the income of firm (NSW government 2007). Hence, $R_q = 1$.

The revise package is finished in June 2010. Firm need finance the extra \$ 41 million AUD when government requires an *ex post* revise. The compensation will be realized in the manner of change over payment mechanism (the Treasury 2013e). In other words, the additional \$41 million AUD will be compensated in the amended contract. Combining above facts, there are following.

$S_{BC}^1 = \frac{TF_{gb}}{TF} = \frac{255.4-200+41}{255.4+41} = \frac{96.4}{296.4} = 0.3252, S_{BC}^2 = \frac{V_d}{TF^c} = \frac{255.4-200}{255.4+41} = \frac{55.4}{296.4} = 0.3252, S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = \frac{96.4}{296.4} - \frac{55.4}{255.4} = 0.1083, S_{BC}^4 = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{55.4}{296.4} - \frac{55.4}{255.4} = -0.0300, t_{CA} = \frac{\{t|Dec\ 2007 - June\ 2010\}}{t_{program}} = \frac{30}{336} = 0.0893.$

Seen from above, the total project fund is 296.4 million AUD (see S_{BC}^1). At the same time, it is originally expected to raise 255.4 million AUD (see S_{BC}^{01}). Hence, $R_c = \frac{296.4}{255.4} = 1.1605$.

After above investigation, there is government's *ex post* compensation while firm has a *ex post* investment from shareholders (41 million AUD, see above) in this case, so $x1 = 0$ and $x2 = 1$. Finally, government adopts rescue policy under CA.

Case 31 (Norfolk and Norwich University Hospital in UK)

Norfolk and Norwich University Hospital (NNUH) is one of first PPP program in UK. Octagon Healthcare is the holder of contract under PPP program.

This case has three CAs, $N_{CA} = 3$. The first one is the extension to include a second-phase project (Wikipedia 2013m). After that, *ex post* subsidy (£20 million) is to bail out firm at the first year of operation (UNISON 2002). Finally, there is a refinancing agreement between the partners in 2003.

At initial proposal, firm will raise 148 million (85%) in senior debt, £20 million (12%) in subordinate debt and £5 million (3%) in equity while the total fund will reach £173 million (Edwards 2009). However, this is not fixed in original contract because there are extensions of project before the contract assignment[41]. All extensions get fund from founder shareholders of firm while government gives higher usage fee to firm in return (Edwards 2009). At the contract assigned, the total fund reaches £214 million (BBC 1998). Namely, at the real (and original) contract, the debt stays £168 million while the equity rises to £46 million. The real date of completion is 14 Aug 2001. The minimum time is 34 years, which is revised to the 39th year (towards 2037) in 2003 (HM Treasury 2006). Namely, the program starts from Jan 1998 (NAO 2005) to Aug 2037 except firm implements the option of concession extension. For measuring the length of program, we use 39 years because the longer length cannot be sure until now. Combining these facts, there are followings.

$$R_d = \frac{V_d^r}{V_d^c} = 1, S_{BC}^{01} = \frac{TF_g^c}{TF^c} = \frac{168}{214} = 0.7850, S_{BC}^{02} = \frac{V_d^c}{TF^c} = \frac{168}{214} = 0.7850, S_{BC}^{03} = \frac{TF_g^c}{TF^c} = 0, R_i = 0, t_{program} = \{t|Jan\ 1998 - Aug\ 2037\} = 475.$$

[41] Obviously, these revises or extensions are not CAs since the contract is not assigned.

Firm completes project five months ahead (Wikipedia 2013m). As mentioned above, the completion data is 14 Aug 2001. Hence, $R_t = \frac{\{t|Jan\ 1998 - Aug\ 2001\}}{\{t|Jan\ 1998 - Aug\ 2001\}+5} = \frac{43}{48} = 0.8958$.

This project gets payment from its performance (NHS foundation Trust 2008), firm will be paid without demand risk. Hence, $R_q = 1$.

The first CA extends the scope of project and leads to a refinancing package. At the second CA, the hiding £ 20 million is actually subsidy. The third CA, which takes place in Dec 2003 (NAO 2005), makes £ 116 million gain (HM Treasury 2006). Of this refinancing gain, firm gets £ 82 million while the rest goes to the public partner (HM Treasury 2006). Meanwhile, firm gets additional £106 million debt when the total debt increases from £200 million[42] towards £306 million (HM Treasury 2006). Before the third CA, firm has raised £229 million totally (HM Treasury 2006) except the hiding subsidy. Hence, the project fund at final CA includes £229 million (existing project fund), £20 million (hiding subsidy), £106 million (new debt) and £82 million (gain of restructure). Considering this structure of project fund, there are followings.

$S_{BC}^1 = \frac{TF_g}{TF} = \frac{200+106+20+82}{229+106+20+82} = \frac{408}{437} = 0.9336, S_{BC}^2 = \frac{V_d}{TF^c} = \frac{306}{229+106+20+82} = \frac{306}{437} = 0.7002, S_{BC}^3 = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^c}{TF^c} = \frac{408}{437} - \frac{168}{214} = 0.1486, S_{BC}^4 = \frac{V_d}{TF^c} - \frac{V_d^c}{TF^c} = \frac{306}{437} - \frac{168}{214} = -0.0848, t_{CA} = \frac{\{t|Jan\ 1998 - Dec\ 2003\}}{t_{program}} = \frac{71}{475} = 0.1495$.

Seen from above, the total project fund is 437 million AUD (see S_{BC}^1). At the same time, it is originally expected to raise 214 million AUD (see S_{BC}^{01}). Hence, $R_c = \frac{437}{214} = 2.0421$.

[42] Though the original debt should be £168 million, the debt before the final CA has been updated towards £200 million.

After above investigation, there is government's *ex post* subsidy (£20 million) and gain approval (£82 million) while firm has no *ex post* investment from shareholders in this case, so $x1 = 1$ and $x2 = 0$. Finally, government adopts rescue policy under CA.

Case 32 (Royal Armouries Museum in UK)

Royal Armouries Museum is 60-year PPP program in Leeds. Royal Armouries (International) plc is the holder of contract right under PPP.

This case has three CAs, there is $N_{CA} = 1$. After financial distress, firm experiences two renegotiations twice (NAO 2001). However, both do not change the relationship with government since there is only debt restructure. After that, firm still gets worse and then bank refuses to do more (NAO 2001). To solve the third crisis, government decides to take over the project (NAO 2001).

At the original contract, the project raises £ 42.6 million (NAO 2001: 14). Firm provides £14.1 million while public partner contributes the rest of fund (NAO 2001). In particular, the private fund is consisted of £ 6.1 million in debt, £ 8 million in equity & subordinated debt (NAO 2001: 14). At the same time, the lender of firm, the Bank of Scotland, provides £8.4 million (NAO 2001). Considering this, more detailed arrangement could be fixed as following: 6.1 in debt, 2.3 in subordinated debt (the first two both from the Bank of Scotland) and £5.7 million in equity. The contract is signed in Dec 1993 to design and operate for museum 60 years (NAO 2001). As one of early PFI/PPP program in UK, government contributes main fund for the project. Combining these facts, there are followings.

$$R_d = 1, S_{BC}^{01} = \frac{\mathrm{TF_g^c}}{\mathrm{TF^c}} = \frac{42.6-5.7}{42.6} = \frac{36.9}{42.6} = 0.8662, S_C^{02} = \frac{8.4}{42.6} = 0.1972, S_{BC}^{03} = \frac{\mathrm{TF_g^c}}{\mathrm{TF^c}} = \frac{42.6-14.1}{42.6} = \frac{28.5}{42.6} = 0.6690, R_i = 0, t_{program} = 60 * 12 = 720.$$

This program is expected to open on 30 March 1996 while it is actually open on 01 march 1996 (Partnerships UK 2009). Namely, this project is finished in the month expected in schedule. Because the time inflation is only measured with unit of month, this project has approximately $R_t = 1$.

This project experiences *ex post* risk of demand since the number of visitor only has 63% of break-even in the first operation year and 35% in 1999 (NAO 2001). Unfortunately, there is no precise information for demand deflation. We have to estimate the degree with relevant data. At first, there is no delay (see from above). Second, the construction of project has no cost overrun (NAO 2001). When there is no cost overrun and delay, the revenue level relative to the estimated one represents demand risk. As pointed out by (NAO 2001: 16), the planed revenue is £ 34 million while the actual one is only 1.4 million in 1998, the second year of operation[43]. Namely, $R_q = \frac{1.4}{34} = 0.0412$.

Finally, this case ends up with the takeover policy of government in July 1999 (NAO 2001). When it is taken over, the debt reaches £21 million (NAO 2001). Namely, there is *ex post* debt worthy of £12.6 million after original £8.4 million. Combining above facts, there are followings.

$S_{BC}^{1} = \frac{TF_g}{TF} = 1, S_{BC}^{2} = \frac{21}{42.6+12.6} = 0.3804, S_{BC}^{3} = \frac{TF_{gb}}{TF} - \frac{TF_{gb}^{c}}{TF^{c}} = 1 - \frac{36.9}{42.6} = 0.1338, S_{BC}^{04} = \frac{21}{42.6+12.6} - \frac{8.4}{42.6} = 0.1833, t_{CA} = \frac{\{t|Dec\ 1993 - July\ 1999\}}{t_{program}} = \frac{57}{720} = 0.0792.$

Seen from above, the total project fund is 42.6 million GBP. Though firm has no *ex post* fund, it has *ex post* debt (£12.6 million) (see S_{BC}^{2}). Hence, $R_c = \frac{42.6+12.6}{42.6} = 1.2958$.

After above investigation, it could be seen that there is no government's *ex post* compensation or investment and firm's *ex post* investment from shareholders in this case; so $x1 = 0$ and $x2 = 0$. Finally, government adopts the takeover policy when the huge *ex post* risk hits the program and bankruptcy is inevitable (since the loss has been already beyond the equity investment). The risk scale could be seen from the indicator of R_q.

[43] The data in the first year is not available.

Chapter 6: Regression and hypothesis testing

6.1 Introduction

This chapter will use the classic econometrical method, OLS, to make regression on quantitative indicators data in last chapter. According to the Gauss-Markov Theorem, OLS could have the estimator which minimizes the variance of disturbance; the coefficient would be BLUE. In fact, it is the basic and important method in econometrics with cross section data, time series or panel data.

The BLUE coefficient is based on three assumptions under the Gauss-Markov theorem, including linearity, homoscedasticity and independence. In spite of those three assumptions, OLS requires the data has no multicollinearity problem while error is required to distribute normally. Moreover, considering our regression involves simultaneous equations, so the endogeneity issue is also explicitly considered. This chapter will make regression under OLS and then confirm the relevant assumptions or requirements. In particular, this research mainly need solve heteroscedasticity problem for regression, which is very general in cross-section data. The process of verifying homoscedasticity starts WT (White Test) firstly. If the test cannot reject the null hypothesis of homoscedasticity, the ideal property is ensured; otherwise, corresponding manipulation should be taken after the test.

This chapter starts firstly from data description which mainly exploits the information from data by statistics. The initial analysis will be then made secondly, including the correction of data and initial multiple regression. Thirdly, the stepwise regression is used. The stepwise regression involves automatic software regression and manual manipulation; in particular, the manipulation includes adding potential significant variables and removing insignificant variables or the variables leading co-linearity problems. This kind of adding and removing will be repeated unless all significant variables are regressed without any insignificant and co-linearity leading variables. More details could be seen in later. Considering three *ex post* risks are affected by each other, which is seen from the result of stepwise regression, Two-Stage Least Square (TSLS) will be used, fourthly. More details will be seen in Section 6.5. The fifth and sixth steps are to confirm three Gauss-Markov assumptions and the normality requirement of OLS, respectively. The seventh step is to give the final model and give special consideration for endogeneity issue. Eighthly, the results relative to original hypotheses get explained. After those, a simulation will be given upon our data and models from regression to figure out extra insight. The corresponding design could be seen in the section 6.10. This chapter will be summed in the end.

6.2 Data description

Only quantitative data and two dummy variables in Chapter 5 will be used for regression. There is one indicator (R_q) whose data is unavailable for some cases. The data description has option to choose the one on common or individual sample. The descriptive statistics on common sample will omit cases that have no R_q data; the descriptive statistics on individual sample is on the base of individual sample. The latter could take a better use of data. The descriptive statistics on individual sample is given in Appendix 6-1.

Need to mention all of quantitative data are ratio values except dummy variables and N_{CA}, so most of data has the maximum value equal to one and the minimum value equal to zero. When extreme value is mentioned in following, it means 1 or 0.

6.2.1 Descriptive statistics for initial situation

According to Appendix 6-1, four of five initial variables (including R_d, R_i, S_{BC}^{02} and S_{BC}^{03}) has minimum of value at zero. This illustrates corresponding instruments are not necessary to launch PPP program. To be precise, the debt (responding to $R_d$and S_{BC}^{02}), investment under risk (mainly public offering, responding to R_i) and government subsidy (responding to S_{BC}^{03}) will be zero for the project. The sole indicator that must be positive is S_{BC}^{01}, it means the contribution of government seems necessary to initiate a PPP program. It will be found from these minimum values that these financial instruments (debt, investment/equity or subsidy) are substitutive to each other while there must be some of those as original contribution of government.

Four of five indicators (including R_d, R_i, S_{BC}^{01} and S_{BC}^{02}) (almost) has maximum value at 1. Even the sole indicator that is not close to extreme value, S_{BC}^{03}, is also moderately high, reaching 0.7571. on the base of these maximum value, we could say that contract could award the private partner of PPP program all of risk in debt market (see R_d) or equity market (see R_i) while government contribution may involve the whole fund for the project in the manner of debt support (see S_{BC}^{01} and S_{BC}^{02}); in particular, none of program is initiated fully by subsidy (see S_{BC}^{03}).

Finally, as for the mean value, R_d, S_{BC}^{01} and S_{BC}^{02} have moderately high value (bigger than 0.6607) while R_i and S_{BC}^{03} have low values (smaller than 0.1538). This means debt is usually used much more relative to equity issuing or subsidy, so government supports firm mainly in an indirect way.

6.2.2 Descriptive statistics for progress variables

As for the indicators reflecting the process, N_{CA} could be one at least while eight at most. If there is no CA, the case will be not collected. From this indicator, the biggest one is only eight while the mean one is only 2.1875. The contract relationship is adjusted in reality much smaller than the one in theory. This could be explained: with more CAs, PPP program will have a bigger probability of takeover by government; once takeover happens, the number of CA under PPP cannot increase any more.

The cost inflation seems inevitable to PPP project when the program has at least one CA between firm and government. The biggest cost inflation is 3.4324 while minimum one is 1.0425. The mean value is 1.5113. The overrun percentage on average reaches 51%. This may hint that the cost overrun is an objective reason to require rescue package.

The inflation of time is much smaller than the one in cost. The biggest time inflation is 1.85 while the smallest one only 0.825. This means, on one hand, the time overrun may be non-existed; on the other hand, the toleration of delay may be less. The former may be related to the public benefit of PPP program for government; the latter may derive from the control on time-delay since the feasibility of technology for the project has been (relatively) effectively *ex ante* assessed, in general.

As for demand deflation, it is very bad. The traffic volume will be equal to zero as minimum value though the biggest R_q could reach one. More importantly, the mean value is 0.4901; this means the traffic volume does not reach half of *ex ante* estimation on average. This low level of traffic relative to expectation may lead to a very severe crisis upon PPP program. Similar to cost overrun risk, the demand deflation could also be an objective reason to require government to bail firm out.

Combining last three indicators, only delay may be not existed, cost overrun risk and demand overestimation risk must happen in PPP program when CA is needed to keep the program going. On average, those these three kinds of risk must happen to PPP program when CA is inevitable.

Finally, *ex post* CA happens in early stage of PPP program. The biggest value is only 0.5493, namely, the program is only finished about half. The smallest value is just 0.0367. The mean value is only about one fifth (0.2058). Recalling the mean value of N_{CA} (2.1875), this means the PPP program have always more than one CA at early stage. This should attract the attention for PPP program; some *ex ante* contract design ought to consider *ex post* CA at the early stage of project.

6.2.3 Descriptive statistics for dummy variables

The meaning of dummy variable is mainly related to the statistics index of SUM since other statistics are not meaningful. The first dummy variable has sum value equal to thirteen while the second one has sum value of seven. This means there are thirteen cases in research using direct compensation by government to bail out the program while only seven cases witness *ex post* investment from shareholders (to return government's contribution). This value of sum for the dummy variable may be small, but its usage will be reflected in later regression.

6.2.4 Descriptive statistics for softness variables

As for the global softness or indirect softness, the maximum value could reach (almost) the absolute value. This reveals there may be an extreme situation, under which firm under PPP program is (almost) totally supported by government so that firm is not independent any more in essence. Moreover, the minimum of value of global softness is 0.3252, this means government contribution under PPP program does not disappear. At the same time, the contribution in the manner of debt (relying on the support from market) may disappear since the minimum value of $\mathrm{S}_{\mathrm{BC}}^{2}$ could be zero. The zero-debt derives from the strong support of government when firm has no debt from the project launch. More important is the value of mean for $S_{BC}^{1}$and S_{BC}^{2}. The former is 0.8859 while the latter is 0.6251. Recalling the mean value of S_{BC}^{01} and S_{BC}^{02}, so there is $E(S_{BC}^{01}) < E(S_{BC}^{1})$ and $E(S_{BC}^{02}) > E(S_{BC}^{2})$. This points out *ex post* CA has bigger global softness after *ex post* CA while the support of banks (representing the market system) will get smaller. This is very meaningful, it reveals *ex post* CA leads to a situation that government gets more involved while market withdraws partially from PPP program.

The above phenomenon could be supported by $S_{BC}^{3}$and S_{BC}^{4}. The former is positive while the latter is negative on average. Namely, the change of global softness after CA is positive while the change of indirect one is negative on average. This confirms the above phenomenon. As for the maximum, minimum value and mean value of S_{BC}^{3} and S_{BC}^{4}, those are not generally meaningful because those depends on the original softness level, which is different between programs.

Finally, for the final two indicators, R_{ap} is the S_{BC}^{2} divided by S_{BC}^{1} while NR_{ap} is from S_{BC}^{4} divided by S_{BC}^{3}. Namely, as for R_{ap}, the contribution in the manner of debt support relative to the global contribution will be measured. Similarly, for NR_{ap}, the degreeof net debt support relative to the net government contribution will be also measured. From the data, it is seen that mean value of R_{ap} reach 0.7075 while the corresponding value of NR_{ap} is 1.7019. This illustrates the increase of softness has about 70% from market system (bank involvement). Moreover, the maximum value of R_{ap} could be one while the minimum value is zero. This means the *ex post* softness could derive fully from debt increase, in the meanwhile, it could be also totally from government. At the same time, the maximum value of NR_{ap} could be 98.2813 while the minimum value is -39.8333. This hints NR_{ap} may be not able to reflect reality well once again.

6.3 Initial analysis

This section consists of data transformation and initial multiple regression. The former is aimed to fit data better while the latter is to check if data could give enough information for regression.

6.3.1 Initial skewed data correction

As mentioned before, to get big-sample data, author starts focusing on HSR sector and then extends it towards rail sector and finally towards the whole transportation industry. Even so, author has to include some cases outside transportation for research. Considering sample is not huge and data covers different sections, the data may have heterogeneity (and the regression will have heteroscedasticity problem easily in later regression). Transformation seems necessary for some data.

The correction in this research use different tools. When the indicator has only positive values, the natural log function will be tried to see if the skewness of data could be reduced significantly. When the data has zero or negative values, Inverse Hyberbolic Sine (IHS) function will be tried. As for the reason for the precise IHS function, it could be seen in Chapter 3. Considering raw data could be more close to the reality, we will only adopt the transformed data when there is the substantial improvement of data fitting. Otherwise, raw data will be preferred. For example, N_{CA}, its raw data has probability value less than 0.05 while its transformed data has p-value about 0.08 in Jarque-Bera test (see Appendix 6-2). Hence, the raw data of N_{CA} could reject null hypothesis of normality while the transformed data cannot do that. This illustrates the transformation makes a non-normal data become normal. If there is no this kind of improvement, the raw data would be used.

According to the above rule, there are only three variables improved with transformation: N_{CA}, R_t and t_{CA}. All of these indicators have positive data, so only natural log function is adopted in following. The other indicator will use raw data. Though IHS function is tried for some indicators, there is no significant improvement in this research. The histograms of raw data and transformed data will be seen in Appendix 6-2, in which only above three variables have two pictures for the raw data and the transformed data while the others only have one picture for raw data. Precisely, in spite of N_{CA}, mentioned above, R_t has p-value only 0.0001 while it will be equal to 0.1440 after transformation; t_{CA} has p-value 0.0332 while the transformed one has p-value reaching 0.8611.

6.3.2 Initial multiple regression

The initial multiple regression could test roughly whether data have enough explanatory power. It is always aimed to figure out the coefficient of determination when the t-test is not considered. Considering there are two sets of regression, the corresponding results will be listed in separate tables. The result of initial multiple regressions for softness and *ex post* risk are shown in Table 6-1 and Table 6-2, respectively. More details of result could be seen in Appendix 6-3.

Table 6-1: the result of the first set of multiple regression

	Dependent variables					
	S_{BC}^{1}	S_{BC}^{2}	S_{BC}^{3}	S_{BC}^{4}	R_{ap}	NR_{ap}
$R^2/\overline{R^2}$	0.961944 0.929324	0.837614 0.698427	0.875322 0.768455	0.559141 0.181261	0.779327 0.590179	0.635178 0.322474
	R_d	R_i	S_{BC}^{01}	S_{BC}^{02}	S_{BC}^{03}	$ln(N_{CA})$
VIF Value	2.115897	2.080462	14.60787	41.68354	30.60245	2.009387
	R_c	$ln(R_t)$	R_q	$ln(t_{CA})$	$x1$	$x2$
VIF Value	1.354934	1.675727	1.689925	2.515015	1.544424	1.888849

From Table 6-1, it could be seen that S_{BC}^{1} gets a high level of R^2 while S_{BC}^{2} and S_{BC}^{3} get an adequate level. The former is almost equal to 1 while the next two are over 0.8. Comparing the first three, the data fitting for S_{BC}^{4} is bad since only about half of variation of trend in data could be explained. Finally, R_{ap} and NR_{ap} get R^2at 0.7793 level and 0.6352, respectively. In particular, there are big differences between R^2 and $\overline{R^2}$ for some of dependent variables; this indicates independent variables cannot explain those dependent variables well. This problem will be considered later.

In addition, VIF gets some values bigger than 5. All of models in this set of regression use same independent variables, so VIF value will be same in these models. From above table, it could be seen that S_{BC}^{01} reaches 14.6079,S_{BC}^{02} gets 41.6835 and S_{BC}^{03} has 30.6025 in VIF value. This illustrates the data fitting in this set of regression has co-linearity problem. After removing those variables, the coefficient of determination will be lowered.

Moreover, some independent variables should be insignificant in regression. This means there will be some decrease of determination coefficient if the significance is considered and then insignificant variables are removed.

From Table 6-2, about 70 percent of the variation in the data and 89 percent of the variation for t_{CA} could be explained for N_{CA}. Less variance of other three risk indicators could be explained. In addition, there are also big differences between R^2 and $\overline{R^2}$ for all dependent variables except $ln(t_{CA})$. Moreover, some variables get VIF value bigger than 5; for example, the biggest one reach 3.04E+08 for R_q. This means the coefficient of determination will be much less after considering t-test and removing insignificant variables.

Table 6-2: the VIF values of the second set of multiple regression

	Dependent variables				
	$ln(N_{CA})$	R_c	$ln(R_t)$	R_q	$ln(t_{CA})$
R_d	2.327711	2.105451	1.850176	2.152561	2.411189
R_i	3.794335	5.445512	5.345013	5.165661	4.743745
S_{BC}^{01}	1.71E+08	2.44E+08	2.51E+08	2.70E+08	1.71E+08
S_{BC}^{02}	502.9515	525.0136	529.8472	479.4124	462.8797
S_{BC}^{03}	78.84171	78.39811	75.32905	76.55419	59.00616
$ln(N_{CA})$	×	3.181092	3.174081	3.262540	3.235651
R_c	1.518307	×	1.434902	1.587502	1.400045
$ln(R_t)$	3.120379	2.955480	×	3.247608	2.759993
R_q	2.390223	2.436764	2.420231	×	2.261318
$ln(t_{CA})$	8.699020	7.886190	7.547920	8.298271	×
S_{BC}^{1}	1.93E+08	2.75E+08	2.82E+08	3.04E+08	1.92E+08
S_{BC}^{2}	596.8889	607.4959	593.2784	473.7994	588.4937
S_{BC}^{3}	58838835	83889937	86189564	92697899	58612693
S_{BC}^{4}	220.4615	224.9517	217.2288	181.9242	219.0302
$x1$	5.233132	5.601377	5.041311	5.339899	3.962910
$x2$	11.10501	11.41176	7.745107	12.10931	5.222284
$R^2/\overline{R^2}$	0.699346 0.289363	0.370082 -0.488898	0.694171 0.277132	0.589621 0.030013	0.888170 0.735675

It has been pointed out that (1)$\overline{R^2}$ is much smaller than R^2 and (2)the data fitting may be worse in later formal regression due to the insignificance of variable in statistics and the collinearity problem. Given these facts, adding variables could be worthy adding. However, this way is not feasible in this research since indicator category has been biggest one we could get. Another way is adding the non-linearity trend in regression. The non-linearity trend is adopted in the manner of square item of variable, thereby avoiding the breach of linearity assumption in Gauss-Markov theory. This kind of adding square items of variables could make the co-linearity problem worse, but it could be solved later. Therefore, we will add the square items of independent variables to finish stepwise regression before other procedures.

6.4 Stepwise analysis

There are mainly two kinds of methods of stepwise regression, forward stepwise regression and backward stepwise regression. As mentioned in Chapter 3, the former may overlook some significant variable while the latter may keep some insignificant ones in regression. For the safety, the latter is preferred though some manual removal is necessary. This section will have followings.

At first, the initial stepwise regression will be finished under the method of backward-stepwise regression. Secondly, the model after initial stepwise regression will be adjusted to remove or add some variables. Finally, the results under stepwise regression will be given. The details in each step will be given later.

6.4.1 Automatic stepwise regression

When backward-stepwise regression is applied, the upper value and bottom value should be fixed in advance. Under the backward-stepwise regression, the variable whose p-value is bigger than $\bar{p}$ will be removed while the variable whose p-value is smaller than $\underline{p}$ will be added in regression. In theory, this process will be repeated unless all variables whose p-value is smaller than $\underline{p}$ is included in the regression result. Moreover, considering the significance level at the 95%, the upper level and bottom level of p-value is fixed as $\bar{p} = \underline{p} = 0.05$. Namely, Eviews 7 will choose every variable whose p-value is smaller than 0.05 into regression and removing every variables whose p-value is bigger than 0.05. The results of stepwise regression including square item for the first set of regression and the second regression could be seen in Appendix 6-4.

Due to the consideration of non-linearity (represented by the square item of variables), it could be expected, on one hand, that the stepwise regression get fitted much better than before; on the other hand, the multicollineaarity will be severer. The former could be reflected by the more significant variables and higher level of coefficient of determination in appendix 6-4 while the latter could be related to more variables whose VIF value bigger than 5. The potential problems (not only the co-linearity problem) will be solved in next subsection through manual adjustment. It need to point out that stepwise regression have two functions for this research: ⑴ it at least figures out most of (if not full) significant variables, (2) the original variable or its square is chosen by Eviews for the data fitting, thereby determining the linear or quadratic trend existing in data.

6.4.2 Manual adjustment

Considering some insignificant variables may still left after backward-stepwise regression, those should be removed manually. In addition, the variables leading to co-linearity problem should be also removed. To be precise, once VIF value of variable is over 5, the variable should be removed. Given VIF value could give a direct evidence for the judgement about co-linearity problem, the correlation between variables is not used in this research, which is relied on by many previous scholars to avoid the co-linearity problem. In fact, The VIF value as a specific index quantifies the severity of co-linearity problem in regression; meanwhile, the reliance over correlation value is subjective. The highly correlated variables do not have to result in co-linearity problem, vice versa.

After removing, some intuitively important variables are worthy adding back. At the first set of regression, two variables $ln(N_{CA})$ and $ln(t_{CA})$, are tried to add back since these have direct relationship with *ex post* CA. At the second set of regression, other progress variables are tried to add back, considering *ex post* element could affect each other. In fact, for safety, every variable unselected by backward-stepwise regression is experimented to add back manually in estimation. In the way mentioned, the adjustment (adding and removing) will not stop unless the models include all significant variables without insignificant variables and co-linearity problem.

6.4.3 Final results of stepwise regression

After manual adjustment described as above, the result of regression should include all of variables whose p-value is less than 0.05 and whose VIF value is less than 5, simply speaking. Table 6-3 and Table 6-4 give final results for the first and second set of regression, respectively.

At Table 6-3, it could be seen that the model of $\mathrm{S}_{\mathrm{BC}}^{1}$ has the coefficient of determination 0.8460. The model of $\mathrm{S}_{\mathrm{BC}}^{2}$ or R_{ap} gets moderately big value of coefficient, 0.7300 or 0.6714, respectively. Comparing those three, the rest three get fitted not sufficiently. The models of $\mathrm{S}_{\mathrm{BC}}^{3}$, $\mathrm{S}_{\mathrm{BC}}^{4}$ and NR_{ap} could only get 0.5608, 0.3603 and 0.2797, respectively.

Considering some models are not fitted well, there may be hetersocedasticity making data-fitting bad.

Table 6-3: The result of the first set of final stepwise regression

Independent variables	Dependent variables S_{BC}^{1}	S_{BC}^{2}	S_{BC}^{3}	S_{BC}^{4}	R_{ap}	NR_{ap} *
C	0.700368 12.21557*** Na	0.531386 5.859543** Na	0.408749 6.144013*** Na	0.181807 2.777688** Na	0.905075 21.46708*** Na	Na Na Na
R_i	Na Na Na	Na Na Na	Na Na Na	-0.229530 -2.741297* 1.059837	-0.352303 -3.751195 1.071480	Na Na Na
$(R_i)^2$	Na Na Na	-0.358232 -3.493919** 1.155319	Na Na Na	Na Na Na	Na Na Na	36.22047 3.520138** 1.000000#
S_{BC}^{01}	Na Na Na	Na Na Na	-0.269073 -3.395823** 1.111106	Na Na Na	Na Na Na	Na Na Na
$(S_{BC}^{01})^2$	Na Na Na	0.439387 3.285838** 1.141947	Na Na Na	Na Na Na	Na Na Na	Na Na Na
$(S_{BC}^{02})^2$	0.055143 2.200271* 1.614946	Na Na Na	Na Na Na	-0.263604 -2.631600* 1.037797	Na Na Na	Na Na Na
S_{BC}^{03}	-0.085921 -3.380216** 1.164260	Na Na Na	Na Na Na	Na Na Na	Na Na Na	Na Na Na
$(S_{BC}^{03})^2$	Na Na Na	-1.122626 -6.195397*** 1.081231	Na Na Na	Na Na Na	-1.260333 - 6.116068*** 1.063052	Na Na Na
$\ln(R_t)$	-0.185407 -2.389701* 1.300697	Na Na Na	-0.167742 -2.422497* 1.124674	-0.034391 -2.633284* 1.169491	Na Na Na	Na Na Na
$\ln(t_{CA})$	-0.139576 -4.170262*** 1.430123	Na Na Na	Na Na Na	Na Na Na	Na Na Na	Na Na Na
$x1$	0.650227 7.507205*** 2.724772	-0.153319 -3.024741** 1.072772	-0.084917 -3.599445** 1.088718	-0.139962 -2.717433* 1.051409	-0.156625 -2.668716* 1.093328	Na Na Na
$x2$	0.586599 8.472176*** 2.211262	Na Na Na	-0.143758 -4.656285*** 1.321070	Na Na Na	Na Na Na	Na Na Na
$R^2/\overline{R^2}$	0.846013 0.809056	0.730028 0.690032	0.560788 0.495719	0.360330 0.291794	0.671381 0.636172	0.279669 0.279669

The figures in each cell for variables are the Coefficient, t-value and VIF value in order. Na: the variable is removed by the stepwise regression. Robust t statistics: *significance at 5%, **significance at 1%, ***significance at 0.1%.

C does not exists in final result and then the value of VIF has to use the Uncentered one to take place of Centered one. All of these will be followed in Table 6-4, Table 6-5 and Table 6-6.

At Table 6-4, we could see the model of $\ln(N_{CA})$ gets a small coefficient (0.4554) while $\ln(t_{CA})$ has a moderately high value (0.6636). The others get smaller values of coefficient, which means the data itself cannot give sufficient information so that determination coefficient is relatively small. Or it hints the heteroscedasticity problem may exist so that the data fitting is bad.

Table 6-4: the result of the second set of final stepwise regression

Independent variables	Dependent variables				
	$ln(N_{CA})$	R_c	$\ln(R_t)$	R_q	$\ln(t_{CA})$
C	0.607122 3.089346** Na	1.790842 12.70672 Na	0.107898 3.532322** Na	Na Na Na	-2.688017 -15.26882*** Na
R_d	Na Na Na	-0.419732 -2.552673* 1.032878	Na Na Na	Na Na Na	Na Na Na
R_i	1.086787 3.413277** 1.070965	Na Na Na	Na Na Na	Na Na Na	Na Na Na
$(S_{BC}^{02})^2$	Na Na Na	Na Na Na	Na Na Na	Na Na Na	1.210858 4.845568*** 1.047355
S_{BC}^{03}	Na Na Na	Na Na Na	Na Na Na	-0.785147 -2.465492* 1.496215	Na Na Na
$(S_{BC}^{03})^2$	Na Na Na	-1.161873 -2.262661* 1.078798	Na Na Na	Na Na Na	Na Na Na
$(R_q)^2$	Na Na Na	Na Na Na	Na Na Na	Na Na Na	-0.401661 -2.598752* 1.049019
$ln(t_{CA})$	Na Na Na	Na Na Na	Na Na Na	-0.326061 -7.571715*** 1.496215	Na Na Na
$(\ln(t_{CA}))^2$	-0.128945 -2.902219** 1.074536	Na Na Na	Na Na Na	Na Na Na	Na Na Na
$x1$	0.452124 2.260723* 1.104056	Na Na Na	Na Na Na	Na Na Na	Na Na Na
$x2$	Na Na Na	Na Na Na	Na Na Na	Na Na Na	0.387063 2.559277* 1.099953
S_{BC}^3	Na Na Na	Na Na Na	Na Na Na	Na Na Na	3.121567 4.345966*** 1.101455
S_{BC}^4	Na Na Na	1.950252 2.887676** 2.546060	Na Na Na	Na Na Na	Na Na Na
$(S_{BC}^4)^2$	Na Na Na	5.778120 3.767145*** 2.473071	Na Na Na	Na Na Na	Na Na Na
$R^2/\overline{R^2}$	0.455377 0.397025	0.450791 0.369426	0.000000 0.000000	0.164673 0.131260	0.663648 0.602493

Though all models in Table 6-3 and Table 6-4 could be able to go through t-test for every variable and multicollinearity problem has been avoided, three basic assumptions in Gauss-Markov theorem are not verified yet and normality requirement of residual series has not been confirmed. The verification or confirmation job will be finished before the final results.

6.5 Simultaneous equations estimation

Seen from Table 6-4, three *ex post* risk ($ln(N_{CA})$, $\mathrm{R_q}$ and $ln(t_{CA})$) could be explained by each other. Considering the existence of endogenous variables, OLS may be upwards biased (Crinò 2008); the following will use Two-Stage Least Square (TSLS) to estimate the potential simultaneous equations.

In particular, as the common rule of TSLS, the exogenous explanatory variables of the dependent variable and the ones of variable of interest should be the instruments for estimation. This rule would be used consistently under TSLS in following. Before TSLS, the relationships between simultaneous equations need be analysed. The equations are listed especially in following.

$$\begin{cases} ln(N_{CA}) = 0.6071 + 1.0868R_i - 0.1289(ln(t_{CA}))^2 + 0.4521x1, \\ R_q = -0.3260ln(t_{CA}) - 0.7851S_{BC}^{03}, \\ ln(t_{CA}) = -2.6880 + 1.2109(S_{BC}^{02})^2 - 0.4017(R_q)^2 + 0.3871x2 + 3.1216S_{BC}^{3}. \end{cases} \tag{9}$$

It could be seen that the models of R_q and $ln(t_{CA})$ are affected by each other while the model of $ln(N_{CA})$ depends on $ln(t_{CA})$. Hence, the 'equilibrium' between R_q and $ln(t_{CA})$ should be figured out firstly; namely, TSLS is used to estimate the models of R_q and $ln(t_{CA})$, respectively. Only after identifying the form/model of $ln(t_{CA})$, the model of $ln(N_{CA})$ could be estimated under TSLS. The corresponding results could be seen in Table 6-5, 6-6 and 6-7 in following. In those tables, in spite of coefficients and other statistics, we especially give the instruments under TSLS.

6.5.1 The result of TSLS

Firstly, as for the regression of $ln(t_{CA})$, we use S_{BC}^{03}, $(S_{BC}^{02})^2$, $x2$ and S_{BC}^{3} as instruments under TSLS. Here S_{BC}^{03} is the exogenous explanatory variable for R_q, the variable of interest; $(S_{BC}^{02})^2$, $x2$ and S_{BC}^{3} are the ones of dependent variable, $ln(t_{CA})$.

Under TSLS, ${R_q}^2$ is insignificant (see Table 6-5). This indicates the bias of OLS; the regression overestimates the effect of relevant variable (here is ${R_q}^2$). Once removing ${R_q}^2$ in the model of $ln(t_{CA})$, two dummy variables are not significant any more (see the result of OLS for $ln(t_{CA})$ in Appendix 6-6). Namely, the real causing variables include only $(S_{BC}^{02})^2$ and S_{BC}^3. This would be mentioned again in following.

Table 6-5 the result of TSLS for $ln(t_{CA})$

Instrument specification: SBC03 SBC02^2 X2 SBC3

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.987004	0.622422	-4.799000	0.0001
SBC02^2	0.643170	1.023380	0.628476	0.5362
RQ^2	1.387082	2.484527	0.558288	0.5823
X2	0.417306	0.404777	1.030953	0.3138
SBC3	2.437420	2.129568	1.144560	0.2647
R-squared	-1.384109			
Adjusted R-squared	-1.817584			
Prob(J-statistic)	0.946837			

After identifying the equation of $ln(t_{CA})$, the model of $ln(N_{CA})$ is estimated under TSLS. In particular, R_i and $x1$, as the exogenous explanatory variables of $ln(N_{CA})$ and the exogenous explanatory variables of $ln(t_{CA})^2$, $(S_{BC}^{02})^2$ and S_{BC}^3, are used as instruments under TSLS. Unfortunately, $ln(t_{CA})^2$ is also insignificant in the TSLS regression of $ln(N_{CA})$ (see Table 6-6). Hence, OLS overestimates the effect of $ln(t_{CA})^2$ towards $ln(N_{CA})$.

Table 6-6: the result of TSLS for $ln(N_{CA})$

Instrument specification: RI X1 SBC02^2 SBC3

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.355310	0.290558	1.222853	0.2316
RI	1.154017	0.340801	3.386192	0.0021
LNTCA^2	-0.048659	0.080015	-0.608115	0.5480
X1	0.376996	0.219857	1.714737	0.0974
R-squared	0.391863			
Adjusted R-squared	0.326705			
Prob(J-statistic)	0.809529			

Seen from Table 6-5, $ln(t_{CA})$ cannot be explained by ${R_q}^2$ since ${R_q}^2$ is not really significant under TSLS. Hence, R_q should be only affected by $ln(t_{CA})$, not simultaneously. Simultaneity need not be considered for the regression of R_q. However, noting only 16% of variation of R_q could be explained under OLS (see Table 6-4), for the sake of safety, we still try to use TSLS as instrument variable method for estimation. When we consider the potentially omitted variables or measurement error related to $ln(t_{CA})$, the corresponding instrument include the real causing variables of $ln(t_{CA})$, $(S_{BC}^{02})^2$ and S_{BC}^{3}, with exogenous explanatory variable of R_q, $(S_{BC}^{02})^2$.

Seen from Table 6-7, the result of TSLS regression suggests the model is valid since p-value of J-statistics is bigger than 0.39, the exogeneity of instrument is satisfied. At the same time, the coefficient of determination is almost unchanged after TSLS. The signal of explanatory variables under TSLS stay same as the one under OLS.

Table 6-7: the result of TSLS for R_q

Instrument specification: SBC03 SBC02^2 SBC3

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNTCA	-0.319486	0.044211	-7.226423	0.0000
SBC03	-0.757148	0.321393	-2.355832	0.0266

R-squared	0.163894
Adjusted R-squared	0.130450
Prob(J-statistic)	0.394517

The following gives the results for $ln(N_{CA})$ and $ln(t_{CA})$ under OLS (by removing seemingly significant variables) while for R_q under TSLS.

$$\begin{cases} ln(N_{CA}) = 0.3564 + 1.0710R_i, \\ R_q = -0.3195ln(t_{CA}) - 0.7571S_{BC}^{03}, \\ ln(t_{CA}) = -2.5573 + 1.0169(S_{BC}^{02})^2 + 2.6483S_{BC}^{3}. \end{cases} \tag{10}$$

6.5.2 The discussion of result and regression model

Seen from (10), N_{CA}, R_q and t_{CA} are not affected simultaneously. Namely, those *ex post* risks are not related significantly to each other. This conclusion is different from the intuitive prediction, but it is true from our data.

Firstly, the final result of regression for *ex post* risk issue, (10), is different from the original result of regression without consideration of the simultaneity issue, (9). For one thing, this reflects the bias due to simultaneity issue over coefficient of independent variables. For another, the correlation between *ex post* risk indicators is not significant causing relationship, at least from our original data. This help government to avoid relevant excessive bailing-out compensation when the firm under PPP asserts the influence of some implicit *ex post* risk caused by observable *ex post* risk.

Secondly, the last three tables show *ex post* risk of our 32 PPP programs are from natural element instead of economic behaviour. Our regression relies on stepwise regression, which pick out the significant variables from data. Our regression model refers to mainly the reality; only the significant variable from reality data would be used for the explanation over variation of dependent variables. After removing seemingly significant variables, the coefficient of determination in (10) is relatively low (see Appendix 6-6). The biggest one is just about 31%. Need to note, under the specific regression model emphasizing the reality, we give thirteen indicators and two dummy variables, which measure economic situation of PPP program, as potential explanatory variables. The consequence is that few of explanatory variables are significant for these regression models. Hence, *ex post* risk could get explained inadequately by economic property of program under PPP. In other words, *ex post* risks in reality cannot be explained reasonably by economic behaviour under CA for PPP program.

Thirdly, three *ex post* risk are very difficult to control or avoid. (10) tells us *ex post* risk indicators have different independent variables. We cannot say which indicator (as independent variable) could be generally meaningful to control *ex post* risks. $ln(N_{CA})$, the log value of number of *ex post* CA, could be only explained by R_i, *ex ante* risk of raising project fund in share market. We must note that only PPP program starting with a public offering could use the contracting design of R_i to avoid or constrain *ex post* risk of N_{CA}. Similarly, *ex post* demand risk, R_q, is determined by the stage of *ex post* CA under whole program duration, t_{CA}, *ex ante* subsidy of government, S_{BC}^{03}. Especially, t_{CA} is very difficult to control; it should be dependent on the incentive of firm holding up government and the progress of project construction that is affected by the physical property of project. As for t_{CA} itself, it depends on *ex ante* debt support of government, S_{BC}^{02}, and *ex post* subsidy of government, S_{BC}^{3}. In particular, S_{BC}^{3} could be only identified by final *ex post* CA relative to original contract, for which nobody could really know until contract termination or contract end. To sum up these relationships, we could say that, even when we could really ignore the low explanation on *ex post* risk indicators, the independent variables are difficult to control, so the meaning of this regression in reality is limited.

For the implication of above ideas, the second and third one are meaningful and relevant. It could be concluded that *ex post* risks on PPP program are mainly from natural element instead of economic behaviour and then the design or contracting for *ex post* risk seems limited in reality.

6.6 Confirming Gauss-Markov assumptions

The Gauss-Markov assumptions involve three aspects, including linearity, homoscedasticity and the independence of residual error. These assumptions will be confirmed after following procedures.

6.6.1 Linearity assumption

In fact, this aspect has been considered in stepwise regression. Though the non-linearity trend represented by the square items is included as independent variables, it does not contradict linearity assumption. The reason is that the square item of variable and the original variable (both themselves as independent variables) are not included simultaneously in final results. Taking regression of $\mathrm{S}_{\mathrm{BC}}^{1}$ as an example, the potential non-linearity trend between $\mathrm{S}_{\mathrm{BC}}^{1}$ and $\mathrm{S}_{\mathrm{BC}}^{02}$ is added because of $(\mathrm{S}_{\mathrm{BC}}^{02})^2$ included in model while the linearity assumption between dependent variable ($\mathrm{S}_{\mathrm{BC}}^{1}$) and independent variable, $(\mathrm{S}_{\mathrm{BC}}^{02})^2$, is still satisfied.

6.6.2 Homoscedasticity assumption

Heteroscedasticity is always an important problem in cross-section data. The general way for testing heteroscedasticity is WT though other tests (e.g. Harvey test) could be applied. The WT has null hypothesis of homoscedasticity. When the probability is lower than (or equal to) 5%, the null hypothesis could be rejected at the significance level of 95% and then there is heteroscedasticity. On the contrary, there is no heteroscedasticity[44].

[44] We do not wrest with the situation when the test value is precisely equal to 0.05.

Table 6-8 shows the result of WT, more details could be seen in Appendix 6-7. Seen from Table 6-8, only the first and third model has no heteroscedasticity problem at the first set of regression while all models in second set of regression satisfy homoscedasticity assumption.

Table 6-8: the result of WT					
Model	S_{BC}^1	S_{BC}^2	S_{BC}^3	S_{BC}^4	R_{ap}
Value	0.2286	0.0265	0.8783	0.0005	0.0157
Model	NR_{ap}	$ln(N_{CA})$	R_C	R_q	$ln(t_{CA})$
Value	0.0000	0.6009	0.3671	0.7019	0.2016
There is no result of WT because the regression of R_t collapses (see Table 6-4).					

The relevant details in theory about heteroscedasticity have been revealed in Chapter 3; the following is to solve the hetersokedasticity problem for four models. The first step is to do OLS with White Standard Errors (WSE) in Eviews 7. The corresponding result except the one of NR_{ap} is given in the left part of Table 6-8. More details could be seen in Appendix 6-8. The model of NR_{ap} under OLS with WSE, WLS and FLGS would be talked finally in this subsection.

Secondly, the WLS will be used. One of independent variable (or its other form) or residual series of OLS (or its other form) will be used as weight series for regression. After that, WT will be used again to check if the weight series could be able to solve the problem really. If it is successful, the WT cannot reject null hypothesis anymore. When there are more than one series solving heterskedatsticity problem, the series that results into a biggest coefficient of determination and smallest value of t-test for variables will be chosen for the final result. In particular, the weight series include ten forms of independent variable or error of OLS. For example, for the model of S_{BC}^2, ESBC2^-3, ESBC2^-2, ESBC2^-1.5,ESBC2^-1, ESBC2^-0.5, ESBC2^0.5, ESBC2, ESBC2^1.5, ESBC2^2 and ESBC2^3 will be experimented. ESBC2 means the residual series of S_{BC}^2in regression. The result under WLS is given in the right part of Table 6-8. The result details could be seen in Appendix 6-9.

Thirdly, when WLS cannot deal with the problem, Feasible Generalized Least Squares (FGLS) will be used. WLS has already solved the problem except the model of NR_{ap}, so the model of NR_{ap} need be experimented to use FGLS. At the same time, as an extra example to use FGLS, the model of S_{BC}^{4} whose determination coefficient is lowest under WLS may become better under FGLS. Hence, these two models are tried to apply FGLS. Under FGLS, we use the exponential function for the relationship between error variance and independent variables, which isgeneral for multiplicative heteroscedasticity. The other reason for exponential function is following. Recalling there are three kinds of source of heteroscedasticity: ⑴group data, ⑵random coefficient,⑶mean square of fitted value. The first one is only applied for the average data. The second and third one has been used in WLS. When group data is not used and WLS cannot solve the heteroscedasticity, the exponential function is the last resort.

The result details could be seen in Appendix 6-10. From Appendix 6-10, FGLS indeed seems to give a really best estimation since the coefficient of determination reach 0.928087, which is fairly close to one. However, it is also found that FGLS may lead to the bigger problems of multicollinearity problem. The model of S_{BC}^{4} under FGLS has two variables whose VIF value bigger than 5: $x1$ get VIF value at 5.6392 and $(S_{BC}^{02})^2$ gets VIF value at 5.7297. Moreover, heteroscedasticity problem is not solved since the value of WT is 0.0002. Accordingly, it could be concluded that heteroscedasticity in the model of S_{BC}^{4} does not come from exponential relationship (between standard variance of error and fitted value). The result of WLS cannot be replaced by the one under FGLS.

Table 6-9 includes result under OLS with White error and under WLS for three models. Every model in Table 6-9 has some variable less significant and the data fitting becomes worse under OLS with White error. In fact, this is general phenomenon after using White error for the estimation. Though the adverse effect of heteroscedasticity problem could be avoided, the data fitting is always worse than before. In three models of Table 6-6, only the model of R_{ap} satisfies the significance level at 95% for independent variables, while others need adjustment.

Moreover, it could be seen that every model in Table 6-9 under WLS gets the variable more significant and fits data seems better (the determination coefficient is bigger than before). More importantly, all these models have no heteroskedacicity problem anymore since all of values of WT after manipulation get bigger than 5 percent.

Table 6-9: the results of OLS with white error and WLS						
	OLS with White error			WLS		
Independent variables	Dependent variables			Dependent variables		
	S_{BC}^2	S_{BC}^4	R_{ap}	S_{BC}^2	S_{BC}^4	R_{ap}
C	0.531386 4.116888*** Na	0.181807 2.612360* Na	0.905075 38.15388*** Na	0.513936 8.906042*** Na	0.466454 7.006861*** Na	0.903311 2144.653*** Na
R_i	Na Na Na	-0.229530 -1.425322 1.288532	-0.352303 -2.574978 1.058119	Na Na Na	-0.691907 -12.15662*** 1.113391	-0.324516 -13.68339*** 1.002766
$(R_i)^2$	-0.358232 -1.844902 1.445875	-0.167154 -4.287043*** 1.150028	Na Na Na	-0.366935 -4.406430*** 1.092803	Na Na Na	Na Na Na
$(S_{BC}^{01})^2$	0.439387 2.404269* 1.496030	-0.670422 -4.509158*** 9.013677	Na Na Na	0.466080 5.849349*** 1.119426	Na Na Na	Na Na Na
$(S_{BC}^{02})^2$	Na Na Na	-0.263604 -2.420073* 1.286756	Na Na Na	Na Na Na	-0.569309 -6.755746*** 1.158596	Na Na Na
$(S_{BC}^{03})^2$	-1.122626 -15.65673 1.069540	-0.918489 -4.728512*** 8.993706	-1.260333 -11.16298*** 1.108133	-1.109338 -17.61259*** 1.176058	Na Na Na	-1.272156 -48.64322*** 1.395549
$x1$	-0.153319 -3.679309*** 1.142307	-0.139962 -3.299072** 1.027441	-0.156625 -3.106803* 1.167062	-0.152069 -6.199003*** 1.213935	-0.235374 -9.688997*** 1.143580	-0.153301 -314.8519*** 1.393023
$R^2/\overline{R^2}$	0.730028 0.690032	0.360330 0.291794	0.671381 0.636172	0.957161 0.950815	0.901413 0.890850	0.999990 0.999989
The value of WT				0.2052	0.2653	0.2746

From the above table, it could be seen that WLS has better results for the models rather than the OLS with White error, so the former will be preferred. At the same time, the model of S_{BC}^4 fitted better under the FGLS, but it has heteroscedasticity under FGLS (see Appendix 6-10). Combining these, those three applies the WLS method.

Finally, the model of NR_{ap} has only one significant independent variable, $(R_i)^2$, after stepwise regression; but it become insignificant under OLS with WSE. Namely, p-value becomes 0.2027 (see Appendix 6-8) from 0.0001 (see Appendix 6-5). Moreover, it has still heteroscedasticity problem under WLS, the value of WT is 0.0000 (see Appendix 6-9). Hence, the null hypothesis of homoscedasticity should be rejected. The model of $(R_i)^2$ could have no heteroscedasticity problem under the FGLS, the WT value could reach 0.4761 (see Appendix 6-10). However, that model will be still abandoned because of the residual error of regression cannot satisfy the normality distribution, which could be seen section 6.7.

6.6.3 Independence assumption

This assumption requires $\mathrm{cov}(\varepsilon_i, \varepsilon_j) = 0$, but it could be neglected directly when cross-section data is used unless the consideration of spatial autocorrelation. When the cross-section data has autocorrelation problem, it means nothing for different section. A simple numerical example is given in following.

We assume three values for residual items (for convenience and simplicity): 0.2, 0.4, 0.9. Namely, $\varepsilon_1 = 0.2, \varepsilon_2 = 0.4, \varepsilon_3 = 0.9$. So there is $\mathrm{cov}(\varepsilon_i, \varepsilon_{i-1}) = \mathrm{E}\left(\left(\varepsilon_i - \mathrm{E}(\varepsilon_i)\right)\left(\varepsilon_{i-1} - \mathrm{E}(\varepsilon_{i-1})\right)\right) = \left(0.4 - \frac{0.4+0.9}{2}\right)\left(0.2 - \frac{0.2+0.4}{2}\right) + \left(0.9 - \frac{0.4+0.9}{2}\right)\left(0.4 - \frac{0.2+0.4}{2}\right) = 0.1223.$

However, if the order is changed (as usual, cross-section data is given in random order), for example, the residual series become following. $\varepsilon_1 = 0.4, \varepsilon_2 = 0.9, \varepsilon_3 = 0.2$. Therefore, there is $\mathrm{cov}(\varepsilon_i, \varepsilon_{i-1}) = \mathrm{E}\left(\left(\varepsilon_i - \mathrm{E}(\varepsilon_i)\right)\left(\varepsilon_{i-1} - \mathrm{E}(\varepsilon_{i-1})\right)\right) = \left(0.9 - \frac{0.9+0.2}{2}\right)\left(0.4 - \frac{0.4+0.9}{2}\right) + \left(0.2 - \frac{0.9+0.2}{2}\right)\left(0.9 - \frac{0.4+0.9}{2}\right) = 0.2441.$

This illustrates value of covariance of error series for cross-section data is unreliable; it is affected by the order of data. When the data must be kept in specific order (for example, time series), the covariance of error series could explains some effect, for example, ratchet effect. However, the independence assumption is meaningless when the order of cross-section data is totally random; this explains why researcher with cross-section data always skips independence testing. This opinion gets supported by a group of scholars. The details could be seen in Chapter 3.

6.7 Verifying normality

The result of normality test is following. The histogram and relevant details could be seen in Appendix 6-11. The normality test has null hypothesis of normal distribution, any probability of test over 5% could not reject the null hypothesis and then the normality of error distribution is satisfied.

The Table 6-10 includes every p-value of Jarque-Bera test for two sets of regression. In particular, the models of S_{BC}^1, S_{BC}^3, $ln(N_{CA})$, $ln(t_{CA})$ and $R_c$gets tested directly after OLS, the model of R_q is checked after TSLS, the models of S_{BC}^2, S_{BC}^4 and R_{ap} are done after WLS and the model of NR_{ap} is examined after FGLS. Two models of NR_{ap} and R_c cannot satisfy the normality requirement. In addition, the model of R_t is not tested for the normality distribution since R_t cannot be regressed over any independent variable. It is seen that all of histograms of models except the one of NR_{ap} and R_c satisfy the normal distribution, which could be seen from the figure in Appendix 6-11.

Table 6-10: The results of Jarque-Bera test on residual errors

Model	S_{BC}^1	S_{BC}^2	S_{BC}^3	S_{BC}^4	R_{ap}
p-value	0.6750	0. 3164	0.1081	0.1891	0.7281
Model	NR_{ap}	$ln(N_{CA})$	R_c	R_q	$ln(t_{CA})$
p-value	0.0044	0.0778	0.0000	0.7146	0.6550

6.8 The final model and the endogeneity issue

This section gives final models firstly and then give our consideration for endogeneity issue. It has been seen that eight models satisfy all of assumptions and requirements. The final results come from Table 6-5 for $S_{BC}^1$and S_{BC}^3, Table 6-6, 6-7 and 6-8 for $ln(N_{CA})$, R_q and $ln(t_{CA})$, respectively, and from Table 6-9 for S_{BC}^2, S_{BC}^4 and R_{ap}. All of established models of regression are given in following as (11).

$$\begin{cases} S_{BC}^1 = 0.7004 + 0.0551(S_{BC}^{02})^2 - 0.0860S_{BC}^{03} - 0.1854\,ln(R_t) - 0.1396l\,n(t_{CA}) + \\ 0.6502x1 + 0.5866x2, \\ S_{BC}^2/w_i = 0.5139/w_i - 0.3670(R_i)^2/w_i + 0.4661(S_{BC}^{01})^2/w_i - 1.1093(S_{BC}^{03})^2/w_i - \\ 0.1521x1/w_i, \\ S_{BC}^3 = 0.4088 - 0.2691S_{BC}^{01} - 0.1678\,ln(R_t) - 0.0849x1 - 0.1438x2, \\ S_{BC}^4/w_j = 0.4665/w_j - 0.6919R_i/w_j - 0.5693(S_{BC}^{02})^2/w_j - 0.2354x1/w_j, \\ R_{ap}/w_k = 0.9033/w_k - 0.3245R_i/w_k - 1.2722(S_{BC}^{03})^2/w_k - 0.1533x1/w_k, \\ l\,n(N_{CA}) = 0.3564 + 1.0710R_i, \\ R_q = -0.3195l\,n(t_{CA}) - 0.7571S_{BC}^{03}, \\ ln(t_{CA}) = -2.5573 + 1.0169(S_{BC}^{02})^2 + 2.6483S_{BC}^3. \end{cases} \tag{11}$$

w_i, w_j and w_k in (11) represent the weight for the regression on S^2_{BC}, S^4_{BC} and R_{ap} under WLS, respectively. The precise forms of weight could be seen in Appendix 6-9.

As mentioned before, endogeneity will make OLS estimation biased; that is why we use TSLS for the second set of regression. Here endogeneity issue is especially discussed for the first set of regression since the potential endogeneity issue in the second set of regression has been solved by TSLS.

In the first set of regression, the simultaneity does not exist. At first, the softness indicators (in final situation) cannot affect *ex ante* indicators in theory. Similarly, the dummy variables measuring the package of CA cannot be affected nether by softness indicators since the package depends on the external elements (i.e. debt relies on bank involvement, compensation need political support and extra investment from firm need contribution from shareholders instead of firm. More details about the feasibilities of CA packages could be seen in section 6.10). The sole potential reverse causality involves *ex post* risk indicators, i.e. more contribution leads to more *ex post* risk over program. The fact denies this reverse causality. There is no any couple of softness indicator and *ex post* risk indicator affecting each other. Seen from the final results above, the only softness indicator affected by *ex post* risk, S^3_{BC}, cannot affect its dependent variable, t_{CA}. Thereafter, the endogeneity issue is basically rejected.

It is worthy of mentioning again that endogeneity may be from omitted variable and measurement mistake in spite of simultaneity. Either omitted measurement or measurement mistake is always related to questionable (not all) dummy variables (see Beuve and Saussier 2012, Desrieux et al 2013 and Chong et al 2006). The dummy variable is a qualitative indicator that easily ignores other aspect or measures the variable wrongly due to unsuitable standard/definition. However, for the first set of regression, there is no logic for these potential problems. Our dummy variables are for a really physical existence; those are actually instruments to divide the method of CA under PPP. Even we assume the dummy variables have problems, an instrument variable for each dummy variable need be used. Namely, instrument variables of instrument variables should be used. This is not logical. Thereafter, it gives us confidence in the results. The design of our dummy variables are based on the other data; the main objective is to fit data better, the design and measurement of our dummy variables are very clear; it give us the confidence to avoid omitted variable and measurement problem.

6.9 The discussion of regression results

This section discusses the regression results. Precisely, it involves three procedures. At first, the result and regression model will be explained. Then the detailed regression result will be compared with the predicted relationship constructed in Chapter 5. Finally, by summing up the comparison between prediction and real relationships, we could test the hypotheses.

6.9.1 The discussion of result and regression model

The discussion of result and regression model for *ex post* risk indicators has been done in section 6.5. Here only involves the regression of four final softness indicators ($S_{BC}^1, S_{BC}^2, S_{BC}^3$ and S_{BC}^4) and one reliance indicator (R_{ap}) in (11).

Seen from (11), those dependent variables get explained at least by four causing variables (including dummy variable or constant). In particular, S_{BC}^1 and S_{BC}^3 has seven and five causing variables, respectively. About 85% of S_{BC}^1 variation and more than 50% of S_{BC}^3 variation could be explained. Considering this thesis does not add control variables in regression, the coefficient of determination for S_{BC}^1 and S_{BC}^3 are satisfactory. Moreover, for S_{BC}^2, S_{BC}^4 and R_{ap}, after WLS, the coefficient of determination is very high. The least one is bigger than 90% (see Table 6-9). We cannot say S_{BC}^2, S_{BC}^4 and R_{ap} are explained better than S_{BC}^1 and S_{BC}^3 since the former three and the latter two use different estimation method, but considering the high coefficient value of determination, we could see the estimations of S_{BC}^2, S_{BC}^4 and R_{ap} could be efficient after removing the source of heteroskedasticity.

Moreover, the regression of four final softness indicators ($S_{BC}^1, S_{BC}^2, S_{BC}^3$ and S_{BC}^4) and one reliance indicator (R_{ap}) could be divided into two categories of regression model, homoscedasticity regressions under OLS and heteroskedasticity regressions under WLS. The former involves S_{BC}^1 and S_{BC}^3 while the latter is related to S_{BC}^2, S_{BC}^4 and R_{ap}. In fact, the difference between regression models reflects that S_{BC}^1 and S_{BC}^3 could be general under CA for PPP program while S_{BC}^{2}, S_{BC}^{4} and R_{ap} are different project by project. We have controlled and constrained the difference in data when we design indicators, the remaining difference could be could be reflected by the weight series under WLS. seen from Table 6-9, the weight series of S_{BC}^{2} and R_{ap} under WLS are related to the residual series of OLS, namely, the heteroskedasticity of S_{BC}^{2} and R_{ap} comes from the mean of fitted value. In other words, the heteroskedasticity of S_{BC}^{2} and R_{ap} happens when the data value scales up. The weight series of S_{BC}^{4} under WLS involves its explanatory variable $((S_{BC}^{02})^2)$, namely, the heteroskedasticity S_{BC}^{4} comes from the random effect of $(S_{BC}^{02})^2$ across section. To sum up, the indicators of S_{BC}^{1} and S_{BC}^{3} are general for PPP programs; the indicators of S_{BC}^{2} and R_{ap} could be general after removing the difference in scale while the indicator of S_{BC}^{4} should considers the difference in the levels of $(S_{BC}^{02})^2$.

In addition, seen from (11), *ex ante* variable(s) of government contribution should be meaningful generally for constraining government contribution. At first, just focusing on OLS regression results, for S_{BC}^{1}, S_{BC}^{02} and S_{BC}^{03} are significant. Though S_{BC}^{01} is not significantly meaningful for S_{BC}^{1}, it should be considered for the sake of S_{BC}^{3}. These significant variables do not need consider the specific property of PPP program since the homoscedasticity assumption is satisfied. Secondly, if removing the variation due to heteroskedasticity, we could see S_{BC}^{01} and S_{BC}^{03} are significant for S_{BC}^{2}. At the same time, S_{BC}^{02} is not significantly meaningful for S_{BC}^{2}, but it ought to be related for S_{BC}^{4}. For R_{ap}, S_{BC}^{03} cannot be ignored. In other words, after excluding the influence of the idiosyncratic variation in data, which is reflected by weight series in (11), *ex ante* government contribution must affect one of softness indicators.

Furthermore, relative to *ex ante* variables of government contribution, another two indicators of *ex ante* situation has only limited implication. Precisely, *ex ante* risk of raising project fund in share market, R_d, is not significant at all for five softness indicators. R_i, *ex ante* risk of raising project fund in debt market, is only meaningful for S_{BC}^{2} and S_{BC}^{4}. At the same time, the explanation power of R_d and R_i must consider the idiosyncratic variation in data. Namely, *ex ante* risk of raising project fund is either insignificant or significant after considering the property of project or contract of PPP program. To sum up, *ex ante* risk of raising project fund is limited for implication of PPP program for CA.

Finally, *ex post* risk are only meaningful for controlling or constraining global government contribution after CA(s). Seen from (11), only S_{BC}^{1}, the global government contribution (the total softness) for PPP program after CA(s) is affected significantly by R_t and t_{CA}. Other *ex post* risk indicators are not meaningful for explanation on S_{BC}^{1}; R_t and t_{CA} are not useful any more for the explanation on the other softness. Therefore, *ex post* risk has limited explanation over softness indicators. As found in section 6.5.2, *ex post* risks cannot be affected to each other and the relevant effects are not general. Putting these two findings together, our original data tell us *ex post* risk is not only difficult to control but also little valuable for controlling or constraining softness indicator of PPP program under CA. More discussion about the result for economics relationship could be seen in next subsection.

6.9.2 The result of prediction testing

Considering all of weights used for WLS are the n-th power of absolute value of some series, the weight must be positive; hence, we could omit weights for the relationship in (11). All of relationships from our data are concluded in Table 6-11.

The above models involve three kinds of result relative to initial prediction. In spite of nine mixed relationship are confirmed from data, fourteen relationships cannot be rejected while two ones go to the opposite. In particular, the relationship is fixed instead of confirmed or denies because the original prediction has no clear expectation; the fixed relationship is aimed for extra insight (e.g. policy suggestion in Chapter 7). Therefore, for the prediction testing and later hypothesis testing, we omit the fixed relationship. Moreover, some relationships cannot be identified due to the variable insignificance. Those potential relationships are also omitted since our data cannot satisfy significance test in regression.

Relative to original prediction, the effect of following seven variables get supported or rejected fully from data (except when those are insignificant, see Table 6-11). Those include R_i, S_{BC}^{01}, S_{BC}^{02}, S_{BC}^{03}, R_t, $x1$ and $x2$. Of these variables, R_t gets totally rejected when it is significant. The negative relationships of R_t with S_{BC}^{1} and S_{BC}^{3} hints the delay have a constraint effect over softness. This is counterintuitive. It is worthy to mention that R_q get only one fixed relationship while all of others are not significant. Combining

$R_t$and R_q, it could be seen that this kind of *ex post* risk monitored closely by economic regulator cannot have a direct and meaningful relationship with economic elements. This hints CA based on *ex post* risk is justified. Furthermore, $x1$ or $x2$ have two negative relationships as same as prediction. This illustrates $x1$ has a role of decreasing S_{BC}^2 and S_{BC}^4 while $x2$ could constrain S_{BC}^1 and S_{BC}^3. The way of CA at rescue package indeed has relationships as predicted.

Table 6-11: the results of hypothesis test

Independent variables	Softness					*Ex post* risk		
	S_{BC}^1	S_{BC}^2	S_{BC}^3	S_{BC}^4	R_{ap}	N_{CA}	R_q	t_{CA}
R_i	Na	Yes	Na	Yes	Yes	Yes	Na	Na
S_{BC}^{01}	Na	Yes	Yes	Na	Na	Na	Na	Na
S_{BC}^{02}	Yes	Na	Na	Yes	Na	Na	Na	Fix
S_{BC}^{03}	Fix	Yes	Na	Na	Fix	Na	Yes	Na
R_t	No	Na	No	Na	Na	Na	Na	Na
t_{CA}	Fix	Na	Na	Na	Na	Na	Fix	×
$x1$	Yes	Yes	Fix	Yes	Fix	Na	Na	Na
$x2$	Fix	Na	Yes	Na	Na	Na	Na	Na
S_{BC}^3	×	×	×	×	×	Na	Na	Fix

Na: the indicator is removed by regression, Yes: cannot be rejected, No: rejected, Fix: fixed relationship from regression, ×: not in regression.

As for the discussion of specific economic relationships, it will be finished when we suggest policy for PPP program under CA. as mentioned above, the fourteen relationships fixed from data will be analysed over there.

6.9.3 The result of hypothesis testing

As mentioned above, we only consider the confirmed economic relationship and denied one for hypothesis testing.

Firstly, Hypothesis 3 and Hypothesis 5 are rejected by our data. There are only two prediction denied; R_t is denied for S_{BC}^1 or S_{BC}^3. Moreover, R_t, an indicator of *ex post* risk has no confirmed (or even fixed) predictions except those two denies ones. At the same time, the other significant *ex post* risk indicator, t_{CA}, just get two fixed relationships. Namely, even when t_{CA} is not denied by data, it is neither accepted by data. It could be confident that the prediction of *ex post* risk cannot be accepted by data. Recalling Hypothesis 3 expecting *ex post* risk to have a positive relationship with final softness indicators (S_{BC}^1, S_{BC}^2, S_{BC}^3 and S_{BC}^4), regression result illustrates Hypothesis 3 is rejected. In spite of hypothesis 3, Hypothesis 5 expecting *ex post* risks are affected to each other, it is also rejected by our regression result. It is worth noting that two relationships are confirmed by regression result, R_i related positively to N_{CA} and S_{BC}^3 positively correlated to R_q. However, those two are not relevant for the hypothesis testing; we will analyse those for policy suggestion in Chapter 7.

Secondly, Hypothesis 4 is not rejected. All prediction of variables except R_t and t_{CA} are not rejected by regression result. Precisely, *ex ante* risk indicators are expected to have positive relationships with final softness indicators in Hypothesis 4, our regression result does not reject the predicted relationships and even confirmed some of those.

Thirdly, *ex ante* government contribution (S_{BC}^{01}, S_{BC}^{02} and S_{BC}^{03}) are involved in Hypothesis 1 for S_{BC}^3 and S_{BC}^4 while those are related to S_{BC}^1 and S_{BC}^2 in Hypothesis 2; no rejection from regression result means Hypothesis 1 and Hypothesis 2 are not rejected.

In fact, combining the hypothesis testing, it could be summed up that *ex post* risk is not meaningful as it is expected while all of other variables (*ex ante* variables, final softness indicators, reliance indicators and dummy variables) are not rejected by data.

6.10 The test on feasibility of CA with different methods

Based on our data and econometrical models, the following will figure out feasibility of CA with different methods. As mentioned before, whether CA is feasible or not actually relies on some other parties instead of firm and government. Recalling the definition of dummy variables, if $x_1 = 0$, bank involvement is necessary; otherwise, political support is needed for compensation. Similar, if $x_2 = 1$, extra investment from shareholders is needed, which is difficult to realize when PPP program is under CA; because extra investment from shareholders means *ex post* contribution from shareholders instead of existing resource within firm. *Ex post* proposal for CA must satisfy relevant premise, otherwise, the feasibility will be vulnerable.

Different combination in model means different way of CA. To be precise, $x1 = x2 = 0$ means government does not compensate directly firm while firm has no extra investment; namely, this is an indirect and unilateral support way of government for CA. $x1 = 0, x2 = 1$ tells government supports firm in an indirect way (in the manner of debt support) while firm has *ex post* investment; namely, this is an indirect and reciprocal support way. Similarly, $x1 = 1, x2 = 0$ should represents a direct and unilateral support way while $x1 = x2 = 1$ reflects a direct and reciprocal way. If anyone leads to an irrational value of dependent variables under simulated situations, it is infeasible for CA.

Only S_{BC}^{1} and $\mathrm{S}_{\mathrm{BC}}^{3}$ get simulated results in following tables though dummy variables are significant in above seven models. Three WLS models are not applied for this simulation. The reason is WLS could only give a reliable model with relevant weight that derives from dependent variable or residual error of OLS. If those are used for simulation, the weight must be added. The weight derives from our data; it cannot just reflect the minimum, mean or maximum level. Namely, adding a weight series will break the scenario we construct for simulation. To some extent, this test on simulation is not complete since those three models from WLS cannot be used; however, this simulation will help get extra insight from our data and models. Moreover, three models of *ex post* risk are not used for simulation since it has no relationship with dummy variables.

The following will use our data to construct nine scenarios. From the descriptive statistics of data, which is shown in Appendix 6-1, we choose three kinds of data: minimum, mean and maximum. For S_{BC}^{1} and $\mathrm{S}_{\mathrm{BC}}^{3}$, in spite of dummy variables, the corresponding independent variables could be divided as two categoriesof variables, which reflecting initial government contribution and *ex post* risks, respectively. Two categories of independent variables could be represented by values at three levels (mini, mean and max). Every category has three situations, so the combination of two categories of independent variables must have nine situations. That is why Table 6-9and Table 6-10 have three rows and three columns labelled with minimum, mean and maximum.

After that, combining four sets of x1 and x2 with nine simulated scenarios reflected by dependent variables and then obtaining the values of dependent variables. This process is finished with Matlab 7.0. Four sets of our econometrical models get simulated result in following two tables.

According to the definition, S_{BC}^{1} and $\mathrm{S}_{\mathrm{BC}}^{3}$ must be into the following set, $[0,1]$ and $[-1,1]$, respectively. Hence, any values at simulated scenarios outside corresponding ranges will expose that the corresponding combination of dummy variables are not feasible. Seen from Table 6-12, CA could easily lead to an irrational value of S_{BC}^{1}, which is shaded in Table 6-12. Very importantly and meaningfully, only when *ex post* risk is not at minimum level and government adopts an indirect and unilateral support way of government for CA, simply speaking, only pure debt package (pure here means no *ex post* shareholder investment as a return for *ex post* government contribution; this will be followed later) is feasible for CA. this reflects the conclusion in modelling, *ex post* risk transfer is the first (and dominant) option for CA. In fact, those irrational values will not happen really, those will end up with a takeover policy of government. It is worthy attention that compensation package ($x1 = 1$) and *ex post* shareholder's investment ($x2 = 1$) are generally infeasible in any of three scenarios though those really exist (see Table 5-3). This derives from that the reality is more complicated than the simulation.

Moreover, $\mathrm{S}_{\mathrm{BC}}^{3}$ under simulated scenarios have no irrational values. According to definition, there is $S_{BC}^{3} + S_{BC}^{01} = S_{BC}^{1}$; S_{BC}^{1} whose maximum value and minimum value are 1 and 0.3253 in data, respectively. S_{BC}^{3} should fall into the range of $[-1, 0.6747]$. The simulation still has no irrational values. This uncover *ex post* contribution cannot reach the potential Maximum value after CA. This indicates the constraint effect of CA.

It need extra attention is that some CA package could lead to a negative value of $\mathrm{S}_{\mathrm{BC}}^{3}$ (see numbers framed by box in Table 6-13). There are two conditions: (1)$x2 = 0$, (2)S_{BC}^{01} cannot be at minimum level. This indicate *ex post* contribution from shareholders for program should be on the base of big enough level of initial government contribution though it indeed reduces the softness level. To sum up, there are two conclusions as following: only pure debt package could be generally feasible under CA for PPP program; *ex post* contribution from shareholders has preliminary condition to realize.

Table 6-12: the simulation results for S_{BC}^{1}													
Ex post Risks (R_t & t_{CA})		minimum				mean				maximum			
$(x1, x2)$		(0,0)	(0,1)	(1,0)	(1,1)	(0,0)	(0,1)	(1,0)	(1,1)	(0,0)	(0,1)	(1,0)	(1,1)
Initial contribution (S_{BC}^{02} and S_{BC}^{03})	mini	1.1973	1.7840	1.8476	2.4342	0.8982	1.4848	1.5484	2.1350	0.6699	1.2565	1.3202	1.9068
	mean	1.2110	1.7976	1.8612	2.4478	0.9119	1.4985	1.5621	2.1487	0.6836	1.2702	1.3338	1.9204
	max	1.1848	1.7714	1.8350	2.4216	0.8857	1.4723	1.5359	2.1225	0.6574	1.2440	1.3076	1.8942
Note: all values in shadow are irrational for CA, which means the corresponding CA package is feasible in reality.													

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Table 6-13: the simulation results for S_{BC}^{3}													
Ex post risks (R_t)		Minimum				mean				maximum			
$(x1, x2)$		(0,0)	(0,1)	(1,0)	(1,1)	(0,0)	(0,1)	(1,0)	(1,1)	(0,0)	(0,1)	(1,0)	(1,1)
Initial contribution (S_{BC}^{01})	mini	0.3827	0.2389	0.2977	0.1540	0.3298	0.1860	0.2448	0.1011	0.2472	0.1034	0.1623	0.0185
	mean	0.2344	0.0907	0.1495	0.0057	0.1815	0.0378	0.0966	$\boxed{-0.0472}$	0.0990	$\boxed{-0.0448}$	0.0140	$\boxed{-0.1297}$
	max	0.1779	0.0342	0.0930	$\boxed{-0.0507}$	0.1250	$\boxed{-0.0187}$	0.0401	$\boxed{-0.1036}$	0.0425	$\boxed{-0.1013}$	$\boxed{-0.0424}$	$\boxed{-0.1862}$
Note: all values in box are negative, which mean the corresponding CA package reduces government contribution.													

6.11 Summary

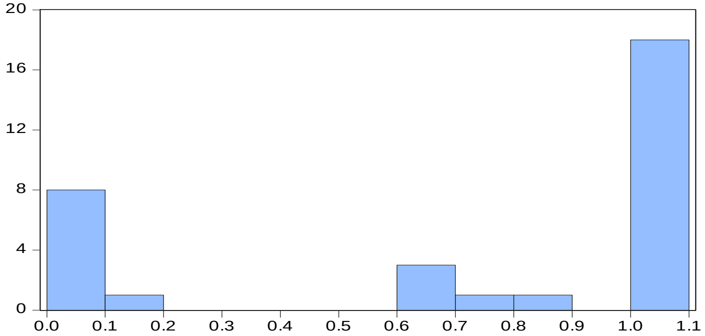
This chapter analyses especially our data. At first, data gets analysed with descriptive statistics for different groups of indicators. Then, softness indicators and *ex post* risk indicators are regressed to figure out potential relationships. In particular, the regression goes through initial analysis, stepwise analysis, the confirmation on Gauss-Markov assumptions and the verification of normality. Endogeneity issue is also considered. In the end, hypothesis gets tested on the base of final result.

There is a very important conclusion from this chapter. *Ex post* risk is not meaningful as it is expected while all of other variables (*ex ante* variables, final softness indicators, reliance indicators and dummy variables) are not rejected by data. In spite of that, it could be seen from simulation as following: only pure debt package could be generally feasible under CA for PPP program; *ex post* contribution from shareholders has preliminary condition to realize.

Appendix 6-1 the descriptive statistics of data

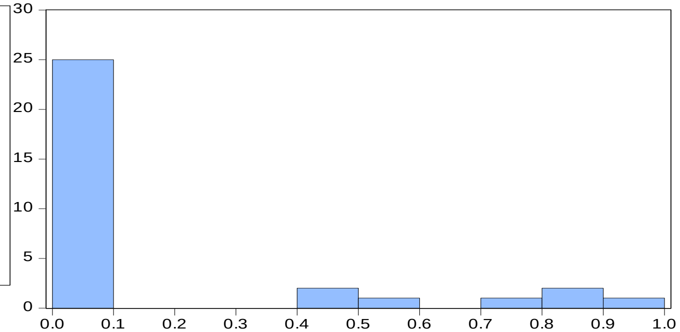
	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability	Sum	Sum Sq. Dev.	Observations
RD	0.684447	1	1	0	0.428212	-0.81435	1.829765	5.36285	0.068466	21.9023	5.684321	32
RI	0.153738	0	0.955	0	0.30869	1.650998	4.084852	16.10677	0.000318	4.9196	2.953971	32
SBC01	0.767819	0.7817	0.9777	0.2169	0.150088	-1.78133	7.444462	43.26095	0	24.5702	0.698318	32
SBC02	0.660744	0.76	0.9756	0	0.238418	-1.24351	3.654917	8.818892	0.012162	21.1438	1.762135	32
SBC03	0.121197	0	0.7571	0	0.224029	1.624157	4.268165	16.21305	0.000302	3.8783	1.555852	32
NCA	2.1875	1	8	1	1.891194	1.760904	5.206119	23.02678	0.00001	70	110.875	32
RC	1.511294	1.37475	3.4324	1.0425	0.485762	2.248099	8.910145	73.52749	0	48.3614	7.3149	32
RT	1.130909	1.0764	1.85	0.825	0.210652	1.357619	5.449022	17.82696	0.000135	36.1891	1.375606	32
RQ	0.490111	0.3881	1	0	0.359468	0.31186	1.73863	2.227592	0.32831	13.233	3.359655	27
TCA	0.205784	0.16555	0.5493	0.0367	0.120649	1.077467	3.682851	6.813362	0.033151	6.585100	0.451245	32
X1	0.40625	0	1	0	0.498991	0.381771	1.145749	5.361657	0.068506	13	7.71875	32
X2	0.21875	0	1	0	0.420013	1.360672	2.851429	9.903717	0.00707	7	5.46875	32
SBC1	0.885928	0.9306	1	0.3252	0.149779	-2.00719	7.558678	49.19571	0	28.3497	0.695451	32
SBC2	0.625119	0.6606	0.9476	0	0.244214	-0.74812	2.763037	3.059863	0.216551	20.0038	1.848856	32
SBC3	0.118106	0.1132	0.36	-0.018	0.088458	0.652783	3.241862	2.350666	0.308716	3.7794	0.24257	32
SBC4	-0.03994	0	0.1833	-0.629	0.163683	-1.57528	6.447821	29.08471	0	-1.2781	0.830552	32
RAP	0.707493	0.773138	1	0	0.258529	-0.86669	3.069612	4.012618	0.134484	22.63978	2.07196	32
NRAP	1.701922	0	98.28125	-39.8333	19.02224	3.945153	22.88445	610.198	0	54.46151	11217.21	32

Appendix 6-2 histogram of data distribution



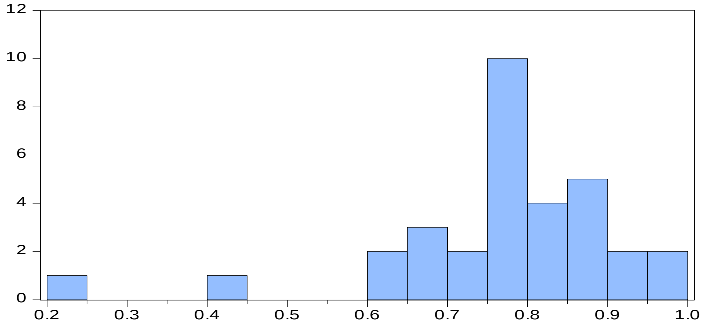
Series: RD
Sample 1 32
Observations 32

Mean	0.684447
Median	1.000000
Maximum	1.000000
Minimum	0.000000
Std. Dev.	0.428212
Skewness	-0.814354
Kurtosis	1.829765
Jarque-Bera	5.362850
Probability	0.068466



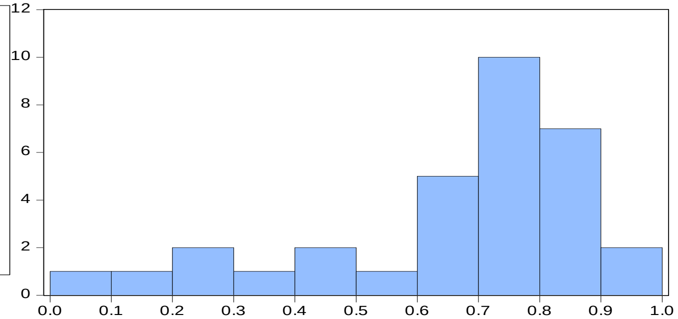
Series: RI
Sample 1 32
Observations 32

Mean	0.153738
Median	0.000000
Maximum	0.955000
Minimum	0.000000
Std. Dev.	0.308690
Skewness	1.650998
Kurtosis	4.084852
Jarque-Bera	16.10677
Probability	0.000318



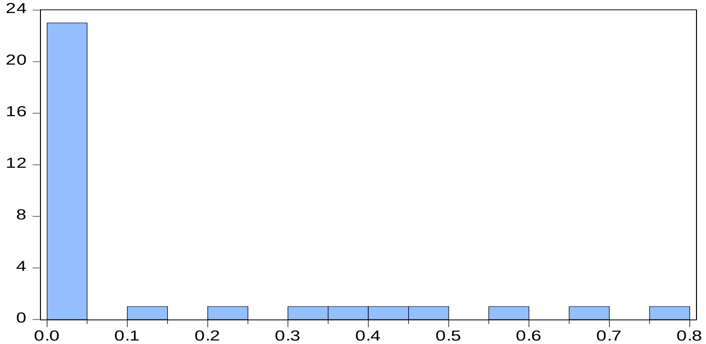
Series: SBC01
Sample 1 32
Observations 32

Mean	0.767819
Median	0.781700
Maximum	0.977700
Minimum	0.216900
Std. Dev.	0.150088
Skewness	-1.781325
Kurtosis	7.444462
Jarque-Bera	43.26095
Probability	0.000000



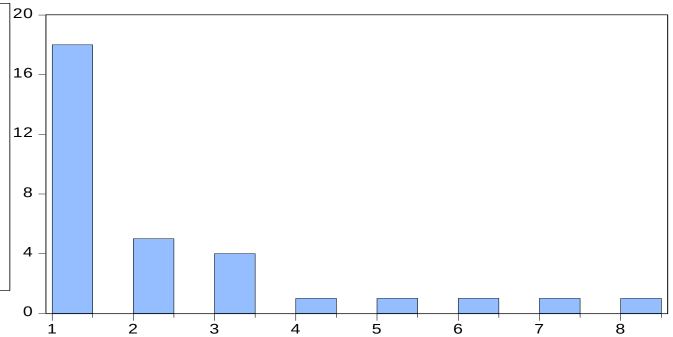
Series: SBC02
Sample 1 32
Observations 32

Mean	0.660744
Median	0.760000
Maximum	0.975600
Minimum	0.000000
Std. Dev.	0.238418
Skewness	-1.243508
Kurtosis	3.654917
Jarque-Bera	8.818892
Probability	0.012162



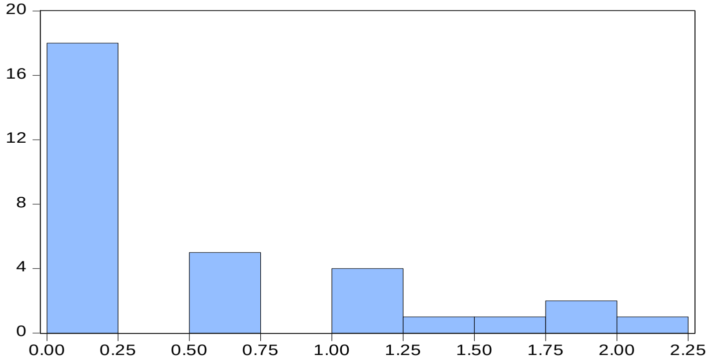
Series: SBC03
Sample 1 32
Observations 32

Mean	0.121197
Median	0.000000
Maximum	0.757100
Minimum	0.000000
Std. Dev.	0.224029
Skewness	1.624157
Kurtosis	4.268165
Jarque-Bera	16.21305
Probability	0.000302

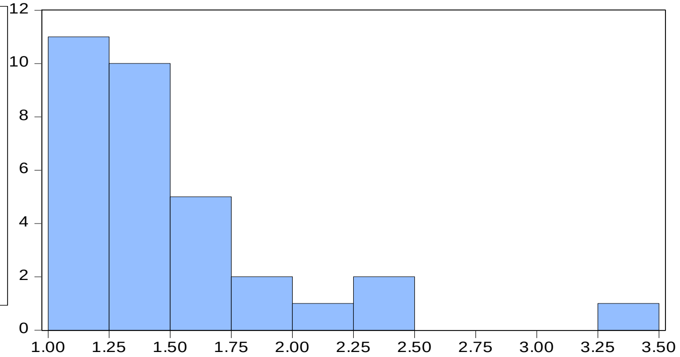


Series: NCA
Sample 1 32
Observations 32

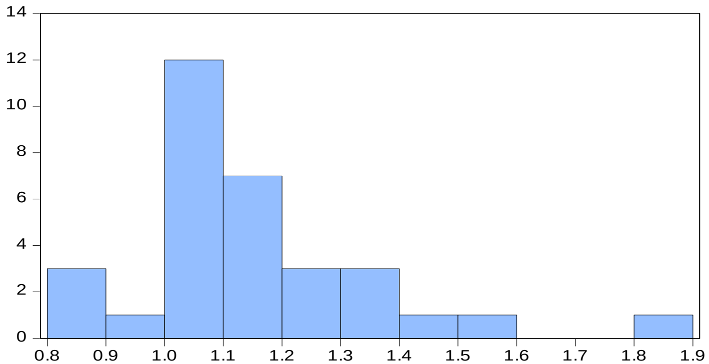
Mean	2.187500
Median	1.000000
Maximum	8.000000
Minimum	1.000000
Std. Dev.	1.891194
Skewness	1.760904
Kurtosis	5.206119
Jarque-Bera	23.02678
Probability	0.000010



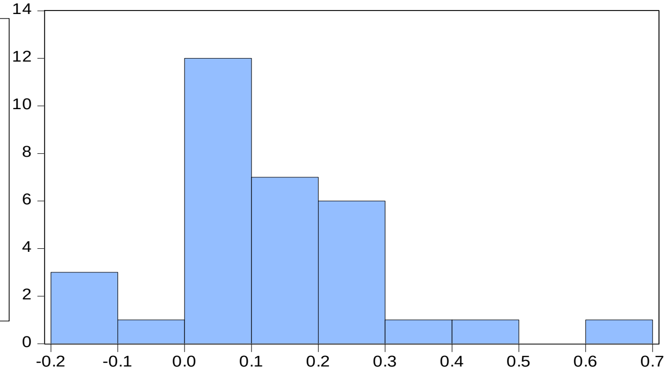
Series: LNNCA	
Sample 1 32	
Observations 32	
Mean	0.521032
Median	0.000000
Maximum	2.079442
Minimum	0.000000
Std. Dev.	0.680987
Skewness	0.925407
Kurtosis	2.534312
Jarque-Bera	4.856505
Probability	0.088191



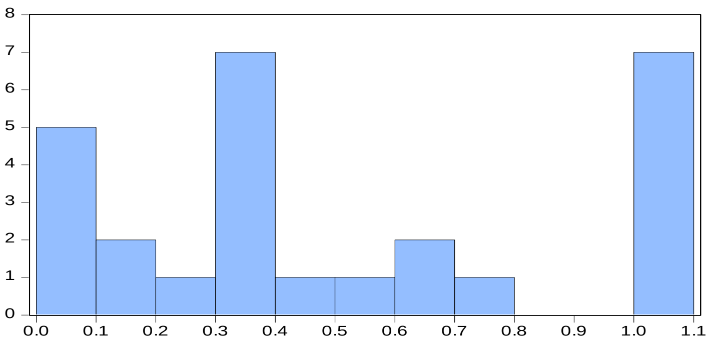
Series: RC	
Sample 1 32	
Observations 32	
Mean	1.511294
Median	1.374750
Maximum	3.432400
Minimum	1.042500
Std. Dev.	0.485762
Skewness	2.248099
Kurtosis	8.910145
Jarque-Bera	73.52749
Probability	0.000000



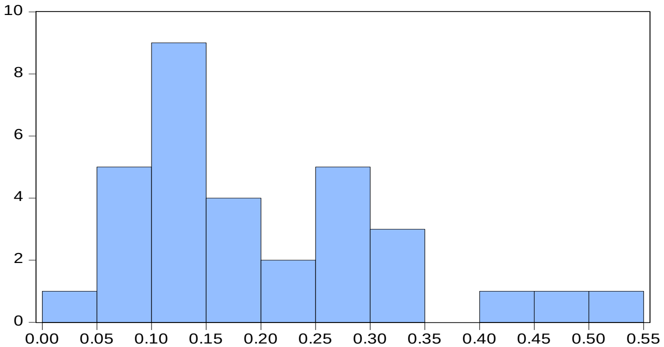
Series: RT	
Sample 1 32	
Observations 32	
Mean	1.130909
Median	1.076400
Maximum	1.850000
Minimum	0.825000
Std. Dev.	0.210652
Skewness	1.357619
Kurtosis	5.449022
Jarque-Bera	17.82696
Probability	0.000135



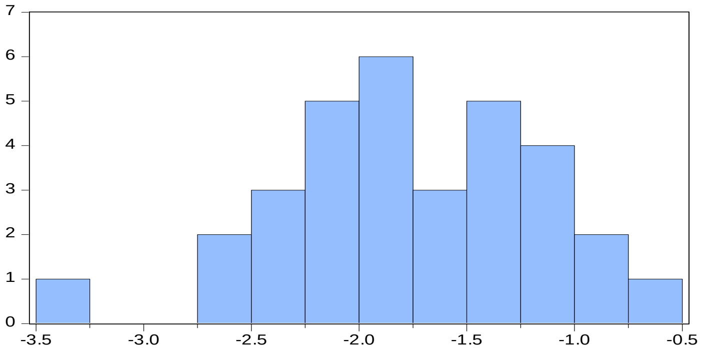
Series: LNRT	
Sample 1 32	
Observations 32	
Mean	0.107898
Median	0.072602
Maximum	0.615186
Minimum	-0.192372
Std. Dev.	0.172794
Skewness	0.777931
Kurtosis	3.697004
Jarque-Bera	3.875362
Probability	0.144038



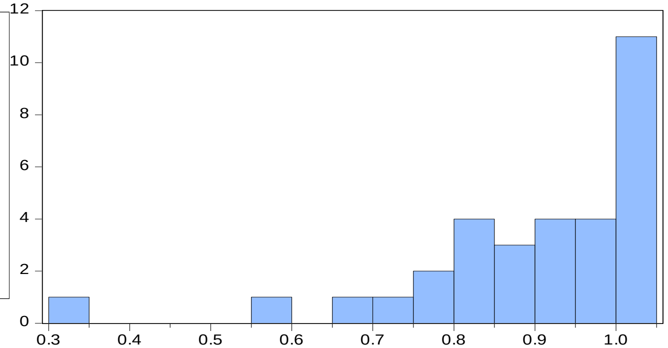
Series: RQ	
Sample 1 32	
Observations 27	
Mean	0.490111
Median	0.388100
Maximum	1.000000
Minimum	0.000000
Std. Dev.	0.359468
Skewness	0.311860
Kurtosis	1.738630
Jarque-Bera	2.227592
Probability	0.328310



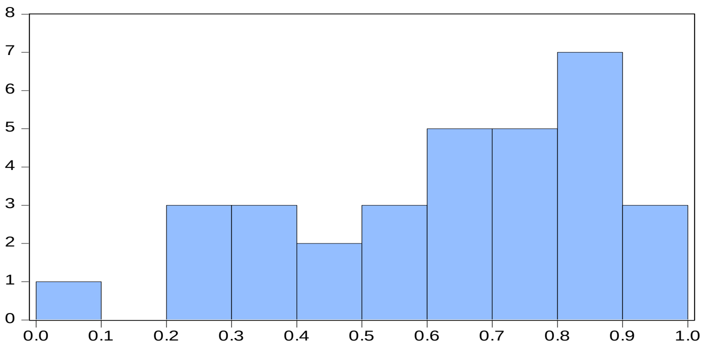
Series: TCA	
Sample 1 32	
Observations 32	
Mean	0.205784
Median	0.165550
Maximum	0.549300
Minimum	0.036700
Std. Dev.	0.120649
Skewness	1.077467
Kurtosis	3.682851
Jarque-Bera	6.813362
Probability	0.033151



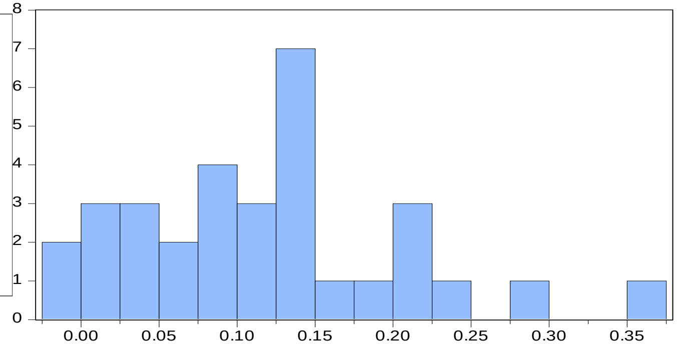
Series: LNTCA	
Sample 1 32	
Observations 32	
Mean	-1.744613
Median	-1.799107
Maximum	-0.599111
Minimum	-3.304979
Std. Dev.	0.596056
Skewness	-0.236304
Kurtosis	2.970242
Jarque-Bera	0.298991
Probability	0.861142



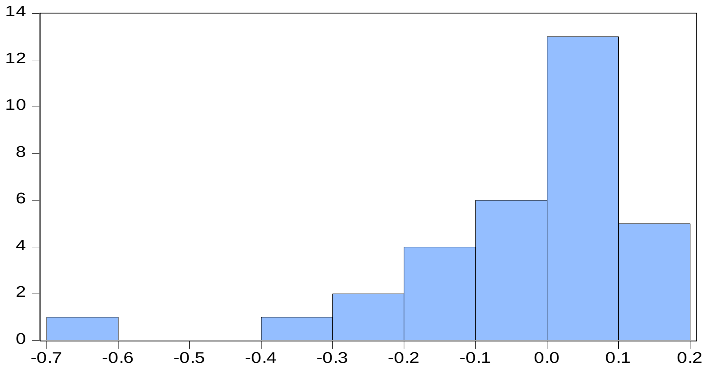
Series: SBC1	
Sample 1 32	
Observations 32	
Mean	0.885928
Median	0.930600
Maximum	1.000000
Minimum	0.325200
Std. Dev.	0.149779
Skewness	-2.007189
Kurtosis	7.558678
Jarque-Bera	49.19571
Probability	0.000000



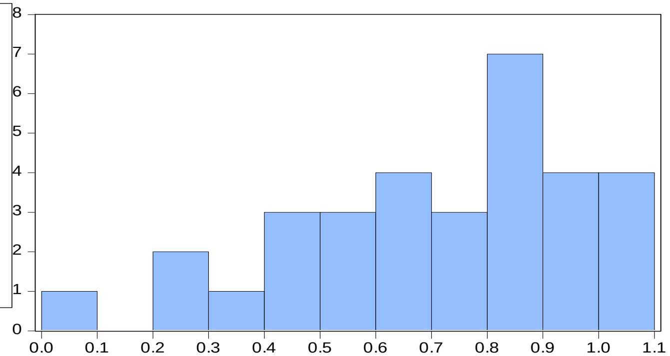
Series: SBC2	
Sample 1 32	
Observations 32	
Mean	0.625119
Median	0.660600
Maximum	0.947600
Minimum	0.000000
Std. Dev.	0.244214
Skewness	-0.748122
Kurtosis	2.763037
Jarque-Bera	3.059863
Probability	0.216551



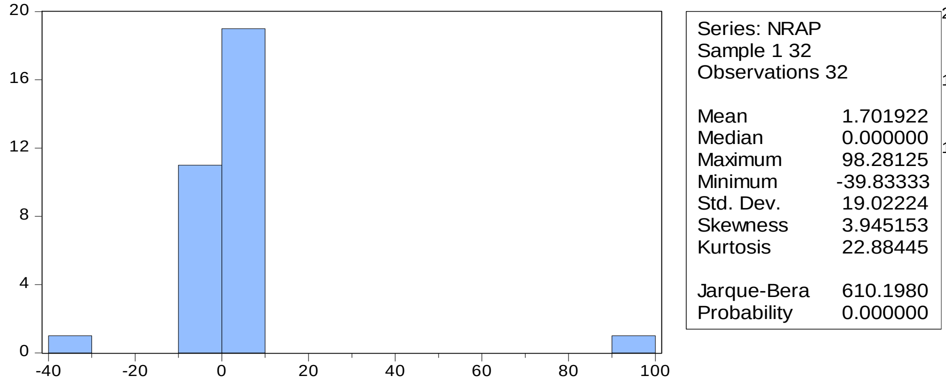
Series: SBC3	
Sample 1 32	
Observations 32	
Mean	0.118106
Median	0.113200
Maximum	0.360000
Minimum	-0.018000
Std. Dev.	0.088458
Skewness	0.652783
Kurtosis	3.241862
Jarque-Bera	2.350666
Probability	0.308716

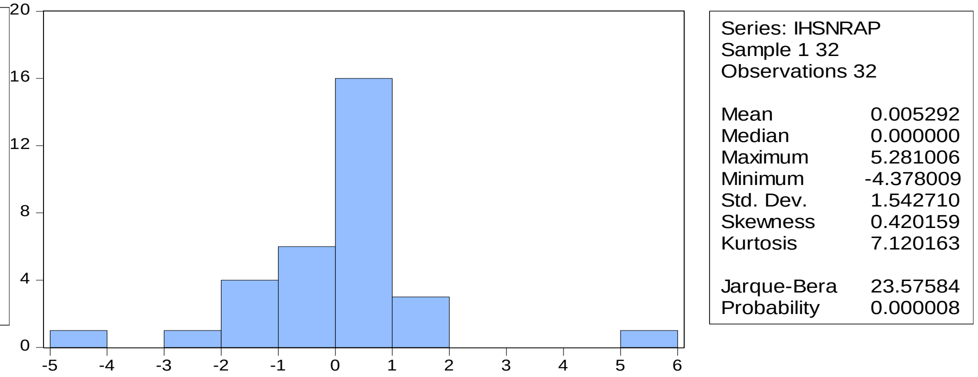


Series: SBC4	
Sample 1 32	
Observations 32	
Mean	-0.039941
Median	0.000000
Maximum	0.183300
Minimum	-0.629000
Std. Dev.	0.163683
Skewness	-1.575283
Kurtosis	6.447821
Jarque-Bera	29.08471
Probability	0.000000



Series: RAP	
Sample 1 32	
Observations 32	
Mean	0.707493
Median	0.773138
Maximum	1.000000
Minimum	0.000000
Std. Dev.	0.258529
Skewness	-0.866692
Kurtosis	3.069612
Jarque-Bera	4.012618
Probability	0.134484


Series: NRAP
Sample 1 32
Observations 32
Mean 1.701922
Median 0.000000
Maximum 98.28125
Minimum -39.83333
Std. Dev. 19.02224
Skewness 3.945153
Kurtosis 22.88445
Jarque-Bera 610.1980
Probability 0.000000
0 4 8 12 16 20
-40 -20 0 20 40 60 80 100


Series: IHSNRAP
Sample 1 32
Observations 32
Mean 0.005292
Median 0.000000
Maximum 5.281006
Minimum -4.378009
Std. Dev. 1.542710
Skewness 0.420159
Kurtosis 7.120163
Jarque-Bera 23.57584
Probability 0.000008
0 4 8 12 16 20
-5 -4 -3 -2 -1 0 1 2 3 4 5 6

Appendix 6-3 details of multiple regression

Dependent Variable: SBC1

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.656198	0.086696	7.568972	0.0000	0.007516	110.0629	NA
RD	-0.025166	0.029998	-0.838914	0.4156	0.000900	9.367160	2.115897
RI	0.003266	0.036922	0.088456	0.9308	0.001363	2.743205	2.080462
SBC01	0.161764	0.211252	0.765740	0.4565	0.044627	383.5767	14.60787
SBC02	0.528701	0.221457	2.387371	0.0316	0.049043	343.7551	41.68354
SBC03	0.601008	0.207024	2.903082	0.0116	0.042859	38.49753	30.60245
LNNCA	-0.010434	0.017465	-0.597409	0.5598	0.000305	3.125165	2.009387
RC	-0.014580	0.019727	-0.739085	0.4721	0.000389	13.90662	1.354934
LNRT	-0.147524	0.059841	-2.465279	0.0272	0.003581	2.519672	1.675727
RQ	-0.000763	0.030454	-0.025053	0.9804	0.000927	4.952238	1.689925
LNTCA	0.107411	0.027029	3.973874	0.0014	0.000731	35.88799	2.515015
X1	-0.064936	0.021785	-2.980679	0.0099	0.000475	2.316635	1.544424
X2	-0.145218	0.027318	-5.315752	0.0001	0.000746	2.428520	1.888849

R-squared	0.961944
Adjusted R-squared	0.929324

Dependent Variable: SBC2

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.556464	0.276499	2.012535	0.0638	0.076452	110.0629	NA
RD	0.003219	0.095674	0.033647	0.9736	0.009153	9.367160	2.115897
RI	-0.195754	0.117755	-1.662387	0.1187	0.013866	2.743205	2.080462
SBC01	0.955540	0.673746	1.418249	0.1780	0.453934	383.5767	14.60787
SBC02	-0.527021	0.706294	-0.746179	0.4679	0.498851	343.7551	41.68354
SBC03	-1.105157	0.660262	-1.673817	0.1164	0.435946	38.49753	30.60245
LNNCA	-0.014081	0.055700	-0.252802	0.8041	0.003102	3.125165	2.009387
RC	0.004009	0.062916	0.063721	0.9501	0.003958	13.90662	1.354934
LNRT	-0.239823	0.190850	-1.256608	0.2295	0.036424	2.519672	1.675727
RQ	0.144282	0.097127	1.485499	0.1596	0.009434	4.952238	1.689925
LNTCA	0.047239	0.086205	0.547987	0.5923	0.007431	35.88799	2.515015
X1	-0.173866	0.069480	-2.502372	0.0254	0.004828	2.316635	1.544424
X2	-0.195416	0.087126	-2.242903	0.0416	0.007591	2.428520	1.888849

R-squared	0.837614
Adjusted R-squared	0.698427

Dependent Variable: SBC3

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.656188	0.086726	7.566258	0.0000	0.007521	110.0629	NA
RD	-0.025171	0.030009	-0.838787	0.4157	0.000901	9.367160	2.115897
RI	0.003294	0.036935	0.089189	0.9302	0.001364	2.743205	2.080462
SBC01	-0.838195	0.211325	-3.966385	0.0014	0.044658	383.5767	14.60787
SBC02	0.528677	0.221533	2.386445	0.0317	0.049077	343.7551	41.68354
SBC03	0.600991	0.207095	2.902006	0.0116	0.042888	38.49753	30.60245
LNNCA	-0.010453	0.017471	-0.598302	0.5592	0.000305	3.125165	2.009387
RC	-0.014577	0.019734	-0.738660	0.4723	0.000389	13.90662	1.354934
LNRT	-0.147539	0.059861	-2.464677	0.0273	0.003583	2.519672	1.675727
RQ	-0.000200	0.030950	-0.006453	0.9949	0.000928	4.952238	1.689925
LNTCA	0.106780	0.027500	3.882956	0.0017	0.000731	35.88799	2.515015
X1	-0.066161	0.022029	-3.003413	0.0095	0.000475	2.316635	1.544424
X2	-0.145815	0.027651	-5.273419	0.0001	0.000747	2.428520	1.888849

R-squared	0.875322
Adjusted R-squared	0.768455

Dependent Variable: SBC4

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.473965	0.292134	1.622420	0.1270	0.085342	110.0629	NA
RD	-0.007836	0.101084	-0.077524	0.9393	0.010218	9.367160	2.115897
RI	-0.168313	0.124414	-1.352850	0.1975	0.015479	2.743205	2.080462
SBC01	0.962340	0.711845	1.351895	0.1978	0.506724	383.5767	14.60787
SBC02	-1.406060	0.746233	-1.884210	0.0805	0.556864	343.7551	41.68354
SBC03	-0.989519	0.697598	-1.418466	0.1779	0.486643	38.49753	30.60245
LNNCA	-0.012315	0.058849	-0.209259	0.8373	0.003463	3.125165	2.009387
RC	0.001711	0.066474	0.025744	0.9798	0.004419	13.90662	1.354934
LNRT	-0.280405	0.201642	-1.390606	0.1861	0.040659	2.519672	1.675727
RQ	0.130069	0.102620	1.267489	0.2257	0.010531	4.952238	1.689925
LNTCA	0.049393	0.091079	0.542303	0.5961	0.008295	35.88799	2.515015
X1	-0.160259	0.073409	-2.183081	0.0466	0.005389	2.316635	1.544424
X2	-0.204566	0.092053	-2.222263	0.0433	0.008474	2.428520	1.888849

R-squared	0.559141
Adjusted R-squared	0.181261

Dependent Variable: RAP

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.913380	0.339168	2.693006	0.0175	0.115035	110.0629	NA
RD	0.067759	0.117358	0.577371	0.5729	0.013773	9.367160	2.115897
RI	-0.351094	0.144444	-2.430655	0.0291	0.020864	2.743205	2.080462
SBC01	0.704379	0.826451	0.852293	0.4084	0.683022	383.5767	14.60787
SBC02	-0.917726	0.866376	-1.059270	0.3074	0.750607	343.7551	41.68354
SBC03	-1.609685	0.809910	-1.987485	0.0668	0.655955	38.49753	30.60245
LNNCA	0.018285	0.068324	0.267623	0.7929	0.004668	3.125165	2.009387
RC	0.010660	0.077176	0.138126	0.8921	0.005956	13.90662	1.354934
LNRT	-0.113646	0.234106	-0.485449	0.6349	0.054806	2.519672	1.675727
RQ	0.168770	0.119141	1.416552	0.1785	0.014195	4.952238	1.689925
LNTCA	-0.025195	0.105743	-0.238269	0.8151	0.011182	35.88799	2.515015
X1	-0.175410	0.085228	-2.058127	0.0587	0.007264	2.316635	1.544424
X2	-0.065795	0.106874	-0.615637	0.5480	0.011422	2.428520	1.888849

R-squared	0.779327
Adjusted R-squared	0.590179

Dependent Variable: NRAP

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	-89.51228	31.55456	-2.836746	0.0132	995.6904	110.0629	NA
RD	0.278679	10.91846	0.025524	0.9800	119.2129	9.367160	2.115897
RI	13.40985	13.43842	0.997874	0.3353	180.5911	2.743205	2.080462
SBC01	-40.28903	76.88918	-0.523988	0.6085	5911.946	383.5767	14.60787
SBC02	92.84140	80.60357	1.151827	0.2687	6496.936	343.7551	41.68354
SBC03	70.32472	75.35028	0.933304	0.3665	5677.664	38.49753	30.60245
LNNCA	10.99531	6.356559	1.729758	0.1056	40.40585	3.125165	2.009387
RC	11.63108	7.180136	1.619897	0.1276	51.55435	13.90662	1.354934
LNRT	27.92950	21.78014	1.282338	0.2206	474.3743	2.519672	1.675727
RQ	-11.68850	11.08434	-1.054505	0.3095	122.8626	4.952238	1.689925
LNTCA	-15.33506	9.837836	-1.558783	0.1414	96.78303	35.88799	2.515015
X1	1.384783	7.929231	0.174643	0.8639	62.87270	2.316635	1.544424
X2	19.92480	9.943029	2.003897	0.0648	98.86382	2.428520	1.888849

R-squared	0.635178
Adjusted R-squared	0.322474

Dependent Variable: LNNCA

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	-4.992776	4.060983	-1.229450	0.2446	16.49159	1341.177	NA
RD	0.265221	0.422207	0.628178	0.5427	0.178259	10.30488	2.327711
RI	1.470524	0.669088	2.197804	0.0503	0.447679	5.003045	3.794335
SBC01	-24704.91	9710.466	-2.544152	0.0273	94293156	4.50E+09	1.71E+08
SBC02	-8.170482	10.32243	-0.791527	0.4454	106.5526	4147.737	502.9515
SBC03	-3.564281	4.458941	-0.799356	0.4410	19.88215	99.18200	78.84171
RC	0.198412	0.280221	0.708054	0.4936	0.078524	15.58345	1.518307
LNRT	0.795263	1.095745	0.725773	0.4831	1.200657	4.691895	3.120379
RQ	0.224940	0.486007	0.462833	0.6525	0.236203	7.004432	2.390223
LNTCA	-0.373998	0.674546	-0.554445	0.5904	0.455012	124.1308	8.699020
SBC1	24711.48	9713.720	2.543977	0.0273	94356347	6.14E+09	1.93E+08
SBC2	4.916891	11.07062	0.444139	0.6656	122.5587	4550.450	596.8889
SBC3	-24704.79	9710.135	-2.544227	0.0273	94286721	1.86E+08	58838835
SBC4	-4.984681	10.49250	-0.475071	0.6440	110.0925	225.5551	220.4615
X1	0.683627	0.538116	1.270409	0.2302	0.289568	7.849702	5.233132
X2	1.005646	0.888846	1.131407	0.2819	0.790047	14.27788	11.10501

R-squared	0.699346
Adjusted R-squared	0.289363

Dependent Variable: RC

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	6.230596	4.152184	1.500559	0.1616	17.24063	1266.271	NA
RD	-0.534042	0.422532	-1.263910	0.2324	0.178533	9.320935	2.105451
RI	-0.146803	0.843451	-0.174051	0.8650	0.711410	7.180215	5.445512
SBC01	13670.53	12200.57	1.120482	0.2864	1.49E+08	6.42E+09	2.44E+08
SBC02	4.121751	11.09761	0.371409	0.7174	123.1570	4329.685	525.0136
SBC03	3.928011	4.678771	0.839539	0.4190	21.89090	98.62399	78.39811
LNNCA	0.219693	0.310278	0.708054	0.4936	0.096272	4.947502	3.181092
LNRT	-1.213709	1.122135	-1.081607	0.3026	1.259187	4.443951	2.955480
RQ	0.002767	0.516363	0.005358	0.9958	0.266631	7.140824	2.436764
LNTCA	0.820194	0.675826	1.213616	0.2503	0.456741	112.5322	7.886190
SBC1	-13676.25	12204.20	-1.120618	0.2863	1.49E+08	8.75E+09	2.75E+08
SBC2	-0.492071	11.75229	-0.041870	0.9674	138.1162	4631.320	607.4959
SBC3	13669.28	12200.38	1.120397	0.2864	1.49E+08	2.66E+08	83889937
SBC4	0.449173	11.15276	0.040275	0.9686	124.3841	230.1490	224.9517
X1	-0.518934	0.585824	-0.885818	0.3947	0.343190	8.402074	5.601377
X2	-0.924122	0.948131	-0.974677	0.3507	0.898953	14.67226	11.41176

R-squared	0.370082
Adjusted R-squared	-0.488898

Dependent Variable: LNRT

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	1.975514	1.000287	1.974948	0.0739	1.000573	1126.152	NA
RD	-0.184795	0.101182	-1.826358	0.0950	0.010238	8.190790	1.850176
RI	-0.104071	0.213465	-0.487533	0.6355	0.045567	7.047695	5.345013
SBC01	3044.591	3159.061	0.963765	0.3559	9979663.	6.59E+09	2.51E+08
SBC02	-0.542892	2.847943	-0.190626	0.8523	8.110778	4369.525	529.8472
SBC03	1.273580	1.171580	1.087062	0.3003	1.372600	94.76305	75.32905
LNNCA	0.057462	0.079174	0.725773	0.4831	0.006269	4.936589	3.174081
RC	-0.079202	0.073227	-1.081607	0.3026	0.005362	14.72735	1.434902
RQ	-0.036043	0.131458	-0.274177	0.7890	0.017281	7.092351	2.420231
LNTCA	0.240754	0.168899	1.425430	0.1818	0.028527	107.7048	7.547920
SBC1	-3046.464	3159.957	-0.964084	0.3557	9985326.	8.99E+09	2.82E+08
SBC2	1.528424	2.966823	0.515172	0.6166	8.802039	4522.910	593.2784
SBC3	3043.708	3159.058	0.963486	0.3560	9979648.	2.73E+08	86189564
SBC4	-1.754551	2.799679	-0.626697	0.5436	7.838203	222.2477	217.2288
X1	-0.205438	0.141972	-1.447030	0.1758	0.020156	7.561962	5.041311
X2	-0.512897	0.199534	-2.570468	0.0260	0.039814	9.957992	7.745107

R-squared	0.694171
Adjusted R-squared	0.277132

Dependent Variable: RQ

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	-1.826708	2.603494	-0.701637	0.4975	6.778181	1460.124	NA
RD	-0.286807	0.249467	-1.149680	0.2747	0.062234	9.529476	2.152561
RI	0.380088	0.479680	0.792377	0.4449	0.230093	6.811213	5.165661
SBC01	-2259.384	7488.718	-0.301705	0.7685	56080903	7.09E+09	2.70E+08
SBC02	-6.775822	6.192226	-1.094246	0.2972	38.34367	3953.611	479.4124
SBC03	2.681734	2.699675	0.993354	0.3419	7.288244	96.30431	76.55419
LNNCA	0.084921	0.183480	0.462833	0.6525	0.033665	5.074172	3.262540
RC	0.000943	0.176056	0.005358	0.9958	0.030996	16.29362	1.587502
LNRT	-0.188318	0.686848	-0.274177	0.7890	0.471761	4.883198	3.247608
LNTCA	-0.373972	0.404803	-0.923838	0.3754	0.163865	118.4122	8.298271
SBC1	2257.542	7491.106	0.301363	0.7688	56116663	9.67E+09	3.04E+08
SBC2	10.68100	6.060325	1.762447	0.1057	36.72754	3612.060	473.7994
SBC3	-2256.756	7488.615	-0.301358	0.7688	56079350	2.94E+08	92697899
SBC4	-9.449799	5.856404	-1.613584	0.1349	34.29747	186.1274	181.9242
X1	0.389745	0.333991	1.166933	0.2679	0.111550	8.009849	5.339899
X2	0.291701	0.570295	0.511491	0.6191	0.325237	15.56911	12.10931

R-squared	0.589621
Adjusted R-squared	0.030013

Dependent Variable: LNTCA

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	-5.374343	1.009968	-5.321298	0.0002	1.020036	426.8032	NA
RD	-0.002000	0.189445	-0.010558	0.9918	0.035889	10.67447	2.411189
RI	0.425213	0.329824	1.289212	0.2238	0.108784	6.254899	4.743745
SBC01	-10928.16	4272.527	-2.557773	0.0266	18254484	4.48E+09	1.71E+08
SBC02	-5.579010	4.365757	-1.277902	0.2276	19.05984	3817.287	462.8797
SBC03	-3.628175	1.700627	-2.133434	0.0562	2.892131	74.22916	59.00616
LNNCA	-0.072691	0.131107	-0.554445	0.5904	0.017189	5.032360	3.235651
RC	0.143973	0.118631	1.213617	0.2503	0.014073	14.36969	1.400045
LNRT	0.647609	0.454325	1.425432	0.1818	0.206411	4.150013	2.759993
RQ	-0.192534	0.208406	-0.923839	0.3754	0.043433	6.626697	2.261318
SBC1	10933.75	4273.335	2.558599	0.0266	18261388	6.11E+09	1.92E+08
SBC2	2.895571	4.846217	0.597491	0.5623	23.48582	4486.465	588.4937
SBC3	-10927.01	4272.634	-2.557441	0.0266	18255403	1.86E+08	58612693
SBC4	-2.521414	4.610746	-0.546856	0.5954	21.25897	224.0907	219.0302
X1	0.491025	0.206447	2.378458	0.0366	0.042620	5.944375	3.962910
X2	1.044678	0.268722	3.887571	0.0025	0.072212	6.714370	5.222284

R-squared	0.888170
Adjusted R-squared	0.735675

Appendix 6-4 the result of stepwise regression (with square items)

Dependent Variable: SBC1

Variable	Coefficient	Std. Error	t-Statistic	Prob.*	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.350555	0.061405	5.708896	0.0001	0.003771	136.2068	NA
RQ^2	0.045650	0.018688	2.442702	0.0296	0.000349	3.668785	1.991263
RI^2	0.613130	0.129766	4.724906	0.0004	0.016839	55.46410	43.97729
X2	-0.183425	0.018410	-9.963120	0.0000	0.000339	2.720847	2.116214
X1	-0.099483	0.015583	-6.384211	0.0000	0.000243	2.923821	1.949214
RD^2	-0.230997	0.099548	-2.320469	0.0372	0.009910	242.5665	61.68771
RI	-0.431628	0.109841	-3.929579	0.0017	0.012065	59.89116	45.42179
SBC02	1.430642	0.151633	9.434894	0.0000	0.022993	397.5587	48.20773
LNTCA^2	-0.036067	0.006617	-5.451034	0.0001	4.38E-05	22.20749	4.411457
LNNCA	0.164215	0.034236	4.796515	0.0003	0.001172	29.62619	19.04875
RD	0.256620	0.106133	2.417919	0.0310	0.011264	289.2376	65.33432
SBC02^2	-0.701096	0.125440	-5.589094	0.0001	0.015735	164.4947	34.26534
LNNCA^2	-0.115825	0.018559	-6.240958	0.0000	0.000344	23.02159	16.93019
SBC03^2	1.353978	0.080599	16.79897	0.0000	0.006496	5.758590	4.875632

R-squared	0.985675
Adjusted R-squared	0.971350

Dependent Variable: SBC2

Variable	Coefficient	Std. Error	t-Statistic	Prob.*	Coefficient Variance	Uncentered VIF	Centered VIF
C	-0.630102	0.292712	-2.152636	0.0452	0.085680	208.4864	NA
SBC02	-2.556363	0.790196	-3.235100	0.0046	0.624410	727.2617	88.18732
RI	-0.402555	0.081552	-4.936199	0.0001	0.006651	2.223857	1.686585
X1	-0.223041	0.053042	-4.205027	0.0005	0.002813	2.281961	1.521307
SBC03^2	-2.986825	0.753107	-3.966002	0.0009	0.567170	33.86720	28.67438
SBC01	6.700828	1.661560	4.032853	0.0008	2.760782	3943.067	150.1650
RQ^2	0.229534	0.073520	3.122066	0.0059	0.005405	3.824643	2.075857
SBC01^2	-2.973284	0.862979	-3.445372	0.0029	0.744733	686.7088	62.38838
SBC03	-1.112429	0.544776	-2.041993	0.0561	0.296781	44.29753	35.21298

R-squared	0.876477
Adjusted R-squared	0.821577

Dependent Variable: SBC3

Variable	Coefficient	Std. Error	t-Statistic	Prob.*	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.356363	0.063833	5.582722	0.0001	0.004075	139.6391	NA
SBC02^2	-0.681505	0.133083	-5.120906	0.0003	0.017711	175.6505	36.58917
X2	-0.179471	0.020075	-8.939850	0.0000	0.000403	3.069235	2.387183
RD	0.243446	0.111292	2.187449	0.0492	0.012386	301.7259	68.15522
X1	-0.098988	0.016022	-6.178260	0.0000	0.000257	2.932396	1.954930
LNTCA^2	-0.037015	0.006985	-5.299561	0.0002	4.88E-05	23.47662	4.663567
SBC03^2	1.238313	0.214969	5.760415	0.0001	0.046212	38.86296	32.90414
SBC02	1.327588	0.235478	5.637847	0.0001	0.055450	909.5743	110.2944
LNNCA^2	-0.113174	0.019603	-5.773341	0.0001	0.000384	24.36663	17.91934
RQ^2	0.047913	0.019573	2.447919	0.0307	0.000383	3.817736	2.072108
RI^2	0.605651	0.133858	4.524566	0.0007	0.017918	55.98961	44.39397
RI	-0.430337	0.112795	-3.815204	0.0025	0.012723	59.91563	45.44035
LNNCA	0.160241	0.035818	4.473772	0.0008	0.001283	30.76280	19.77956
SBC01	-0.915787	0.144356	-6.343965	0.0000	0.020839	419.1660	15.96322
RD^2	-0.220487	0.103790	-2.124354	0.0551	0.010772	250.1537	63.61724

R-squared	0.954367
Adjusted R-squared	0.901129

Dependent Variable: SBC4

Variable	Coefficient	Std. Error	t-Statistic	Prob.*	Coefficient Variance	Uncentered VIF	Centered VIF
C	-0.735557	0.292544	-2.514341	0.0223	0.085582	226.1393	NA
RI	-0.344510	0.082350	-4.183477	0.0006	0.006782	2.462439	1.867527
SBC03	-1.321518	0.540190	-2.446395	0.0256	0.291805	47.29680	37.59716
X1	-0.252630	0.054010	-4.677453	0.0002	0.002917	2.569351	1.712901
X2	-0.121272	0.064127	-1.891119	0.0758	0.004112	2.414690	1.878092
SBC01	7.208872	1.599722	4.506329	0.0003	2.559109	3969.045	151.1543
SBC02	-3.590717	0.758420	-4.734473	0.0002	0.575200	727.5033	88.21662
SBC03^2	-2.747672	0.751946	-3.654080	0.0020	0.565423	36.66353	31.04195
SBC01^2	-3.354218	0.829278	-4.044746	0.0008	0.687702	688.6002	62.56022
RQ^2	0.228120	0.070590	3.231638	0.0049	0.004983	3.828755	2.078088

R-squared	0.738721
Adjusted R-squared	0.600397

Dependent Variable: RAP

Variable	Coefficient	Std. Error	t-Statistic	Prob.*	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.274552	0.338653	0.810718	0.4281	0.114686	208.4864	NA
SBC03	-1.913588	0.630278	-3.036102	0.0071	0.397250	44.29753	35.21298
SBC01^2	-2.461222	0.998423	-2.465110	0.0240	0.996848	686.7088	62.38838
X1	-0.238760	0.061366	-3.890734	0.0011	0.003766	2.281961	1.521307
SBC02	-3.306333	0.914217	-3.616575	0.0020	0.835792	727.2617	88.18732
SBC03^2	-2.988835	0.871307	-3.430291	0.0030	0.759175	33.86720	28.67438
SBC01	5.992193	1.922340	3.117135	0.0060	3.695392	3943.067	150.1650
RI	-0.476160	0.094351	-5.046682	0.0001	0.008902	2.223857	1.686585
RQ^2	0.257912	0.085059	3.032159	0.0072	0.007235	3.824643	2.075857

R-squared	0.850673
Adjusted R-squared	0.784306

Dependent Variable: NRAP

Variable	Coefficient	Std. Error	t-Statistic	Prob.*	Coefficient Variance	Uncentered VIF	Centered VIF
C	-90.23133	28.46952	-3.169401	0.0046	810.5135	196.4870	NA
RC^2	-11.37519	6.348432	-1.791811	0.0876	40.30259	100.6357	38.95444
LNNCA	6.416951	3.598591	1.783184	0.0890	12.94986	2.262603	1.410352
RI^2	121.4961	40.64722	2.989039	0.0070	1652.196	30.81426	25.42967
SBC02	26.37278	14.03339	1.879287	0.0742	196.9361	23.47222	2.628985
RC	55.49602	27.25399	2.036253	0.0545	742.7802	452.4361	41.16161
RI	-72.50482	33.03748	-2.194623	0.0396	1091.475	30.67937	24.42552
LNRT	119.9287	26.49325	4.526765	0.0002	701.8923	6.902646	4.921696
LNRT^2	-200.1958	61.06689	-3.278304	0.0036	3729.165	6.238518	4.750774
X2	17.26137	5.957316	2.897508	0.0086	35.48961	1.882015	1.470324
SBC03^2	68.54602	25.59627	2.677969	0.0141	655.1691	3.658082	3.021493

R-squared	0.752878
Adjusted R-squared	0.635201

Dependent Variable: LNNCA (omitting LNTCA and LNTCA^2, SBC3^2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*	Coefficient Variance	Uncentered VIF	Centered VIF
C	-105.8427	11.76340	-8.997633	0.0121	138.3776	146244.9	NA
SBC3	-39544.17	4629.089	-8.542538	0.0134	21428462	5.51E+08	1.74E+08
X1	-2.116994	0.304924	-6.942686	0.0201	0.092979	32.75512	21.83677
SBC02	-464.9149	56.69775	-8.199883	0.0145	3214.635	1626187.	197191.2
SBC02^2	69.07226	9.381942	7.362256	0.0180	88.02084	26921.01	5607.843
SBC4^2	61.82566	5.318639	11.62434	0.0073	28.28792	183.0261	164.0521
RI^2	-8.412138	1.088513	-7.728101	0.0163	1.184861	114.1790	90.53222
SBC2	356.6183	44.37081	8.037228	0.0151	1968.769	949940.8	124605.6
SBC01^2	-70.21526	21.80025	-3.220847	0.0844	475.2507	190332.4	17292.01
RC	-16.29271	1.636238	-9.957420	0.0099	2.677274	6904.743	672.7376
SBC4	-333.3817	42.51855	-7.840853	0.0159	1807.827	48133.26	47046.30
RQ	-5.703832	1.539369	-3.705304	0.0657	2.369658	913.2009	311.6257
SBC03	38.50444	6.864814	5.608956	0.0303	47.12567	3055.064	2428.532
LNRT	-21.05521	2.087848	-10.08465	0.0097	4.359110	221.3707	147.2244
RQ^2	4.926225	1.308747	3.764079	0.0639	1.712817	526.3944	285.7054
RC^2	3.166792	0.327266	9.676520	0.0105	0.107103	1165.470	491.4164
RD	-8.658371	1.305147	-6.634022	0.0220	1.703408	1279.682	289.0612
SBC01	-39430.99	4612.632	-8.548478	0.0134	21276376	1.32E+10	5.03E+08
LNRT^2	29.48254	3.151466	9.355182	0.0112	9.931739	85.84654	61.61100
RD^2	7.053168	1.181539	5.969475	0.0269	1.396035	999.7486	254.2493
SBC03^2	-140.8619	16.15657	-8.718552	0.0129	261.0349	6769.920	5731.899
X2	-3.995923	0.510794	-7.822961	0.0160	0.260911	61.27679	47.65975
SBC1^2	-181.5139	19.09867	-9.504004	0.0109	364.7594	268362.5	21500.47
SBC2^2	-9.622813	1.978503	-4.863685	0.0398	3.914473	1159.113	296.8066
SBC1	39854.87	4644.446	8.581189	0.0133	21570881	1.82E+10	5.73E+08

R-squared	0.995794
Adjusted R-squared	0.945317

Dependent Variable: RC (omitting LNTCA and LNTCA^2, SBC3^2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*	Coefficient Variance	Uncentered VIF	Centered VIF
C	-71.50128	8.702907	-8.215792	0.0038	75.74060	88925.57	NA
SBC4^2	18.98630	2.841749	6.681203	0.0068	8.075540	58.04551	52.02805
SBC2^2	-3.209645	1.814339	-1.769044	0.1750	3.291825	1082.860	277.2823
SBC02^2	7.713802	2.955280	2.610177	0.0797	8.733679	2967.469	618.1483
RD	-0.822541	0.133079	-6.180847	0.0085	0.017710	14.78040	3.338686
LNRT	1.489767	0.856768	1.738822	0.1805	0.734051	41.41263	27.54186
SBC4	-183.6016	23.32296	-7.872138	0.0043	543.9606	16089.44	15726.11
X1	-1.392342	0.320278	-4.347293	0.0225	0.102578	40.14518	26.76353
LNNCA^2	-4.814080	0.585930	-8.216135	0.0038	0.343314	745.8210	548.4817
SBC02	-201.8546	26.59566	-7.589759	0.0047	707.3289	397505.7	48201.71
SBC3	-75592.79	9513.678	-7.945695	0.0042	90510072	2.58E+09	8.15E+08
LNRT^2	-5.901221	1.873148	-3.150430	0.0512	3.508684	33.69196	24.18034
X2	-1.907552	0.346342	-5.507708	0.0118	0.119953	31.29678	24.34197
SBC1^2	-129.6780	14.21961	-9.119664	0.0028	202.1972	165262.1	13240.42
RI^2	15.52633	3.263797	4.757137	0.0176	10.65237	1140.381	904.2058
RI	-11.61929	2.299074	-5.053898	0.0149	5.285741	852.8092	646.7764
RQ^2	-4.036508	0.897788	-4.496058	0.0205	0.806023	275.1896	149.3620
RQ	4.612635	0.937686	4.919170	0.0161	0.879254	376.4254	128.4539
SBC2	190.0409	24.03490	7.906870	0.0042	577.6766	309648.9	40617.47
SBC1	75816.56	9532.845	7.953193	0.0041	90875140	8.54E+10	2.68E+09
LNNCA	6.554829	0.846813	7.740586	0.0045	0.717092	589.0978	378.7734
SBC01	-75634.55	9516.864	-7.947423	0.0042	90570710	6.24E+10	2.38E+09
SBC03^2	-10.98716	4.773334	-2.301779	0.1048	22.78471	656.4677	555.8130
SBC01^2	28.18529	6.918179	4.074092	0.0267	47.86120	21293.96	1934.601

R-squared	0.989253
Adjusted R-squared	0.906860

Dependent Variable: LNRT (omitting LNTCA, LNTCA^2 and SBC3^2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*	Coefficient Variance	Uncentered VIF	Centered VIF
C	-4.774463	3.186270	-1.498449	0.1599	10.15231	14239.43	NA
SBC1^2	-10.24570	5.352022	-1.914361	0.0797	28.64414	28088.62	1950.063
SBC3	-2917.610	4043.233	-0.721603	0.4844	16347735	4.94E+08	1.74E+08
X2	-0.200942	0.171345	-1.172734	0.2637	0.029359	9.007780	7.037322
SBC2	17.53077	8.657173	2.025000	0.0657	74.94664	47150.96	6073.380
X1	-0.006661	0.111241	-0.059879	0.9532	0.012375	7.050991	4.186517
SBC01	-2918.304	4043.381	-0.721748	0.4843	16348931	1.40E+10	5.00E+08
SBC02	-19.32740	10.47722	-1.844707	0.0899	109.7722	75696.32	8478.255
RI	0.019815	0.187345	0.105769	0.9175	0.035098	5.707779	4.544270
SBC4^2	2.865985	1.763459	1.625207	0.1301	3.109787	24.63002	21.31947
SBC02^2	1.461530	1.615243	0.904837	0.3834	2.609008	1110.480	225.9480
RC	-1.306944	0.503473	-2.595861	0.0234	0.253485	893.3098	81.27090
SBC03	1.332457	1.217120	1.094762	0.2951	1.481381	131.5401	101.0206
LNNCA	0.035444	0.192381	0.184238	0.8569	0.037011	37.41291	23.32060
RD	-0.098615	0.095860	-1.028740	0.3239	0.009189	8.327327	2.289450
SBC1	2935.094	4050.032	0.724709	0.4825	16402762	1.86E+10	5.00E+08
SBC03^2	-2.605226	2.672283	-0.974907	0.3489	7.141096	230.6836	190.5393
SBC4	-16.79549	8.313459	-2.020277	0.0663	69.11359	2670.609	2515.969
LNNCA^2	-0.081144	0.142136	-0.570894	0.5786	0.020203	53.77260	39.05374
RC^2	0.260225	0.107114	2.429421	0.0318	0.011473	165.7547	64.16073

R-squared	0.704209
Adjusted R-squared	0.235872

Dependent Variable: RQ (omitting LNNCA, LNTCA^2 and SBC3^2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*	Coefficient Variance	Uncentered VIF	Centered VIF
C	-43.60629	13.88437	-3.140675	0.0348	192.7757	246137.4	NA
LNRT^2	10.28223	2.483905	4.139543	0.0144	6.169786	64.42891	46.23997
SBC01	-38038.53	10965.79	-3.468838	0.0256	1.20E+08	9.01E+10	3.43E+09
LNTCA	-1.207094	0.298522	-4.043567	0.0156	0.089115	383.2555	26.90042
SBC4	-119.2366	35.41502	-3.366837	0.0281	1254.224	40343.90	39432.85
SBC03	12.13603	2.484930	4.883853	0.0081	6.174875	483.6202	384.4404
SBC2	125.4383	36.71243	3.416780	0.0269	1347.802	785667.1	103058.5
X1	0.454615	0.161046	2.822879	0.0477	0.025936	11.03851	7.359038
LNNCA^2	-0.414303	0.153068	-2.706651	0.0537	0.023430	55.35316	40.70713
SBC02	-163.0172	49.55608	-3.289550	0.0302	2455.805	1500870.	181997.0
SBC1^2	-81.59538	26.49141	-3.080069	0.0369	701.7948	623785.9	49976.51
SBC4^2	28.31516	8.659631	3.269788	0.0308	74.98922	586.1718	525.4049
LNRT	-7.789198	1.960025	-3.974031	0.0165	3.841697	235.6993	156.7543
RI	4.363628	1.434348	3.042238	0.0383	2.057354	360.9808	273.7706
SBC3	-38035.33	10965.98	-3.468486	0.0256	1.20E+08	3.73E+09	1.18E+09
RD^2	4.901725	0.863207	5.678504	0.0047	0.745127	644.6681	163.9488
RD	-5.806786	1.073917	-5.407109	0.0057	1.153298	1046.733	236.4433
SBC02^2	23.12379	6.399875	3.613162	0.0225	40.95840	15134.20	3152.592
RC	-5.566827	1.913845	-2.908713	0.0437	3.662804	11412.45	1111.939
RC^2	1.057309	0.373770	2.828770	0.0474	0.139704	1836.626	774.4117
SBC03^2	-46.37592	14.14627	-3.278315	0.0305	200.1169	6270.214	5308.821
SBC1	38183.65	11011.13	3.467733	0.0256	1.21E+08	1.24E+11	3.89E+09
RI^2	-8.303721	2.560486	-3.243025	0.0316	6.556090	763.2693	605.1950

R-squared	0.974823
Adjusted R-squared	0.836352

Dependent Variable: LNTCA (omitting RC^2, SBC2^2, & SBC3^2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*	Coefficient Variance	Uncentered VIF	Centered VIF
C	-9.234637	2.211479	-4.175775	0.0006	4.890638	1235.582	NA
SBC02	-5.416974	1.799723	-3.009893	0.0079	3.239004	402.3209	45.06159
SBC1	51.83189	17.41993	2.975437	0.0085	303.4538	61838.30	1666.153
SBC1^2	-27.09337	9.838262	-2.753878	0.0136	96.79140	17096.60	1186.944
LNNCA	0.161903	0.403453	0.401293	0.6932	0.162774	29.63888	18.47485
X2	0.278977	0.253764	1.099355	0.2869	0.064396	3.558882	2.780376
X1	-0.262570	0.248266	-1.057613	0.3050	0.061636	6.326083	3.756112
RI	0.146272	1.265120	0.115619	0.9093	1.600528	46.88437	37.32721
SBC2	-1.344298	0.578118	-2.325299	0.0327	0.334220	37.87478	4.878566
SBC01^2	21.65825	8.241931	2.627812	0.0176	67.92942	7047.759	633.1619
SBC03	-7.130790	1.698228	-4.198960	0.0006	2.883977	46.12790	35.42551
LNNCA^2	0.138679	0.232796	0.595712	0.5592	0.054194	25.98275	18.87067
SBC01	-32.23089	12.67149	-2.543576	0.0210	160.5666	24800.70	885.2468
RC	0.170092	0.158425	1.073641	0.2980	0.025099	15.93232	1.449486
RI^2	-1.758007	1.522817	-1.154444	0.2643	2.318971	45.07313	37.19690

R-squared	0.804495
Adjusted R-squared	0.643491

Appendix 6-5 the final result of stepwise regression

Dependent Variable: SBC1

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.700368	0.057334	12.21557	0.0000	0.003287	24.55640	NA
X2	0.586599	0.069238	8.472176	0.0000	0.004794	10.86777	2.211262
X1	0.650227	0.086614	7.507205	0.0000	0.007502	3.547952	2.724772
LNRT	-0.185407	0.077586	-2.389701	0.0247	0.006020	1.824219	1.300697
SBC02^2	0.055143	0.025062	2.200271	0.0372	0.000628	15.89635	1.614946
SBC03	-0.085921	0.025419	-3.380216	0.0024	0.000646	1.960859	1.164260
LNTCA	-0.139576	0.033469	-4.170262	0.0003	0.001120	1.830557	1.430123

R-squared	0.846013
Adjusted R-squared	0.809056

Dependent Variable: SBC2

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.531386	0.090687	5.859543	0.0000	0.008224	14.23588	NA
RI^2	-0.358232	0.102530	-3.493919	0.0017	0.010512	1.399951	1.155319
X1	-0.153319	0.050688	-3.024741	0.0054	0.002569	1.806773	1.072772
SBC03^2	-1.122626	0.181203	-6.195397	0.0000	0.032835	1.309032	1.081231
SBC01^2	0.439387	0.133722	3.285838	0.0028	0.017881	12.71107	1.141947

R-squared	0.730028
Adjusted R-squared	0.690032

Dependent Variable: SBC3

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.408749	0.066528	6.144013	0.0000	0.004426	35.89312	NA
X2	-0.143758	0.030874	-4.656285	0.0001	0.000953	1.690969	1.321070
X1	-0.084917	0.023592	-3.599445	0.0013	0.000557	1.833630	1.088718
SBC01	-0.269073	0.079237	-3.395823	0.0021	0.006278	31.12826	1.111106
LNRT	-0.167742	0.069243	-2.422497	0.0224	0.004795	1.577348	1.124674

R-squared	0.560788
Adjusted R-squared	0.495719

Dependent Variable: SBC4

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.181807	0.065453	2.777688	0.0097	0.003927	6.924943	NA
X1	-0.139962	0.051505	-2.717433	0.0112	0.002472	1.770794	1.051409
SBC02^2	-0.263604	0.100169	-2.631600	0.0137	0.009531	5.100498	1.037797
RI	-0.229530	0.083730	-2.741297	0.0105	0.009466	1.284252	1.059837

R-squared	0.360330
Adjusted R-squared	0.291794

Dependent Variable: RAP

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.905075	0.042161	21.46708	0.0000	0.001778	2.339144	NA
X1	-0.156625	0.058689	-2.668716	0.0125	0.003444	1.841395	1.093328
SBC03^2	-1.260333	0.206069	-6.116068	0.0000	0.042464	1.287023	1.063052
RI	-0.352303	0.093918	-3.751195	0.0008	0.008821	1.345818	1.071480

R-squared	0.671381
Adjusted R-squared	0.636172

Dependent Variable: NRAP

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF
RI^2	36.22047	10.28950	3.520138	0.0014	105.8739	1.000000

R-squared	0.279669
Adjusted R-squared	0.279669

Dependent Variable: LNNCA

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.607122	0.196521	3.089346	0.0045	0.038621	4.419698	NA
RI	1.086787	0.318400	3.413277	0.0020	0.101378	1.345172	1.070965
LNTCA^2	-0.128945	0.044430	-2.902219	0.0071	0.001974	3.667336	1.074536
X1	0.452124	0.199991	2.260723	0.0317	0.039996	1.859462	1.104056

R-squared	0.455377
Adjusted R-squared	0.397025

Dependent Variable: RC

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	1.790842	0.140937	12.70672	0.0000	0.019863	4.271841	NA
SBC4^2	5.778120	1.533819	3.767145	0.0008	2.352602	2.857095	2.473071
RD	-0.419732	0.164428	-2.552673	0.0167	0.027037	3.756831	1.032878
SBC4	1.950252	0.675371	2.887676	0.0076	0.456126	2.702549	2.546060
SBC03^2	-1.161873	0.513498	-2.262661	0.0319	0.263681	1.306087	1.078798

R-squared	0.450791
Adjusted R-squared	0.369426

Dependent Variable: LNRT

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.107898	0.030546	3.532322	0.0013	0.000933	1.000000	NA

R-squared	0.000000
Adjusted R-squared	0.000000

Dependent Variable: RQ

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF
LNTCA	-0.326061	0.043063	-7.571715	0.0000	0.001854	1.496215
SBC03	-0.785147	0.318455	-2.465492	0.0209	0.101413	1.496215

R-squared	0.164673
Adjusted R-squared	0.131260

Dependent Variable: LNTCA

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	-2.688017	0.176046	-15.26882	0.0000	0.030992	8.622971	NA
RQ^2	-0.401661	0.154559	-2.598752	0.0164	0.023889	1.932755	1.049019
X2	0.387063	0.151239	2.559277	0.0179	0.022873	1.414225	1.099953
SBC02^2	1.210858	0.249890	4.845568	0.0001	0.062445	5.027950	1.047355
SBC3	3.121567	0.718268	4.345966	0.0003	0.515908	3.490122	1.101455

R-squared	0.663648
Adjusted R-squared	0.602493

Appendix 6-6 the result of OLS after removing seemingly significant variables

The result of LNTCA under OLS

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	-2.557330	0.242874	-10.52944	0.0000	0.058988	7.230116	NA
SBC02^2	1.016866	0.364696	2.788254	0.0093	0.133004	4.947134	1.006592
SBC3	2.648258	1.040858	2.544302	0.0165	1.083386	2.858892	1.006592

R-squared	0.312568
Adjusted R-squared	0.265159

The result of LNNCA under OLS (after removing those seemingly significant variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.356376	0.119899	2.972297	0.0058	0.014376	1.256037	NA
RI	1.071019	0.352117	3.041655	0.0049	0.123987	1.256037	1.000000

R-squared	0.235701
Adjusted R-squared	0.210225

Appendix 6-7 the result of heteroscedasticity test

The following include results for all models except the one for NR_{ap} (when the significance level is at 5 percent) and $\ln(R_t)$ since no variable get significant in these two models and then the regression is failed.

SBC1
Heteroskedasticity Test: White

F-statistic	2.604228	Prob. F(24,7)	0.0974
Obs*R-squared	28.77705	Prob. Chi-Square(24)	0.2286
Scaled explained SS	16.59710	Prob. Chi-Square(24)	0.8653

SBC2
Heteroscedasticity Test: White

F-statistic	4.557417	Prob. F(13,18)	0.0018
Obs*R-squared	24.54334	Prob. Chi-Square(13)	0.0265
Scaled explained SS	27.86526	Prob. Chi-Square(13)	0.0094

SBC3
Heteroscedasticity Test: White

F-statistic	0.417404	Prob. F(12,19)	0.9377
Obs*R-squared	6.675999	Prob. Chi-Square(12)	0.8783
Scaled explained SS	6.400524	Prob. Chi-Square(12)	0.8946

SBC4
Heteroscedasticity Test: White

F-statistic	16.38649	Prob. F(8,23)	0.0000
Obs*R-squared	27.22363	Prob. Chi-Square(8)	0.0006
Scaled explained SS	38.04819	Prob. Chi-Square(8)	0.0000

RAP
Heteroscedasticity Test: White

F-statistic	4.120186	Prob. F(8,23)	0.0036
Obs*R-squared	18.84810	Prob. Chi-Square(8)	0.0157
Scaled explained SS	19.79082	Prob. Chi-Square(8)	0.0112

NRAP
Heteroscedasticity Test: White

F-statistic	46.87370	Prob. F(18,13)	0.0000
Obs*R-squared	19.51198	Prob. Chi-Square(18)	0.0000
Scaled explained SS	89.47853	Prob. Chi-Square(18)	0.0000

LNNCA
Heteroskedasticity Test: White

F-statistic	0.168882	Prob. F(2,29)	0.8454
Obs*R-squared	0.368414	Prob. Chi-Square(2)	0.8318
Scaled explained SS	0.431288	Prob. Chi-Square(2)	0.8060

RC
Heteroscedasticity Test: White

F-statistic	1.090104	Prob. F(13,18)	0.4234
Obs*R-squared	14.09588	Prob. Chi-Square(13)	0.3671
Scaled explained SS	29.98447	Prob. Chi-Square(13)	0.0047

RQ
Heteroskedasticity Test: White

F-statistic	0.476291	Prob. F(3,23)	0.7019
Obs*R-squared	1.579261	Prob. Chi-Square(3)	0.6641
Scaled explained SS	0.861614	Prob. Chi-Square(3)	0.8347

LNTCA
Heteroskedasticity Test: White

F-statistic	0.602891	Prob. F(5,26)	0.6982
Obs*R-squared	3.324637	Prob. Chi-Square(5)	0.6501
Scaled explained SS	3.437862	Prob. Chi-Square(5)	0.6328

Appendix 6-8 the results of regression with White Error

SBC2
White heteroscedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.531386	0.129075	4.116888	0.0003	0.016660	62.84942	NA
RI^2	-0.358232	0.194174	-1.844902	0.0760	0.037704	1.478186	1.445875
X1	-0.153319	0.041671	-3.679309	0.0010	0.001736	1.656459	1.142307
SBC03^2	-1.122626	0.071702	-15.65673	0.0000	0.005141	1.578218	1.069540
SBC01^2	0.439387	0.182753	2.404269	0.0233	0.033399	61.31756	1.496030

R-squared	0.730028
Adjusted R-squared	0.690032

SBC4
White heteroscedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.181807	0.069595	2.612360	0.0143	0.004843	15.93451	NA
X1	-0.139962	0.042425	-3.299072	0.0026	0.001800	2.289663	1.027441
SBC02^2	-0.263604	0.108924	-2.420073	0.0223	0.011864	12.64276	1.286756
RI	-0.229530	0.161037	-1.425322	0.1651	0.025933	1.401170	1.288532

R-squared	0.360330
Adjusted R-squared	0.291794

RAP
White heteroscedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.905075	0.023722	38.15388	0.0000	0.000563	1.198221	NA
X1	-0.156625	0.050414	-3.106803	0.0043	0.002542	1.361463	1.167062
SBC03^2	-1.260333	0.112903	-11.16298	0.0000	0.012747	1.172375	1.108133
RI	-0.352303	0.136818	-2.574978	0.0156	0.018719	1.110884	1.058119

R-squared	0.671381
Adjusted R-squared	0.636172

NRAP
White heteroscedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF
RI^2	36.22047	27.83135	1.301427	0.2027	774.5842	1.000000

R-squared	0.279669
Adjusted R-squared	0.279669

Appendix 6-9 the results of WLS

SBC2

Weighting series: ABS(ESBC2)^-0.5
Weight type: Inverse standard deviation (EViews default scaling)

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.513936	0.057706	8.906042	0.0000	0.003330	33.19262	NA
RI^2	-0.366935	0.083273	-4.406430	0.0001	0.006934	1.182906	1.092803
X1	-0.152069	0.024531	-6.199003	0.0000	0.000602	1.690193	1.213935
SBC03^2	-1.109338	0.062985	-17.61259	0.0000	0.003967	1.465788	1.176058
SBC01^2	0.466080	0.079681	5.849349	0.0000	0.006349	30.41815	1.119426

R-squared	0.957161
Adjusted R-squared	0.950815

Heteroscedasticity Test: White

F-statistic	1.568309	Prob. F(14,17)	0.1876
Obs*R-squared	18.03565	Prob. Chi-Square(14)	0.2052
Scaled explained SS	6.261017	Prob. Chi-Square(14)	0.9595

SBC4

Weighting series: ABS(SBC02^2)^3
Weight type: Inverse standard deviation (EViews default scaling)

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.466454	0.066571	7.006861	0.0000	0.004432	34.44663	NA
X1	-0.235374	0.024293	-9.688997	0.0000	0.000590	2.172625	1.143580
SBC02^2	-0.569309	0.084270	-6.755746	0.0000	0.007102	35.87015	1.158596
RI	-0.691907	0.056916	-12.15662	0.0000	0.003239	1.188355	1.113391

R-squared	0.901413
Adjusted R-squared	0.890850

Heteroscedasticity Test: White

F-statistic	1.308045	Prob. F(9,22)	0.2881
Obs*R-squared	11.15458	Prob. Chi-Square(9)	0.2653
Scaled explained SS	8.137052	Prob. Chi-Square(9)	0.5204

RAP

Weighting series: ABS(ERAP)^-2
Weight type: Inverse standard deviation (EViews default scaling)

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.903311	0.000421	2144.653	0.0000	1.77E-07	4.510017	NA
X1	-0.153301	0.000487	-314.8519	0.0000	2.37E-07	3.841250	1.393023
SBC03^2	-1.272156	0.026153	-48.64322	0.0000	0.000684	1.638842	1.395549
RI	-0.324516	0.023716	-13.68339	0.0000	0.000562	1.002866	1.002766

R-squared	0.999990
Adjusted R-squared	0.999989

Heteroscedasticity Test: White

F-statistic	1.283391	Prob. F(9,22)	0.3000
Obs*R-squared	11.01672	Prob. Chi-Square(9)	0.2746
Scaled explained SS	2.785144	Prob. Chi-Square(9)	0.9722

NRAP

Weighting series: ABS(SBC02^2)^2
Weight type: Inverse standard deviation (EViews default scaling)

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF
RI^2	56.27909	10.10642	5.568645	0.0000	102.1398	1.000000

R-squared	0.463373
Adjusted R-squared	0.463373

Heteroscedasticity Test: White

F-statistic	894.2278	Prob. F(1,30)	0.0000
Obs*R-squared	30.96129	Prob. Chi-Square(1)	0.0000
Scaled explained SS	136.2652	Prob. Chi-Square(1)	0.0000

Appendix 6-10 the results of FGLS for two models

SBC4

Weighting series: HSBC4
Weight type: Inverse standard deviation (EViews default scaling)

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF	Centered VIF
C	1.309743	0.128522	10.19083	0.0000	0.016518	57.38629	NA
X1	-0.656400	0.088232	-7.439440	0.0000	0.007785	8.013372	5.639163
SBC02^2	-1.969171	0.148966	-13.21889	0.0000	0.022191	20.53464	5.729745
RI	-0.599016	0.130677	-4.583944	0.0001	0.017077	46.90376	1.065886

R-squared	0.928087
Adjusted R-squared	0.920382

Heteroscedasticity Test: White

F-statistic	584.7544	Prob. F(9,22)	0.0000
Obs*R-squared	31.86679	Prob. Chi-Square(9)	0.0002
Scaled explained SS	52.73927	Prob. Chi-Square(9)	0.0000

NRAP

Weighting series: HNRAP
Weight type: Inverse standard deviation (EViews default scaling)

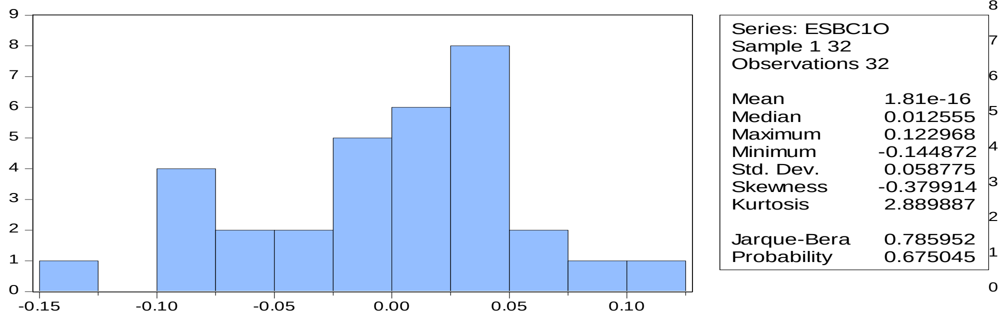
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient Variance	Uncentered VIF
RI^2	9.099247	0.042249	215.3737	0.0000	0.001785	1.000000

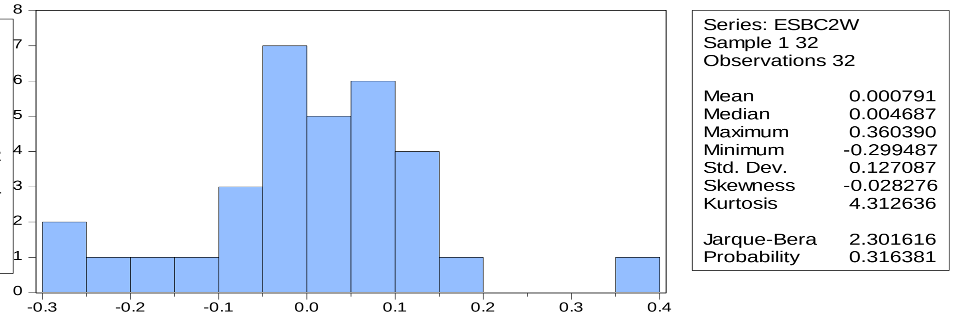
R-squared	0.871314
Adjusted R-squared	0.871314

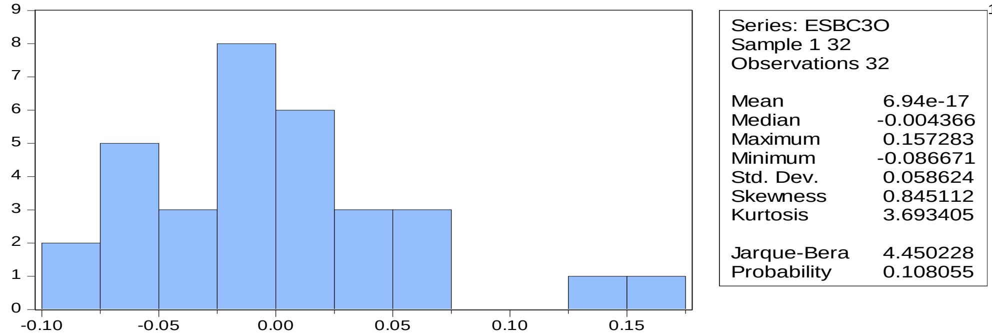
Heteroscedasticity Test: White

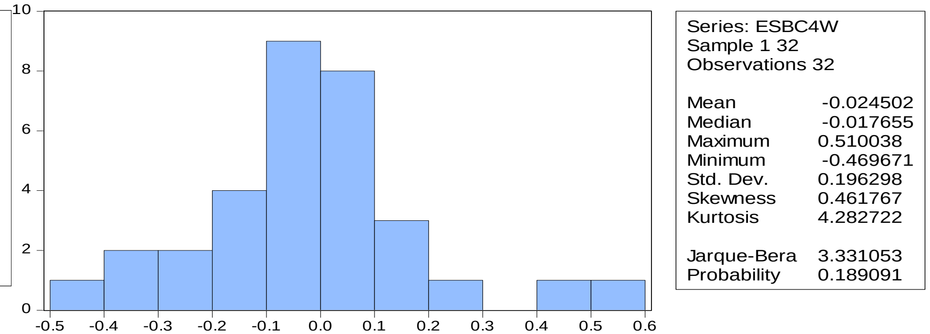
F-statistic	0.479261	Prob. F(1,25)	0.4951
Obs*R-squared	0.507866	Prob. Chi-Square(1)	0.4761
Scaled explained SS	4.859062	Prob. Chi-Square(1)	0.0275

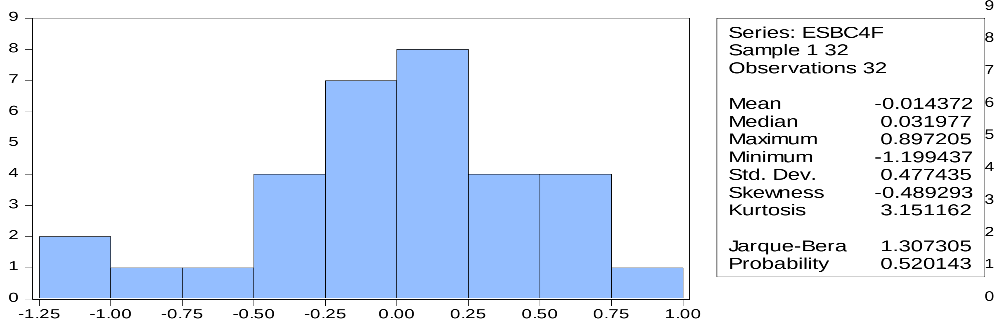
Appendix 6-11 the histogram of residual series

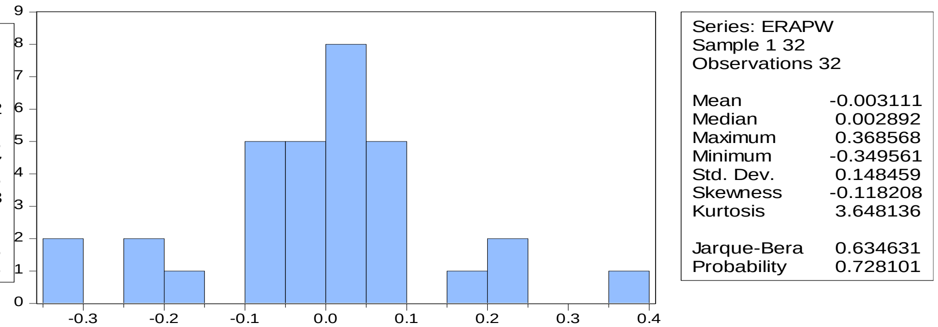


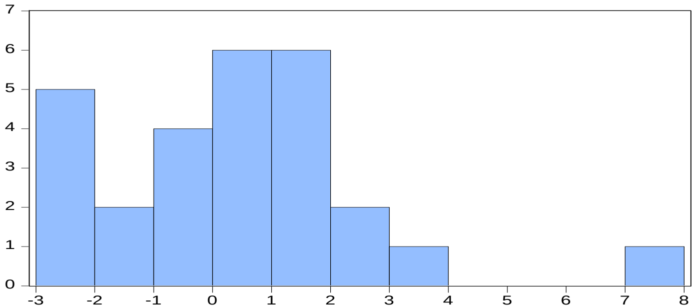




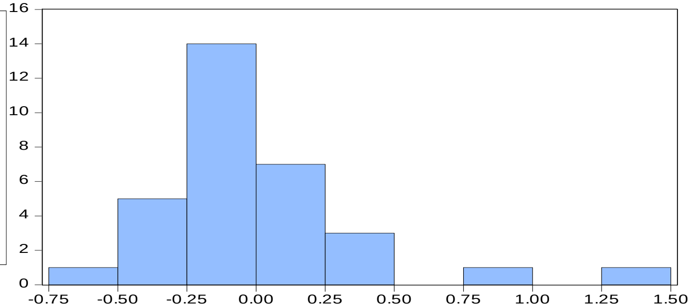




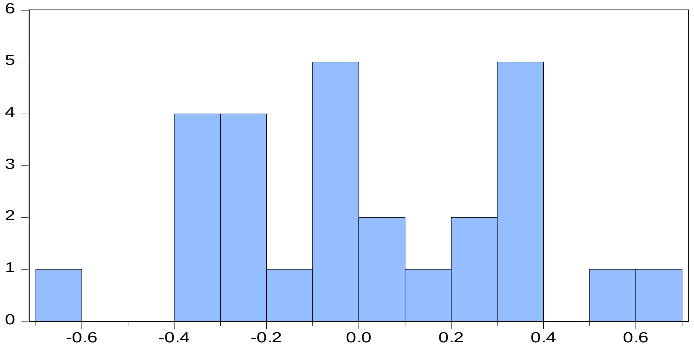




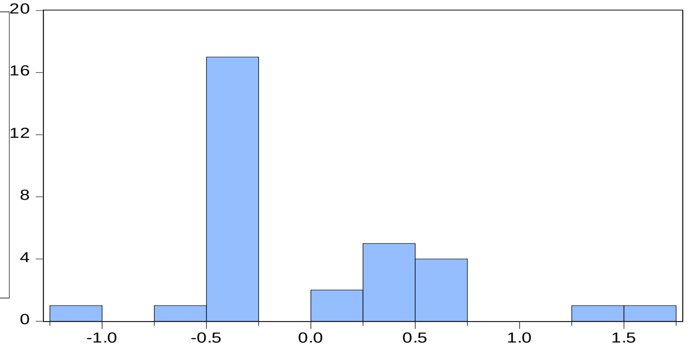
Series: ENRAPF	
Sample 1 32	
Observations 27	
Mean	0.353463
Median	0.004247
Maximum	7.369408
Minimum	-2.659952
Std. Dev.	2.158525
Skewness	1.077139
Kurtosis	5.240900
Jarque-Bera	10.87036
Probability	0.004360



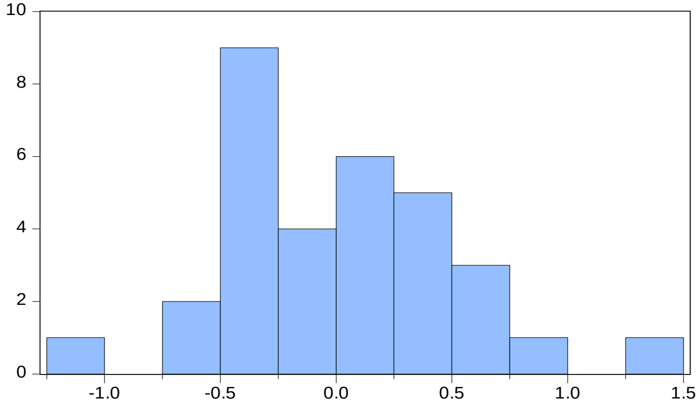
Series: ERCO	
Sample 1 32	
Observations 32	
Mean	2.76e-16
Median	-0.059932
Maximum	1.298628
Minimum	-0.562955
Std. Dev.	0.359992
Skewness	1.650269
Kurtosis	6.975946
Jarque-Bera	35.60227
Probability	0.000000



Series: ERQT	
Sample 1 32	
Observations 27	
Mean	0.010757
Median	-0.039215
Maximum	0.659046
Minimum	-0.671590
Std. Dev.	0.328511
Skewness	0.106441
Kurtosis	2.256906
Jarque-Bera	0.672195
Probability	0.714553



Series: ELNNCAO	
Sample 1 32	
Observations 32	
Mean	9.71e-17
Median	-0.356376
Maximum	1.589534
Minimum	-1.155892
Std. Dev.	0.595347
Skewness	0.920422
Kurtosis	3.663907
Jarque-Bera	5.105976
Probability	0.077849



Series: ELNTCAO	
Sample 1 32	
Observations 32	
Mean	-1.11e-16
Median	-0.021941
Maximum	1.317497
Minimum	-1.181727
Std. Dev.	0.494199
Skewness	0.310234
Kurtosis	3.499705
Jarque-Bera	0.846249
Probability	0.654997

Note: all of these residual series have a name starting 'E' letter, after which are the data name and the signal for estimation method. If the name ends up with 'O', it means the residual series comes from OLS, if it is 'W'; it means WLS; if there is 'F', the method is FGLS; if O is used in the end, the method is TSLS.

CHAPTER 7 SUMMARY, SUGGESTIONS AND CONCLUSION

7.1 Introduction

This chapter will give a summary about what have been done until now. Policy suggestions will be given then. After that, the limitation of this research will be talked about. The corresponding suggestion for future research will be given later. The conclusion of this research will be given in the end.

7.2 Summary

This research follows positivism in Chicago School to explore and investigate *ex post* CA under PPP. Precisely, this research is mainly consisted of two parts, theoretical exploration and empirical investigation. The former figures out economic behaviours under CA for PPP program while the latter discovers the relationship between economic elements related to *ex post* CA under PPP.

The first chapter is introduction for this research. The research theme, *ex post* CA (the following will still ignore *ex post* before CA for convenience) under PPP is illustrated firstly. The research question is orientated to be ‘what are the reason for and consequence of *ex post* CA under PPP?’. For answering this question, this research involves mainly the issues of CR (Contract Restructure) and SBC (Soft Budget Constraint). The significance of research is given then from three aspects. At first, the historical background and current context of PPP uncover that our research is valuable. Secondly, it is found that our research theme is seldom studied in existing literature. Finally, we give clear orientation of this research and the implication. After that, the framework of this research is clarified with a picture.

The second chapter reviews relevant literature for this research. At first, EoC (Economics of Contract) and TCE (Transaction Cost Economics) are reviewed. In particular, the respective relevance of those two theories are figured out especially. After that, two relevant issues, CR and SBC are referred to, respectively. Then some relevant problems are also analysed for this research.

The third chapter illustrates the philosophy, methodology for this research before research design. Namely, before designing research, the philosophy selection, the methodology selection and the approach selection has been done. The research design is illustrated in the sections about method selection. In other words, the relevant design for modelling is illustrated immediately after the method selection for theoretical exploration; the respective design for measurement and regression is given after relevant method selection. In spite of those methods, the simulation, as a supplement tool of study in this research, is also especially illustrated. After that, the data and data collection technology and the software for data analysis are also described. Simply speaking, Chapter 3 introduces and illustrates five levels for this research, including philosophy, methodology, approach, method and data, in order.

The forth chapter sets up one model for theoretical exploration. Government has inherent incentive keep PPP program going, thereby rescuing firm under *ex post* risk. Our model especially explains the potential takeover policy of government under CA for PPP program. The takeover policy of government could be adopted due to holdup problem under asymmetrical information and uncontrollable CAs under consistent *ex post*. In particular, either rescue policy or takeover policy of government is aimed to compensate directly or indirectly firm under PPP through CA. Our modelling is oriented to draw a picture for the compensation effect of CA under PPP and then give a theory of CA under PPP. After that, we give a supplementary illustration for practical way of firm get compensated from government with CA.

The fifth chapter is mainly aimed to finish measurement for later data analysis. Different from general way, the data is our own creature after case studies. For measuring relevant variables, we design indicators firstly. In particular, there is one qualitative indicator for government policy and then the basic conclusion of modelling could get tested. After that, we give a hypothesis on the relationship between those quantitative indicators. After that, we finish a hard process of data generation. Thirty-two cases are studied to identify the values of indicators. Considering four cases outside transportation industry, the data in different categories are compared. It turns out the dilution effect of adding four cases outside transportation is smaller than it seems.

The sixth chapter does mainly regression and give result of hypothesis testing. Before the regression, the data is described by statistics. As for the regression, it could be roughly divided into three steps. The first step is initial analysis, which includes correction for skewed data and multiple regression. The former is considered for later data-fitting while the latter tests how much variation in data could be explained without any constraint (for example, significance). The second step is stepwise analysis. This step includes two minor procedures before results, automatic stepwise regression and manual adjustment. The first one could basically figure out which variables are significant. The second one must ensure that no insignificant variables and the variables leading to co-linearity problem are included in model and no significant variable are overlooked in our model. This process is finished manually. Only after first two processes, this formal estimation under stepwise regression could be completed. After initial analysis and stepwise regression, we should confirm or verify our models satisfy the requirements of estimation. Three assumptions of Gauss-Markov theories will be talked about immediately. To be precise, the linearity and the independence of residual error must be satisfied since cross-section-data are used for this research. However, for the assumption of homoscedasticy, we use three ways to deal potential heteroscedasticy problem, including, OLS with White error, WLS and FGLS. After three above assumptions, the normality of residual error series is confirmed. Finally, to avoid potential bias of estimation, the endogeneity issue is discussed. When all of these three steps of regression, our models could be reliable and efficient.

After above regression, the hypothesis testing on quantitative indicators could be tested clearly. Besides, for dig more from our data and regression, a simulation is especially used to figure out which combination of dummy variables, which corresponds to different way of CA, are infeasible.

Concluding all above, the original work of this research is concentrated in Chapter 4 to Chapter 6. Chapter 4 gives theoretical conclusion (after modelling), Chapter 5 collects data originally for this research and Chapter 6 shows empirical result (after regression with a supplement of simulation).

7.3 Policy suggestions

The following table is constructed to conclude the relationship confirmed from regression results. In the model results from last chapter, there are log item and square item. Considering only the qualitative aspect of relationship is focused, those items are irrelevant. All of following explanation over relationships need not consider the log or square item. Relative to Table 6-8, focusing the hypothesis test, Table 7-1 emphasizes the relationship between variables for policy suggestion.

Table 7-1: the relationships

Independent variables	softness					*Ex post* risk		
	S_{BC}^1	S_{BC}^2	S_{BC}^3	S_{BC}^4	R_{ap}	N_{CA}	R_q	t_{CA}
R_i	Na	–	Na	–	–	+	Na	Na
S_{BC}^{01}	Na	+	–	Na	Na	Na	Na	Na
S_{BC}^{02}	+	Na	Na	–	Na	Na	Na	+
S_{BC}^{03}	–	–	Na	Na	–	Na	–	Na
R_t	–	Na	–	Na	Na	Na	Na	Na
t_{CA}	–	Na	Na	Na	Na	Na	–	×
$x1$	+	–	–	–	–	Na	Na	Na
$x2$	+	Na	–	Na	Na	Na	Na	Na
S_{BC}^3	×	×	×	×	×	Na	Na	+

Na: the indicator is removed by regression, +/-: positive/negative relationship, ×: the indicator is not independent variable in regression.

One of examples could be seen in following. $ln(t_{CA})$ is negatively related to $(S_{BC}^{02})^2$ in the eighth model in result of final estimation, it could be simplified as $(S_{BC}^{02})^2 \sim t_{CA}$ ('~' means 'is positively correlated to') at first since the data transformed by log function has the positive relationship with raw data. Furthermore, the relationship could be simplified as $S_{BC}^{02} \sim t_{CA}$ because S_{BC}^{02} has only non-negative values.

The following explains the effect of indicator as an independent variable. From Table 7-1, there are ten independent variables. In fact, those could be divided into three groups, as categorized in measurement, including *ex ante*/initial variables (designed or stipulated in original contract), process variables (reflecting *ex post* risk) and decision variables (including one softness indicator and dummy variables). Seen from Table 7-1, some of indicators are not important, this is practical. To be precise, the first category includes R_i, S_{BC}^{01}, S_{BC}^{02} and S_{BC}^{03}, the second one includes R_t, R_q and t_{CA} and the final one includes $x1$, $x2$ and S_{BC}^{3}.

At first, R_i it is negatively correlated to S_{BC}^{2}, S_{BC}^{4} and R_{ap} while positively related to N_{CA}. This means more internal risk leads to more CAs while gets less supported by bank. The bank reluctance of involving CA package could be seen in the negative relationship with S_{BC}^{2} and S_{BC}^{4}. Namely, the total debt and the *ex post* added debt will be smaller, if R_i is bigger. At the same time, the reluctance could be also seen in the negative relationship with R_{ap}, which tells us the reliance of government contribution on market system become smaller if there is bigger R_i. This clear reluctance trend of bank and the trend of more CAs (because of bigger value of N_{CA}) warns that the internal risk may be a challenge over the ability of government at CA. Considering these, there should be separate suggestion as following.

Policy Suggestion-1(PS-1): there must be effective ex ante estimation of internal risk; otherwise, government has to bail out firm with bigger weight of direct support.

Three initial variables should be reassessed together. As mentioned, $S_{BC}^{01}\sim S_{BC}^{2}$ and $S_{BC}^{01}\sim\frac{1}{S_{BC}^{3}}$, which means *ex ante* global softness could ensure bigger involvement of bank and constrain the *ex post* softness at CA. Hence, *ex ante* global softness should be encouraged to bigger. At the same time, $S_{BC}^{02}\sim S_{BC}^{1}$, $S_{BC}^{02}\sim\frac{1}{S_{BC}^{4}}$ and $S_{BC}^{02}\sim t_{CA}$, which means *ex ante* debt leads to bigger global softness, longer period under CA and less involvement of bank at CA. Accordingly, *ex ante* debt ought to be smaller. In addition, $S_{BC}^{03}\sim\frac{1}{S_{BC}^{1}}$, $S_{BC}^{03}\sim\frac{1}{S_{BC}^{2}}$,$S_{BC}^{03}\sim\frac{1}{R_{ap}}$ and $S_{BC}^{03}\sim\frac{1}{R_q}$, which means *ex ante* subsidy leads to smaller global softness but less involvement of bank at CA, less reliance over bank for CA package and bigger demand risk. For the sake of CA package, S_{BC}^{2}, R_{ap} and R_q are more relevant, so *ex ante* subsidy should be smaller. Combining above considerations, there are that *ex ante* global softness (contribution) should be bigger, *ex ante* debt support and subsidy should actually be smaller. This is contradictory conclusion since the smaller *ex ante* debt support and subsidy should ensure smaller *ex ante* global softness. The relative advisable way is to have a bigger S_{BC}^{01}, a bigger S_{BC}^{02} and a smaller S_{BC}^{03}. A bigger S_{BC}^{01} and a smaller S_{BC}^{03} have good effects while a bigger S_{BC}^{02} has a less adverse effect than a bigger S_{BC}^{03}. Comparing with S_{BC}^{03}, S_{BC}^{02} has a smaller *ex post* debt (S_{BC}^{4}) and a longer period under CA. However, S_{BC}^{03} has a smaller global debt (S_{BC}^{2}) and an obvious reluctance of bank (R_{ap}) at CA. Considering these initial situation, there should be two separate suggestions as following.

Policy Suggestion-2(PS-2): when PPP program has potential ex post crisis, it is necessary for there to be an ex ante contribution of government; otherwise, more ex post contribution will be incurred.

Policy Suggestion-3(PS-3): when government decides to support firm for the program launch, debt (representing bank involvement or market system) instead of subsidy (representing government as the counterpart of market system) should be approved as ex ante contribution.

$R_t$as one process variable has relationships as: $R_t \sim \frac{1}{S_{BC}^{1}}$and $R_t \sim \frac{1}{S_{BC}^{3}}$. The risk of delay have some negative effect with the softness indicators. It may derive from that delay could have a role of constraining softness. The effect of R_t is benign. Hence, to some extent, the *ex post* risk is not the extremely vicious element, which is only needed to reassessed.

Moreover, $t_{CA} \sim \frac{1}{S_{BC}^{1}}$and $t_{CA} \sim \frac{1}{R_q}$, which reflects that, on one hand, longer period under CA has smaller softness with bigger demand risk. The longer period under CA comes from project itself or transacting parties for renegotiation. Based on the relationships, The deliberated delaying in renegotiation is economical for government but it could leads to a bigger *ex post* risk. In other words, deliberate enlargement of t_{CA}, *ex post* risk of contract implementation under CA, is irrational for *ex post* package though it may constrain the global softness. If government (particularly, in developing countries) does not accept the reality and it wrest still with the original benefit behind contract, the potentially bigger loss (due to more risk) will be incurred. Combining the above two sides, there is a separate policy suggestion as following.

Policy Suggestion-4(PS-4): when the PPP program has really ex post risk, the contribution of government is justified as long as the risk is objective. At the same time, CA under PPP program should not be delayed deliberately for renegotiation, otherwise more ex post risk will be incurred.

Actually, the above policy suggestion is very especially meaningful for PPP program in developing countries where *ex post* risk witnesses the clash (deriving from CA) between government and firm before that government has to bail out firm in the end. From the above relationships, that kind of clash seems meaningless since the clash will end up with government's bailing-out in general (government contribution is inevitable) and the clash will only break the spirit of PPP, the cooperation between public and private partners.

Finally, the relationships of decision variables could suggest followings. $\mathrm{x1}{\sim}\mathrm{S}_{\mathrm{BC}}^{1}$, $x1{\sim}\frac{1}{\mathrm{S}_{\mathrm{BC}}^{2}}$, $x1{\sim}\frac{1}{\mathrm{S}_{\mathrm{BC}}^{3}}$, $x1{\sim}\frac{1}{\mathrm{S}_{\mathrm{BC}}^{4}}$and $x1{\sim}\frac{1}{\mathrm{R_{ap}}}$, which means the way of direct support at CA adds global softness and reduces the reliance of government over the bank involvement. According to definition, the effect of $x1$over S_{BC}^{1} ,S_{BC}^{2} or S_{BC}^{4} is reasonable. However, the unexpected decrease effect of $x1$ over S_{BC}^{3} derives from $x1{\sim}R_{ap}$. When $x1$ leads to bigger R_{ap}, which in turn leads to bigger role of bank and finally leads to smaller $\mathrm{S}_{\mathrm{BC}}^{3}$. Furthermore, $x2{\sim}\mathrm{S}_{\mathrm{BC}}^{1}$ and $x2{\sim}\frac{1}{\mathrm{S}_{\mathrm{BC}}^{3}}$, which means the investment from firm itself at CA increases global softness while decreases *ex post* softness. In spite of $x1$ and $x2$, there is another relationship, $\mathrm{S}_{\mathrm{BC}}^{3}{\sim}\mathrm{t}_{\mathrm{CA}}$. It means bigger *ex post* softness need longer period under CA. Combining above four variables, the third one (S_{BC}^{3}) leads to longer CA (t_{CA}), namely, a bigger t_{CA} comes from a bigger S_{BC}^{3}. So how to decrease t_{CA} seems to decrease S_{BC}^{3}. The decrease of S_{BC}^{3} could refers to $x1$ and $x2$, which could decrease the softness. In particular, $x1 = 1$, there are three options including compensation, *ex post* investment from government and government support over the gain of debt refinancing towards firm. It is obvious that the third one will not affect the original benefit, so the gain approval is optimal though it could be only feasible when there is debt restructure. Considering these, there could be a separate policy suggestions as following.

Policy Suggestion-5(PS-5): the way to constrain ex post softness is ⑴a package of debt restructure with approval of gain to firm, ⑵a package of new debt support with compensation or government support..

7.4 The limitation of this research

There are several limitations of this research as followings. Some derive from the data itself, others comes from the topic itself. The former, it could only be avoided while the latter will be solved in future research. The following will give the limitation in order of precedence.

At first, there is a limitation in modelling. The model in Chapter 4 seem complex but not very hard to understand, some problems do not go further. The aim of modelling is to get best understanding over the reality, so the every model seems complicated. Furthermore, every step of inference is very careful to avoid unnecessary assumptions, so there is no very hard induction in the modelling. Following the philosophy New Institutional Economists (especially the academic though of Steven N.S Cheung) insist on, the complex but not hard exploration is pursued for focusing on the reality. This limitation could be tolerated in NIE's opinion.

Secondly, there is a limitation in measurement. The measurement is not perfect so that some potential relationship cannot be figured out from regression. Any error in measurement could lead to a sensitive change of regression. The solution for data generation may be the experiment economics, but it is hard to get enough data with experimental data for regression. For getting more information from those experimental data, the empirical distribution estimation may be needed. Namely, to solve the measurement problem, experimental economics and empirical distribution estimation must be used together. Both experimental economics and empirical distribution estimation are away from the reality. We insist on focusing on the reality, so that way is not applied in this research.

Thirdly, there is limitation in data itself. The cross-section data is used in this research, the time tendency is overlooked. However, that is not feasible in reality. Many of CAs take place without no clear time record. At the same time, the time tendency could lead to autocorrelation problem. Considering this, as an early research at this topic, the cross-section data is still valuable to use.

Fourthly, there is limitation related to the research topic itself. This research focuses on the general question about CA under PPP program. Though it will contribute to the knowledge in general, it may lose a chance to understand some case deep in reality. Considering the research topic is still at the early stage, the study on general situation seems necessary before a deep case study, so this limitation could be tolerated since there must be a choice between general and deep study.

7.5 The suggestions for future research

According to the limitation of this research, there are two directions to for future research. For one thing, the future research is expected to solve or avoid limitation in data and measurement; for another, the topic will be developed into more general situation or be investigated in deep case study. To be precise, there are followings suggestions for future research.

At first, the way of making the measurement more precise and reliable is to focus on one section. Therefore, both data in the absolute form and ratio indicator could be used. Unlike this research, only data in pure ratio form (for quantitative indicator) could be used. However, that may lead to the number of case not big enough once again. So the data type may be changed or more cases is hoped to get. The former involves the next suggestion while the latter depends on the future information on CA under PPP.

Secondly, it is hoped to get the time series data or panel data about *ex post* CA. To our best knowledge, the unique feasible way is to get data of some firm that has years to issue equity. The equity issue represents the CA within firm and then the different kind of *ex post* CA could be investigated. If we could get the data for several years for every case, the number of case could be reduced. It must be noted that this kind of data is still very hard to get, but it is potential direction for future research. If there is some chance to get this kind of data, it cannot be lost.

Thirdly, the topic in this research could be developed to CA under other mechanism or background. In other words, more general situation could be developed, not only PPP program any more. For example, this research focuses on mainly the relationship between government and firm. The research in future could study the contract within firms, thereby only exploring and investigating the behaviours within market system. In fact, as mentioned above, the data about equity issuing is actually related to CA within firm. On one hand, the topic within firm could make exploration deeper without need of considering political element and make investigation more feasible (since subjects will not varies so different in scale); on the other hand, the information problem may become more difficult since firm keeps it as business secret.

Fourthly, some case could be studied to figure out the actual manipulation of packages under CA. A specific case study could be very meaningful to explain for the reality; it may find out more original contribution in theoretical exploration or empirical investigation. This kind of way requires definitely more information and it relies on the author's ability over the case itself. The former will make the research riskier due to information problem while the latter could be beyond the requirement of PhD dissertation. However, it is really worthy doing in future if it is practical.

Finally, as mentioned in Chapter 4, this research points out one flaw of Coase theorem. That will be very meaningful source to develop, but need a large volume of work in future. The traditional theory neglects the significant effect of *ex post* risk. As proved in our research, *ex post* risk spoils contract and then contract must be able to resist *ex post* risk. The future research needs to reveal how *ex post* risk challenges the property rights allocation stipulated in original contract relationship though the property rights allocation is very hard to investigate objectively.

7.6 The conclusion of findings

This research has theoretical exploration and empirical investigation. In theoretical exploration, we give a clear picture of the behaviour of firm and government under CA for PPP program. In empirical investigation, the quantitative relationships between relevant indicators get figured out. The important conclusions in this research could be abstracted as following.

In modelling, government prefers to rescue firm under *ex post* risk. The package of rescue policy adopts *ex post* risk transfer as the first option. When there is bankruptcy problem, government takes the reallocation package of property rights. Under the bankruptcy danger (the probability of bankruptcy problem is less than one), government still has incentive to delay compensating firm directly when the first options is not feasible anymore. Namely, a temporary package transferring *ex post* risk will be adopted. Only when the danger is more close enough (the probability of bankruptcy problem is big enough[45]), government will take a prompt reallocation package. However, when CA runs out of control, firm and government lose confidence and then the prompt reallocation package will become totally irrational.

In data analysis, the result is complex, but some conclusions from regression is worthy of special attentions. At first, ex *ante* risk of collecting fund at equity market leads to more *ex post* contribution from government, this could be seen *PS-1*. Second, *ex ante* government contribution cannot really control and constrain *ex post* contribution because the former could lead to a bigger value of the latter; this could be seen in *PS-2*. Thirdly, market instead of government itself could have a better ability to control *ex post* contribution, so the package of debt support as *ex ante* contribution from government, which transfers *ex post* risk from firm, is better than the package of subsidy grant, which reallocates property rights, to launch PPP program. This could be seen in *PS-3*. Fourthly, *ex post* risk seems not vicious due to the effect of constraining government contribution. As long as it is objective, government's *ex post* contribution is justified; CA is necessary and then the clash (between firm and government) deriving CA will have nothing to gain for both parties. At the same time, the delay of negotiation for CA cannot be adopted for constraining government contribution; a prompt CA is economical. This could be seen in *PS-4*. The real way of constraining government contribution for PPP program is to take full use of market system to monitor firm. The details could be seen in *PS-5*.

In spite of policy suggestion from regression models, the insight from simulated scenarios is meaningful. Recalling simulation, there are two conclusions about the feasibility of CA methods. The first one tells none of CA methods could be feasible when initial

[45]It is still less than one.

contribution and risk are at high level, so ex ante design could be not safe for ex post contract implementation; the latter points out that CA will constrain *ex post* contribution.

If the above conclusions seem still fussy, we can use following to conclude those findings.

⑴rescue policy is superior for government under CA; debt support is the first option under rescue policy. Putting this conclusion to the level of transaction (not only for CA package under PPP), it could be concluded as that the appropriate risk distribution is also an important condition for transaction and *ex post* risk transfer instead of property rights reallocation will be the first option of CA.

⑵*ex ante* risk need be controlled (see *PS-1*), *ex ante* contribution seems necessary (see *PS-2*), *ex ante* contribution should be more relied on market instead of government itself (see *PS-3*), CA deriving from objective *ex post* risk is justified and a prompt (un-delayed) CA should be adopted (see *PS-4*), the way to adjust contract *ex post* should relies mainly on market instead of government itself (see *PS-5*).

⑶only debt package (without *ex post* contribution from shareholders) could be generally feasible under CA for PPP program; *ex post* contribution from shareholders has preliminary condition to realize.

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