

**Why Social Infrastructure Projects Experience  
Cost Overrun**

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Author

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## **Abstract**

The infrastructure industry has witnessed incredible growth around the world in the past decade. Large-scale investments have been made by governments in the infrastructure industry as an effective way to stimulate the economy. However, it is worth noting that infrastructure projects worldwide suffer from frequent cases of cost overrun. As a critical challenge in the infrastructure industry, cost overrun remains however an under-researched academic topic. Previous studies in this field have mainly adopted quantitative methodological research methods and analyzed data from economic infrastructure projects. Social infrastructure projects, however, have received comparatively less academic attention. This study seeks to fill this gap and to analyze the reasons why social infrastructure projects experience cost overrun. Data were collected from four cases of social infrastructure projects in China and a multiple case-study approach was taken to analyze the data. The findings of the research suggest that, first, the time pressure and changes of orders/scope are the main factors causing the cost overrun in the context of Chinese social infrastructure projects. Moreover, combining the practical cases with existing theorists, it is clear that the evolutionary theorist performs better in explaining the cost overrun in the context of Chinese social infrastructure projects comparing to the psycho theorist.

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## 1. Introduction

The infrastructure industry has grown rapidly all around the world in recent years. Infrastructure, especially social infrastructure, is indispensable for an efficient operation of the society and a sustainable growth of the economy. Social infrastructure commonly refers to facilities such as hospitals, public schools and libraries that are funded, constructed and/or by the government authority. Even though governments have had abundant experience in organizing and procuring social infrastructure projects, cost overrun still occurs and causes massive loss in capital and resources. The current study seeks to analyze why social infrastructure projects experience cost overrun. It relies on a case study of four social infrastructure projects in China.

This proposal is composed of three sections. In the first section, an introduction is given on the role and importance of social infrastructure, and the research question will be elucidated. The second section is a literature review, providing a summary of existing studies focusing on reasons behind cost overrun and a detailed description of the budget estimation process of Chinese social infrastructure projects. Also in this section, the author discusses the definition of a social infrastructure project. The third section--the methodology section--begins with an overview of how the current study is conducted, followed by the introduction of a coding book guiding the documentary analysis. As mentioned above, cost overrun has been a prevailing problem for a long period and considerable academic resources have been devoted to this field trying to solve the problem. However, those studies are mainly conducted in the context of economic infrastructure with very little attention on social ones. The current study then hopes to contribute in filling in this gap.

The current study aims to explore why social infrastructure projects experience cost overrun by borrowing insights from existing theories and documentary analyses on practical cases. The analysis will contain three steps: the document interpretation, the

factor extraction, and cross-case comparison. It will categorize the explanations from documentation and archive based on two dominant schools of thought in the field. Moreover, this study will compare the similarities and differences of explanations within and between cases from different stakeholders' perspectives.

### **1.1. Infrastructure and Its Role in Economic Development**

The infrastructure industry has seen an unprecedented growth worldwide during the past decade. In 2008, however, the economic crisis hit the globe. In order to stimulate the economy and get the unemployment rate off the hook, countries around the world launched numerous investment plans on infrastructure projects. As for developing countries, take China and India as examples, the infrastructure investment budgets in 2008 reached respectively 537.6 billion Yuan (approximately 84.8 billion in USD) ("2018 Central Construction Expenditure Budget Table," 2018) and RS 5.97 lakh crore (approximately 85 billion in USD) ("Budget 2018: Annual infrastructure spending hiked to Rs 6 lakh crore," 2018). Looking into developed countries, just in the single month of February in 2018, the United States proposed a massive infrastructure plan worth USD 1.5 trillion to rebuild crumbling highways, bridges, railways and seaports (Calia, 2018), and Canada plans to deliver projects worth CAD 33 billion (approximately 24.92 billion in USD) in 2017 (*Investing in Canada plan Bilateral Agreements*, 2018).

As an essential driving force of economic growth, infrastructure projects increase productivity and generate more economic opportunities in three ways. Firstly, infrastructure investment helps to create a large amount of vacant jobs in construction and maintenance, thus prevents employment rate from further decrease. According to the Brookings Institution Analysis Bureau of Labor Statistics data, 14 million people, or 11 percent of the US workforce, live on their salaries in industries directly related to infrastructure, from electrical power line installers, truck drivers to construction laborers (Puentes, 2015).

Secondly, infrastructure investment can boost domestic economy by consuming a great quantity of construction materials and promoting mobility of labor, resources and products. Before 2008, thanks to a robust export, China's iron and steel industry expanded at a rapid rate with an annual production capacity of 600 million tons. Due to the 2008 international economic crisis, nevertheless, the whole industry was forced to cut production significantly facing a sluggish export demand, though most factories cannot afford the loss. Consequently, the annual output of iron and steel fell to 420 million tons in October 2008, down 26% from the highest level of the year. In 2009, the Chinese government responded by launching a railway network plan worth 3.5 trillion Yuan, comprising 150 construction projects including railways, bridges, tunnels, culverts and electrification. Just in 2010, this plan consumed more than 580 million tons of iron and steel, which saved the iron and steel industry from misery. As the state's economic stimulus plan released hundreds of thousands of infrastructure construction works (including low-capacity highways, high-speed railways and fixed connection lines etc.), domestic consumption began to grow and gradually made up for the sharp decline in exports. In 2009, the domestic consumption of iron and steel reached a record of 560.04 million tons, increased by 24.8% than the past year; the annual output of iron and steel was 576.84 million tons with an increase of 67.53 million tons (13.5%) compared with the previous year.

Thirdly, infrastructure investment also enhances the transportation system, enables the mobility of labor, resources and products, and even stimulates the growth of other entirely different industries (Zheng, 2011). The express delivery industry in China is one typical example. Back in 2006, the Chinese express delivery business was only one-tenth of that of the United States in terms of production value. Yet, the figure in 2016 is twice of that of the United States, with the total amount exceeding 30 billion, accounting for 40% of the global business (Hu, 2017). Since the reform of the postal system in 2006,

especially after the revision of the postal law, the advantage of the express delivery industry has come into light. For the next six consecutive years, the express delivery business maintains a skyrocketing growth speed of around 50%. Nowadays, people in China are accustomed to shopping online through platform like Taobao.com (the largest online shopping platform operated by Alibaba), buying small luxuries such as diamond and jewelry as well as large and clumpy items such as furniture. On November 11<sup>th</sup> of 2017, 850 million parcels were ordered and delivered during an online shopping festival, and it cost only 2.8 days for the express delivery industry (90% whose transport methods relies on the expressway) to deliver the first 100 million parcels thanks to the advanced transportation system (X. Wang, 2017). The well-developed express delivery network brings Chinese people much convenience to access to whatever they need within a short time from every corner of the country without stepping out of their houses. Moreover, by spreading into even the smallest village, the highway system makes it possible for people in remote villages to bring in resources and export farm products and specialty which helps promote the local economy.

All in all, infrastructure serves as a tool to keep the economy develop at a steady and sustainable pace by adjusting domestic manufacturing and consumption. Besides, infrastructure facility plays an indispensable role in creating investment opportunities for other industries. Whenever a well-prepared new railway line, road or water treatment plant is completed, economies grow through new employment opportunities and increased social productivity. OECD and IMF analyses have shown that for every dollar of investment in infrastructure, “there is a plus 1.6 multiplier in the form of a boost to short-term employment combined with a longer-term productivity gain” (“Why infrastructure matters,” 2017).

## 1.2. Consequences of Cost Overrun in the Infrastructure Industry

It is a widely recognized fact that basic infrastructure facilities and related services are vital for the economic development of a country (Fazekas & Tóth, 2018). If well developed, they stimulate economic development, yet hinder it if inadequate. Moreover, the role of infrastructure as a stimulant of economic growth and development can only be obtained only when its quality is guaranteed (Calderón, Moral-Benito, & Servén, 2015). Once certain problems occur in projects, the expected benefits will vanish but even worse situations are likely to appear instead, as most infrastructure projects require huge financial expenditures. Among those problems, perhaps one of the most recurrent is cost overrun.

Cost overrun refers to the situation when the final cost of a project exceeds the estimated budget. According to Flyvbjerg, Skamris Holm, and Buhl (2003), this phenomenon occurs across the world including both developed and developing countries, in all kinds of infrastructure projects including the railway, road, tunnel and highway project, spanning a long time period from 1920 till 2000 and is expected to linger on. Along with the boom of the infrastructure industry, cost overrun has also become the “new normal” in infrastructure projects as reported by academic studies, media outlets and government reports. Cost has been widely recognized as a prevailing problem confronting the infrastructure industry worldwide<sup>1</sup>. From the Sydney Opera House to the Hong Kong–Zhuhai–Macau Bridge, cost overrun in construction projects has become a historic, industry-wide and global problem which is in urgent need to be fixed.

In recent years, many projects have experienced huge cost overrun. Massive cost overrun and endless schedule delays in infrastructure projects seem to lead to serious

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<sup>1</sup> The outcome ranged from -11 to 106% (Pickrell, 1990), -59 to 183% (Odeck, 2004), -34 to 22.8% (Cantarelli, Flyvbjerg, Molin, & Van Wee, 2013b; Cantarelli, Flyvbjerg, & Buhl, 2012), -69.4—to 343.8% (Love, Sing, Ika, & Newton, 2019) this phenomenon is due, inter alia, to the geographical differences and the variation in the definition of cost overrun which will be further illustrated later in this paper.

consequences, casting a shadow on the industry. One of the most serious consequence is the unbearable finance burden resulting from the sunk cost effect caused by cost overrun. Unable to abandon the unfinished infrastructure facility, governments have to deal with the remaining mess with limited budget reallocation and to face the risk of potential difficulty in cash flow. Though part of the escalating cost will be absorbed by contractors, particularly for those projects delivered through PPP procurement, the majority of the additional cost will be passed on to the government, and ultimately to the taxpayers in most cases. Such unreasonable budget allocation increases finance burden and sometimes may lead to sacrificing other projects, thus undermining public trust in government. Take the Ottawa City Government's case as an example. Take the Ottawa Light Rail Transit (LRT) project as an example. The Ottawa City Government was harshly criticized by its citizens for a lack of guidance and management ability, after the Mayor Jim Watson announced constantly delay of this \$2.1 billion LRT project. The LRT project was originally due on May 24<sup>th</sup> in 2018, yet it was not until September 14<sup>th</sup> in 2019, 478 days later than the schedule handoff date, that the LRT started to roll(Foote, 2019). As documented in a memo to the city council on June 20<sup>th</sup>, 2019, an extra cost reached 33 million (Whan, 2019b), resulted from the extended operation of buses to offset the transit pressure caused by the delay of the project. Even after the launch of the project, new problem surfaced. At the first week, two lines broke down for several times<sup>2</sup>, and the OC transport found that they don't have enough O-Trains to accommodate the commuters, leading to sudden route cancelation and overcrowded trains. In order to conciliate public anger, 7.5 million Canadian dollars was allocated to purchase 40 O-Trains to improve the LRT system, which means increasing financial burdens (Curry, 2019). With the first stage of the LRT project continuingly frustrating Ottawa citizens, the city council

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<sup>2</sup> Since September 14<sup>th</sup> in 2019, Line 1 had broken down for altogether 21 hours and 30 minutes, and Line 2 6 hours and 45 minutes (Foote, 2019).

approved to spend 4.66 billion Canadian dollars on the second stage for improvement (Whan, 2019a)

Moreover, once governments are unable to fill this black hole of investment, they might be forced to adjust project scope and hand out an “emasculated” project that definitely will not perform as expected. One direct outcome is the waste of all kinds of resources including money, labor, manufacturing materials, etc. In this case, companies responsible for the construction usually respond by reducing essential expenditure either by selecting cheaper material with poor quality or adopting adjusted design plan without detailed review to deal with their immediate cash crisis. The construction plan of the Berlin Brandenburg Airport, for instance, originally aimed to replace both the Schönefeld and Berlin Tegel Airports and to function as a single commercial airport serving Berlin and the surrounding states of Brandenburg. However, because of the serious cost overrun and schedule delay, now it is only able to replace the Tegel Airport. Moreover, the construction that started in 2006 is now deemed to continue till 2021, ten years later than the original completion date with a budget overrun exceeding twice than the original plan (Fabricius, 2015)

### **1.3. Social Infrastructure: The Missing Piece in Cost Overrun Research**

Infrastructure, as classified by Hansen (1965), can be divided into two types — economic infrastructure and social infrastructure<sup>3</sup>. The most commonly known infrastructure are constructions including highways, railway networks and links, while others of small scale, such as schools, hospitals, government buildings and community centers are also dispensable parts of the infrastructure system. The former ones related to transportation are economic infrastructure, and the latter are under the category of social infrastructure. It should be noted that social infrastructure cannot be defined according to

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<sup>3</sup> The difference between these two kinds of infrastructure will be discussed in the literature review section.

their scale or size as it includes not only small-sized facilities but also large projects like theatres and stadiums, which plays an indispensable role in the daily life of human beings.

Despite the frequent occurrence of cost overrun in both economic and social infrastructure projects, most of the relevant studies mainly address economic ones (Flyvbjerg et al., 2003; Odeck, 2004; Marion Terrill & Lucille Danks, 2016), thus leaving social infrastructure projects little explored .

The scarcity of studies on social infrastructure projects may lead to a misperception that it is not as important. Nevertheless, the society would not be able to function well without the support of quality social infrastructure. Just as economic infrastructure encourages growth, social infrastructure promotes human development. Since economic growth and human development are interdependent and mutually reinforcing, economic and social infrastructures should be attached equal importance. In the case of China, as the most populous country in the world, it views social infrastructure facilities as with irreplaceable value, and hence places a great emphasis on the development and quality of social infrastructure. Therefore, the key for economic development is to expand the coverage and improve the quality of infrastructure projects, from which both public welfare and domestic economy would benefit a great deal. It can be said that Chinese economy would not develop at the current pace without the solid foundation provided by functional social infrastructure facilities in areas like health system, education and social housing.

#### **1.4. What is social infrastructure?**

In China, infrastructure refers to the facilities that provide public services available to every member of the society (*China Statistical Yearbook*, 2016). Quality social infrastructure plays an essential role in facilitating social and economic activities and

promoting the development of its spatial distribution. Based on the classification by Hansen (1965)<sup>4</sup>, the Chinese National Development and Reform Commission divided infrastructure projects into two sets — productive infrastructure and social infrastructure. By accommodating the growing demands from the public, the efficient provision of social infrastructure assets ensures a well-functioning society (Hansen, 1965). Social infrastructure is the foundation and supporting structure of a nation, region, city and neighborhood. In this case, social infrastructure should include all facilities that go beyond basic economic functions to make a community an appealing place to live. Thus, compared to economic infrastructure, social infrastructure is closer to everyday life (Torrise, 2009).

Although a few studies analyzed social infrastructure projects, the definition of social infrastructure project remains unsettled in the academic field. One possible reason is that the media, academics and even governments have simply assumed that the reviewers and audience have understood the meaning of social infrastructure and that there is no necessity to write extensively to explain social infrastructure projects.

After reviewing the websites of the public sections in charge of infrastructure investment in several countries, we found that most countries prefer to list examples of social infrastructure projects rather than give a formal and theoretic definition. The most common introduction is that “the social infrastructure includes .....” which is followed by examples such as social housing or stadium.

Therefore, this paper will try to define social infrastructure by listing differences between social infrastructure and economic infrastructure.

**Table 1 the Difference between Economic and Social Infrastructure**

Differences	Economic Infrastructure	Social Infrastructure
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<sup>4</sup> Niles M Hansen is the first academic to propose the categories of the economic and social infrastructure project. In his paper, he used the term “economic overhead capital” i.e. EOC and “social overhead capital” i.e. SOC.

	<b>(hereafter EOC)</b>	<b>(hereafter SOC)</b>
<b>General purpose</b> (Moteff & Parfomak, 2004)	EOC refers to all such elements of economic changes which serve as a foundation of economic activity.	SOC refers to the core elements of social changes which are required to provide social services.
<b>Relationship with Economic Development</b> (Eberts, 1990) (Torrissi, 2009)	EOC offers direct support to productive activity and accelerates the movement of economic products. EOC pushes forward the economic growth in a direct way.	SOC is designed to primarily increase social comfort and ultimately act on economic productivity. SOC promotes economic growth in a more subtle and indirect way.
<b>Example of Classification of EOC and SOC in Italy</b> (ISTAT, 2006)	Transportation Network road transport, railway transport, air transport, sea transport. Energy Network electricity network gas network water-system	Health Infrastructure free hospital treatment, health service, social security. Educational Infrastructure nursery, primary, school for pupils aged 11–14, secondary school, compulsory education, universities.
<b>Example of Classification of EOC and SOC in Canada</b> ("Investing in Social Infrastructure," 2018)	Information not found	indigenous communities early education and childcare affordable housing home care cultural and recreational infrastructure
<b>Example of Classification of EOC and SOC in China</b> <i>(State Council's Opinions on Strengthening Urban Infrastructure Construction, 2013)</i>	<b>Productive Infrastructure</b> road, railway, airport, communication, water, electricity and gas system	<b>Social infrastructure</b> education, technology, health care, sports, culture

<p><b>Examples of Classification of EOC and SOC in China</b>  <i>(State Council's Opinions on Strengthening Urban Infrastructure Construction, 2013)</i></p>	<p><b>Productive Infrastructure</b>  road, railway, airport, communication, water, electricity and gas system</p>	<p><b>Social infrastructure</b>  education, technology, health care, sports, culture</p>
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The paper shows a table retrieved from the OECD (abbreviation of the Organization for Economic Co-operation and Development) website in the Appendix, which demonstrates the referring purpose code sorted by section classification that can be used to calculate the economic data of the member countries of OECD. The mission of OECD is to “promote policies that will improve the economic and social well-being of people around the world” (“About the OECD,”). It now has 36 developing and developed countries in the membership including China and has published an annual economic report of the member countries receiving great credence worldwide from the academia, media, public and authority. Thus, the table in Appendix A serves as a credible reference for selecting cases in the next section of data collection.

For the purpose of ensuring the healthy growth of Chinese economy, a healthy social infrastructure industry is indispensable. This paper uses case study approach to analyze social infrastructure projects in the context of China in an effort to identify the potential explanations of cost overrun. By doing so, this paper hopes to improve the quality of future construction management of social infrastructure projects and their delivery within time and budget constraints. Only when the hidden reasons are found can the problem be better addressed in the future. In the next section, the author will review relevant literature on social infrastructure and cost overrun.

## 2. Literature Review

This section will focus on four issues: definitions of cost overrun in previous research; the way to calculate cost overrun; the definition of cost overrun and the way to calculate it in the current study; the possible explanations of cost overrun in the existing literature.

### 2.1. The Definition of Cost Overrun

The definition of cost overrun in existing literature is not as abundant as expected. One of the definitions was given by Flyvbjerg et al. (2018):

*“Cost overrun is the amount by which actual cost exceeds estimated cost, with cost measured in the local currency, constant prices, and against a consistent baseline. Overrun is typically measured in percent of estimated cost, with a positive value indicating cost overrun and a negative value underrun. Size, frequency, and distribution of cost overrun should all be measured as part of measuring cost overrun for a certain investment type. “*

Other commonly adopted definitions are quite plain and straightforward as stated by Invernizzi, Locatelli, and Brookes (2018) -- “a cost overrun refers to the situation where the actual cost is higher than the original estimate”. It seems that cost overrun is regarded as a self-explanatory term.

The meaning of cost overrun can be shown clearly by the equation below:

$$\text{Margin} = \text{Final Cost} - \text{Estimated Budget}$$

If margin > 0, it means that the final cost exceeds the estimated budget, and that is when cost overrun happens. Though the equation is clear, researchers are divided on their views about the definition and calculation of cost overrun. Looking closer into the equation, the debate is actually around the different interpretations of the original budget instead of the final cost since the latter is fixed in every project. As pointed out by Love,

Zhou, Edwards, Irani, and Sing (2017), the secret rests in the “point of reference from where the cost overrun is measured”.

## **2.2. How to Calculate Cost Overrun?**

The statistical analyses on cost overrun of infrastructure projects are well-documented in the literature, official government publications, and the media. Research on the frequency and scale of cost overrun in infrastructure projects varies in results. Flyvbjerg, Holm, and Buhl (2002) reported a mean cost overrun of 20% for railway, roads and links projects, whilst Odeck (2004) revealed a more modest mean of 7.9% in road projects. Despite geography, size and time of the cases being studied, the divergent findings of previous studies mainly resulted from the choice of a reference point.

The infrastructure projects tend to go through a long definition period after the inception, during which more than one estimated budgets will be built. According to several studies investigating cost overrun worldwide, using the estimated budget in different stages will definitely influence the final outcome of the analysis (Cantarelli et al., 2013b; Lind & Brunes, 2015; M Terrill & L Danks, 2016). As argued by Love et al. (2019), defining “the initial reference point for determining a project’s cost performance” remains a bone of contention. Otherwise, it may end up with a misleading conclusion resulted from an inappropriate definition of cost overrun.

Though cost overrun is a global phenomenon, there is currently no internationally acknowledged formula of calculating cost overrun (Eliasson & Fosgerau, 2013), nor a guidance of project management similar to *A guide to the project management body of knowledge (PMBOK® Guide).5th ed.* (2013). Without a unified calculation formula, the argument about the reference point that should be used remains unsettled. In this section, the author will discuss the most commonly used reference points and explain why.

In order to better display the most commonly used reference points, this paper makes a summary of different approaches to calculating cost overrun based on twenty-two papers. The result is shown in the table below.

**Table 2 Key Studies and Their Ways of Calculating Cost Overrun**

<b>Title</b>	<b>Sample Size &amp; Year</b>	<b>Data Resource</b>	<b>Sample Scale</b>	<b>Reference Point for Determination of the Cost Overrun (Equation)</b>
(Love, 2002)	Questionnaire survey on 161 Australian construction projects	Stratified random sampling from telephone directory “yellow pages”	N/A	Project Cost Growth = Contract Value on Practical Completion – Original Contract Value
<b>Outcome &amp; Conclusion</b>				
- <b>The maximum cost growth is 244% and the minimum cost growth is 284%, which results in a range of 328%</b>				
(Baccarini & Love, 2013)	228 Australian water infrastructure projects	Closeout report provided by an Australian water authority	N/A	Cost Overrun= Actual Final Expenditure (Including Scope Changes) – Approved Budget (Base Cost + Cost Contingency)
<b>Outcome &amp; Conclusion</b>				
- <b>The final mean costs of project exceeded the approved budgets including contingency. The mean contingency percentage addition is 8.46%.</b>				
- <b>The mean contingency required for the final cost is 13.58% for the sampled projects.</b>				
(Love, Sing, Wang, Irani, & Thwala, 2014)	Questionnaire survey on 58 Australian transportation projects	Stratified random sampling from telephone directory “yellow pages”	N/A	Project Cost Growth = Contract Value on Practical Completion – Original Contract Value
<b>Outcome &amp; Conclusion:</b>				
- <b>The mean cost-overrun of the 58 projects is 13.28%.</b>				

(Love, Zhou, et al., 2017)	16 railway projects constructed from 2011 to 2014	one contractor in Australia	AU\$3.4 to AU\$353 million	Cost Overrun = Final Cost - Contract Award (Tender Price)
<p><b>Outcome &amp; Conclusion</b></p> <ul style="list-style-type: none"> <li>- <b>The total value of rail projects that had been originally awarded to the contractor was AU \$539,569,997, with an M = AU\$33,723,124 and SD = AU\$78,398,023, and the actual total value of work that was undertaken is AU\$665,479,369, with an increase of 19%.</b></li> <li>- <b>The mean cost overrun from the contract award of the 16 sampled projects is 23%</b></li> </ul>				
(Love et al., 2019)	85 transportation projects out of more than 320 projects of varying types (e.g., civil engineering, drainage and sewerage, transport, and social infrastructure) by several public departments in Hong Kong from 1999 to 2017	Hong Kong Legislative Council	approved budget of HK\$115 billion (~US\$14 billion)	The paper analyzes the differences among the approved budget, pre-tender estimates, contract sum and final cost
<p><b>Outcome &amp; Conclusion</b></p> <ul style="list-style-type: none"> <li>- <b>47% of the projects deviate from their approved budget.</b></li> <li>- <b>Between the approved budget and pre-tender estimate, a mean reduction of 28% in the estimated cost occurred.</b></li> <li>- <b>Between the pre-tender estimate and the contract sum, 36% of projects experienced a reduction in cost.</b></li> <li>- <b>Cost performance of the projects from the contract award to the final contract sum was found 42% were delivered on</b></li> </ul>				

<b>and under the contract sum.</b>				
(Odeck, 2004)	620 projects completed in the period from 1992 to 1995	Trunk road projects carried out and managed by Norwegian Public Roads Administration (NPRA). (no tendered projects included)	15 to 100 million NOK	Cost Overrun = actual costs of the project – estimated cost at the stage of design, specifications and final cost estimates.
<b>Outcome &amp; Conclusion</b>				
- <b>A mean cost-overrun of 7.9% and a range of 759% to 183%.</b>				
(Liu, Wehbe, & Sisovic, 2010)	52 road projects during 2000 and 2005	- Authority of Australia - Office of the Auditor General	Total value of \$2.7 billion	Cost Overrun = Actual Costs of the Project – Detailed Estimated Cost
<b>Outcome &amp; Conclusion</b>				
- <b>Compared to the historical average mean of 34.7% and standard deviation of 37.8% (see Table 1), a mean of –9.71% and SD of 14.48% of the hybrid sample represent a remarkable improvement.</b>				
(Wood, 2010)	46 infrastructure construction projects using alliance procurement deliver method in Australia	Alliancing Association of Australia	Valued over \$100 million	Cost Overrun = Final Target Outturn Cost – Initial Target Outturn Cost

	Procured within the last five years (2005-2010) Current or completed after 2004			
<b>Outcome &amp; Conclusion</b> - <b>The average increase is of 5 – 10%.</b> - <b>The agreed TOC is higher than the business case cost, estimating the average increase is of the order of 35-45%.</b>				
(Andrić, Mahamadu, Wang, Zou, & Zhong, 2019)	102 major infrastructure projects were performed covering railways, roadways and energy sectors in different regions in Asia	Asian Development Bank (ADB)	In sum, the actual costs of these projects are US\$ 69592.083 million	Cost Overrun = $\frac{\text{Actual Costs} - \text{Appraisal Costs}}{\text{Appraisal Costs}}$ Actual costs are estimated after the project completion Appraisal costs are determined at the time of formal approval to begin with the construction
<b>Outcome &amp; Conclusion</b> - <b>56.86% of projects encounters cost overrun; 2% of projects completed on budget; and 41.18% of projects were cost underrun of which the true payoffs on average is lower than forecasted, even if forecasts were unbiased for all projects.</b> - <b>The average cost overrun is 26.24% (SD = 25.63) in projects with a cost overrun and the average cost underrun is – 12.24% (SD = 12.25) in projects with cost underrun.</b>				

<p>(Ahiaga-Dagbui &amp; Smith, 2014a) (Ahiaga-Dagbui &amp; Smith, 2014c)</p>	<p>- Data-mining cluster: - 1600 completed projects from 2004 to 2012 - Research sample: 100 out of the 1600 cases mentioned above</p>	<p>Data mining</p>	<p>£4000 to £15 million</p>	<p>Cost Overrun = Actual Costs of Project – Estimated Cost At Pre-Contract Stage</p>
<p><b>Outcome &amp; Conclusion</b></p> <ul style="list-style-type: none"> <li>- <b>92 out of the 100 validation predictions were within ±10% of the actual final cost; while 77% of the 92 were within ±5% of actual final cost.</b></li> <li>- <b>Only eight out of the 100 validations had predictions beyond ±10% comparing to the final cost of the project case.</b></li> </ul>				
<p>(Shehu, Endut, Akintoye, &amp; Holt, 2014)</p>	<p>359 recently completed construction projects in Malaysia</p>	<p>N/A</p>	<p>N/A</p>	<p>Cost Overrun = Final Cost – Contract Sum</p>
<p><b>Outcome &amp; Conclusion</b></p> <ul style="list-style-type: none"> <li>- <b>More than half of Malaysian construction projects (55%) suffered cost overrun and that public sector projects performed better than private sector projects.</b></li> <li>- <b>Overall, the sample presented a mean overrun of 2% and among positive overrun projects the figure was 11.7%.</b></li> </ul>				
<p>(Koch, 2014)</p>	<p>Seven offshore wind farm of Danish and Swedish (operation lasted from 2001 to 2010)</p>	<p>N/A</p>	<p>N/A</p>	<p>Cost Overrun = Actual Cost – Initial Estimated Budget</p>

<p><b>Outcome &amp; Conclusion</b></p> <ul style="list-style-type: none"> <li>- <b>Three of the projects overruns the initial estimated budget.</b></li> <li>- <b>Two of them underrun the initial estimated budget.</b></li> <li>- <b>Two of them delivered to the initial estimated budget.</b></li> </ul>				
(Al-Hazim & Salem, 2015)	25 major projects in Jordan in the period of 2000- 2008	cost at completion and that originally estimated	N/A	Cost Overrun = Cost at Completion - Originally Estimated
<p><b>Outcome &amp; Conclusion</b></p> <ul style="list-style-type: none"> <li>- <b>Cost overrun between estimated and final cost ranging from 101% to 600% with an average of 214%.</b></li> </ul>				
(Marion Terrill & Lucille Danks, 2016)	836 transport infrastructure projects planned or built in the past 15 years	Deloitte economics and Grattan Institute	valued at \$20 million or more each	Cost Overrun = Final Cost – Initial Budget Estimate at First Public Cost
<p><b>Outcome &amp; Conclusion</b></p> <ul style="list-style-type: none"> <li>- <b>Overall, these projects cost \$28 billion more than they planned. This is 24 percent more than the costs that were announced.</b></li> <li>- <b>Only 9 percent of the projects were finished within their announced cost.</b></li> </ul>				
(Hwang, Zhu, Wang, & Cheong, 2017)	242 traditional and 121 green building projects by 30 different companies were collected through a	government websites, reports from private institutions, and journal papers	N/A	Equation 1 $\text{Project Cost Growth} = \frac{\text{Actual Total Project Cost} - \text{Initial Predicted Project Cost}}{\text{Initial Predicted Project Cost}}$ Equation 2 Project Budget Factor =

	survey in Singapore			$\frac{\text{Actual Total Project Cost}}{\text{Initial Predicted Project Cost} + \text{Approved Changes}}$
<b>Outcome &amp; Conclusion</b> <ul style="list-style-type: none"> <li>- <b>The overall mean of green cost premiums ranged from 2.5% to 12.5%.</b></li> <li>- <b>Green building projects were generally over budget (4.5% to 7%).</b></li> </ul>				
(Flyvbjerg et al., 2003)	258 transportation infrastructure projects	20 nations on five continents	- Total US \$90 billion (1995 price) - Ranged from US 1.5 million to \$8.5 million	Cost Overrun = $\frac{\text{Outturn Cost} - \text{Estimated Cost}}{\text{Estimated Cost}}$ Estimated costs are defined as budgeted or forecasted construction costs determined at the time of the decision to build.
<b>Outcome &amp; Conclusion</b> <ul style="list-style-type: none"> <li>- <b>Rail projects have a mean overrun rate of 44.7%.</b></li> <li>- <b>Fixed links (bridge and tunnel) projects have a mean overrun rate of 33.8%.</b></li> <li>- <b>Road projects have a mean overrun rate of 20.4%.</b></li> </ul>				
(Cantarelli, Molin, van Wee, & Flyvbjerg, 2012) (Cantarelli, Flyvbjerg, et al., 2012)	- 78 Dutch projects that completed after the year of 1980 and before 2012; 806 international projects including road,	Dutch project: - interviews with former project leaders and project teams - archives research at the Ministry of Infrastructure	Dutch project: 20 million Euros (2010 prices) each	Cost Overrun = Actual Cost at Opening Year – Estimated Cost at the Time Of Formal Decision to Build (hereafter ToD) (note that this is the engineering estimate and not the tender price) - Actual opening year: year in which operations begin. - ToD:

<p>(Cantarelli, van Wee, Molin, &amp; Flyvbjerg, 2012) (Cantarelli et al., 2013b)</p>	<p>rail, tunnel and bridge</p>	<p>and the Environment -RWS2 Direction Large Projects and RWS direction Zuid - Holland; internet search - the MIRT (translated as the Multi-year program for infrastructure) reports</p>		<p>- This is one specific point in the process when a decision is made to go ahead with the project, that is, the “go-decision”.</p>
<p><b>Outcome &amp; Conclusion:</b>  <b>78 Netherlands projects:</b>                  - Cost overrun is almost as common as cost underruns, but the average overrun in value is larger than the average underrun in value.                  - Overall projects have an average overrun of 16.5%.  <b>806 international projects:</b>                  - Rail projects have a mean overrun rate 34.1%.                  - Fixed links (bridge and tunnel) projects have a mean overrun rate 30.3%.                  - Road projects have a mean overrun rate 19.8%.</p>				
<p>(Miranda Sarmiento,</p>	<p>243 projects that were developed from 1999 to 2012</p>	<p>Portuguese Court of Audits and the Ministry of</p>	<p>N/A</p>	<p>Cost Overrun =  <math display="block">\frac{\text{Final Cost} - \text{Initial Budget Cost}}{\text{Estimated Cost}}</math></p>

<p>Renneboog, &amp; Policy, 2017)</p>		<p>Finance Internal Audit (IGF)</p>		<p>final cost was indicated in the audit reports and was calculated by the audit institutions, in an ex post audit</p>
<p><b>Outcome &amp; Conclusion</b></p> <ul style="list-style-type: none"> <li>- <b>The average cost deviation is approximately 24% (Table 4), with a weighted average (based on the initial budget cost) deviation of approximately 28%.</b></li> <li>- <b>If we limit the samples to projects with cost overrun, then the mean is 36%.</b></li> </ul>				

The Table 2 above clearly shows that two reference points are the most popular among academics—the original estimated budget around the time of decision-to-build (hereafter ToD budget) and the latest estimation budget previous to the construction stage when design and construction documents are in place. Accordingly, two schools of thought emerge on the calculation method of cost overrun.

It is generally held that the budget established at the beginning will deviate more from the final actual cost compared with the budget forecasted at later stages (Cantarelli, Flyvbjerg, et al., 2012; Flyvbjerg et al., 2018). Based on efficient data, a clear scope and a refined design, forecasters are able to estimate the budget based on a solid foundation. Actually, most of the situations where cost escalation take place are during the phase between the decision to build and early stage of construction (Ameyaw, Chan, Owusu-Manu, & Coleman, 2015; Odeyinka et al., 2012), during which more stakeholders are involved and the related documents are reviewed and verified by separate parties (Invernizzi et al., 2018). Parties formed by professionals such as a construction team help to rectify and adjust the original plan, and the budget might fluctuate during the check-and-balance process and will stabilize at a level which reflects the real core of the projects, after a period of time.

The Big Dig project in Boston is a perfect example to illustrate how unknown brownfield condition will adversely change the development process of an infrastructure project. The construction of Big Dig began in 1991 and finally concluded on December 31<sup>st</sup>, 2007, five years later than the scheduled completion date. The project was originally expected to complete at \$2.6 billion (which was \$5.8 billion in 2007 if taking inflation into account). Yet, the total expenses eventually surpassed \$15 billion, and reached a total figure of \$21.93 billion with interest counted. The cost overrun figure reached a whopping 300%. The project was then hindered by the incident of continual leak in the tunnel dating back to 2001, which threatened the safety of the drivers and passengers.

Thousands of leaking points from the ceiling and wall fissures damaged the steel supports and fireproofing systems and overloaded the drainage systems.

### **2.2.1. Estimated Budget at ToD Stage.**

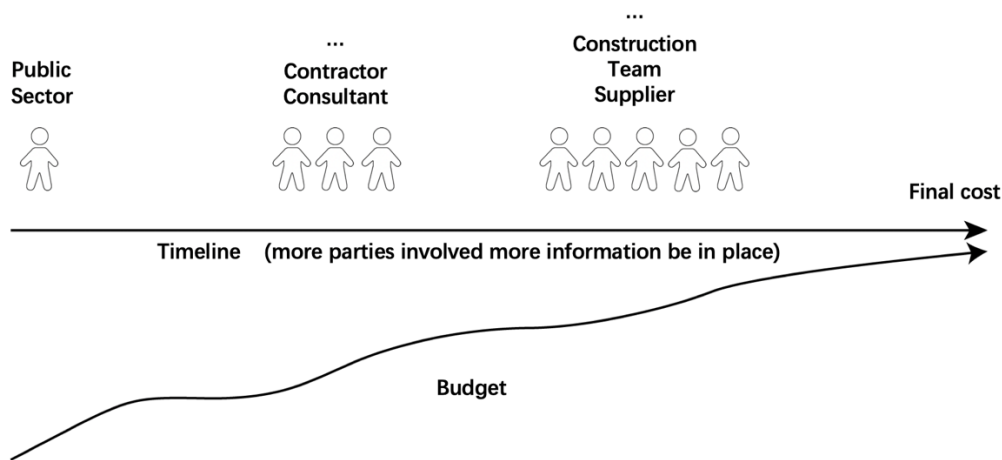
Researchers in favor of ToD budget hold the view that this figure should be developed when decision makers choose to start a particular project. As stated by Flyvbjerg et al. (2018), the goal is to “understand whether decision makers make well-informed decisions” and to “know whether the cost estimate on the basis of which decision makers decide to go ahead with a project is accurate”. If public sectors have no idea about the cost performance and benefit ratio of a project when allocating the fiscal funds, they won’t be able to make any decision that guarantees value for money (VfM) but rather those causing lingering burdens to taxpayers and constituents. In reality, however, the incumbent governments in most cases decide to start infrastructure projects before a detailed cost-benefit study is completed or even launched (Marion Terrill & Lucille Danks, 2016). Moreover, politicians who are eager to seek for re-election repeatedly choose to launch a great deal of infrastructure projects with made to look good cost-benefit ratio, so as to gain support from constituents (Miranda Sarmiento & Renneboog, 2017; Marion Terrill & Lucille Danks, 2016). According to Flyvbjerg, this political trick appears as the main cause of incurring strategic misrepresentation leading to cost overrun in public sectors around the world, which the author will discuss in details in the causation section.

### **2.2.2. Estimated Budget Before the Construction Stage**

Other researchers prefer to input the contract value or the latest estimating budget into the calculation formula of cost overrun right before the construction. They regard it as absurd to ask a forecaster to present a precise figure since the project at the current stage is still subject to adjustment with a lack of detailed design documents, a full investigation of brownfield structure and a definite project scope (Adafin, Rotimi, &

Wilkinson, 2015; Hegazy, 2002). The more the data are gathered gradually at later stages, the clearer the scope will be defined and the better the related parties will integrate. Until then, the forecaster is incapable of conducting a valid forecast, and thus the budget would become increasingly closer to the actual cost in the future (Love, Ahiaga-Dagbui, & Irani, 2016). Only when the estimated budget goes through rigorous risk assessment can the whole picture of the projects be grasped, including the labor and material market price, brownfield structure and condition, the promising future benefit, and the list goes on. The process of a slowly- and gradually-developed budget estimation is demonstrated in Figure 1 as below.

**Figure 1 the Relationship between Budget Evolution and Stakeholders**

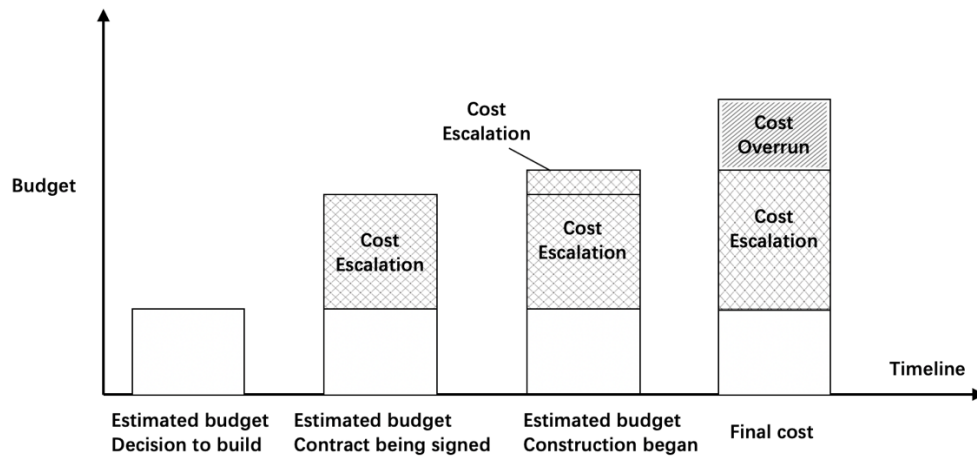


Scholars from the latter school do not just discard the initial cost estimation at the early stage. Instead, they come up with a specific term – cost growth – to describe the difference between the initial cost estimation and the estimated budget forecasted around the time when the construction began. This term is used to separate the cost increase in this period from the real cost overrun (Ahiaga-Dagbui & Smith, 2014c). The relation between budget at different phases and the two terms are showed as in Figure 2.

In order to better set apart cost growth and cost overrun, scholars appeal to contingency which can offset the increase in cost provoked by scope change, flaws or omissions in design documents or unexpected incidence during the construction (De

Marco, Rafele, & Thaheem, 2015; Love, 2002). Rather than a fixed figure, budgets should be more flexible, so that the project will be more resilient to unexpected or uncontrolled events.

**Figure 2 Cost Escalation and Cost Overrun**



In the study conducted by Marion Terrill and Lucille Danks (2016), every step in the entire life-cycle of the infrastructure projects has been examined and analyzed. Cost overrun in this study has been defined as “...the amount by which the actual cost at the end of a particular phase exceeded the estimated cost at the start of that phase, expressed as a percentage of each project’s first cost”. The incumbent government announces to conduct infrastructure projects before a detailed cost-benefit study is completed. The similar process of examining cost overrun by adopting more than one reference points is practiced by other scholars as well. (Cantarelli, Molin, et al., 2012; Love et al., 2019).

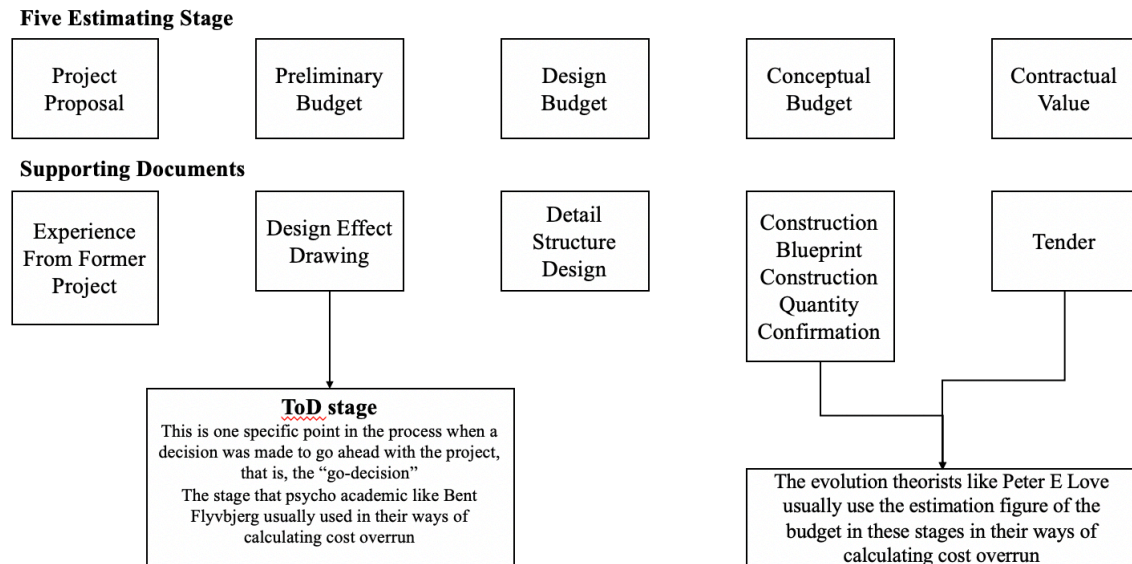
### 2.3. Cost Overrun Calculation Method Adopted by the Current Study

In this paper, cost overrun calculation relies on the specific budget estimation process in Chinese infrastructure industry. The budget estimation of social infrastructure in China consists of several stages. The next section will illustrate the budget estimation procedure in China and compare it with the reference point mentioned in the literature above.

### 2.3.1. The Budget Estimation Procedure in China.

The budget estimation procedure involves five stages. In each stage, the government, assisted by professional agencies, will confirm an estimating budget figure based on available and existing information (Wang, 2006). Depending on the project information provided, the accuracy of the budget estimation figures varies from stage to stage. Figure 3 below illustrated the sequence of five stages supported by information and documents (Wan, 2007). The Capital Budgeting Group (1984) sets up rules and regulations to narrow down the estimation budget. In other words, the estimated budget should normally be smaller than that of the previous stage. If there is an increase in budget, the promoters need to file a report to explain it, which the government authority should review to decide whether or not to approve it (Capital Budgeting Group, 1984). Next, this paper will provide with a detailed illustration by using the estimation procedure of Theatre A with 1500 seats as an example.

**Figure 3 the Budget Estimation Process in China**



Take the example of the project to build Theatre A. At the first stage, the estimation is based on the project proposal and experience from previous constructing projects with similar features (capacity, scale, function, etc.). The project promoters only have a vague

vision of Theatre A at this stage. Questions such as how many seats are there in the theatre or what kind or level of activities this theatre can hold will be considered for selecting reference projects. Next, forecasters responsible for the estimation will review some as-built theatre projects with identical capacity (for example 1500 seats) to Theatre A. Forecasters will calculate the average figure of the final cost from projects that are chosen as reference group, and take it as a key reference of the estimating budget of Theatre A at the current stage. Once the project proposal is approved by the government authority, the architecture design company will be involved (Wan, 2007).

It the second stage, the most important basis of the estimation will be the effect of the drawing of the architecture provided by the design company. The style, shape and construction materials of the architecture have a considerable impact on the estimation. If the government authority chooses the design plan with great constructing difficulty for Theatre A, the budget estimation might need to be adjusted to accommodate difficulties. The construction of the Sydney Opera House is a typical example which encounters severe obstacles due to unexpected construction difficulties. The astonishing cost escalation of the project is mainly due to the extraordinary and modern appearance of the theatre. When the Sydney municipal government chose this design out of numerous competitors, they did not foresee the nightmare brought about by the complex building structure during the construction period. The distinct construction features of the theatre will cause extra construction fees, so the estimating budget is higher than the average cost of the as-built reference projects (Wild, 2015). For Theatre A, the government authority prefers the design plan with a long span and a beamless structure which will definitely create a new landmark for the city. Because this design requires a longer construction period, larger labor investment and advanced construction techniques, the budget grows accordingly (Dong, 2009).

Even though the preliminary design has provided many clues about the vision of Theatre A, a concrete analysis is hardly available due to the lack of detailed documents in this estimation stage. In that case, the estimating budget is still not valid and tenable enough. Later the government authority begins to spend money to hire the design company, suggesting that it has officially decided to construct Theatre A. Also, as stated by Miranda Sarmiento and Renneboog (2017), sometimes, government authority, due to political reasons, will publicize the message of the project construction at this stage. Such stage can be taken as the ToD timing that is frequently used as a reference point for calculating cost overrun in studies of psycho theorists.

At the third and fourth stages, the architecture design company begins to optimize the design by improving details such as the supporting structure and landscape design on the basis of partial field exploration and other available data. The design company will present the precise design drawings and plans covering different aspects including the requirements for labor, the type, quantity and quality of construction materials and the construction workload of forecasters (Darwish, 2005). During these two stages, estimation is built upon reliable and concrete information to make sure that the estimated budget will be closer to reality compared with that estimated at the previous stage. It should be noted that additional documents, design details and site exploration might help to make the estimating budget more reliable, while, more often than not, also increases it for a clearer understanding of the difficulties in the complicated construction work or unexpected site geographical structure (Jarkas, 2014).

In the architecture design industry, the architecture design department is only responsible for the design of building appearance and indoor space, whose work of the building effect drawing is normally finished at the second stage. The data, documents and blueprints crucial at the third and fourth stages are prepared by the engineering

department. The division of work, as a result, resulted in unexpected cost growth during this period since more information is added up to the file.

Different from the four stages discussed above, the estimated figure at the fifth stage is not on the basis of forecasts, but is instead confirmed in the bidding, during which the government authority invites several construction companies to compete for the contract (Capital Budgeting Group, 1984). Normally, the criterion, simple and straightforward, is that the company with the lowest tender price wins. Consequently, the contract price is, in most cases, lower than the estimated budget.

The practice during the fourth stage and the contract value are mostly adopted by evolutionary theorists when calculating cost overrun.

### **2.3.2. The Conceptual Budget Overrun and Cost Overrun**

The most distinguishing feature of Chinese estimation procedure from other countries' methods is its emphasis on the conceptual budget. The Chinese government puts more emphasis on the conceptual budget than on the cost overrun (calculated using the final cost at the end of project lifecycle) (Capital Budgeting Group, 1984). The conceptual budget is the figure that is calculated at the fourth stage before heading to the bidding process. It is normally regarded as the figure reflecting the reality, as forecasters have gathered sufficient information about the project, which enables them to bring up a precise estimation. Still, overrun happens.

Conceptual budget overrun occurred when the original conceptual budget needs to be adjusted due to specific reasons. According to several post-access reports and audit reports, it is found that cost overrun (i.e. final cost is lower than the approved conceptual budget) seldom take place in social infrastructure projects, even though their final cost does exceed the original conceptual budget. The reason behind this paradox is the adjustment mechanism of the conceptual budget. Once the project manager detects the possibility of cost overrun, they will file a report to the government authority, asking to

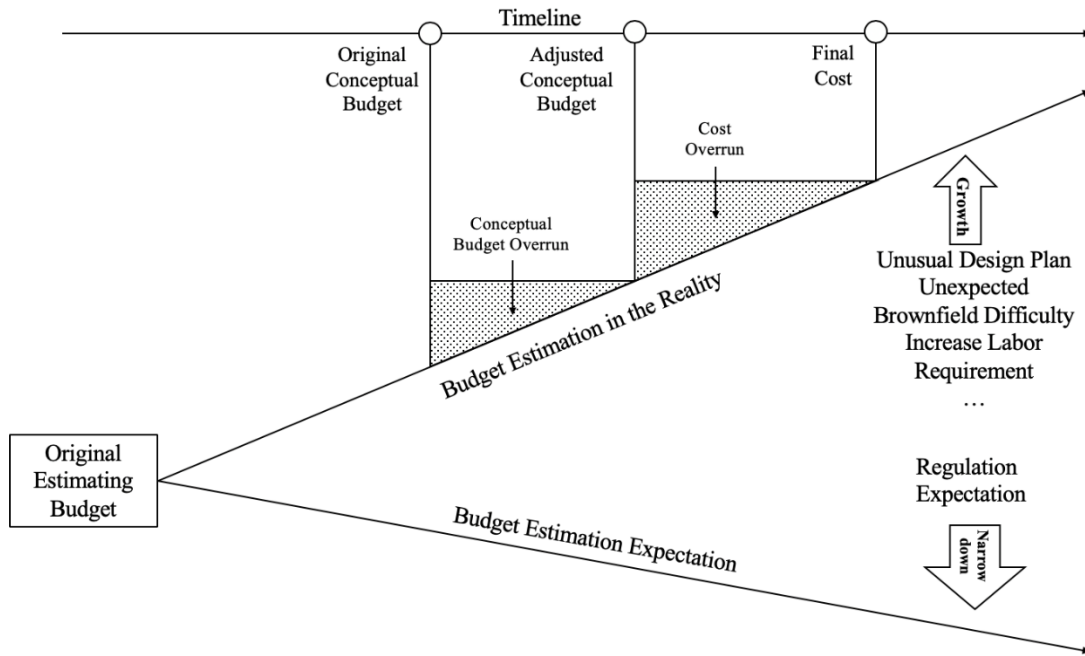
raise the conceptual budget (Dong, 2009). Therefore, the adjustment mechanism leaves a flexible space for the project manager to keep the project completed within or even under the ultimate budget. During the project lifecycle, the conceptual budget can be adjusted for many times till it can fully cover the final cost. In some cases, the “estimated” conceptual budget can be adjusted even when the construction is completed.

Though social infrastructure projects hardly experienced “cost overrun” in China, these projects did bring about severe financial burdens to the government and the society. In other words, taxpayers pay more money than they were originally promised (by the government/politician) for a certain project. Frequent budget adjustments may reflect that the government did not think it through when making the decision to launch a certain project instead of other options. These “on budget” or even “under budget” projects seem to be harmless, nevertheless, they are the possible causes of terrible social and economic problems in the Chinese infrastructure industry (Liao, Lei, Fang, & Liu, 2014).

Actually, the Chinese government has also realized the problems behind this adjustment mechanism (Wang, 2006). The adjustment should follow strict procedures and the project manager needs to provide convincing explanation for approval (Capital Budgeting Group, 1984). The conceptual budget adjustment mechanism cannot be regarded as the way to conceal or “avoid” cost overrun, as it is a simple part in the estimation procedure of the Chinese infrastructure industry. In the as-built appraisal documents such as the post-access reports and the audit reports, the Chinese government discusses and analyzes the conceptual budget overrun specifically.

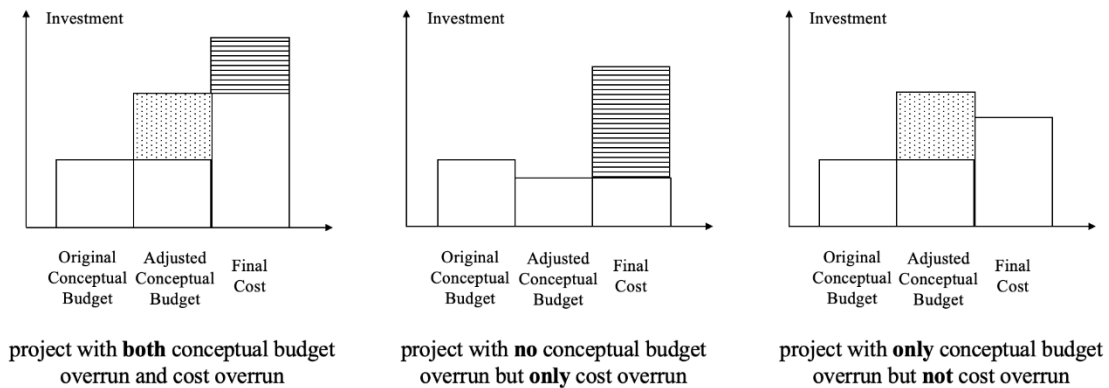
The conceptual budget overrun, though terminologically different, shares the similar characteristics with cost overrun and causes similar problems to the economy and society. In this paper, cost overrun and conceptual budget overrun will both be discussed and hopefully with the analysis in the following case study it can be figured out the **overrun** problems in the Chinese social infrastructure industry.

**Figure 4 Conceptual Budget Overrun**



The notion of conceptual budget overrun is interesting for three reasons: (1) Cost escalation often occurs along the project lifecycle due to reasons like rework, scope change, material change, the increase of labor expense and so on; (2) Thus it requires government to allocate more resources in order to accomplish the project as planned; and (3) It does have social consequences such as worry and accusation from media and taxpayers. In so doing, one can take into account the cost increase/escalation due to conceptual budget overrun which hence reflects the budget problem before the project closure, and thus leaves room to make some adaptations on the estimated budget so that the funding problem can be addressed during the project lifecycle (Wan, 2007).

**Figure 5 Conceptual Budget Overrun and Cost Overrun according to Chinese Regulation**



### 2.3.3. Cost Overrun Definition and Calculation Method in This Thesis

In this paper, cost overrun is defined as

*the amount by which actual cost exceeds the most original conceptual budget that has been approved by the government, with cost measured in the local currency, constant prices, and against a consistent baseline.*

In this paper, the original conceptual budget is used in calculating the cost overrun considering two aspects. First, the original conceptual budget is proposed at the fourth stage when, in theory, the project has been carefully designed and the feasibility study has been completed, based on which the estimation of the original conceptual budget should be accurate, namely, to cover the actual cost. However, in most cases, it did not work this way. Second, if the cost overrun is calculated by using the actual cost to minus the **final** (adjusted) conceptual budget rather than the **original** conceptual budget, as has been mentioned in the last section, the outcome will be negative (which means there is no overrun) in most social infrastructure projects in China.

Based on this definition, the data concerning estimated budget at the second and the fourth stages are accumulated together with the final cost. These two stages are the most common reference points adopted by psycho and evolution theorists respectively. Hence,

a better understanding of the debate between the two schools may be obtained by comparing the results (final cost minus estimated budget at the second stage versus final cost minus estimated budget at the fourth stage ). As for the conceptual budget developed at the fourth stage, the author will review every report that mentioned a conceptual budget, compare the figures in each report and draw out the adjustment process of the figure. With the use of final cost minus the most original conceptual budget figure, cost overrun will be precisely calculated. Once the final cost is higher than the original conceptual budget figure (i.e. the conceptual budget is adjusted and get approved by the government at the very first time), the project is considered to be a case of cost overrun, even though the final conceptual budget figure covers the final cost after the adjustment.

#### 2.3.4. Calculation Formula

Cost overrun is usually calculated in two ways, namely in absolute and relative terms (Flyvbjerg et al., 2018). In this paper, both absolute term and comparative terms will be presented. The absolute term will show the exact amount of money the project incurs on the taxpayer while the comparative term will elaborate on the evaluation of the percentage of loss resulting from the overrun on the project.

The formula of cost overrun calculation in this paper is as follows:

##### **Absolute term:**

$COA_{con} = \text{Final Cost} - \text{Original Conceptual Budget (budget at the fourth stage)}$

The project experiences cost overrun when  $COA_{con} > 0$  (using the original conceptual budget)

(Comparative group:  $COA_{pre} = \text{Final Cost} - \text{Preliminary Budget (budget at the second stage)}$ )

##### **Comparative term**

$$COC_{con} = \frac{COA_{con}}{\text{Conceptual Budget}}$$

The project experiences cost overrun when  $COC_{con} > 1$  (using the original conceptual budget)

$$\text{(Comparative group: } COC_{pre} = \frac{COA_{pre}}{\text{Preliminary Budget}})$$

By comparing these figures, the author intends to, first, understand the difference between the psycho and evolution theorists, and second, to understand cost overrun in the context of Chinese social infrastructure projects.

#### **2.4. What Are the Causes of Cost Overrun?**

According to previous research, causes of cost overrun include technical difficulties, psychological factors (optimistic bias and strategic misrepresentation), managerial incompetence and so on. Generally, the obligations of a project team consist of social responsibility, consulting and coordinating companies, contractors, construction teams and operations and management team as well as their clients (taxpayer). It is usually expected to deliver the project within an acceptable and pre-agreed budget and time constraints. However, the truth is that cost overrun in infrastructure projects is becoming entrenched in work practice (Love, 2011). In this section, this paper will review the current theories about the reasons that lead to cost overrun in infrastructure projects.

The existing studies about the causation of cost overrun can be divided into two types. The first type is simple factor correlation analysis, such as research conducted by Devi and Ananthanarayanan (2017), Mansfield, Ugwu, and Doran (1994), Rosenfeld (2013), Ubani, Okorochoa, and Emeribe (2013) and so on and so forth. Take the study conducted by Shehu et al. (2014) as an example. The authors distributed questionnaires which were designed on the basis of the “specific features of the projects that were identified from the literature as having potential bearing on cost variance” to the “entire of quantity-surveying consultants in Malaysia” (p...). The data of this study were from 359 projects, mainly in infrastructure, educational and residential field. It analyzed the

data and concluded the impact of a typical feature on the cost variance using correlation analysis method. According to this paper, project characteristics including the size, tender method and procurement method significantly affects the cost performance. There are overt relationships among cost overrun and these characteristics.

However, as pointed out by Ahiaga-Dagbui, Love, Smith, and Ackermann (2017), correlation is merely a “causal link depending greatly on the particular circumstances involved” (p...), thus it cannot serve as causation itself. For example, in the study on the Malaysia project described above, the project with a bigger size tends to be more likely to experience cost overrun, yet we cannot take it for granted that project size is the reason why projects perform differently. Size is indeed an influential feature here, but not the roots. Taking all these into consideration, factor correlation analysis is thus beyond the purpose of this paper. Instead, the second type concentrating on identifying the essential causes of cost overrun will be adopted in this paper. The existing theories on the key explanations of cost overrun fall into three categories, namely the evolutionist theory, psychological theory and mechanism flaw theory.

#### **2.4.1. Psycho Theory**

The psychological theory is mainly explained by three concepts: planning fallacy, optimistic bias, and strategic misrepresentation. Researchers who support this theory unequivocally insist that causes of cost overrun rest in the human mind rather than the objective world.

*Your biggest risk is you (Flyvbjerg et al., 2018).*

Optimistic bias occurs when promoters are overly optimistic about the prospect of the project and understate the potential risks in the appraisal phase of the project so that they underestimate the budget while at the same time overestimate the profit unconsciously. This psychological mechanism involved in optimistic bias, as noted by Flyvbjerg et al. (2003), is self-deception. Deception is another mechanism involved, this

time when promoters engage in strategic misrepresentation or deliberately “cook” the report, lower the budget and make the project plan seem perfect in the report in order to have the projects approved and started. In either circumstance, project promoters underestimate the budget whether intentionally or not, ending up with exceeding the actual cost and thus causing cost overrun. In fact, Flyvbjerg, as the most prominent author in this school, noted in his latest research (Flyvbjerg et al., 2018), “overrun is a consequence of underestimation” (p...). In other words, it is underestimation incurred by self-deception or delusion that leads to the subsequent cost overrun.

Human beings firmly regard themselves as rational creature, however, as revealed by behavioral science (Gilovich, Griffin, & Kahneman, 2002; Kahneman & Egan, 2011; Tversky & Kahneman, 1974), humans are prone to being unconsciously and overly optimistic about the future especially towards the one they in favor of. They tend to overestimate the future of their own lives and underestimate the possibility of encountering difficulties such as divorce, unemployment and disease. Likewise, project promoters are usually too optimistic about their own projects to make appropriate judgements of the contingency and adversity, and meanwhile they are likely to exaggerate the feasibility and profit. Optimistic bias, derived from cognitive biases (Flyvbjerg et al., 2002), has long been an influential factor in the project management area.

Unlike optimistic bias which is a subconsciously unintended error, strategic misrepresentation should be taken as purposeful delusion by promoters. Even though Flyvbjerg (2007b) claims that strategic misrepresentation and optimistic bias are both noteworthy, he has his own preference between the two. He regarded strategic misrepresentation as the best answer for the ubiquitous and ingrained problem of cost underestimation (B. Flyvbjerg, 2009).

Wachs (1989) is the first scholar to put forward the concept of strategic misrepresentation to justify cost overrun, which later helps shift the focus to behavioral science in the infrastructure project management field. Wachs (1989) describes the dilemma confronted by every project forecaster due to their complex and conflicting roles in the estimation process: both as a scientist and an advocator. As a scientist, they are supposed to estimate the budget on the basis of valid data, and then provide the clients, who are normally a part of the public sections in the infrastructure circumstance, with “independent professional judgment” (p.476). Professional judgement with scientific accreditation encourages them to make the most reasonable and profitable choice. However, in reality, as revealed by (Wachs, 1989), many forecasters regard themselves as advocates instead of scientific observers of the project. Actually, “these two roles inherently conflict with one another”(p.476). If forecasters identify themselves as advocates, they will care more about the approval of the project. Needless to say, this perception affects their judgment and ultimately leads to a deliberate adjustment of the data and analysis in order to show that the client-preferred option is the best choice. They will take several manipulating methods to cook the estimation so as to please their clients. With the help of the “perfect” cost-benefit ratio figure on paper, the project seems to overweigh other projects. The project forecaster helps their client “win the battle”.

Strategic misrepresentation is normally associated with economic interest, be that of the individual or the public (Flyvbjerg et al., 2002). Politicians, for instance, invest in infrastructure projects mainly for reputation and political interest . This may explain why many correlation factor analyses all reveal a close link between high overrun rate and the projects initiated at election years. Noteworthy, politicians not only fight for their own reputation but also for the local constituents. Pickrell (1990, 1992) argued that the limited fiscal fund from central government left the local government no other choice but to compete with each other for resources and capital. Faced with limited fund, cities resort

to image projects—with “some make-up” on their proposed projects , which turns out to be the ones allocated with investment from central governments (Flyvbjerg, 2009).

Generally, psychological theorists persist that optimistic bias and strategic misrepresentation are sufficient to explain the primary causes of cost overrun. But they are not the sole causes of cost overruns. The other causes include scope changes, complexity and uncertainty and they are the ones that evolution theorists support.

#### **2.4.2. Evolutional Theory**

According to evolutional theorists, represented by Love, Edwards, and Irani (2012) and Gil and Lundrigan (2012), projects are usually adjusted for several times at different stages from the beginning to the completion, during which cost overrun is likely to emerge for various reasons. The most prevalent adjustment is the changes in scope, rework and unexpected uncertainties.

As proposed by evolution theorists, the project scope will be adapted for several times during the whole process and ultimately lead to cost overrun (Odeyinka et al., 2012). Sometimes scope changes should be responsible for nearly 90% of cases of cost overrun<sup>5</sup> (*Auditor General of Western Australia, 2012*). Actually, as reiterated by Love and Ahiaga-Dagbui (2018), it is hard and even unrealistic to develop a precise project scope at the initial stage that requires no amendment later. For most of the infrastructure projects, especially those procured through methods like Traditional Lump Sum that assign the design and construction work to two different parties, it is common to begin with tender directly without completed or precise design documents (Love et al., 2012). According to evolutional theorists, as more information is gathered through processes like field investigations and coordination of different stakeholders, the project scope will become more accurate and the design documents more detailed.

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<sup>5</sup> Here, the cost overrun definition is the difference between actual final cost and the initial estimated budget (the ToD budget mentioned above).

Notably, at the preliminary stage when the project is merely conceptual, the government is likely to inform the public in advance that an infrastructure project will be launched, though in most cases without a precise description of the project including budget, scope and benefits (Love et al., 2019; Marion Terrill & Lucille Danks, 2016). The planning consultant hired by the public sector, on the one hand, is provided with little information to conduct appropriate due diligence. More often than not, the public sector will put pressure on their consultant who, as a result, has no choice other than knowingly make up the budget. Therefore, “ ‘uncertainty’ prevails and ‘guesstimating’ occurs ” (Sing, Love, & Tam, 2011, 2012). According to the existing practice and project process, it is obvious that the project scope developed this way is hardly feasible in reality and will inevitably need adjustment in the future. Governments and the consultant companies are all aware of the inaccurate and arbitrary estimation of the project scope in the preliminary stage, and are prepared for the upcoming adjustment. However, taxpayers are not. The media tend to omit the complicated and gradual evolving progress, and just report the initial stage and the completion stage of a construction. This tendency and its underlying two figures (initial budget and completion cost) prevaricates taxpayers’ understanding as they regard the decision of preparation and planning for an infrastructure project as a mere snap of fingers. A huge gap then appears between reality and reports created by the press, leaving people with an impression that the public sector is constantly changing their mind. At last, with stories of endless cost overrun of infrastructure projects all over the press, taxpayers feel disillusioned with the “perpetual inability” of the public sector to deliver infrastructure projects within budget and on time.

Changes in scope sometimes cause the second incidence — rework, which refers to “doing something at least one extra time due to nonconformance to requirements”, as defined by Australia (1995). Love (2002) already revealed that rework contributes to 52% of the project’s cost growth. In addition to changes in scope estimation, rework also

stems from errors, omissions, damages and incidence of “black swan” (Peter ED Love & Hui Li, 2000; Love, Mandal, & Li, 1999). Infrastructure projects normally involve stakeholders from various fields. Although they all want to complete the project efficiently, there are inevitable obstacles preventing them from cooperating smoothly<sup>6</sup>. Errors and omissions, as a result of inadequate information and inefficient communication among stakeholders (such as between design and construction teams) need to be remedied by rework, which finally leads to frequent cases of cost overrun (Bordat, McCullough, & Sinha, 2004). Coordination can to some extent be improved, but “black swan” is something that is out of control. “Black swan” comes as a surprise and has a tremendous effect on the cost performance of the infrastructure project. force majeure including but not limited to severe weather, labor strike and construction site fatality are all potential unpredictable events that might deteriorate cost escalation.

Some “black swan” incidences might not need to be fixed by restarting the whole project, but the public sector is forced to add more capital and resources into the project. After an extremely long period of preparation and planning, the initial estimated budget is no longer realistic. Looking into the example of the Honolulu Rapid Transit project, one can find that the project was originally budgeted \$5.2 billion (\$1.8 billion in federal funding and \$3.4 billion in taxation) in 2012, yet the forecasted completion cost turned out to increase by 83% to \$9.5 billion at the end of 2016 after construction commenced (Hrushka, 2017). As examined by Love, Zhou, et al. (2017), the Honolulu Rapid Transit Project suffered cost overrun mainly because the construction industry in Hawaii witnessed dramatic changes during the long period of preparation for this project. Thus, an unforeseen gap emerged between the original budget established in the midst of a recession and the contractual value during the “construction boom”. The original

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<sup>6</sup> The unsatisfied cooperation might result from the unwillingness of collaborations from at least one party or geography and/or time constraint.

budget was unable to reflect the actual market condition later. A similar case is the Forest Highway Project in Australia with an original estimated budget set at AU\$136 million. At the end of 2007, the cost rose by 406% at AU\$ 631 billion due to the skyrocketing price of local materials, labor and equipment owing to the insatiable export of raw material including minerals, oil and gas to countries such as China, India and Korea (Love et al., 2019).

Besides unpredictable events, unexpected construction difficulties on brownfield site are another type of the uncertainties encountered by infrastructure projects. According to Love et al. (2019), a pedestrian bridge constructed in a high-density downtown district in Hong Kong ends up being accomplished at HK\$113.20 million, with 122.4% of overrun than the initial budget. The major trigger is the unpredicted constructing difficulties caused by the complicated traffic management, which leads to the schedule delay.

Evolution theorists take infrastructure projects as a gradually developing and shaping progress, arguing that those changes (sometimes improvements) along this procedure are the elemental causes of cost overrun (Love & Ahiaga-Dagbui, 2018). Love (2011) criticized Flyvbjerg and his colleagues of putting all eggs into one basket (strategic misrepresentation and optimistic bias) and disregarding the fact that projects progresses in a convoluted and changeable way. Moreover, Love (2011) further put forward a “Pathogen” theory, claiming that the fundamental cause of cost overrun is a series of pathogenic influences embedded in the project for a long period of time without being recognized. Pathogenic influence is defined as a succession of “routine” decisions and practices along the life-cycle of the project, before the “pathogens” get stimulated by a specific event<sup>7</sup>. It can lay dormant within the project system and be treated as an “innate” component of everyday work practices (Love et al., 2016). However, as these

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<sup>7</sup> For example strategic decisions conducted by senior decision-makers or project management.

“pathogens” are intertwined in a very intricate way in the system, the outcome will be devastating once it is activated.

### **2.4.3. Mechanism Flaw**

This paper has no intention to further discuss about the deficiencies in risk assessment or budget estimation. As pointed out by Flyvbjerg (2007b, 2014); Flyvbjerg, Hon, and Fok (2017), a great effort has been made to improve the assessment and estimating approaches such as the Reference Class Forecasting and they have been proved to be effective<sup>8</sup> in improving the accuracy of forecasting. In this section, mechanism flaw is defined as unavoidable flaws embedded in the estimation and procurement mechanism, such as selection bias and tendering system. Mechanism flaw is different from psychological and evolutionary problems discussed above, as mechanism flaw is not from the outside environment but from the inherent shortcomings that result from regulations or operation process through the project lifecycle (Eliasson & Fosgerau, 2013). These mechanism flaws are a stimulus of psychological and evolutionary problems. When mechanism flaws, psychological factors and evolution factors occur together, cost overrun happens subsequently.

Researchers like Flyvbjerg and Love claim that the sample they used in their study is randomly selected from a bigger population. However, a crucial fact should be noted that the population itself has already been selected. Selective bias exists when the selection process is influenced by a noisy prediction (Heckman, 1979). For example, the patients recruited in the study for a particular disease will be more curious about the certain disease or have higher expectation over the drug associated to the study, compared with the other patients. This tendency will unconsciously affect the outcome of the study.

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<sup>8</sup> According to Flyvbjerg (2008), The RCF has had success in making impressive improvement in the cost performance in mega transportation infrastructure project worth 15 billion pounds in the UK.

Similarly, in studies about cost overrun, the projects catching the attention of the public typically survived the strict selection process. The projects that survived are more favorable than their competitors (other projects in the pipeline) with “appealing and promising” benefit-cost ratio. As a result, they are more likely to be chosen by the decision maker (Eliasson & Fosgerau, 2013). Since the projects that are finally launched and accomplished all possess in principle a “perfect” benefit-cost ratio to win the battle, they are more likely to fail to live up the expectation and encounter cost overrun. In other words, a high benefit-cost ratio is the key determinant to choose a certain project.

Therefore, project promoters have the tendency to “calculate” a benefit-cost ratio that is high enough to make the project approved. However, this “perfect” benefit-cost ratio is hardly feasible, and the project selected in accord with this ratio is deemed to overrun its budget along with the underperformed return. In this case, selection bias might be able to explain the high frequency of cost overrun observed in the “randomly selected” sample.

The other mechanism flaw exists in the tender rule that is commonly adopted by governments worldwide, namely the lowest bidding price wins the contract. However, as demonstrated in numerous cases, the contractor who offers the lowest price is not the one who can provide the best VfM (Love, 2011). If the contractor constantly fails to keep the promise to complete the project in accord with contractual price, public sectors have to dole out more funds, leading to cost overrun (Shehu et al., 2014). In the study conducted by Flyvbjerg, Skamris Holm, and Buhl (2004), a positive correlation is claimed to exist between contract value and cost overrun.

**Table 3 Summary of Three Theories and Key Authors**

Theorist	Theory	Major Scholar
Evolutional Theorist	<ul style="list-style-type: none"> <li>▪ Scope Change (Love, Edwards, &amp; Smith, 2005)</li> <li>▪ Change of Orders (Love, Irani, Smith, Regan, &amp; Liu, 2017)</li> <li>▪ Rework (Love, 2002)</li> </ul>	Peter ED Love Dominic Doe Ahiaga-Dagbui James Odeck Jim Smith Zahir Irani
	Premature Announcement/political factors (Marion Terrill & Lucille Danks, 2016)/(Miranda Sarmiento & Renneboog, 2017)	Marion Terrill
Psycho Theorist	Optimistic Bias/Planning Fallacy (Flyvbjerg, 2007b)	Bent Flyvbjerg Bert van Wee Chantal Cantarelli
	Strategic Misrepresentation (Wachs, 1989)	Martin Wachs Bent Flyvbjerg
Other Theorist	Selection Bias (Eliasson & Fosgerau, 2013)	N/A * These theories have been mentioned by many scholar as supplementary points, but there is very few study taken them as the main topic. Thus, it is hard to conclude the major scholar of each theory.
	Coordination (Minato, 2003)	
	Risk Management (Ökmen & Öztaş, 2010)	
	Low Price Bidding (Shehu et al., 2014)	

#### 2.4.4. The Potential Solutions to Cost Overrun.

With a focus on the causation of cost overrun, in this section, the current research aims to review the main ways in which cost overrun is addressed.

Admittedly, it has been verified that the Reference Class Forecast<sup>9</sup> exerts a positive impact on the certainty of estimated budget (Baccarini & Love, 2013; Flyvbjerg et al.,

<sup>9</sup> A forecasting method that is adopted by governments worldwide. RCF method makes budget estimation based on previous as-built projects that possessed features alike the project being estimated.

2017). However, this approach is not the panacea<sup>10</sup>. Because of the unique characteristics (for example, history, culture, geography and market) of different cities, there is a limitation using the as-built documents or experience from the other projects to establish an accurate budget for a certain project (Love, Zhou, et al., 2017). At the same time, it is hard to find enough references that share similar features with a particular project, so it seems difficult to draw a conclusion or come up with suggestions using a reference consisting of only one or two cases. Railway projects, for example, resemble each other at the planning stage as many vital components are standardized according to Council (2012). In this case, the price and supply chain are in place and are controlled properly. Nevertheless, at the construction phase, problems tend to surface, with unexpected incidence in the brownfield site and complex and time-consuming coordination of several parties including the public, contractors, sub-contractors, field workers, worker unions and suppliers.

The concepts of strategic misrepresentation and optimistic bias, developed from Flyvbjerg's black and white theory which holds that cost overrun results from the two aforementioned concepts (Love, Ahiaga-Dagbui, Welde, & Odeck, 2017), are commonly used terms in social media, and taxpayers are quite familiar with these two terms. Some of them firmly believe that the combination of strategic misrepresentation and optimistic bias is the one and only cause for cost overrun. In order to regain the faith from the public, governments place great emphasis on the two issues and spend enormous resources and energy to address these two problems, which might lead to their negligence of other factors such as change-orders that also affect the final cost and that are worth equal attention (Love & Ahiaga-Dagbui, 2018).

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<sup>10</sup> Criticism of RCF approach can be found in studies conducted by Liu et al. (2010), Liu and Napier (2010), and Love and Ahiaga-Dagbui (2018).

While admitting the problem brought by strategic misrepresentation and optimistic bias, Love insists that literature and government should move beyond these two concepts. As mentioned earlier, the strategic misrepresentation and optimistic bias are not the only explanations of cost overrun. Other possible factors regarding policies, procurement method and delivery approach should also be taken into account. With all attention on the “Psycho theory”, Love et al. (2019) are afraid that public sector might neglect other important factors and thus fail to improve and innovate.

As a matter of fact, it is hard to determine whether a project has suffered from strategic misrepresentation. The Hawaii Honolulu Rapid Transit Project mentioned before is a typical example. When analyzing the severe cost overrun of this project, Prevedouros (2016) listed an array of underlying issues such as change-orders, quality and safety to justify that this project is riddled with instances of strategic misrepresentation. In fact, this project used RCF approach in the budget estimation stage. However, as the market price fluctuated dramatically after 2011<sup>11</sup>, the estimated budget calculated using scientific method failed to prevent a detrimental cost overrun from happening (Love, Zhou, et al., 2017).

The second solution receiving great academic attention is Public–Private Partnership (hereafter PPP) (Osei-Kyei & Chan, 2015). PPP is portrayed as a strategy of building a long-term relationship between public sector and private organizations or companies, which may bring about an efficient construction of infrastructure (Ke, Wang, Chan, & Cheung, 2011). PPP has two unique features that differentiate it from other procurements and that can ultimately lower the scale and frequency of cost overrun of the infrastructure project. First, PPP requires a fully-defined scope and design documents in place before proceeding to the contractual stage (Love, Zhou, et al., 2017). Second, the PPP procurement builds a closer relationship among stakeholders, and contractors are involved

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<sup>11</sup> The as-built projects that were used in this project finished before 2011.

in the process at an earlier stage (Wilson, Pelham, & Duffield, 2010). These two features seek to mitigate, if not eliminate, the worries of “Evolution theorists”.

### 3. Methodology

As shown in the literature review, early studies on cost overrun focused on economic infrastructure projects such as railways, express road, and bridges, etc. Social infrastructure, however, did not receive much academic attention. Therefore, the current paper aims to contribute to filling the research gap in this regard.

This paper explores the following research questions: why social infrastructure in China experiences cost overrun? This research conducts an in-depth exploration of factors causing cost overrun in social infrastructure projects. The current study seeks to offer suggestions to the Chinese government authorities in charge of promoting and constructing social infrastructure to reduce the occurrence of cost overrun in their future projects. This paper analyzes four cases of social infrastructure projects where severe cost overrun occurred.

Two steps are involved in this research design. First, a case study approach is taken to explore cost overrun in the four projects selected. Throughout the case study, the author expects to gain more insights into the practical projects and that new explanations or factors may emerge. Second, this study combines factors developed from the case study and theories extracted from existing literature together. The combination can bring better understanding about the research question.

The case study approach is relevant in this case because it helps unravel the factors explaining cost overrun in social infrastructure projects in China. This approach fits the situation where the boundaries between phenomenon and context are hard to identify (Gil, 2016). As a good way to deal with various sources of information, especially qualitative data like textual materials (Yin, 2017), this research approach performs well for our analysis of government documents, meeting minutes and reports. Moreover, the case study method is particularly suited to in-depth exploratory investigation of a social phenomenon, especially of a contemporary event (Yin & Davis, 2007). In a nutshell, the

case study approach is an appropriate method to explore the research question of the current study.

The data for the case study are withdrawn from the government website for Xiamen<sup>12</sup>. These data include feasibility study reports, application and approval of preliminary budget, application and approval of the conceptual budget, application and approval of the adjustment of the conceptual budget, meeting memos, post-evaluation reports and final audit reports. By reviewing the documents, the author aims not only to collect general information of the project, such as scale, scope, budget, actual cost and official analysis, but more importantly to unravel the subtle differences in the stances different stakeholders may take. Since all the documents are first-hand, the validity of the information regarding the project is guaranteed. These documents contained valuable context-specific content which is critical in addressing the research question.

According to the documents collected from different stakeholders, a wide range of hierarchical levels are revealed, and the diversity of perspectives is provided, which enable us to integrate different information and identify new factors. All documents are written by front-line staff who have been devoted to infrastructure construction work for years and who thus have a deep understanding of the projects they worked on (Pitsis, Clegg, Marosszeky, & Rura-Polley, 2003). That is to say, those documents and memos contain details that incur subtle differences and ultimately influence the project result.

With the case study method, we probe the prevailing two schools of thought in cost overrun literature and hopefully contribute to the debate between “psycho theorists” and “evolution theorists” with a fresh perspective from China. The research provides a strong

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<sup>12</sup> Xiamen is located at the southeast coast of the People's Republic of China, and has been one of the first four special economic zones of China since 1992. The built-up area of Xiamen is 348.23 square kilometers, with a resident population of 4.11 million by 2018.

narrative of the practical cases, probing the theoretical framework developed from the literature review.

### **3.1. Data Selection**

There is a severe lack of studies on cost overrun in social infrastructure project. It is understandable for two reasons. Firstly, cost overrun in projects is regarded as a politically sensitive topic as most of the projects are promoted and invested by the incumbent government. Secondly, even though sometimes the government is willing to provide data, other problems, including omissions and absence of certain information of the documents, are inevitable.

Multiple case study is considered as a more robust design than a single case study since the former explores a phenomenon in several settings. (Casey & Houghton, 2010). In order to lay a solid data foundation, this study selects four as-built social infrastructure projects in China. It has been appealed by OECD that government should make the database available to the public in order to promote transparency and accountability, in that way, the author obtained permission to documents of infrastructure projects in government sectors, state-owned companies and design companies, including a completed dataset consisted of data sufficient for a case study. The dataset being used in this study contains figures of the estimated budget at every stage and of the final cost. More importantly, besides the statistical material, the author was provided with textual documents with comprehensive descriptive information of the cases.

The selection criteria of the cases are as followed:

1. The project should be categorized into social infrastructure projects such as government facility, social housing, education facility, cultural facility and health facility.
2. The project should be invested by government. In other words, taxpayers pay for the construction, operation and maintenance of the project.

3. The project should experience dramatic budget adjustment. In other word, the original conceptual budget has increased to adapt the massive change of the project.
4. There are data of estimated budget on every stage.
5. The project should be accomplished, and the actual final cost has been concluded<sup>13</sup>.

### 3.2. Overview of the Cases

In accordance with the criteria listed above, the following four cases were selected. The four projects were undertaken in the city of Xiamen. The construction time ranged from 2010 to 2018.

The first case (CASE#1) was an important part of a big portfolio which was aimed at improving the cultural public service in Jimei district in Xiamen. The portfolio was proposed and invested by the city government and commissioned to a city-owned construction company called *Eastern Develop (hereafter, ED)*. By implementing the portfolio, the city government planned to provide advanced cultural and educational services for people in this area. As a municipal project with influence on the regional development, this project was under incredibly heavy time pressure in order to coordinate and keep up with the intense construction schedule. Facing a seemingly unreasonable completion deadline, the ED company had to start the tendering process and even the ground-level construction without the guidance of detailed construction documents. This

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<sup>13</sup> The conclusion and auditing of final cost of infrastructure projects in China are extremely time-consuming, especially of large projects. Take the Guangzhou-Baiyun-International-Conference center as an example. Despite the fact that the project was completed in 2008, as reported in the Guangzhou Audit Bureau website, it took them 10 years to finish the auditing and evaluation of the project. Incidentally, the website only informed that they have finished the job, while no content of the auditing report was disclosed.

resulted in incidences like rework, process reschedule, scope changes and so on, all of which contributed to cost escalation.

CASE#2 aimed at improving the reception capacity of Hospital A, one of the top hospitals in Xiamen. The project consisted of two parts—the construction of an automated parking garage and a new outpatient hall. The hospital had long been criticized for its poor reception capacity resulting from limited space, therefore this project would undoubtedly be welcome among the citizens. As required by the government, the hospital kept open when the project was under construction. Unfortunately, after the on-site inspection and feasibility study, the best site for constructing the garage was right beside the main entrance of the hospital. In order to avoid interfering with the normal operation of the hospital, the construction team had to shorten the construction period. Moreover, the location of the hospital also made it hard for the construction team to accomplish their job in a common way. Time pressure and construction difficulty made the construction more challenging and ultimately led to extra cost.

The third project (CASE #3) was the construction of the third waste incineration plant in the city of Xiamen. This plant was designed to process 600 tons of garbage per day. Along with the other two plants, 50% of the garbage produced by the city would be incinerated to generate electricity. A feasibility study for the project was conducted in 2006 and was approved later. The Environment and Energy Company (hereafter EE company), an equivalent of the ED company mentioned in CASE #1, was a city-owned company, representing the government and responsible for choosing the design plan and putting related contracts out to tender. The first version of the conceptual budget was calculated and approved in 2008. However, when the construction began, problems started to surface. The construction-related regulations and standards were modified, the workload increased, and the cost escalated. As a result, the EE company raised the conceptual budget by 17.6%. Finally, the project was delivered and went into operation in

2014. While under construction, the promotion of the second stage of construction was proposed and approved, and later accomplished and brought into operation in 2018.

The last case (CASE #4) was the construction of a new campus of a high-school consisting of the south and north part. The plan to construct the south part was first proposed in 2013 but was not approved at that time. The project was launched in the early 2014. The north part was approved one year after. In the first version of the project proposal, the Sponge City strategy was not mentioned (This will be presented below). However, in 2016 when the construction of both parts started, the city government included the project into a big portfolio as a part of the Sponge City strategy to improve the city's ability to address the issue of the urban flood. The changes included replacing the pavement materials of the roads and playground, adding the rainwater recycling pools, upgrading the drainage systems, for which the budget committee had to recalculate the budget of the project.

The general information, including the background, scope, duration, budget at different stages, and final cost, can be found in Table 4. Also, information on the three groups of stakeholders participating in the project is presented in Table 5.

Table 4 Project Information

Case#	Case Name/ Infrastructure Category/Duration	Project Scope Project Result	Budget Development	Final Cost/Overrun	Documents Used in the Case Study
<b>CASE#1</b>	<b>Name:</b> the construction work of the science museum (this project is part of a Cultural Facility Center Construction Portfolio)	<b>Scope:</b> To improving the cultural and educational public services in Jimei district (Achieved)	<ul style="list-style-type: none"> <li>▪ 2011.01.18: the <b>preliminary</b> budget: 321.34 million RMB</li> <li>▪ 2011.03.03: the <b>original</b> <b>conceptual</b> budget: 261.47 million</li> <li>▪ 2014.10.29: the <b>adjusted</b> <b>conceptual budget:</b></li> </ul>	<b>Final cost:</b> 368.49 million	<ul style="list-style-type: none"> <li>▪ Post-evaluation report (256 pages double side)</li> <li>▪ Budget estimation report on preliminary budget</li> <li>▪ Budget estimation report on first conceptual budget</li> <li>▪ Application to adjust the conceptual budget</li> <li>▪ Approval documents for the adjustment of the conceptual budget</li> <li>▪ Final cost audit report</li> </ul>
	<b>Category:</b> educational infrastructure	<b>Result:</b> The science museum was finished and served as a new educational infrastructure facility for Jimei district after one year of operation. The annual visitor		<b>Overrun:</b> overrun compared to the <b>preliminary</b> <b>budget:</b> 14.67% overrun compared to the <b>original</b>	

	<p>Duration: From 2011.03.09 to 2015.01.30 887 days later than the expected completion date</p>	<p>attendance reached the expected level (210 thousand people per year), and feedbacks from visitors were mostly positive.</p>	<p>375.58 million (interior decoration is not included<sup>14</sup>)</p> <ul style="list-style-type: none"> <li>▪ <b>Conceptual budget overrun:</b> 114.11 million</li> <li>▪ 2014.04.23: <b>the conceptual budget</b> of the interior decoration: 132.53 million</li> <li>▪ 2014.10.29: <b>the adjusted conceptual budget</b> of the interior decoration: 223.41 million</li> <li>▪ <b>Conceptual budget overrun:</b> 90.88 million 68.57%</li> </ul>	<p><b>conceptual budget:</b> 40.93% overrun compared to the <b>adjusted conceptual budget:</b> -1.89%</p>	<ul style="list-style-type: none"> <li>▪ Meeting memos from September 2010 to Jun 2014</li> </ul>
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<sup>14</sup> The budget estimation of interior decoration and the exhibition installation was separated from the whole project. With the final conceptual budget estimation of these two works were 132 million and 223 million respectively and were approved in 2014 April 23<sup>rd</sup>.

<b>CASE#2</b>	<p><b>Name:</b> construction of an automated public parking garage and expansion of a reception building hall</p>	<p><b>Scope:</b> To improve the reception capacity of the Hospital A (Achieved)</p>	<p><b>preliminary budget:</b> 230.57 million <b>original conceptual budget:</b> 130.48 million (garage: 90.63 million; reception building 39.85 million)</p>	<p><b>Final cost</b> 135.50 million</p>	<ul style="list-style-type: none"> <li>▪ Feasibility study report (102 pages double side)</li> <li>▪ Budget estimation report on preliminary budget</li> <li>▪ Budget estimation report on first conceptual budget</li> <li>▪ Application to adjust the conceptual budget</li> <li>▪ Approval documents for the adjustment of the conceptual budget</li> <li>▪ Post-evaluation report</li> <li>▪ Meeting memos from November 2010 to January 2014</li> </ul>
	<p><b>Category:</b> health system infrastructure</p>	<p><b>Result:</b> The project achieved its goal by increasing the parking space by 302%, and the reception capacity reached 1200 people per day.</p>	<p><b>adjusted conceptual budget:</b> 141.00 million (garage: 92.09 million; reception building 48.91 million)</p>	<p><b>Overrun</b> overrun compared to the <b>original conceptual budget:</b> 3.85%</p>	
	<p><b>Duration:</b> The foundation construction started on August 1<sup>st</sup> 2011<sup>15</sup> The upper part construction started on June 1<sup>st</sup>, 2012 and finished on August 22<sup>nd</sup>, 2014<sup>16</sup> The estimated construction period</p>		<p><b>conceptual budget overrun:</b> 10.52 million 7.4%</p>	<p>overrun compared to the <b>adjusted conceptual budget:</b> - 3.90%</p>	

<sup>15</sup> According to the budget adjustment application submitted at August 31<sup>st</sup>, 2017

<sup>16</sup> According to the Final Acceptance and Inspection report submitted at October 2014. The project is ready for delivery after the approval of this report.

	was 30 months <sup>17</sup> , and the real construction time was 27 months (upper part construction). The project was accomplished three months earlier than the original schedule.				
<b>CASE#3</b>	<b>Name:</b> construction of a waste incineration plant	<b>Scope:</b> To increase the waste-to-energy recycling rate of Xiamen (Achieved)	2009.07.29: <b>Original conceptual budget:</b> 347.10 million	<b>Final cost</b> 398.61million	<ul style="list-style-type: none"> <li>▪ Feasibility study report (102 pages double side)</li> <li>▪ Budget estimation report on preliminary budget</li> <li>▪ Budget estimation report on first conceptual budget</li> <li>▪ Application to adjust the conceptual budget</li> <li>▪ Approval documents</li> </ul>
	<b>Category:</b> utility system infrastructure	<b>Result:</b> The project was delivered on schedule, and the pilot operation started in 2014. Later in 2015, the full operation was underway. This project achieved its goal to improve the waste-	2012.10.28: The <b>first</b> version of modified <b>conceptual budget:</b> 355.34 million	<b>Overrun</b> Overrun compared to the <b>original conceptual budget:</b> 51.51million (14.84%) Overrun compared to the <b>first version of the modified conceptual</b>	
	<b>Duration:</b> The construction started on December 14 <sup>th</sup> , 2010 and finished		<b>Conceptual budget overrun:</b> 8.24 million (2.31%) 2017:		

<sup>17</sup> According to the feasibility study report written at September 29<sup>th</sup>, 2011.

	on August 20 <sup>th</sup> , 2014	energy recycling rate of the city.	The <b>second</b> version of modified <b>conceptual budget</b> : 408.27 million <b>Conceptual budget overrun</b> : 61.17 million; 14.98% compared to original conceptual budget 52.83 million; 12.93% compared to first version	<b>budget</b> :43.27 million (12.17%) Overrun compared to the <b>second version of the modified conceptual budget</b> :- 9.66 million ( -2.3%)	for the adjustment of the conceptual budget <ul style="list-style-type: none"> <li>▪ Post-evaluation report</li> <li>▪ Meeting memos from November 2010 to January 2014</li> </ul>
<b>CASE#4</b>	<b>Name:</b> Construction of a high-school campus	<b>Scope:</b> <ul style="list-style-type: none"> <li>▪ First stage objective (Achieved):</li> </ul> The south campus: two six-stories building for classrooms, one building for cafeteria, one building for dormitory, outdoor	<b>Preliminary budget:</b> 312.50 million (both north and south part) <sup>18</sup> <b>Conceptual budget:</b> south campus: 239.89 million north campus: 102.71 million <b>Adjusted conceptual budget:</b>	<b>Final cost</b> <ul style="list-style-type: none"> <li>▪ south campus: 154.65 million</li> <li>▪ north campus: 71.11 million</li> </ul> <b>Overrun</b> <ul style="list-style-type: none"> <li>▪ overrun compared to the <b>preliminary budget</b>: -2.78%</li> </ul>	<ul style="list-style-type: none"> <li>▪ Feasibility study report (68 pages double side)</li> <li>▪ Budget estimation report on preliminary budget for the architecture</li> <li>▪ Budget estimation report on first conceptual budget for the architecture</li> </ul>
	<b>Category:</b> educational infrastructure				

<sup>18</sup> The preliminary budget documented in the feasibility study report did not divided into two part. Thus, here when discussed the preliminary budget we considered the south campus and north campus as a whole.

	<p>playground and other supporting facilities. The north campus: the main build which was able to accommodate twenty-four classes with library, multifunctional gymnasium, hall and outdoor playground (a 400-meter track) Second stage objective: apart from the first stage goal, the outdoor landscape construction project needed to be aligned with the portfolio of Sponge City (Achieved)</p>	<p><b>south</b> campus: 4.31 million <b>north</b> campus: 6.26 million *Here in this project the adjustment is only a reallocation of budget. In other words, part of the budget was reallocated for the new workload related to the change orders while the budget did not increase as a whole.</p>	<p>▪ overrun compared to the <b>conceptual budget:</b> <b>south</b> part: -35.53% <b>north</b> part: -30.77%</p>	<p>▪ Application to adjust the conceptual budget to accommodate the additional design and construction of the upgraded outdoor landscape ▪ Approval documents for the adjustment of the conceptual budget ▪ Final cost audit report ▪ Meeting memos of 2016</p>
	<p><b>Duration:</b> The south campus construction started on June 27<sup>th</sup>,2015 and finished on May 8<sup>th</sup>, 2018</p>	<p><b>Result:</b> The project was accomplished within both schedule and budget. The project was awarded as “the top-performing</p>		

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	without any schedule overrun. The north campus construction started on January 8 <sup>th</sup> , 2016 and finished on June 28 <sup>th</sup> , 2018 without any schedule overrun	social infrastructure project” of the city.			
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**Table 5 Stakeholders and Their Roles**

<b>Case#</b>	<b>Organization</b>	<b>Stakeholders</b>	<b>Roles</b>	<b>Involvement Period</b>
<b>CASE#1</b>	Government	Reformation and Development Department	decision maker/investor	the whole project cycle
		Budget Estimation Committee	budget estimator	pre-preparation-Tod
		Audit Department	cost audit	acceptance check
	SOE	Eastern Develop company	agency company/project manager/tendering organizer	The whole project cycle
	Contractor	design company	design	pre-preparation-design stage-the mid-period of construction stage
		construction company	construction	construction stage-acceptance check
<b>CASE#2</b>	Government	Reformation and Development Department	decision maker/investor	the whole project cycle
		Budget Estimation Committee	budget estimator	pre-preparation-Tod
		Audit Department	cost audit	acceptance check
	SOE	Eastern Develop company	agency company/project manager/tendering organizer	The whole project cycle

	Contractor	design company	design	pre-preparation-design stage-the mid-period of construction stage
		construction company	construction	construction stage-acceptance check
<b>CASE#3</b>	Government	Reformation and Development Department	decision maker/investor	the whole project cycle
		Budget Estimation Committee	budget estimator	pre-preparation-Tod
		Audit Department	cost audit	acceptance check
	SOE	Construction and Development company (hereafter: CD company)	agency company/project manager/tendering organizer	the whole project cycle
		Hospital	end-user/investor	the whole project cycle
	Contractor	design company	design	pre-preparation-design stage
		construction company	construction	construction stage-acceptance check
<b>CASE#4</b>	Government	Reformation and Development Department	Project promoter /decision maker/investor	the whole project cycle
		Budget Estimation Committee	budget estimator	pre-preparation-Tod
		Audit Department	cost audit	acceptance check

	SOE	Construction and Development company (hereafter: CD company)	agency company/project manager/tendering organizer	the whole project cycle
	Contractor	design company	design	pre-preparation-design stage
		construction company	construction	construction stage-acceptance check

### **3.3. Data Analysis**

#### **3.3.1. Documentary analysis**

The documents used in this study include feasibility study reports, application and approval of preliminary budget, application and approval of the conceptual budget, application and approval of the adjustment of the conceptual budget, meeting memos, post-evaluation reports and final audit reports.

First, figures of the original budget estimation and final cost were withdrawn from the budget application filed by the Budget Estimation Committee. Then, budget adjustment application filed by project manager and approval signed by the Reformation and Development Department provided the adjustment process of the budget. Finally, the final cost was recorded in the audit report signed by Audit apartment.

The feasibility study report was carried out before the official approval of the project, and a qualified feasibility study could thus lay a solid foundation to soundly prepare the stakeholders for the project as the opening of a project (Peter ED Love & Heng Li, 2000). The feasibility study should include information about the necessity and the potential influence of the project (social, environmental, economic, etc.), the source of funds, the size and scale of the project, the selection of site and the estimated budget and duration ("Feasibility Study," 2020).

As for the post-project evaluation, it referred to a systematic and objective analysis of the purpose, execution process, benefit, role, and impact of a plan or a completed project (Myers, Fisher, Pickering, & Garnett, 2014). This evaluation conducted after the delivery of the project was delegated to an independent third-party to ensure the credibility, reporting concerning problems that occur in the implementation and operation of the evaluated project, so as to improve investment efficiency (Anbari, Carayannis, & Voetsch, 2008).

The meeting memo is the overview of a certain meeting during the project lifecycle (Pitsis et al., 2003). This kind of document is highly disorganized, therefore consumes lots of time for a logical analysis and for extracting useful information. Reviewing the meeting memo can reveal how a project develops along the time.

Two steps were taken in the documentary analysis. To begin with, a coding process was carried out on the raw data. Then, a table was formed to show the counting of keywords related to reasons behind the cost overrun concluded from the documentary analysis.

### **Coding**

The coding process went through two phases: a deductive one using a coding book developed based on the existing literature on cost overrun and an inductive one driven by the data. Although the case study, as a qualitative research method, is flexible, the coding process should follow a strict logic chain to ensure trustworthiness or reliability (Houghton, Casey, Shaw, & Murphy, 2013).

Firstly, explanations of cost overrun in the realm of social are used as topic codes. A rough central codebook for the **deductive** coding analysis is then developed. When reviewing the collected documents and memo of the cases, the author will use the explanations, case number and title of documents to name the code. For example, a paragraph or sentence written in the budget estimation report describing a field accident that happened in Case #1 and that contributed to the occurrence of cost overrun will be coded as Field-1-BudgetEst.

As well, an inductive coding approach was also be adopted to address emerging explanations that come into light during the review of archives. Unlike deductive analysis, inductive research allowing the new concepts to emerge from the content of the raw data, does not involve the testing of pre-conceived hypotheses. As a bottom-up approach, the inductive coding process is most helpful when researchers conduct

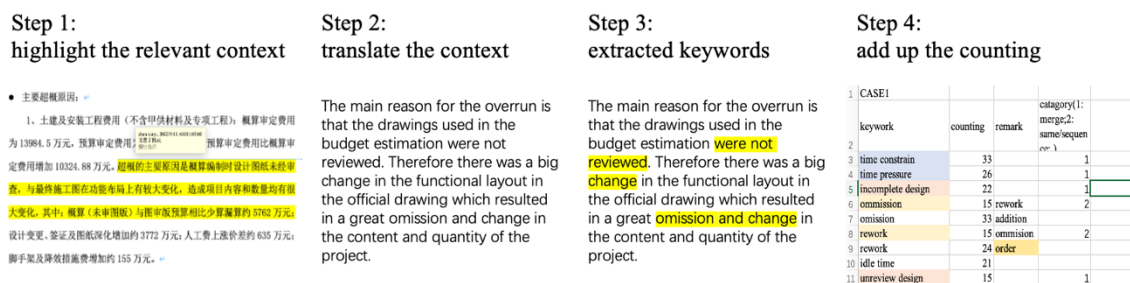
exploratory research, which is the case of social infrastructure cost overrun research in China (Fereday & Muir-Cochrane, 2006). A coding rule was developed during the scanning of the documents in the inductive process. The combination of deductive and inductive approaches offers a way to organize and present the structure of the data.

Next, using the coded data, we can conclude which contribution has been mentioned most frequently.

### Keywords and Counting

Distinguishing the sentence and keyword related to reasons behind overrun is a vital part in the documentary analysis. First, sentences and paragraphs regarding why cost overrun happened were highlighted. Second, since the documents were all written in Chinese, the highlighted message was translated into English. Third, the keywords were extracted from the highlighted message and comparison with the coding book was done. Fourth, the keywords and their frequency were recorded, and the keywords with similar meaning (e.g., incomplete drawing and sketchy drawing) were merged. An example of how document analysis is given below.

Figure 6 Documentary analysis step



### 3.3.2. Comparative Analysis

After the documentary interpretation, explanations of cost overrun were grouped together to identify common patterns and examine themes. With a clear structure of the data, the author was able to draw the convergency of opinions and contrasts coming from

various stakeholders (such as...) to explore the phenomenon of cost overrun in social infrastructure projects in different settings in China.

For every case, the author collected and analyzed documents that came from different stakeholders with different stances on the projects. Each stakeholder expresses their own point of view of the project through documents. Therefore, the focus of the research is to analyze and compare the archives developed by different stakeholder organizations. Thus, similar or different perspectives among the stakeholders emerged through different words they chose to explain and describe the cost overrun situation or incidence. Through the vertical inner comparison, the author was able to identify the similarity of explanations suggested by different stakeholders in documents explaining cost overrun in social infrastructure projects.

Besides, a cross-case analysis or a method that enhances knowledge flow between individual cases (Khan & VanWynsberghe, 2008), was also be used. Similar reasons offered by different stakeholders for cost overrun might still function differently in each case. A cross-case analysis was therefore applied to examine those similarities, to derive patterns, and finally to reach potential conclusions. A cross-case analysis was both a way of aggregating across cases and a mean to identify common patterns and, by doing so, it promotes theoretical elaboration.

Four questions were proposed to examine each explanation/factor. These subsidiary questions were asked in order to address the core research question stated before. The case analysis section, the discussion section and the conclusion section were organized in accordance with these four subsidiary questions.

1. How often is a certain explanation being mentioned as a contributor for cost overrun?
2. Has a certain explanation been studied before? Does it fall into categories of the “psycho theorists” or the “evolution theorists”?

3. Which case is considered to be influenced by a certain explanation? To what extent has it been influenced? How did the explanation function in adding up to cost growth?
4. How many different organizations have mentioned a certain explanation? What are their opinions towards this explanation? In their opinion, who is supposed to be responsible for controlling this explanation?

## 4. Findings

### 4.1. Within-case Findings

This section presents the within-case findings. For each case, first, a table of keywords and the counting result is shown. This table includes the counting figures of the keywords related to reasons/factors causing the cost overrun mentioned by documents including the post-evaluation report, meeting memos, application of the budget adjustment and final audit report. Second, documents used in the case study like application to adjust the conceptual budget, post-evaluation report and meeting memo have documented stakeholders' opinion towards why cost overrun happened. Therefore, in this section the recorded cases of cost escalation are listed. Last, we further explain in detail how this recorded causes influenced the cases.

#### 4.1.1. CASE#1

**Table 6 Keywords and counting for CAES#1**

<b>Keyword</b>	time constraint/time pressure	additional workload (outdoor landscaping)	additional workload (architecture style)	additional workload (omission)	additional workload (internal decoration design change)
<b>Counting</b>	59	23	43	33	18
<b>Keyword</b>	rework (change of design)	rework (omission)	change order (elevator)	change order (fire regulation change)	extra design fee
<b>Counting</b>	24	15	27	17	41
<b>Keyword</b>	idling time/waiting time	incomplete design/sketchy design drawing	inflation (manpower/material)	extra fee for inspection of the construction site	
<b>Counting</b>	21	37	22	16	

#### List of the recorded causes for cost escalation:

- 1、 Increased unit cost due to the special architecture style design (from post-evaluation report/meeting memo #07-12)
- 2、 Additional cost for ungraded material in order to follow regulations on fire prevention that came into force during the construction period. (application to adjust the

conceptual budge/meeting memo#08-10)

- 3、 Workload (additional fees for extra materials and labors) because of the incomplete design. (application to adjust the conceptual budge/post evaluate report)
- 4、 Additional workload to compensate the idle time to wait for design documents to complete (application to adjust the conceptual budge/post evaluate report/meeting memo #11-17)
- 5、 Design fees for outdoor landscaping (application to adjust the conceptual budge/post evaluate report/ meeting memo #07-20)
- 6、 Preparation for additional design document (meeting memo #15-20/ application to adjust the conceptual budge/post evaluate report)
- 7、 Additional workload (demolishing 25% of the indoor walls) to adapt to the new indoor decoration plan.(post evaluate report/meeting memo #17-20)
- 8、 Additional expense resulted from the change order of the elevator system, with domestic brand replaced by imported one for security consideration (application to adjust the conceptual budge/post evaluate report/ meeting memo #10-15)
- 9、 Additional expense as a result of the upgrade of power distribution system to match the the changed elevator system. (application to adjust the conceptual budge/post evaluate report/ meeting memo #10-15)

### **Document Interpretation**

The first problem which negative influenced the project was time pressure. As we can see from the chart above, words such as “rush”, “time constraint” and “urgent” were mentioned frequently in descriptions and analyses of the project, which means that the project is under great time pressure throughout the whole project cycle. This project was an important part of a significant municipal portfolio, in that case, the project needed to coordinate with other projects in the portfolio. The need of coordination equates to mere partial control of the project team and unexpected situations brought by other projects in

the same portfolio. First, the fact that the government authority had to deal with multiple projects at the same time makes approval procedures of budgets, design plans and contracts longer than before. Next, with more than one mega-infrastructure projects being constructed at the same period, they were competing for the scarce resources. The limited resources not only influenced the schedule but also the cost. In an effort to avoid slowing down the progress of the whole portfolio, project managers had no choice but speed up the project at any cost. Under such enormous pressure, improper decisions might be made, like starting the tender prematurely with incomplete design.

The delivery of shop drawing was originally set for April of 2011, but at the urging of the government, delivered sooner by January 25<sup>th</sup> of 2011, two months earlier than the plan. However, the truth is that the drawing was incomplete at that time, the government only receive a set of unreview sketchy drawings. In order to accelerate the progress, with the consent from the government, ED company used the unreviewed drawings to calculate the workload then estimate the budget. Bidders gave their offers based on the bidding documents and the estimated budget provided by the government, however, those documents without thorough consideration did not reveal the whole picture of the project. After the tender process and the signing of the contract, the contractor was surprised to find that there was enormous omission in workload calculation and dramatic changed orders from the client, making it impossible for the contractor to construct the project within the original budget. In the end, the workload calculation omission led to an extra of 57.62 million on top of the original conceptual budget calculated in accordance with the unreviewed sketchy drawing. When comparing the unreviewed drawing to the finalized reviewed drawing, the first great distinction is a modified layout with a series of updates in the structure of the upper part building. The modification caused chain reactions including the rework of some parts of the foundation and the additional support units. To cope with the layout modification, the contractor had to reconsider the project,

to reschedule a set of procedures, to rearrange the order of materials and to employ additional manpower. The labor fee and the material cost were respectively 6.35 million and 21.94 million higher than the original estimation.

The supplementary workload was not only derived from omissions, but also from the changed orders from client, which in the case of social infrastructure projects refers to the government.

While the upper part construction was under process, in August 2011, the government decided to raise the standard by purchasing the imported elevators and lifts instead of the domestic ones. The new decision regarding the equipment escalated the budget by 4.15 million. Subsequently, to accommodate the imported equipment, the power distribution system was upgraded as well. This generated 2.47 million of extra design fees and material cost. Furthermore, when estimated the first version of the conceptual budget, the outdoor landscaping plan was not included. While the government took the outdoor landscaping into account when constructing the main architecture. This newly added part counted for 5.92 million of the adjustment of the budget.

Actually, apart from the extra cost derived from the unreviewed sketchy drawing, the work to improve the drawing itself cost the government more than 58.25 million to the design company.

The second problem is the underestimation of budget in the first place. Being part of a portfolio that targeted on improving the cultural and educational facilities in the district, this project followed a specific architectural style called Jiageng style in memory of a great man called *Jiageng Chen* who devoted his whole life and all his assets to the development of this district about 100 years ago. This particular architectural style is famous due to its extensive roof overhang, in need of extra amount of steel and concrete compared to the regular style of same size. Yet, the planner did not take into consideration of the increment needed in constructing the Jiageng style architectures

when calculating the preliminary budget, despite his review of the data from as-built scientific museums. The estimation built on poor referencing data was bound to be far from the reality. Worse still, the conceptual budget developed using the same documents that came out only one month after (once again, due to the time pressure) was cut by 20%, because the Chinese government required that the budgets should be narrowed down stage by stage. The post-evaluation report shows that the conceptual budget approved in 2011 March 3<sup>rd</sup> was 261.47 million, decreased by 20 % compared to the preliminary budget, while the preliminary budget was already underestimated.

Besides, the interior decoration (accounted for 9.86% of the original conceptual budget) was removed from the work course of the whole project since when the detailed design was accomplished, it was found that to carry on this interior decoration plan within the old conceptual budget was unrealistic. Therefore, the government decided to separate the interior decoration from the project. The second version of conceptual budget approved in 2014 October 29<sup>th</sup> did not cover the interior decoration, and so did the conceptual budget that get adjusted and approved later. In other words, though it seems that the adjusted conceptual budget was only 114.11 million higher than the original conceptual budget, the real cost increase was much larger since the “disappeared” interior decoration should be taken into account. The conceptual budgets of the interior decoration and the exhibition installation were 132 million and 223 million respectively and were approved in 2014 April 23<sup>rd</sup>.

The dramatic change of the interior decoration and exhibition installation resulted from an absence of the future operating company at the design stage of the project. Although the design company had certain experience in designing a science museum, they had no clue what themes would be introduced and what exhibitions would be presented because the future operating company had not yet been selected the time when the design was going on. Worse still, the decision makers (government) had little

experience in planning a science museum. As a result, the space arrangement of the building was different from what the operating company expected of an extraordinary science museum when the operating team was finally involved. To solve the problem, the interior design has to be modified.

The unit cost of this project was 6.46 thousand per square meter. The post-evaluation report compared it with other similar projects. The first referenced project was an art gallery in the same portfolio, the formal inauguration of which was in 2012, in the same period of CASE #1. The unit cost of this art gallery was 5.43 thousand per square meter, lower than that of CASE #1. The second referenced project is a science museum located Shaoxing, a city with a similar population size and economic status as Xiamen. The science museum in Shaoxing was constructed over the same period and open to public in 2014. As for the unit cost, the Shaoxing science museum cost 6.97 thousand per square meter, higher than that of CASE #1.

Because of several adjustments of the budget, the project was still under the conceptual budget adjustment procedure even after the museum was handed in to the operator and already open to the public. According to the laws and regulations, the government would only formally allocate the money to the contractor after the conceptual budget is finalized. Being stuck in the procedure implies that the contractor was unable to be paid on time, which would cause serious social problems subsequently.

### 4.1.2. CASE #2

**Table 7 Keywords and counting for CASE #2**

keyword	time pressure/cut the time	traffic jam/inconvenience	location	additional workload (omission)	additional workload (fire prevention system)
counting	43	35	50	29	14
keyword	additional equipment investment	space utilization	extra design fee		
counting	11	33	27		

#### List of the recorded causes for cost escalation:

1. Additional cost for manpower due to a complex construction plan in order to relieve the traffic burden caused by the project surrounding the hospital. (application to adjust the conceptual budget/post evaluate report/meeting memo #4-6)
2. Workload (additional fees for materials and labors) because of the incomplete design (application to adjust the conceptual budget/post evaluate report/meeting memo #6-8)
3. Additional workload as a result of the rearrangement of the internal space utilization. (application to adjust the conceptual budget/post evaluate report/meeting memo #6-10)
4. Addition workload and additional equipment investment for the modification of the fire prevention design. (application to adjust the conceptual budget/post evaluate report/meeting memo #8-12)
5. Additional preparation for the design document (application to adjust the conceptual budget /meeting memo #5-10)

#### Document Interpretation

The first problem was the time pressure. This hospital was located in the middle of the downtown, surrounded by skyscrapers and subjected to heavy traffic. Therefore, the construction site had to be confined to avoid blocking the traffic and disturbing the daily life of the inhabitants in the nearby areas. Secondary, the hospital had to keep open to the public during the construction period. Noteworthy, the construction site was right beside

the entrance of the hospital which could not be separated from the hospital and would inevitably interfere with the normal operation of the hospital. After the inspection of the construction site, the project team found the original plan with open-cut method was time consuming and occupied too much space, so, they decided to switch to a new construction plan which would occupy less land to save more space for the entrance of the hospital. The new construction plan not only requested more labor power, but also consumed more time to complete.

Besides the complex location, the hospital served a massive daily flow of patients. This created a great pressure on the project team to complete the construction as early as they could to let the hospital resume its normal operation<sup>19</sup>. To achieve this, another change in the order took place. The project team re-designed the beam structure of the garage and the new reception building to shorten the construction period. Moreover, according to the meeting memos, the project team came up with an uncommon solution to reduce the impact. That is, after the main bodies of the garage and reception building were finished, the project team would first resume the construction site that blocked the entrance linking the hospital driveway to the main street (patients had to use a temporary entrance where traffic was limited when the construction was going on). And the interior decoration would proceed inside the building without further occupying the outdoor space. The new beam structure provided enough support to support some dangerous interior decoration constructions like directional demolish blasting. Undeniably, these actions would minimize the impact, but these changes were also costly. In addition, other structural changes include enlarging the windows on the ceiling of the outpatient hall to let the air flow and more sunlight in.

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<sup>19</sup> As found in a report on Xiamen Daily newspaper (March 28<sup>th</sup>, 2012) (Xiaolong, 2012), a newspaper company owned by the city, the construction was expected to end at October 2013. However, the reference of this data cannot be found in any official document published by the city government.

Time pressure to finish the project not only led to anxiety from the construction team but also reckless actions from the government. If the project followed a regular approval procedure, it would not begin construction until the end of 2011. However, in order to start the construction as soon as possible, an action discussed in CASE #1 was adopted by the team, who used the sketchy and unreviewed drawing and design in the tendering process. Noteworthy, CASE #1 and Case #2 were being processed and constructed around the same period. This action caused the same problem in both cases: as the design and drawing were detailed and modified, the workload of the project increased, and the cost subsequently raised as well. In the end, the original estimated budget was underestimated and could hardly cover the actual workload.

As the project objective stated, it intended to improve the reception capacity of the hospital on the basis of the existing space of the old garage. Thus, when assessing the design plan, the commission complied with the rule that the winning design plan should be the one that maximizes the utilization of the limited space. In the end, with the existing space and the upgrade of the site considered, the plan that provided most parking space and cost comparatively lower per unit was selected. However, this design plan did not observe the current construction standards for fire prevention. Also, a related regulation on the modification of fire prevention design was still under revision at that time. Fortunately, the project team followed previous conduct of a terminal construction project in Xiamen by inviting the experts in fire prevention to put forward a proposal to reinforce the fire protection system of the project. This proposal suggested solutions including the use of a special fire-resistant roller shutter door, a smoke exhaust system inside the garage, an automatic fire alarming and extinguishing system and sufficient emergency luminaries and fire hydrants. Though the project was later approved by the fire prevention authority with those solutions, all equated to additional investment not calculated in the original conceptual budget.

### 4.1.3. CASE#3

**Table 8 Keywords and counting for CASE #3**

keyword	regulation modification	upgrade technology	design incomplete	additional workload (omission)	inflation
counting	51	42	31	30	18
keyword	additional equipment investment	space utilization	extra design fee	environment friendly	
counting	32	33	27	36	

#### List of the Recorded Causes for Cost Escalation:

1. Inflation of the price of manpower, construction materials and equipment during the construction period (applications to adjust the conceptual budget/meeting memo #5-8)
2. Workload (additional fees for materials and labors) because of the incomplete design (applications to adjust the conceptual budget/meeting memo #6-12)
3. Additional workload as a result of the design change in response with the regulation modification (applications to adjust the conceptual budget/meeting memo #7-12)
4. Additional workload and equipment investment from upgraded technologies (applications to adjust the conceptual budget/meeting memo #6-12)
5. Additional preparation for design documents (applications to adjust the conceptual budget/meeting memo #8-10)

#### Document Interpretation

Similar to CASE #1, this project was also faced by the cost overrun derived from change order –a modification of related construction regulations and standards. When the project was under construction, a new governmental standard on the design of waste incineration plants came into force. Although the design of the project had already been finalized and the contract signed, the government requested the EE company to modify the design in compliance with the new standard after careful consideration and discussions. In order to achieve this goal, an array of civil engineering construction work

has been added. Firstly, the design company was required to re-design the plant, generating an additional design fee. Secondly, according to the new version of design in accordance the new standard, the workload increased as the foundation ditch was deepened by four meters and a slope was added in the construction to support the side around the ditch. Thirdly, a wall which separated the plant outside was needed according to the new standard. Those adjustment gave rise to an increased investment worth 4.71 million. Moreover, the ash silo, originally exposed in the air as planned in the first design, should be covered to ensure that the plant would function properly, based on the new standard. The architecture used to protect the ash silo costed an extra 2.36 million.

What may seem a relief to the contractor was that the agreement they signed with EE company adopted a fixed unit price. In other words, though the actual workload may be flexible in practice, the final settlement of the cost would be calculated in line with the actual workload. Supplemental agreements were signed for additional work and investment. Hence, this contract protected the benefit of the contractor so that they would not be worried about the possible loss due to the endlessly increasing workload which was not covered in the original contract.

Other changes of orders to observe the new standard included the import of advanced equipment so as to be safe, harmless and eco-friendly. First, an extra expense of 1.89 million was deployed to increase the capacity of the drainage tank, add the cooling tank, sludge tank and a water recycle unit and to construct supporting facilities for the water recycle unit. Besides, an automatic controlling system was added, costing 19.74 million together with the fees of designing the system and upgrading the supporting equipment. Meanwhile, the pipe system of the project was adapted for the imported equipment. In order to create and sustain a healthy and pleasant working environment, the project added a deodorization stem in the hall and the elevators, costing another 1.04 million. The water

pump system was also upgraded to comply with the newly adopted facility, spending 2.87 million.

Furthermore, the construction work in this project consisted of more categories than those of other three cases. This compound project contained work in civil engineering, industrial construction and electric power facility installation which required a better coordination from the project manager with designers, suppliers and contractors from different fields. As recorded in the meeting memos, the civil engineering bidding process was completed on September 16<sup>th</sup> in 2010, yet most of the supporting facility was not finished until December of the same year after the preparation of the bidding documents. As for the electricity power system and the meter and instrument system, it was not until August of 2012 when the supplier and contractor had been chosen. In order to accelerate the process and reduce the idle time, the project team used the old trick. They adopted the preliminary design for the bidding, and a modified version for the contract.

By the time when contracts were sign, the numbers of the complementary design drawings for each category are listed as below.

- Automatic controlling system: 14 sets
- Incineration machine: 13 sets
- Electricity power system: 16 sets

All these factors mentioned above not only raised the cost, but also triggered a chain reaction. First was the additional fee of 1.58 million for detailing the design and another 1.28 million for the on-site management responding to the increasing workload. Second, 1.16 million was spent on environmental inspection during the construction to make sure that the project could be approved in future examination. Finally, an electricity supply system with higher reliability, with a price of 1.25 million, was installed to ensure an effective and efficient construction.

#### 4.1.4. CASE#4

**Table 9 Keywords and counting for CASE #4**

keyword	time constraint/time pressure	additional workload (sponge city)	change order (sponge city)	extra design fee	material upgrade (outdoor pavement)
counting	12	55	34	33	41
keyword	rework (change of design)				
counting	24				

#### List of the recorded causes for cost reallocation:

1. Additional workload (manpower and materials) for realizing the new landscape plan in order to achieve the Sponge City strategy (applications to adjust the conceptual budget/meeting memo #1-10/final cost audit report)
2. Additional Design fees for outdoor landscape plan in order to achieve the Sponge City strategy (applications to adjust the conceptual budget/meeting memo #3-8)
3. Preparation for additional design document (applications to adjust the conceptual budget/meeting memo #3-9/final cost audit report)

#### Document Interpretation

The world is in hustle and bustle amid climate change. Xiamen, as a city with subtropical monsoon climate, has suffered a lot from urban flood caused by storm. Since 2014, the Chinese Central Government has proposed an innovative water management strategy called “Sponge City” which aimed at resolving this problem. The Sponge City indicated a particular type of city that acts like a sponge to absorb the rainwater, which was then naturally filtered by the soil and reached the urban aquifers. The Sponge City strategy served to replenish groundwater, reduce risks of flood and lower the burdens on drainage systems. The Sponge City strategy could be implemented by constructing more open green space like the storm water park and the green roof or by paving the surface with permeable materials rather than traditional concrete. The whole

idea of Sponge City strategy was to utilize the outdoor landscape of the city to absorb rainwater and thus to prevent floods caused by large and sudden precipitation. It was an effective and sustainable strategy to deal with the natural disasters caused by climate change. However, because of the costly permeable materials and the extra design fees, the private company lacked motivation to implement this strategy within their own project. Therefore, the government managed to encourage the private company and meanwhile implemented the Sponge City strategy in all suitable social infrastructure projects. The construction project of the high-school campus in CASE #3 consists of adequate open space, so it is suitable to carry out the strategy. It was also a good opportunity to raise the awareness of environmental protection among teenagers by promoting the strategy in this project.

According to the meeting memos, when the government made the decision to conduct the Sponge City strategy in this project in June of 2016, the south part had already been constructed for more than one year and the north part for half a year. The government first invited the design company back into the project to redesign the outdoor space of the campus. Then the project management team from the agency company recalculated the budget and came up with a solution to accommodate the additional cost out of the change of design. Instead of asking for more money, the project team reallocated the budget. They increased the budget by 4.31 million to construct outdoor space and by 6.26 million for the south and north parts of the campus respectively. This change of the budget covered the work listed below:

- Replacing the traditional materials used to pave roads, pathways and sidewalks with permeable clay bricks and permeable concrete.
- Adopting the permeable artificial turf technique for the outdoor soccer playground.
- Adding reservoir and silos to store and recycle the rainfall.
- Constructing green space with sunk face to better absorb the rainfall and to replenish

ground water.

CASE #4 is distinct from the other cases in this study. As shown in the data of the budget above, the project was not only finished as planned but was also within the budget. It seems like this project was well-planned, -managed and -conducted, and therefore awarded as “the top-performing social infrastructure project” of the city. However, through detailed analysis, it is clear that the project was not without problems.

First, despite the fact that change orders took place during this project to adapt to the special strategy, the final cost was lower than the conceptual budget and that the balance was nearly one third of the total budget. It implies that, unlike the frequent underestimation in other cases, the budget in this project was overestimated.

After the official approval of the conceptual budget for a certain project, the government would reserve the money and resources to make sure that the project could be proceeded smoothly. CASE #4 reveals that the government might reserve more money than needed for a project. This overestimation resulted in a waste of resources. Some projects under construction at the same period might be negatively affected and other productive projects waiting in the pipeline might be sacrificed due to the overly pessimistic allocation of budget.

In the psych theory discussion about optimistic bias and strategic misrepresentative, an idea was introduced about deliberately underestimating the budget to make the project competitive and more likely to be approved. When analyzing CASE #4, a contrasting logic was found. Is it possible that the project planner exaggerated the cost to make sure that the project would be completed within the budget so as to make the project seemingly well-forecasted and well-performing?

## 4.2. Cross-case Findings

The following section discusses the cross-case findings of this thesis. It provides an overview of the common cost overrun contributors as mentioned in the documentation of the four cases. The analysis of crucial events causing cost overrun along the project lifecycle then follows. The stakeholders in those events are highlighted in each phase. Through the discussion, factors leading to the problems can hopefully be identified and concluded.

### 4.2.1. Cost Overrun Contributors

The key cross-case cost overrun contributors we found based on the analysis of the four cases are as follows: time pressure, long period of ex-ante preparation, and coordination among stakeholders.

**Table 10 Cross-case keywords summary**

	CASE#1	CASE#2	CASE#3	CASE#4
time pressure-unrealistic time schedule	✓	✓	✓	✓
change orders	✓	✓	✓	✓
extra design fee	✓	✓	✓	✓
additional workload after bidding process	✓	✓	✓	
additional equipment investment		✓	✓	
inflation of labor/material	✓		✓	
idling time	✓	✓		
rework	✓			✓
incomplete design	✓	✓		
scope change				✓

## Time Pressure

Time pressure played a vital role in all four cases. The project team spared no effort in order to shorten the construction period, yet, these approaches added up to the budget burden of the project to cause cost overrun. The reasons behind time pressure include unrealistic construction schedule, idle time, and utilization of incomplete design.

**Table 11 Keywords related to time pressure** <sup>20</sup>

CASE#1				
time constraint/time pressure	additional workload (outdoor landscaping)	additional workload (architecture style)	additional workload (omission)	additional workload (interior decoration design change)
59	23	43	33	18
<b>rework (change of design)</b>	<b>rework (omission)</b>	change order (elevator)	change order (fire regulation change)	<b>extra design fee</b>
24	15	27	17	41
<b>idling time/waiting time</b>	<b>incomplete design/sketchy design drawing</b>	inflation (manpower/material)	<b>extra fee for inspection of the construction site</b>	
21	37	22	16	
CASE#2				
<b>time pressure/cut the time</b>	<b>traffic jam/inconvenience</b>	location	<b>additional workload (omission)</b>	additional workload (fire prevention system)
43	35	50	29	14
<b>additional equipment investment</b>	space utilization	<b>extra design fee</b>		
11	33	27		
CASE#3				
regulation modification	upgrade technology	<b>design incomplete</b>	<b>additional workload (omission)</b>	inflation
51	42	31	30	18
<b>additional equipment investment</b>	space utilization	<b>extra design fee</b>	environment friendly	
32	33	27	36	
CASE#4				
<b>time constraint/time pressure</b>	additional workload (sponge city)	change order (sponge city)	<b>extra design fee</b>	material upgrade (outdoor pavement)
12	55	34	33	41
<b>rework (change of design)</b>				
34				

## Unrealistic Construction Schedule

Unrealistic schedule arrangement was one of the main causes for constrained construction time. An endeavor to stick to the unfeasible delivery date scheduled without reasonable plan at an early stage caused the cost escalation.

As suggested by Marion Terrill and Lucille Danks (2016), the politicians know that investment in social infrastructure projects can gain them popularity as they may provide a healthy, fulfilled and productive life. Therefore, when scheduling a deadline of the delivery, in some instances, planners put too much emphasis on political or economic

<sup>20</sup> This table is an assembling of the keywords accounting for the four cases. In this table the bold cell shows the keywords extracted from documents related to time pressure, whilst the grey shadow ones show the keywords referred to the other contributors.

elements so that they disregarded the feasibility of completing the project within a short time depending on the existing construction technology and planned resources (Miranda Sarmiento & Renneboog, 2017). This happens in China when the government announces a project at an early stage with no qualified feasibility study or a detailed design plan, only to rectify the situation once as the project progresses and more information is available. Moreover, according to Hirschman (2014) and his “Hiding Hand” theory, people are usually over optimistic at the beginning when they have little knowledge about the project and later when the full picture of possible problems unfolds, they will strive to overcome them. Hence, people may reserve less construction time for a certain project in the preliminary design stage than in the later stage when the design is completed (Love, Zhou, et al., 2017).

After the construction inception of the construction, the delivery time frequently gets postponed regardless of all the effort to deliver the project in line with the schedule initially announced as it was far from the reality. Nevertheless, the public is not informed with the whole process. All they hear from the media is that the social infrastructure project suffers schedule overrun, which draws pressure on the project manager. CASE #4 clearly shows the dilemma of this situation: it creates favorable impression among the public but criticism later towards the government when the project fails to fulfill its commitment on time.

Sometimes a project could not postpone but adapt to the impractical timeline in order to keep pace with other projects in the same portfolio. CASE #1 is a good example. Part of an array of projects within a portfolio to deliver as early as possible, the museum project there was limited time left for the design company to detail the drawing. The project team in CASE #2 also had to deal with a tight schedule but for a different reason: to reduce the negative impact of construction work in the vicinity.

## **Idle Time**

The notion of idle time refers to the time that a labor or machine is unproductive during the duration of a project (Hapka, 1997). Various reasons include management actions and the factors beyond their control (Christian & Hachey, 1995).

Idle time can emerge simply because the project team does not know what to do next. In the story of CASE #1, when the contractor responsible for the foundation excavation accomplished their work, the design company was still struggling with the detailed drawing of the upper part. As a result, the contractor assigned to the construction of the upper part of the museum had nothing to do except wait for the design company to clarify the next step. As for CASE #2, the government urged the project team to begin the construction work by May 1<sup>st</sup>, 2011, when the design company was still working on the preliminary design documents. Regardless, the project was forced to go prematurely into excavation. The unplanned and messy procedures may account for much of the delay. Idle time is thus an unavoidable consequence of the unrealistic schedule discussed above. If the design company had been given adequate time to complete their work, there would not have been much idle time.

Factors beyond management control may include the delay of transporting materials due to insufficient supply as in CASE #3 and weather disruption such as typhoon (typhoon is prevailing in Xiamen city especially from August to October) as in CASE #4. However, these factors had comparatively less influence on delaying the schedule compared to management related factors.

Idle time is both a trigger of time pressure as well as a consequence of trying to compensate for the lost time. The construction team has to “innovate” in some ways to reduce the time, which may increase cost or creates a vicious circle.

## Utilization of Incomplete Design

To relieve time pressure and deliver the project on time, the project teams in three out of four cases resorted to the same solution, which is using the incomplete design in budget estimation and tendering process to accelerate the project progress. In CASE #1 and #2, the government and project manager deal with time pressure by entering the bidding process regardless of incomplete design. The miscalculated workloads on the bidding documents prepared on the preliminary design mislead the bidders. Along with the process, the design company gradually modified and detailed the design, hence the “additional workload”. Contractors finally found it impossible to finish the project in accordance with the original budget.

Love, Smith, and Li (1999) in their study imply that the downstream quality costs of the on-site construction will be cut significantly if more work is put on upstream design. At the meantime, it has been pointed out by previous research that the budget overrun can be traced back in the early stage, especially during the design process of the project (Cantarelli, Flyvbjerg, van Wee, & Molin, 2010; Love, Ahiaga-Dagbui, et al., 2017). Our findings are consistent with them, the main reason for cost overrun was the use of incomplete design document in the tendering process. A qualified and integral design plan should be able to provide precise information for the project, so that the budget estimator can come up with a reliable budget figure. Unfortunately, in all cases, the design plan used in estimating the conceptual budget did not fulfill that obligation.

While nowadays the RCF approach becomes popular in assisting the budget estimation, without including the unique features of each project, this estimation may still lacks credibility (Darwish, 2005; Jarkas, 2014; Minato, 2003). Without the support of qualified design documents, the “guesstimating” occurs (Sing et al., 2012). Furthermore, the “guesstimating” is systematically underestimated due to optimistic bias (Flyvbjerg,

2018). When the design document is completed and the actual workload revealed, the required cost of resources skyrockets consequently.

**Long Period of Ex Ante Preparation**

In general, social infrastructure projects experience prolonged preparation. During this long-time preparation, the project is refined progressively. As pointed out by evolutionary theorists like Peter Love, cost overrun accumulates because of the “evolution” of the project in term of the design, resources, requirements and scope. During the evolution process, some events occur out of the blue and ultimately influence the project and raise the cost (Van Wee, 2007). Among these factors, we note changes in scope, change orders and inflation, which we discuss below.

**Table 12 Keywords related to changes of orders/scope <sup>21</sup>**

CASE#1				
time constraint/time pressure	additional workload (outdoor landscaping)	additional workload (architecture style)	additional workload (omission)	additional workload (internal decoration design change)
59	23	43	33	18
<b>rework (change of design)</b>	<b>rework (omission)</b>	<b>change order (elevator)</b>	<b>change order (fire regulation change)</b>	<b>extra design fee</b>
24	15	27	17	41
idling time/waiting time	incomplete design/sketchy design drawing	inflation (manpower/material)	extra fee for inspection of the construction site	
21	37	22	16	
CASE#2				
time pressure/cut the time	traffic jam/inconvenience	location	additional workload (omission)	additional workload (fire prevention system)
43	35	50	29	14
<b>additional equipment investment</b>	<b>space utilization</b>	<b>extra design fee</b>		
11	33	27		
CASE#3				
regulation modification	upgrade technology	design incomplete	additional workload (omission)	inflation
51	42	31	30	18
<b>additional equipment investment</b>	<b>space utilization</b>	<b>extra design fee</b>	<b>environment friendly</b>	
32	33	27	36	
CASE#4				
time constraint/time pressure	additional workload (sponge city)	change order (sponge city)	extra design fee	material upgrade (outdoor pavement)
12	55	34	33	41
<b>rework (change of design)</b>				
24				

<sup>21</sup> This table assembles the keywords for the four cases. In this table the bold cell shows the keywords extracted from documents related to change order/scopes, whilst the grey shadowed ones show the keywords referring to other contributors.

### **Changes in Scope**

A social infrastructure project is initiated in order to satisfy a public need (*A guide to the project management body of knowledge (PMBOK® Guide).5th ed.*, 2013). For example, a park provides an open space for exercising, a library an environment for educating, and a low-cost housing program a shelter for people with low incomes. For most social infrastructure projects, the scope is not always simple and straightforward to determine. The scope of some projects evolves from time to time and covers more than one social need (Atkinson, Crawford, & Ward, 2006). As witnessed in several studies focusing on cost overrun in infrastructure projects, the change of scope accounts for the amendment of the budget to a certain degree (Love, Zhou, et al., 2017). Take CASE #4 for example. During three years of preparation, the “Sponge City” strategy kicked in which brought workload escalation and subsequently caused cost overrun.

### **Changes of Orders**

A change of orders is a modification of workload that is added to or deleted from the original contract of a project (Hanna, Russell, Nordheim, & Bruggink, 1999). According to Love, Irani, et al. (2017), change of orders is one of the predominant cost overrun factors. The evidence can be found in CASES #1 & 3.

In CASE #1, a change to upgrade the elevator system generate an extra 6.62 million. Also, the change to add the outdoor landscaping work into the project counted for 5.92 million in budget adjustment. In the construction of the incineration plant (CASE #3), the government modified the construction standards after the project inception. To adapt to the new regulations, the project team had to upgrade the technology and materials. The adjustment led to an increased investment of 7.07 million.

### **Inflation**

Due to the long preparation time, the market price of labor and materials were different from the time when the original conceptual budget was estimated. Love, Sing,

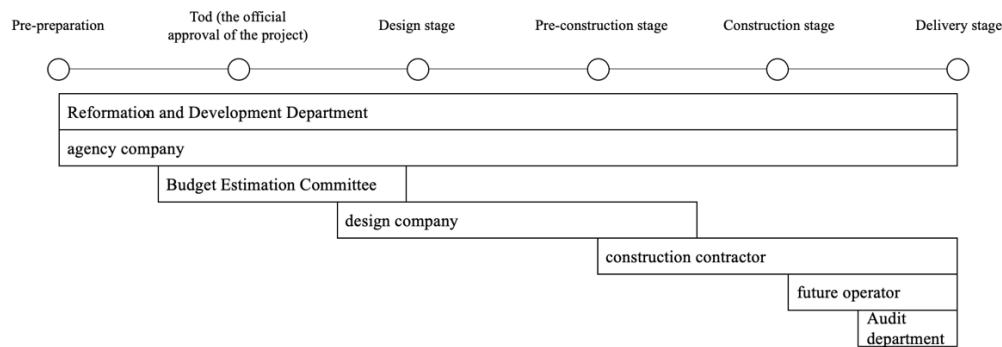
Wang, et al. (2014) suggest that inflation should be excluded from cost overrun, because it is hard to anticipate the escalation caused by inflation. However, in this study, inflation is still considered as overrun as the taxpayers needed to pay more money than they were told before the construction of the project.

The inflation problem haunted the museum construction in CASE #1. The inflation of manpower and materials translated into a total of extra 6.21 million. The price of the materials and equipment also increased by 100 million in the CASE #3.

### Coordination among Stakeholders

It takes more than one party to accomplish a project. The figure below shows what stakeholders were involved at different stages of the four case projects. The figure shows six most important time nodes of the project, and each bar show the involvement period of each stakeholder.

**Figure 7 Stakeholders and involvements**



As shown in the figure, besides the Reformation and Development Department and the representative company, other stakeholders only took part in the project when they were needed. The design company, construction contractor and the company who was in charge of the future operations might overlap in their involvement, but they work separately in general. Tasks conducted by different stakeholders needed to maintain a certain degree of continuity. The drawing developed by the design company was used as guidance for construction work carried out by the construction company, and the future

operations company acted as the end-user, whose concerns should be fulfilled by the design company. Love (2011), based on the examination of two social infrastructure projects in Australia, suggested that the reason laid behind the omissions and errors of the construction is the deficient communication between the design company and the construction contractor (Love, 2011). It has also been shown in previous literature that the overrun problem can be mitigated by close coordination between design and construction parties (Minato, 2003).

As documented in the post-evaluation report of Case #1, the operations company did not participate at the design stage was the reason why the museum experienced a massive change of internal decoration. When the operations company was finally picked by the government, the construction of the main building had already been completed. Though the operations company was not satisfied with the design, there is little they could do. At last, the government agreed to separate the internal decoration and exhibition fees from the whole project, the operations company helped the design company revise the plan with the extra budget. If the operations company were able to express their demand and request at the beginning of the project, the overrun might not occur. As stated by Loosemore (2016), the early involvement of the construction and operation teams at the design stage will positively impact the project. Adopting the PPP procurement may also help (Atmo, Duffield, Zhang, & Wilson, 2017; Ismail, 2013; Olusola Babatunde, Opawole, & Emmanuel Akinsiku, 2012; Osei-Kyei & Chan, 2015; Rangel & Galende, 2010; Zhang, Gao, Feng, & Sun, 2015).

### **4.3. Stakeholders**

In this section, we address the question of which stakeholders should take the responsibility for cost overrun. In order to achieve this goal, we integrate the contributors, the timeline and stakeholders together to see the relationship in between. Figure 7-10 exhibit CASE #1-4 respectively. In the figure, the white cell shows the stakeholders and

the responsibility they carried in the project, on the other hand, the grey cell show contributions caused the overrun.

**Figure 8 CASE#1**

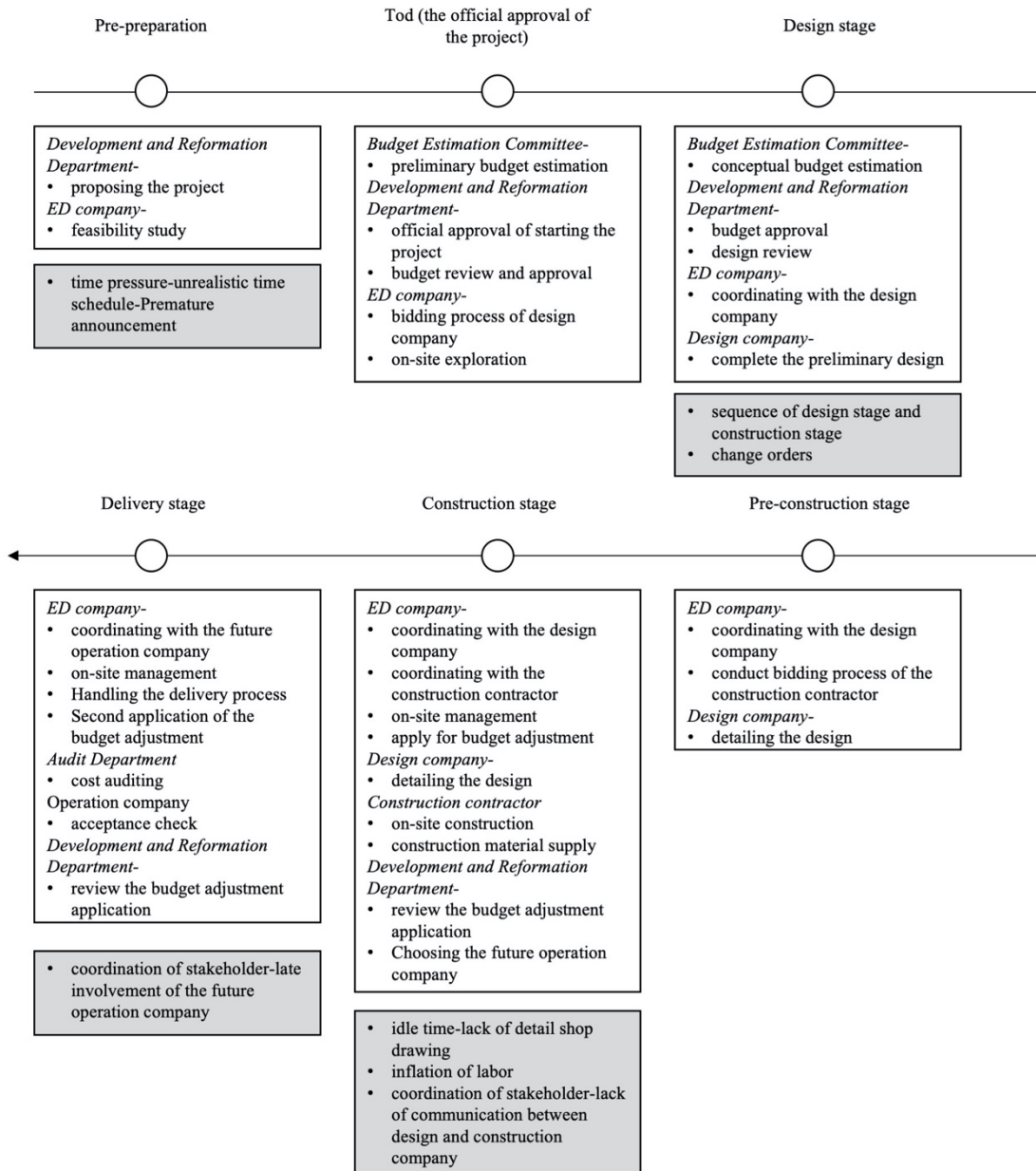


Figure 9 CASE#2

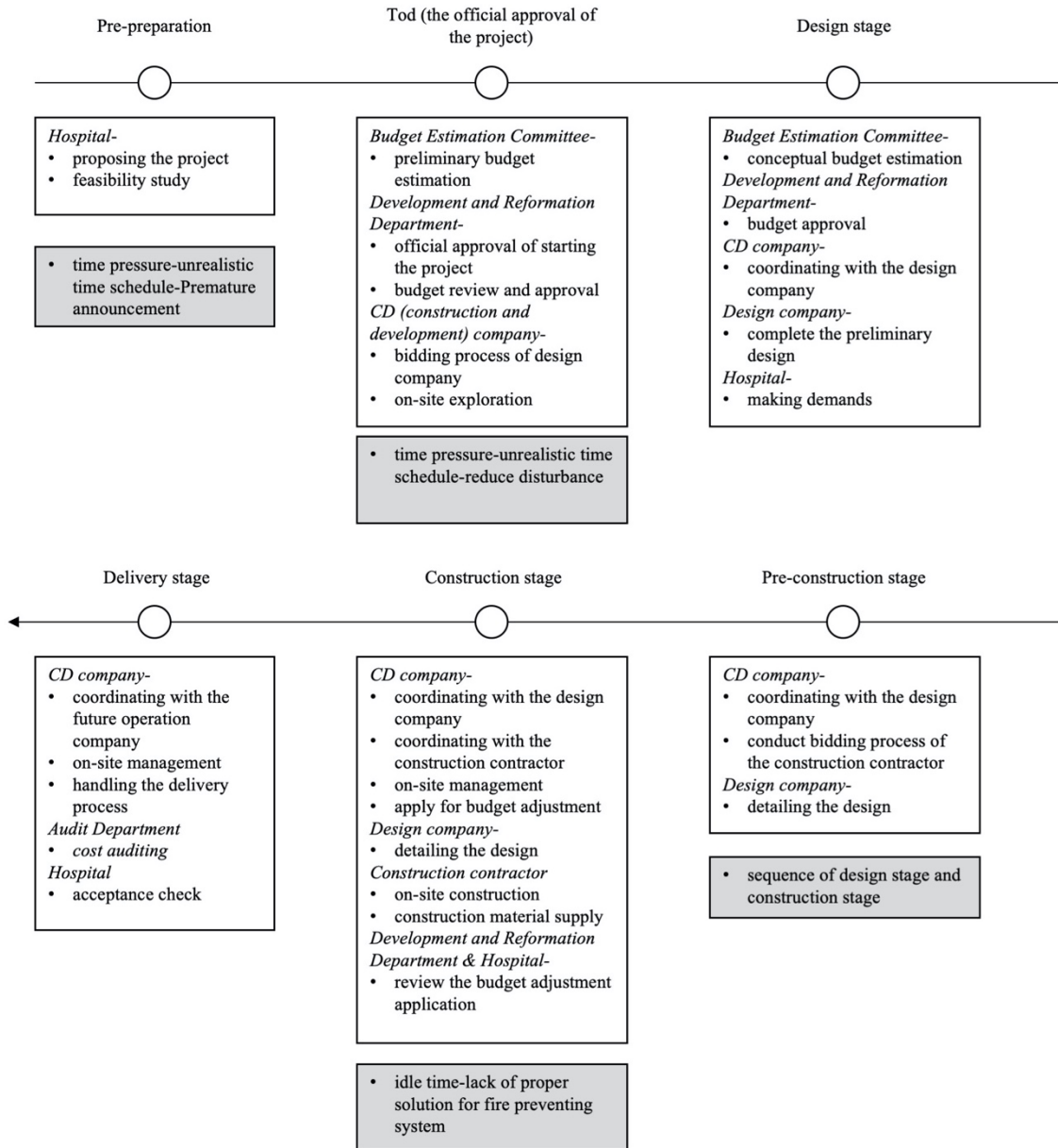
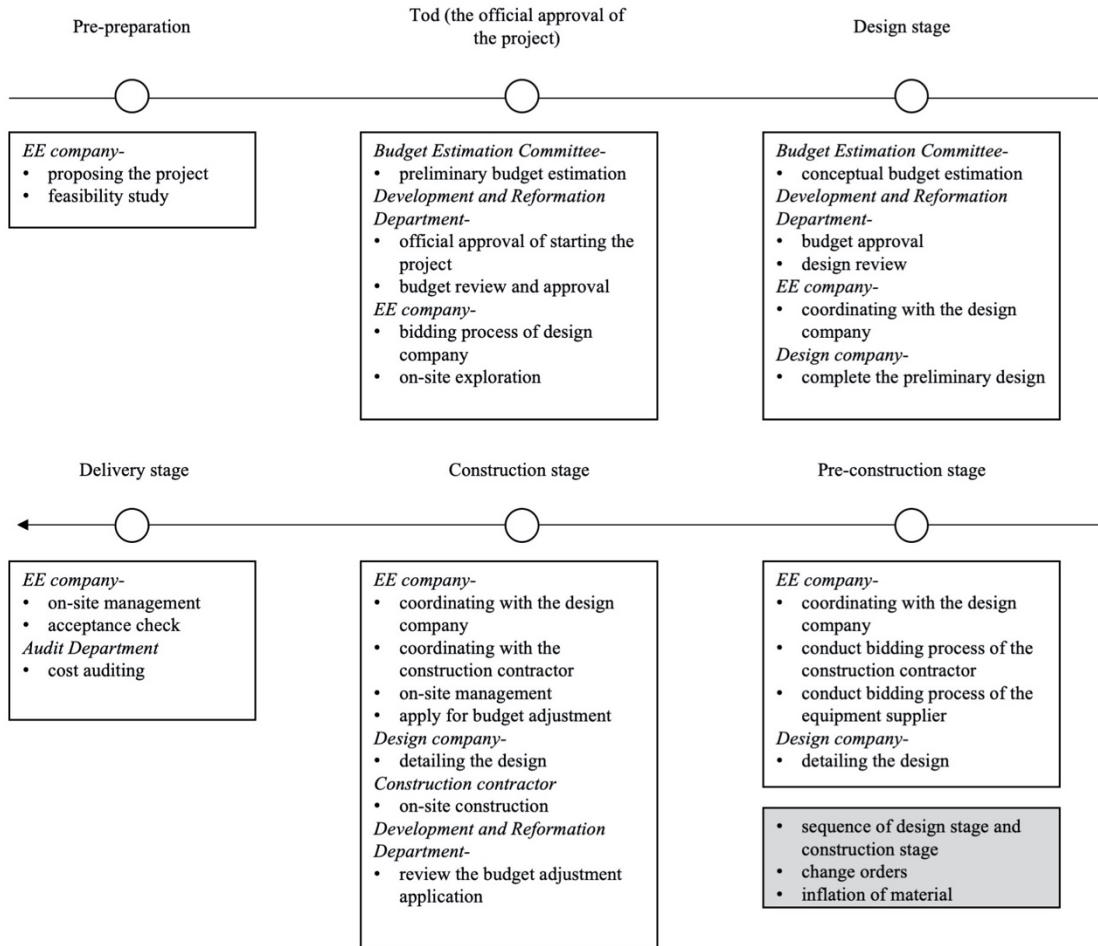
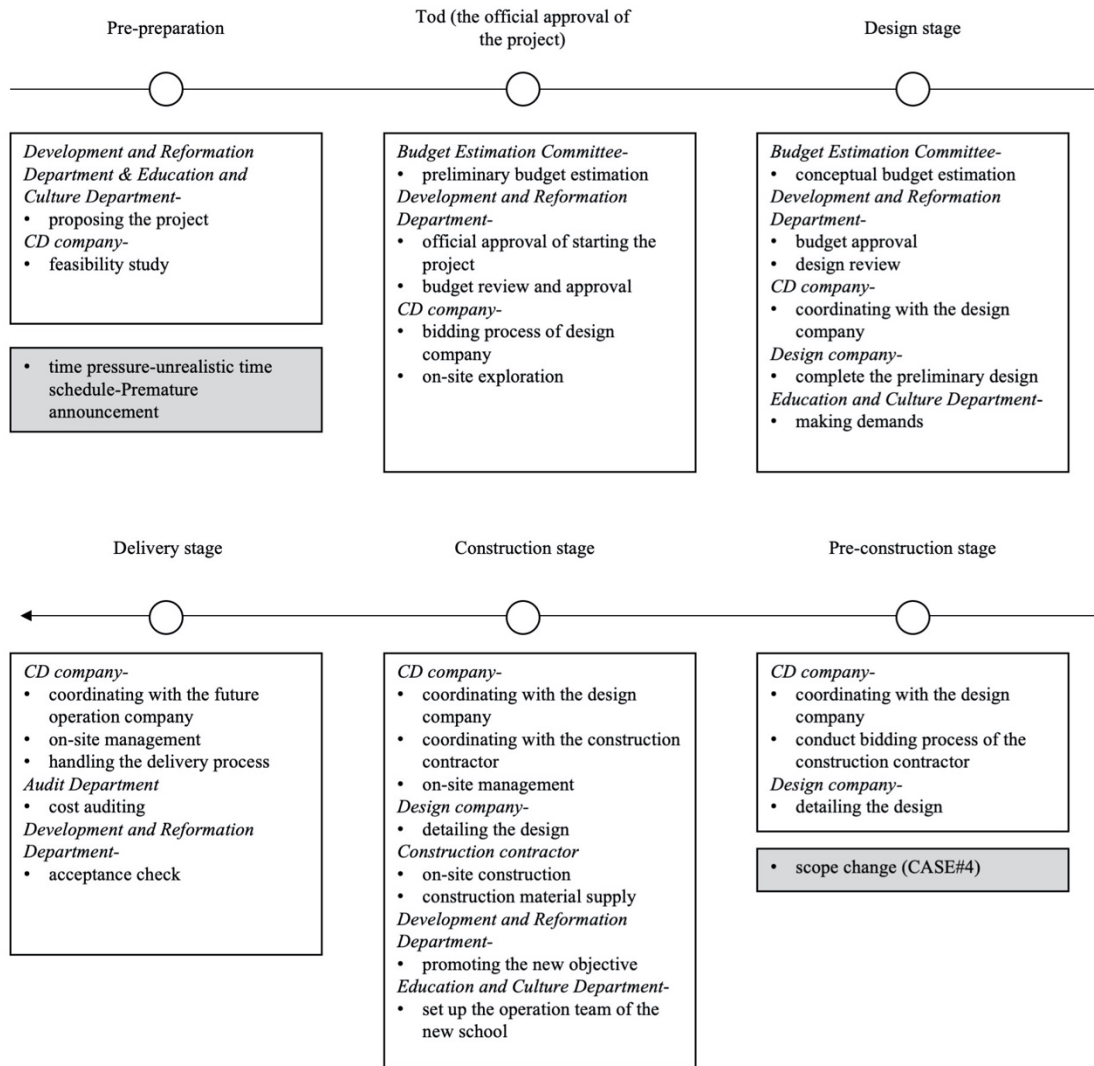


Figure 10 CASE#3



**Figure 11 CASE#4**



The table below maps cost overrun contributors and the role stakeholders play.

**Table 13 the Cross-case analysis of contributors and stakeholders**

	CASE#1	CASE#2	CASE#3	CASE#4
Time pressure-unrealistic time schedule-premature announcement (CASE1,3&4)/reduce	The ED company (planner); the Reformation and Development	The hospital (request); the Reformation and Development Department	The EE company (planner); the Reformation and Development	The Reformation and Development Department (planner/announcer)

Disturbance (CASE#2)	Department (announcer)	(decision maker)	Department (announcer)	
Idling time	Inadequate detail in drawings (the design company)	Lack of proper solution for fire preventing system (the design company)		
Sequence of design stage and construction stage	The ED company (proposer); the Reformation and Development Department (decision maker)	The Reformation and Development Department (decision maker)	The EE company (proposer); the Reformation and Development Department (decision maker)	
Change orders	Change in national standard; the Reformation and Development Department (decision maker)		Change in national standard; the Reformation and Development Department (decision maker)	
Scope changes				The provincial government (request)
Inflation of labor/material	External factor		External factors	
Coordination	The design company & construction contractor; late involvement of the future operation company			

The initial schedule was planned in the feasibility report by different stakeholders based on each case. According to the meeting memo, these initial schedules were then used as a referencing timeline through the project lifecycle regardless of the fact that the schedule planned on this stage was highly unreliable. This problem is quite obvious in CASE#1 & 2. This schedule was unrealistic and unachievable, yet it was treated as an ideal schedule that could be followed. As a result, pressure emerged to deliver the project as early as possible. It can thus be argued that the decision maker, namely, the Reformation and Development Department who insisted to stick with the unachievable schedule, should take the major responsibility even though the schedule was planned by various parties in different cases, rather than the planner.

Another problem causing the tight schedule is the idle time during construction. It might seem that the problem was caused by lack of detailed drawing from the design company, and that the design company should be responsible for it. The design company did get criticized for failing to hand in the detailed drawing on time according to the memo of CASE#1 & 3. In reality, however, as shown in post-project evaluation report of CASE #1, after the delivery of first stage design, the project manager only gave the design company 25 days to detail the design. According to the author's personal work experience in architecture industry, it is impossible to accomplish this mission within 25 days. Hence, once again, the decision maker who set up the unachievable delivery deadline should take the responsibility.

Other cost overrun contributors which concern the decision maker include its decision to reverse the sequence of design and bidding for the construction and the changed orders. These two contributors were both derived from the decision made by the Reformation and Development Department, nevertheless, there was a slight difference between them. The use of incomplete design for bidding was proposed by the agency company in CASE#1 & 3. On the other hand, the changed orders emerged from the

modification of the national standard which was not in the control of the city government. It was clearly stated in the red line documents distributed by the national government, so the change of order to adapt to the new standard must be implemented. This was unforeseen event, in other words, an external factor. Another sudden event that negatively influenced CASE#4 was the forced change of the scope of the project to carry out the “Sponge City” strategy. This scope change was not a deliberate act taken by the Reformation and Development Department, but instead an environmental-friendly strategy promoted nationally, so the Xiamen government had to comply with it.

The inflation problem was another external cost overrun contributor, though the budget estimator was supposed to foresee the inflation and be prepared (Rothballer, 2012). The inflation, in most cases, stems from the turbulence of the marketplace (Buffie, 1995). Since the project usually goes through a long period of preparation, adding up to the chance to be affected by such external environment as the market constantly changes. In reality, the inflation accounts for a large portion of cost overrun.

As stated in the meeting memos, the design company and construction contractors hardly had the opportunity to discuss about the project face to face. They participated in the project during different stages. Although their involvement periods sometimes overlapped each other, their communication was mainly through a third party: the project manager. The project manager from the agency company handled the transition from the design stage to construction stage, and thus it was the manager’s obligation to make sure that the transition went smoothly, avoiding misunderstanding between the parties and expanding coordination (Ford, 1995).

## 5. Discussion

As noted earlier in this thesis, there are two main theoretical schools that prevail in the literature to explain the cost overrun phenomenon: evolution and psycho theories. In this section, we discuss the findings in light of these two schools of thought.

### 5.1. Evolution Theories

Evolution theorists advance that modification along the project lifecycle constitutes the overarching reason for cost overrun (Ahiaga-Dagbui et al., 2017). As the word “evolution” suggests, scholars from this school focus more on accumulating outcomes resulted from a series of events within the duration of the project. In their opinion, even with the most advanced forecasting technology, the budget and duration estimated in the early stage are inherently unreliable and unstable due to a lack of adequate information (Love et al., 2019). The project gradually becomes more well-defined as time goes by and the final design is different from the conceptual design. Therefore, the budget estimation in the late stage that covers all work costs is bound to be closer to the reality, different from the budget estimated in the early stage using the sketchy design. The differences in workload, design, definition and orders between the budget estimation at the two stages of the project lifecycle are key reasons causing cost overrun (Ahiaga-Dagbui & Smith, 2014b). The case analysis in this study suggests evolution theory fits well in the context of the four social infrastructure projects in China.

First, changes of orders and scope occurred in all four cases and explained cost overrun to a certain extent. Changes of orders and changes of scope result in the increase/decrease of the workload of the project and are ultimately reflected in the final cost.

In the table below, changes of orders and changes of scope are listed. The figure of the overrun caused by changes of orders used below to calculate the portion is collected

from the documents. By reviewing the documents, the study adds up figures which are clearly described as the overrun caused by changes of orders or scope.

**Table 14 Overrun caused by increased workload (change order/scope)**

	<b>Type of change order or scope</b>	<b>Portion (overrun caused by change of orders divided by total overrun) unit: thousand (RMB)</b>
CASE#1	<ul style="list-style-type: none"> <li>▪ added fire suppression gaseous systems</li> <li>▪ upgrade of the elevator equipment and the supporting electricity system</li> <li>▪ outdoor landscaping design</li> <li>▪ additional investment in interior decoration (this part has been removed from the budget of the project and the city government decided to set the budget indecently for the interior decoration)</li> </ul>	$\frac{\text{cost overrun caused by change of orders}}{\text{total cost overrun}} = \frac{9755.71}{114108.82} = 8.55\%$
CASE#2	<ul style="list-style-type: none"> <li>▪ upgrade of the fire preventing system</li> <li>▪ upgrade of technique of excavating work</li> <li>▪ additional fees to accelerate the pile foundation construction</li> </ul>	$\frac{\text{cost overrun caused by change of orders}}{\text{total cost overrun}} = \frac{1266.14}{2305.71} = 54.91\%$
CASE#3	<ul style="list-style-type: none"> <li>▪ excavating standard improvement</li> <li>▪ upgrade of incineration technique (towards eco-friendly)</li> </ul>	$\frac{\text{cost overrun caused by change of orders}}{\text{total cost overrun}} = \frac{107.42}{515.16} = 20.85\%$
CASE#3	<ul style="list-style-type: none"> <li>▪ including the “sponge city” strategy into the project scope</li> <li>▪ additional design fee and workload for the change in outdoor landscaping (in order to cope with “sponge city” strategy)</li> <li>▪ additional fee in changing the paving material (in order to cope with “sponge city” strategy)</li> </ul>	$\frac{\text{cost adjustment caused by change of scope}}{\text{total cost adjustment}} = 100\%$

Another cost overrun contributor which results in an extremely massive increase of the workload is the utilization of incomplete design in the early budget estimation and duration. This phenomenon can also be explained through the evolution theory. The

essential argument in evolution theory is that the budget and duration will get modified as the project is defined more and more precisely through the project lifecycle (Ahiaga-Dagbui et al., 2017). Actually, as reiterated by Love and Ahiaga-Dagbui (2018), it is hard and even unrealistic to forecast what will happen to a project at the initial stage when nothing has been settled down. The fundamental root of the cost overrun and schedule delay is the lack of complete information in the early project phase.

As found in the documentary analysis, when estimating the conceptual budget, the budget estimation committee, based on the workload calculated by the fragmentary documents, came up with a conceptual budget as early as possible and proceeded further even though against a time pressure. At the meantime, with the anxiety to further shorten the time, the agency company and city government tended to just grab the sketchy drawing and used it in the bidding process rather than waiting for the design company to offer a set of complete drawings qualified for tendering. However, the reality was that, the workload calculated from the sketchy drawing which had been provided to the competing contractors inevitably had errors and omissions. Therefore, once the design company finished the design in which the real workload was taken into fuller consideration, the workload calculated based on the detailed drawing was bound to increase considerably compared to that which had been estimated previously. The increased workload would definitely generate escalation on cost. Sometimes, construction contractors were even forced to start the on-site work way ahead before the detailed drawing (which is supposed to lead the construction work) was completed to save time. This rashness in some cases even resulted in reworks (CASE#1) and idle time (CASE#1 &2). Besides the additional labor and material fees derived from the increase of workload, the design fees for the design company and the on-site management fees also skyrocketed.

**Table 15 Overrun caused by increased workload (omission)**

	<b>Increase of the workload</b>	<b>Portion (overrun caused by omission of workload divided by total overrun) unit: thousand (RMB)</b>
CASE#1		$\frac{\text{cost overrun caused by omission}}{\text{total cost overrun}} = \frac{63442.01}{114108.82} = 55.60\%$
CASE#2	<ul style="list-style-type: none"> <li>▪ additional design fees for the design company</li> <li>▪ additional labor and material fees</li> <li>▪ additional on-site management</li> </ul>	$\frac{\text{cost overrun caused by omission}}{\text{total cost overrun}} = \frac{395.88}{2305.71} = 17.17\%$
CASE#3		$\frac{\text{cost overrun caused by omission}}{\text{total cost overrun}} = \frac{291.07}{515.16} = 56.50\%$

The two contributors engendered cost overrun in the same way, that is, generating a growth in work costs in addition to the existing workload. However, there is a subtle difference. The increase of workload stemmed from changes of orders/scope driven by unforeseen events/changes. On the other hand, the growth of workload originated from the utilization of sketchy drawing or in essence an omission. This “additional” workload was a part of the project from the very beginning, yet was not noticed by the project team until the design had been completed.

### 5.1.1. The paradox of narrowing down the budget

Although evolution theory works for explaining cost overrun in social infrastructure projects in China, there is a small paradox this study would like to point out.

In China, there are three stages of budget – the preliminary budget, the design budget and the conceptual budget. To ensure a sound investment of the money from taxpayers, the Chinese government enforces strict management system on the budget estimation of

the infrastructure project. The Chinese government requires that the budget estimation committee and the agency company narrow down the budget stage by stage. In other words, the budget should be less than or equal to the figure in the last stage during the “evolution”. Whenever the budget increases, the project promoter is required to file a report explaining about the increment. This budget management system intends to prevent the project budget from increasing without a compelling reason.

Nevertheless, according to evolutionary theorists, however, as more detailed project information come into light, the budget is supposed to increase rather than decrease (Love, Smith, Simpson, Regan, & Olatunji, 2015). Interestingly, at the same time, the situation found in the practical cases in this study shows the same development path as pointed out by evolution theorists. Indeed, with the increase in workload induced by changes of scope and changes of orders, cost exceeded the original conceptual budget in all four cases. Hence, the following paradox emerged: the government’s requirement contradicted the academic theory and reality. The intension to prevent the budget escalation turns out to be in vain in these four cases.

## **5.2. Psycho theories**

Psycho theorists hold that cost-overrun is due to budget underestimation (Flyvbjerg, 2007b). Optimistic bias and strategic misrepresentation are commonly mentioned in the literature on cost overrun in social infrastructure projects. Optimistic bias is a cognitive bias that makes people believe that the task they are taken is less likely to experience a negative event or end up with a negative outcome (Flyvbjerg, 2007a). Strategic misrepresentation is an unethical action undertaken by some project planners to promote a project. Similar to optimistic bias, strategic misrepresentation is also related to budget underestimation. Their difference is that the optimistic bias is unconscious, while strategic misrepresentation is deliberate deception to make the project profitable and favorable on paper (Flyvbjerg, 2007a).

No direct evidence can be found in the documentary analysis that suggests the existence of optimistic bias (delusion) and strategic misrepresentation (deception) in the four cases. That is also a limitation which can be found in most studies that try to verify the psycho theories, since it is common that people refuse to admit that they tell a lie. However, the tendency of consistent overrun in social infrastructure projects in China seems in line with the pattern revealed by psycho theorists like Bent Flyvbjerg. Also, during the case study, a few discoveries indicate that some action taken by the project promoters is questionable and worth considering.

First, even the previous evidence clearly shows that an action has a tendency to cause the cost overrun, the project team insists to adopt it again and again without any amendment and consequently leads to overrun without exception. From the documentary analysis and this discussion of the contributors, it is inferred from that the government frequently resorted to a solution, which involved a sketchy design in the bidding of construction contractors to save as much time as possible. However, in three cases, this measure not only failed to reduce the time but also caused massive omission of workload when signing the construction contract, from which severe cost escalation stemmed. It is clear that an early start of bidding before having a fully-prepared design document will do more harm than good. It is worth pondering why the government sticks to this “solution”. As described in the section about the responsibility of stakeholders, it is known that this “solution” was proposed by the agency company and was approved by the Reformation and Development Department. Nevertheless, as evidence showed that the “solution” was ineffective, the project promoter insisted that the project could save more time regardless of the idle time which would emerge later.

Second, the paradox in the rules set by the Chinese government to narrow down the budget stage by stage also reflects the possible existence of strategic misrepresentation or deception. In order to fulfill the mission of narrowing down the budget, the budget

estimation committee tended to overestimate the conceptual budget slightly in the early phase. CASE#4 witnessed a surprising cost underrun despite a massive increase of workload due to the changes of scope. The question then is: was the original conceptual budget realistic? Did the budget estimation committee excessively overestimate budget to reserve more room for the narrowing down of the budget? This remains to be ascertained.

Furthermore, previous studies on strategic misrepresentation focus mostly on deception in budget estimation at the proposal stage in an attempt to increase the chance of the project approval (Flyvbjerg, 2007b). However, due to the unique budget adjusting mechanism, the two findings discussed above could happen at any phase of the project lifecycle.

Still, as shared by many studies about psycho theorists, scholars are unable to force project stakeholders to acknowledge whether there is delusion or deception, or optimistic bias or strategic misrepresentation or to deny their existence (Flyvbjerg, 2013). It is not easy to find direct evidence of strategic misrepresentation, so this study is only able to catch some signals of the existence of it.

**Table 16 the Comparison Between Two Schools of Thought**

Evolution Theorist	Psycho Theorist
<ul style="list-style-type: none"> <li>▪ changes of order</li> <li>▪ changes of scope</li> <li>▪ unrealistic schedule arrangement</li> <li>▪ utilization of incomplete design</li> <li>▪ overestimation of the budget at the early stage</li> </ul>	<ul style="list-style-type: none"> <li>▪ Evidence unavailable</li> </ul>

## 6. Conclusion

This study sought to understand why social infrastructure projects experience cost overrun in the context of China. To answer this question, a literature review about the causes of cost overrun was conducted. From the literature review, it was concluded that there are two main schools of thought, namely, evolution and psycho theories.

Second, this study undertook a case study, using documentary analysis to explore the causes of cost overrun for four social infrastructure projects that were completed in the city of Xiamen in China. Case documentation includes feasibility study reports, application and approval of preliminary budget, application and approval of the conceptual budget, application and approval of the adjustment of the conceptual budget, meeting memos, post-evaluation reports and final audit reports. This study coded the documents, highlighted and counted the keywords related to cost overrun, and identified contributors that increased the cost of projects. Three cases (#1, 2 & 3) out of four experienced severe cost overrun (cases #1, 2 & 3). Case # 4, though delivered within budget, witnessed dramatic budget adjustment and re-allocation.

Last, taking a cue from the existing two schools of thought, this study concluded with key explanations for cost overrun in the four social infrastructure projects examined in China. Besides the main research question, this study also analyzed the responsibilities of different stakeholders with regards to cost overrun. This section reviews and discusses the findings and limitations of the case study and offers suggestions for future research as well as practical implications.

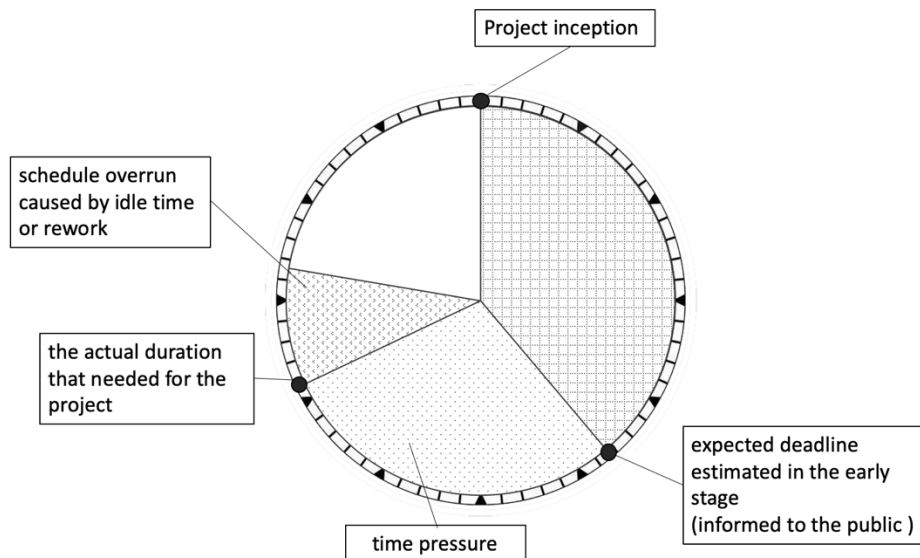
## 6.1. The causes of cost overrun

This study identified four reasons why cost overrun occurred in the four cases: time pressure, changes during the long duration, inflation and coordination. But keywords counting revealed that the first two are the major reasons for the overrun.

### 6.1.1. Time pressure

Time pressure and equivalent keywords have been frequently mentioned in the documents. The obligation to stick to prematurely announced delivery dates and the complexity of on-site management are the root causes of the time pressure. In order to relieve the pressure, the workload was increased due to the utilization of an incomplete design for estimation and tendering process and finally more time was idled away. The figure below shows the how time pressure, premature announcement, idle time and change of order interacting with each other.

**Figure 12 Time Pressure**



### **6.1.2. Changes of orders and project scope**

Change of orders/scope happened in all four cases and caused a dramatic workload increase. Those changes led to additional investments in labor, material and equipment which intensified the cost overrun. Also, in China, every change of orders/scope needs to be examined through a lengthy approval procedure by many administrations. The red tape induced idle time which was an aggravation to time pressure and ultimately further eroded the project performance.

### **6.1.3. Theoretical contribution**

The literature on the reasons of cost overrun can be divided into three categories: evolution theories, psycho theories and other non-mainstream theories. Evolution theories and psycho theories differ not only in the way they calculate overrun and their respective points of reference (Invernizzi et al., 2018), but also in the framework of causes of overrun they consider. The evolution theorists, as the word “evolution” suggests, believe that change along the project lifecycle is the main influencing factor in causing overrun (Ahiaga-Dagbui & Smith, 2014a). Nevertheless, the psycho theorists put the blame on the behavioral factors such as optimistic bias and strategic misrepresentation (Cantarelli, Flybjerg, Molin, & Van Wee, 2013a).

In this study, it is found that evolution theory fits better the data than its counterpart psycho theory in explaining cost overrun in Chinese social infrastructure projects. Documentary evidence suggests cost overrun can be explained by evolution theory, while only a faint trace of psycho theory could possibly be related to strategic misrepresentation and optimistic bias. Indeed, the study found that the two main reasons explaining cost overrun are time pressure and changes of orders/scope, which can be traced back to evolution theory (Hanna et al., 1999; Love, Irani, et al., 2017).

## 6.2. Practical Implications

- *Avoid the premature announcement of the delivery date*

Premature announcement was the main reason why the project team was always under enormous time pressure. In most cases, time pressure forced the project team to speed up procedure in spite of a poor work quality and therefore exerted negative impact on the project. Therefore, in order to guarantee the project's quality and mitigate cost overrun, the government should not release the deadline to the public before the project planner is equipped with adequate information to forecast a reliable and steady delivery date.

- *Leave the design company enough time to complete their work before rush into next stage.*

A well-organized project schedule should leave enough time for each stakeholder to carry out their own work and thus form a solid foundation for next step. In the case study analysis, it is found that the government did not wait for the design company to finish the detailed drawings in order to cut the time. They instead brought the sketchy drawing to the budget estimation committee and the construction contractor. This reckless action caused errors in workload determination. Moreover, the government might even force the construction team to start their work without a clear instruction from the drawings, which resulted in reworks and much time being idled, intensifying time pressure. Therefore, this study appeals to the government to leave adequate time, so that the budget estimator can be capable of coming up with a correct estimation and the construction contractor can be fully prepared for the project.

- *The end-user should be involved at an early stage*

In social infrastructure contexts, the end-user is the future operator of the facility. For example, the end-user of the science museum in case #1 is the curator; the garage and reception building construction work in case #2 is the hospital; the incineration plant in

case #3 is the EE company; the campus construction project in case #4 is the president. The end-user has all the expertise required for operating the facility and therefore they have a good knowledge of what the project should fulfill. The project planner and designer have to take their input into consideration. The case study in this report clearly stated the benefit of early involvement of the end-user. The science museum experienced massive interior space transformation, which was both costly and time-consuming, just because the operation company was picked by the government after the construction phase and the operator was unable to share their opinions and make change requests in the design phase. In the case of the incineration plant, it was managed and constructed by its end-user. Although this project also suffered from changes of orders, none of the change was issued by the end-users.

- *Be prepared for unexpected events*

It is vital for project planners to identify that a change in the project lifecycle is inevitable, so it is important to integrate a change management plan to prepare for unexpected changes that can potentially lead to subsequent cost overrun. The management plan can include an independent contingency fund that would cater to changes especially the sudden ones. A contingency preparation means that the project can have some breathing space when encountering “black swan” incidence (Love, Sing, Carey, & Kim, 2014).

- *The specialty of conceptual budget overrun*

Through the research, we found that, the scale of the overrun that took place in the Chinese social infrastructure projects appears smaller than that in the West, and the conceptual budget system in Chinese projects might be the main reason. The Chinese authority puts much emphasis on the conceptual budget and takes it as a warning line for the budget management, so to guard against cost increases. It comes from the third

budget estimation stage, which is based on the construction blueprint and the workload calculation. Therefore, this budget is supposed to reflect the reality accurately. During the project lifecycle, once the cost exceeds the conceptual budget, the government authority needs to figure out reasons for the cost escalation and adjusts the conceptual budget according to the situation so as to have the adjusted conceptual budget closer to the final cost. This explains why, the cost overrun calculated using the adjusted figure might be less than that in existing studies using data from the West.

### **6.3. Limitations of the study**

This research conducted a case study through documentary analysis approach. Although the documents used in the case study helped to address the reasons for cost overrun to a great extent, it still has its own limitations. Data collection techniques like interviews might generate new insights through a direct and face to face contact with diverse interviewees. Thus, the validity of the study's findings can be further strengthened by interviews with stakeholders involved in the four social infrastructure projects. Another limitation is that documents are likely to reflect the issues that their authors seek to highlight, not the ones they choose to avoid. In this regard, both the documentary and interview analysis may fall short when it comes to revealing strategic misrepresentation in infrastructure projects, which remain a key empirical challenge.

Secondary, the research limited the case sample to four projects from one city due to data accessibility. Increasing the number of projects across broader geographical regions would lead to a more robust representativeness of the Chinese social infrastructure industry.

Next, the research focused on cases with massive budget adjustment. A comparative study on social infrastructure projects with small budget adjustment and those with a sound budget execution will add more insight into this research question.

Finally, this thesis adopted merely qualitative approach (case study) in addressing the research question, while the existing literature on cost overrun focused more on quantitative approaches, which makes the analysis approach of this thesis less informed. In the future study, literatures discussed relevant topics which put an emphasis on conducting case study like works from Nuno Gil should be taken into consideration.

#### **6.4. Suggestions for future research**

Besides the four cases introduced before, the author also examined 10 more social infrastructure projects of Xiamen city. During the study, an interesting pattern emerged. The project type with more previous experience normally yielded a better cost performance. This conjecture is proposed based on two observations.

- In the 2007-2017 decade in Xiamen city, there have been 53 projects related to campus construction, yet the figures for museum-related projects and incineration plant projects were only four and five respectively ("Annual Report for Infrastructure Project," 2017). The number of campus construction projects is ten times that of museum-related projects.
- Within the ten cases, four campus construction projects (including CASE #4) experienced budget underrun, while the museum construction project overrun (CASE #1) its budget dramatically.

It seems that the projects with unique characteristics are more likely to encounter cost overrun because of their higher levels of complexity or uncertainty compared to the projects which are more general (Love, Ika, Sing, & Newton, 2019; Love, Ika, & Ahiaga-Dagbui, 2019; Love, Ika, & Sing, 2020). While it has been long been argued that

Reference Class Forecasting (hereinafter RCF) can be useful to capture the previous experience of as-built projects and have positive influence on cost estimation (Flyvbjerg, 2007a; Flyvbjerg et al., 2017), it does not account for complexity. These observations suggest a possibility to connect the two schools together to further explore the relationship between complexity, cost overrun and RCF estimation approach.

### Appendix: CRS Code of Social Infrastructure Facility

DAC 5 CODE	CRS CODE	DESCRIPTION	Clarifications / Additional notes on coverage
<b>130</b>		<b>POPULATION POLICIES/ PROGRAMMES AND REPRODUCTIVE HEALTH</b>	
	<b>13010</b>	Population policy and administrative management	Population/development policies; census work, vital registration; migration data; demographic research/analysis; reproductive health research; unspecified population activities.
	<b>13020</b>	Reproductive health care	Promotion of reproductive health; prenatal and postnatal care including delivery; prevention and treatment of infertility; prevention and management of consequences of abortion; safe motherhood activities.
	<b>13030</b>	Family planning	Family planning services including counselling; information, education and communication (IEC) activities; delivery of contraceptives; capacity building and training.
	<b>13040</b>	STD control including HIV/AIDS	All activities related to sexually transmitted diseases and HIV/AIDS control e.g. information, education and communication; testing; prevention; treatment, care.
	<b>13081</b>	Personnel development for population and reproductive health	Education and training of health staff for population and reproductive health care services.

DAC 5 CODE	CRS CODE	DESCRIPTION	Clarifications / Additional notes on coverage
<b>120</b>		<b>HEALTH</b>	
<b>121</b>		<b>Health, general</b>	
	<b>12110</b>	Health policy and administrative management	Health sector policy, planning and programmes; aid to health ministries, public health administration; institution capacity building and advice; medical insurance programmes; unspecified health activities.
	<b>12181</b>	Medical education/training	Medical education and training for tertiary level services.
	<b>12182</b>	Medical research	General medical research (excluding basic health research).
	<b>12191</b>	Medical services	Laboratories, specialised clinics and hospitals (including equipment and supplies); ambulances; dental services; mental health care; medical rehabilitation; control of non-infectious diseases; drug and substance abuse control [excluding narcotics traffic control (16063)].
<b>122</b>		<b>Basic health</b>	
	<b>12220</b>	Basic health care	Basic and primary health care programmes; paramedical and nursing care programmes; supply of drugs, medicines and vaccines related to basic health care.
	<b>12230</b>	Basic health infrastructure	District-level hospitals, clinics and dispensaries and related medical equipment; excluding specialised hospitals and clinics (12191).
	<b>12240</b>	Basic nutrition	Direct feeding programmes (maternal feeding, breastfeeding and weaning foods, child feeding, school feeding); determination of micro-nutrient deficiencies; provision of vitamin A, iodine, iron etc.; monitoring of nutritional status; nutrition and food hygiene education; household food security.
	<b>12250</b>	Infectious disease control	Immunisation; prevention and control of infectious and parasite diseases, except malaria (12262), tuberculosis (12263), HIV/AIDS and other STDs (13040). It includes diarrheal diseases, vector-borne diseases (e.g. river blindness and guinea worm), viral diseases, mycosis, helminthiasis, zoonosis, diseases by other bacteria and viruses, pediculosis, etc.
	<b>12261</b>	Health education	Information, education and training of the population for improving health knowledge and practices; public health and awareness campaigns; promotion of improved personal hygiene practices, including use of sanitation facilities and handwashing with soap.
	<b>12262</b>	Malaria control	Prevention and control of malaria.
	<b>12263</b>	Tuberculosis control	Immunisation, prevention and control of tuberculosis.
	<b>12281</b>	Health personnel development	Training of health staff for basic health care services.

DAC 5 CODE	CRS CODE	DESCRIPTION	Clarifications / Additional notes on coverage
<b>140</b>		<b>WATER AND SANITATION</b>	
	<b>14010</b>	Water sector policy and administrative management	Water sector policy and governance, including legislation, regulation, planning and management as well as transboundary management of water; institutional capacity development; activities supporting the Integrated Water Resource Management approach (IWRM: see box below).
	<b>14015</b>	Water resources conservation (including data collection)	Collection and usage of quantitative and qualitative data on water resources; creation and sharing of water knowledge; conservation and rehabilitation of inland surface waters (rivers, lakes etc.), ground water and coastal waters; prevention of water contamination.
	<b>14020</b>	Water supply and sanitation - large systems	Programmes where components according to 14021 and 14022 cannot be identified. When components are known, they should individually be reported under their respective purpose codes: water supply (14021), sanitation (14022), and hygiene (12261).
	<b>14021</b>	Water supply - large systems	Potable water treatment plants; intake works; storage; water supply pumping stations; large scale transmission / conveyance and distribution systems.
	<b>14022</b>	Sanitation - large systems	Large scale sewerage including trunk sewers and sewage pumping stations; domestic and industrial waste water treatment plants.
	<b>14030</b>	Basic drinking water supply and basic sanitation	Programmes where components according to 14031 and 14032 cannot be identified. When components are known, they should individually be reported under their respective purpose codes: water supply (14031), sanitation (14032), and hygiene (12261).
	<b>14031</b>	Basic drinking water supply	Rural water supply schemes using handpumps, spring catchments, gravity-fed systems, rainwater collection and fog harvesting, storage tanks, small distribution systems typically with shared connections/points of use. Urban schemes using handpumps and local neighbourhood networks including those with shared connections.
	<b>14032</b>	Basic sanitation	Latrines, on-site disposal and alternative sanitation systems, including the promotion of household and community investments in the construction of these facilities. (Use code 12261 for activities promoting improved personal hygiene practices.)
	<b>14040</b>	River basins' development	Infrastructure-focused integrated river basin projects and related institutional activities; river flow control; dams and reservoirs [excluding dams primarily for irrigation (31140) and hydropower (23065) and activities related to river transport (21040)].
	<b>14050</b>	Waste management / disposal	Municipal and industrial solid waste management, including hazardous and toxic waste; collection, disposal and treatment; landfill areas; composting and reuse.
	<b>14081</b>	Education and training in water supply and sanitation	Education and training for sector professionals and service providers.

DAC 5 CODE	CRS CODE	DESCRIPTION	Clarifications / Additional notes on coverage
150		<b>GOVERNMENT AND CIVIL SOCIETY</b>	<i>Includes assistance to strengthen the administrative apparatus and government.</i>
151		Government and civil society, general	<b>N.B.</b> Use code 51010 for general budget support.
	15110	Public sector policy and administrative management	Institution-building assistance to strengthen core public sector management systems and capacities. This includes macro-economic and other policy management, co-ordination, planning and reform; human resource management; organisational development; civil service reform; e-government; development planning, monitoring and evaluation; support to ministries involved in aid co-ordination; other ministries and government departments when sector cannot be specified. (Use specific sector codes for development of systems and capacities in sector ministries.)
	15111	Public finance management	Fiscal policy and planning; support to ministries of finance; strengthening financial and managerial accountability; public expenditure management; improving financial management systems; budget drafting; inter-governmental fiscal relations, public audit, public debt. (Use code 15114 for domestic revenue mobilisation and code 33120 for customs).
	15112	Decentralisation and support to subnational government	Decentralisation processes (including political, administrative and fiscal dimensions); intergovernmental relations and federalism; strengthening departments of regional and local government, regional and local authorities and their national associations. (Use specific sector codes for decentralisation of sector management and services.)
	15113	Anti-corruption organisations and institutions	Specialised organisations, institutions and frameworks for the prevention of and combat against corruption, bribery, money-laundering and other aspects of organised crime, with or without law enforcement powers, e.g. anti-corruption commissions and monitoring bodies, special investigation services, institutions and initiatives of integrity and ethics oversight, specialised NGOs, other civil society and citizens' organisations directly concerned with corruption.
	15114	Domestic revenue mobilisation	Support to domestic revenue mobilisation/tax policy, analysis and administration as well as non-tax public revenue, which includes work with ministries of finance, line ministries, revenue authorities or other local, regional or national public bodies. (Use code 16010 for social security and other social protection.)
	15130	Legal and judicial development	Support to institutions, systems and procedures of the justice sector, both formal and informal; support to ministries of justice, the interior and home affairs; judges and courts; legal drafting services; bar and lawyers associations; professional legal education; maintenance of law and order and public safety; border management; law enforcement agencies, police, prisons and their supervision; ombudsmen; alternative dispute resolution, arbitration and mediation; legal aid and counsel; traditional, indigenous and paralegal practices that fall outside the formal legal system.  Measures that support the improvement of legal frameworks, constitutions, laws and regulations; legislative and constitutional drafting and review; legal reform; integration of formal and informal systems of law.  Public legal education; dissemination of information on entitlements and remedies for injustice; awareness campaigns.  (Use codes 152xx for activities that are primarily aimed at supporting security system reform or undertaken in connection with post-conflict and peace building activities.)

DAC 5 CODE	CRS CODE	DESCRIPTION	Clarifications / Additional notes on coverage
	<b>15150</b>	Democratic participation and civil society	Support to the exercise of democracy and diverse forms of participation of citizens beyond elections (15151); direct democracy instruments such as referenda and citizens' initiatives; support to organisations to represent and advocate for their members, to monitor, engage and hold governments to account, and to help citizens learn to act in the public sphere; curricula and teaching for civic education at various levels. (This purpose code is restricted to activities targeting governance issues. When assistance to civil society is for non-governance purposes use other appropriate purpose codes.)
	<b>15151</b>	Elections	Electoral management bodies and processes, election observation, voters' education. (Use code 15230 when in the context of an international peacekeeping operation).
	<b>15152</b>	Legislatures and political parties	Assistance to strengthen key functions of legislatures/parliaments including subnational assemblies and councils (representation; oversight; legislation), such as improving the capacity of legislative bodies, improving legislatures' committees and administrative procedures,; research and information management systems; providing training programmes for legislators and support personnel. Assistance to political parties and strengthening of party systems.
	<b>15153</b>	Media and free flow of information	Activities that support free and uncensored flow of information on public issues; activities that increase the editorial and technical skills and the integrity of the print and broadcast media, e.g. training of journalists. (Use codes 22010-22040 for provision of equipment and capital assistance to media.)
	<b>15160</b>	Human rights	Measures to support specialised official human rights institutions and mechanisms at universal, regional, national and local levels in their statutory roles to promote and protect civil and political, economic, social and cultural rights as defined in international conventions and covenants; translation of international human rights commitments into national legislation; reporting and follow-up; human rights dialogue.  Human rights defenders and human rights NGOs; human rights advocacy, activism, mobilisation; awareness raising and public human rights education.  Human rights programming targeting specific groups, e.g. children, persons with disabilities, migrants, ethnic, religious, linguistic and sexual minorities, indigenous people and those suffering from caste discrimination, victims of trafficking, victims of torture.  (Use code 15230 when in the context of a peacekeeping operation.)
	<b>15170</b>	Women's equality organisations and institutions	Support for institutions and organisations (governmental and non-governmental) working for gender equality and women's empowerment.

DAC 5 CODE	CRS CODE	DESCRIPTION	Clarifications / Additional notes on coverage
152		<b>Conflict prevention and resolution, peace and security</b>	<i>N.B. Further notes on ODA eligibility (and exclusions) of conflict, peace and security related activities are given in paragraphs 76-81 of the Directives.</i>
	15210	Security system management and reform	<p>Technical co-operation provided to parliament, government ministries, law enforcement agencies and the judiciary to assist review and reform of the security system to improve democratic governance and civilian control;</p> <p>technical co-operation provided to government to improve civilian oversight and democratic control of budgeting, management, accountability and auditing of security expenditure, including military budgets, as part of a public expenditure management programme;</p> <p>assistance to civil society to enhance its competence and capacity to scrutinise the security system so that it is managed in accordance with democratic norms and principles of accountability, transparency and good governance. [Other than in the context of an international peacekeeping operation (15230).]</p>
	15220	Civilian peace-building, conflict prevention and resolution	<p>Support for civilian activities related to peace building, conflict prevention and resolution, including capacity building, monitoring, dialogue and information exchange.</p> <p>Bilateral participation in international civilian peace missions such as those conducted by the UN Department of Political Affairs (UNDPA) or the European Union (European Security and Defence Policy), and contributions to civilian peace funds or commissions (e.g. Peacebuilding Commission, Peacebuilding thematic window of the MDG achievement fund etc.). The contributions can take the form of financing or provision of equipment or civilian or military personnel (e.g. for training civilians).</p> <p>(Use code 15230 for bilateral participation in international peacekeeping operations).</p>

DAC 5 CODE	CRS CODE	DESCRIPTION	Clarifications / Additional notes on coverage
	<b>15230</b>	Participation in international peacekeeping operations	<p>Bilateral participation in peacekeeping operations mandated or authorised by the United Nations (UN) through Security Council resolutions, and conducted by international organisations, e.g. UN, NATO, the European Union (Security and Defence Policy security-related operations), or regional groupings of developing countries.</p> <p>Direct contributions to the UN Department for Peacekeeping Operations (UNDPKO) budget are excluded from bilateral ODA (they are reportable in part as multilateral ODA, see Annex 9).</p> <p>The activities that can be reported as bilateral ODA under this code are limited to: human rights and election monitoring; reintegration of demobilised soldiers; rehabilitation of basic national infrastructure; monitoring or retraining of civil administrators and police forces; security sector reform and other rule of law-related activities; training in customs and border control procedures; advice or training in fiscal or macroeconomic stabilisation policy; repatriation and demobilisation of armed factions, and disposal of their weapons; explosive mine removal. The enforcement aspects of international peacekeeping operations are not reportable as ODA.</p> <p>ODA-eligible bilateral participation in peacekeeping operations can take the form of financing or provision of equipment or military or civilian personnel (e.g. police officers). The reportable cost is calculated as the excess over what the personnel and equipment would have cost to maintain had they not been assigned to take part in a peace operation. Costs for military contingents participating in UNDPKO peacekeeping operations are not reportable as ODA.</p> <p>International peacekeeping operations may include humanitarian-type activities (contributions to the form of equipment or personnel), as described in codes 7xxxx. These should be included under code 15230 if they are an integrated part of the activities above, otherwise they should be reported as humanitarian aid.</p> <p>NB: When using this code, indicate the name of the operation in the short description of the activity reported.</p>
	<b>15240</b>	Reintegration and SALW control	Reintegration of demobilised military personnel into the economy; conversion of production facilities from military to civilian outputs; technical co-operation to control, prevent and/or reduce the proliferation of small arms and light weapons (SALW) – see para. 80 of the Directives for definition of SALW activities covered. [Other than in the context of an international peacekeeping operation (15230) or child soldiers (15261)].
	<b>15250</b>	Removal of land mines and explosive remnants of war	All activities related to land mines and explosive remnants of war which have benefits to developing countries as their main objective, including removal of land mines and explosive remnants of war, and stockpile destruction for developmental purposes [other than in the context of an international peacekeeping operation (15230)]; risk education and awareness raising; rehabilitation, reintegration and assistance to victims, and research and development on demining and clearance. Only activities for civilian purposes are ODA-eligible.
	<b>15261</b>	Child soldiers (Prevention and demobilisation)	Technical co-operation provided to government – and assistance to civil society organisations – to support and apply legislation designed to prevent the recruitment of child soldiers, and to demobilise, disarm, reintegrate, repatriate and resettle (DDR) child soldiers.

DAC 5 CODE	CRS CODE	DESCRIPTION	Clarifications / Additional notes on coverage
<b>160</b>		<b>OTHER SOCIAL INFRASTRUCTURE AND SERVICES</b>	
	<b>16010</b>	Social/ welfare services	Social legislation and administration; institution capacity building and advice; social security and other social schemes; special programmes for the elderly, orphans, the disabled, street children; social dimensions of structural adjustment; unspecified social infrastructure and services, including consumer protection.
	<b>16020</b>	Employment policy and administrative management	Employment policy and planning; labour law; labour unions; institution capacity building and advice; support programmes for unemployed; employment creation and income generation programmes; occupational safety and health; combating child labour.
	<b>16030</b>	Housing policy and administrative management	Housing sector policy, planning and programmes; excluding low-cost housing and slum clearance (16040).
	<b>16040</b>	Low-cost housing	Including slum clearance.
	<b>16050</b>	Multisector aid for basic social services	Basic social services are defined to include basic education, basic health, basic nutrition, population/reproductive health and basic drinking water supply and basic sanitation.
	<b>16061</b>	Culture and recreation	Including libraries and museums.
	<b>16062</b>	Statistical capacity building	Both in national statistical offices and any other government ministries.
	<b>16063</b>	Narcotics control	In-country and customs controls including training of the police; educational programmes and awareness campaigns to restrict narcotics traffic and in-country distribution <sup>1</sup> .
	<b>16064</b>	Social mitigation of HIV/AIDS	Special programmes to address the consequences of HIV/AIDS, e.g. social, legal and economic assistance to people living with HIV/AIDS including food security and employment; support to vulnerable groups and children orphaned by HIV/AIDS; human rights of HIV/AIDS affected people.

**200 - ECONOMIC INFRASTRUCTURE AND SERVICES***(This major heading groups assistance for networks, utilities and services that facilitate economic activity.)*

DAC 5 CODE	CRS CODE	DESCRIPTION	Clarifications / Additional notes on coverage
<b>210</b>		<b>TRANSPORT AND STORAGE</b>	<i>Note: Manufacturing of transport equipment should be included under code 32172.</i>
	<b>21010</b>	Transport policy and administrative management	Transport sector policy, planning and programmes; aid to transport ministries; institution capacity building and advice; unspecified transport; activities that combine road, rail, water and/or air transport. Whenever possible, report transport of goods under the sector of the good being transported.
	<b>21020</b>	Road transport	Road infrastructure, road vehicles; passenger road transport, motor passenger cars.
	<b>21030</b>	Rail transport	Rail infrastructure, rail equipment, locomotives, other rolling stock; including light rail (tram) and underground systems.
	<b>21040</b>	Water transport	Harbours and docks, harbour guidance systems, ships and boats; river and other inland water transport, inland barges and vessels.
	<b>21050</b>	Air transport	Airports, airport guidance systems, aeroplanes, aeroplane maintenance equipment.
	<b>21061</b>	Storage	Whether or not related to transportation. Whenever possible, report storage projects under the sector of the resource being stored.
	<b>21081</b>	Education and training in transport and storage	

DAC 5 CODE	CRS CODE	DESCRIPTION	Clarifications / Additional notes on coverage
230		<b>ENERGY GENERATION, DISTRIBUTION AND EFFICIENCY</b>	Categories 231 through 235 include both electric power plants and combined heat and power (CHP) plants. Heat-only plants, whatever the type of fuel, are reportable under category 236. Activities relating to fuelwood/charcoal production, energy manufacturing and natural resources extraction (including oil and gas pipelines) are reportable under categories 312, 321 et 322 respectively.
231		<b>Energy generation, distribution and efficiency – general</b>	
	23110	Energy policy and administrative management	Energy sector policy, planning; aid to energy ministries; institution capacity building and advice; unspecified energy activities.
	23181	Energy education/training	All levels of training not included elsewhere.
	23182	Energy research	Including general inventories, surveys.
	23183	Energy conservation and demand-side efficiency	All projects in support of energy demand reduction, e.g. building and industry upgrades, smart grids, metering and tariffs. Also includes efficient cook-stoves and biogas projects.
232		<b>Energy generation, renewable sources</b>	
	23210	Energy generation, renewable sources – multiple technologies	Renewable energy generation programmes that cannot be attributed to one single technology (codes 23220 through 23280 below). Fuelwood/charcoal production should be included under forestry 31261.
	23220	Hydro-electric power plants	Including energy generating river barges.
	23230	Solar energy	Including photo-voltaic cells, solar thermal applications and solar heating.
	23240	Wind energy	Wind energy for water lifting and electric power generation.
	23250	Marine energy	Including ocean thermal energy conversion, tidal and wave power.
	23260	Geothermal energy	Use of geothermal energy for generating electric power or directly as heat for agriculture, etc.
	23270	Biofuel-fired power plants	Use of solids and liquids produced from biomass for direct power generation. Also includes biogases from anaerobic fermentation (e.g. landfill gas, sewage sludge gas, fermentation of energy crops and manure) and thermal processes (also known as syngas); waste-fired power plants making use of biodegradable municipal waste (household waste and waste from companies and public services that resembles household waste, collected at installations specifically designed for their disposal with recovery of combustible liquids, gases or heat). See code 23360 for non-renewable waste-fired power plants.
233		<b>Energy generation, non-renewable sources</b>	
	23310	Energy generation, non-renewable sources – unspecified	Thermal power plants including when energy source cannot be determined; combined gas-coal power plants.
	23320	Coal-fired electric power plants	Thermal electric power plants that use coal as the energy source.

DAC 5 CODE	CRS CODE	DESCRIPTION	Clarifications / Additional notes on coverage
	23330	Oil-fired electric power plants	Thermal electric power plants that use fuel oil or diesel fuel as the energy source.
	23340	Natural gas-fired electric power plants	Electric power plants that are fuelled by natural gas.
	23350	Fossil fuel electric power plants with carbon capture and storage (CCS)	Fossil fuel electric power plants employing technologies to capture carbon dioxide emissions. CCS not related to power plants should be included under 41020. CCS activities are not reportable as ODA.
	23360	Non-renewable waste-fired electric power plants	Electric power plants that use non-biodegradable industrial and municipal waste as the energy source.
234		<b>Hybrid energy electric power plants</b>	
	23410	Hybrid energy electric power plants	Electric power plants that make use of both non-renewable and renewable energy sources.
235		<b>Nuclear energy electric power plants</b>	
	23510	Nuclear energy electric power plants	Including nuclear safety.
236		<b>Heating, cooling and energy distribution</b>	
	23610	Heat plants	Power plants which are designed to produce heat only.
	23620	District heating and cooling	Distribution of heat generated in a centralised location, or delivery of chilled water, for residential and commercial heating or cooling purposes.
	23630	Electric power transmission and distribution	Grid distribution from power source to end user; transmission lines. Also includes storage of energy to generate power (e.g. pumped hydro, batteries) and the extension of grid access, often to rural areas.
	23640	Gas distribution	Delivery for use by ultimate consumer.

DAC 5 CODE	CRS CODE	DESCRIPTION	Clarifications / Additional notes on coverage
240		<b>BANKING AND FINANCIAL SERVICES</b>	
	24010	Financial policy and administrative management	Finance sector policy, planning and programmes; institution capacity building and advice; financial markets and systems.
	24020	Monetary institutions	Central banks.
	24030	Formal sector financial intermediaries	All formal sector financial intermediaries; credit lines; insurance, leasing, venture capital, etc. (except when focused on only one sector).
	24040	Informal/semi-formal financial intermediaries	Micro credit, savings and credit co-operatives etc.
	24081	Education/training in banking and financial services	

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